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Author(s)	Mary Brennan, Angela Tregear, Maysara Sayed (UNED); Ružica Brečić, Irena Colić Barić, Andrea Lučić, Martina Bituh, Ana Ilić, Dubravka Sinčić Ćorić (ZAG); Efthimia Tsakiridou, Konstadinos Mattas, Christos Karelakis, Alexandros Gkatsikos, Ioannis Papadopoulos (AUTH); Filippo Arfini, Beatrice Biasani, Daniele Del Rio, Michele Donati, Francesca Giopp, Gianluca Lanza, Alice Rosi, Francesca Scazzina (UNIPR); Jelena Filipovic, Zorica Anicic (BEL) Steve Quarrie (EUTA)
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Academic Partners

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2. **UNIPR**, University of Parma (Italy)
3. **UNED**, University of Edinburgh (United Kingdom)
4. **WU**, Wageningen University (Netherlands)
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EXTENDED ABSTRACT

This final report presents the methods and results of WP6.2, evaluating the nutritional outcomes of different models of PSFP in a primary school context, including the role of plate waste. Maintaining a healthy diet that satisfies nutritional needs is extremely important in childhood, due to the increased need for a balanced intake of energy and nutrients to ensure optimal growth and development. The provision of adequate nourishment for children in institutional contexts (i.e. schools) is considered a matter of special public health concern, and European and national governments have established specific school food based standards and nutritional guidelines for organized meal planning. However, the nutritional value of institutionally organized diets is not only determined by food based standards and nutritional guidelines, but also by food procurement policy. Therefore, this research explores how, if at all, different public sector food procurement (PSFP) models may be linked to, and influence the healthfulness and nutritive value of school meals.

The research was conducted across 5 European countries namely Croatia, Greece, Italy, Serbia and UK. Using case studies, pairs of contrasting procurement models were analysed. For Croatia, Greece, Serbia and UK, the contrasting procurement models were: (i) a local model (LOC), in which the procurement contract encouraged local sourcing of foods, and/or a proportion of the suppliers were local, and (ii) a low cost model (LOW), in which the procurement contract made no reference to local sourcing. For Italy, the contrasting procurement models were: (i) a local and organic (LOC-ORG) model, in which the procurement contract specified a minimum amount of food from organic agriculture, integrated production, typical or traditional products (in total to comprise at least 70% of all foods); and (ii) an organic (ORG) model, in which the procurement contract specified that the majority of foods must be organic. In each country, and for each case, two from the five case schools described D6.3 Final Report, were selected to participate in the study. School selection was driven by specific criteria to allow for meaningful comparison with the other European case studies.

Our first goal was to examine the planned nutritive values of the meals served by the schools in each PSFP case. Hence, via a food composition analysis (FCA) of a sample of daily lunch menus at each selected primary school, we identified the energy, macronutrient and micronutrient contents of each menu and evaluated these against standards recommended either by the relevant national body or World Health Organisation (WHO). In addition, we recognised that no matter the nutritional guidelines or PSFP model used, children sometimes do not like to eat some food, resulting in refusal and plate waste. These refusal and wastage rates result in an actual nutritional intake that is lower than planned by the menu design. Therefore, as well as calculating the nutritive values of menus via FCA, we also collected and evaluated plate waste from a set of daily lunch services at the same selected schools, to reveal the nutritional as well as the financial losses, and embodied carbon burden, attributed to the collected plate waste.

In terms of the <u>nutritional composition</u> of the school lunch menus, we found some notable nutritional deficiencies in daily lunch menus across all countries and cases. Regarding the energy content of planned school lunches, the menus of the two Italian cases had the highest rate of alignment to national recommendations (90% and 95%, respectively), whilst both Greek case menus had the lowest rate of alignment (100% contained excessive calories) followed by both Croatian case menus (80-95% contained too few calories). Although menus across all cases generally met recommendations for carbohydrate and protein content, in some cases, a high proportion of menus provided insufficient fibre (such as in Croatia), or were found to be too high in fat (Greece) or saturated fat (UK). In addition, a large proportion of daily menus across the cases were found to be deficient in key micronutrients (iron, calcium, folate and Vitamin A). Worryingly, across some cases, the salt content of school lunches was found to be

very high, such that for example in Greece, certain menus exceeded the total daily sodium recommendations for children. Despite the variations across cases that were revealed by the nutritional analysis, the nutritive values of menus did not appear to be affected by the type of procurement model adopted.

In terms of plate waste, we also found high degrees of variation across countries and cases. The two cases with the lowest rates of plate waste to total food served were Croatia LOW (12%) and Serbia LOC (19%), whilst the cases with the highest rates of waste were Greece LOW and LOC (43% and 38%, respectively), and Italy ORG (38%). For the remaining cases, waste rates were between 25% and 32% of total food served.

Considering the composition of total collected plate waste by food category, and the proportional contribution of each category to total collected, the majority of collected waste came from starchy food (Croatia, Italy, Greece and United Kingdom), vegetables (Croatia and Serbia), and fruit (Italy). The food categories which represented a smaller proportion of waste were desserts, other food, and soups in all countries. The exception to this was the UK where in the LOW case only 6% of total waste came from vegetables. However, significant child refusal of vegetables at the point of service meant that very little vegetables were actually put on plates in UK LOW schools, which highlights how certain service practices play a role in plate waste levels and the nutritional intake of children from school meals.

Considering collected plate waste, both in total, and as a proportion of the total amount of food served per category, very interesting and diverse results emerged across the countries which can be explained through a range of observed factors including: number and size of served portions; children's eating habits, canteen design and layout; level of supervision and encouragement provided by staff to children; wider school and catering food policies; organoleptic appearance of food, a child's previous experience of a food, and the time allocated per child for eating lunch.

According to this, the most wasted food categories in Croatia were vegetables (35% in LOC case and 15% in LOW case) and meat and fish (35% in LOC case and 12% in LOW case), where a higher amount of waste was observed in LOC case for both categories. In Greece all food categories had wastage rates of between 30-54.8%, except for meat and fish in the LOW case. In Italy more then 30% of served starchy food was wasted, followed by meat and fish (ORG case only), and vegetable, fruit, and bread across both cases. In Serbia, LOC case children wasted 21.6% and 23.3% of served vegetables and salad respectively followed by bread (37.1%), meat and fish and soup (both 19.2%), starchy food (8.8%), and dessert (7.8%). In contrast, children in Serbia LOW case wasted 43.1% and 39% of served vegetables and salad respectively, 36.7% of served bread, 31.4% of served starchy food, 31.1% of served meat and fish, 26.2% of served soup and 25.8% of served dessert. In UK LOC case, where overall levels of plate waste were 26% of planned food served, children wasted 43% of estimated served vegetables, 29% of estimated served starchy foods, 16% of estimated served fruit, 14% of estimated served meat and fish, 12% of estimated served dessert and 2 % of estimated other food. In UK LOW case, where overall levels of plate waste were 25% of planned food served, children wasted 31% of estimated served starchy foods, 13% of estimated served meat and fish, 8% of estimated served vegetables, 9% of estimated served fruit, 7% of estimated served dessert and 5% of estimated served other food. While differences in collected plate waste as a proportion of planned food served were found between PSFP model (higher in Greece, Italy and Serbia in the LOW/ORG model (5.8%, 12.7%; 12.8% respectively), and 16%, and 1%, higher in the LOC model for Croatia and the UK), the PSFP model is not considered to be driving force behind these differences. Instead other factors are considered to be much more influential including: portion size, variety and format of food served, canteen environment and layout, length and positioning of lunchtime relative playtime, and the provision of adult supervision and encouragement.

In terms of nutritional impact of waste, across the 5 countries, and different PFSP models, similarities and differences were found in terms of the % losses across energy, macro-, and micronutrient categories. For LOC case schools, children were estimated to consume between 63-82% of food served with energy losses of between 18-35%, protein losses of between 17-35%, carbohydrate losses of 21-37%, total fat losses of 15-38%, saturated fatty acid losses of 15-37% and dietary fibre losses of 22-38%. For LOW case schools, children were estimated to consume between 57-87% of food served with energy losses of between 12-43%, protein losses of between 14-39%, carbohydrate losses of 19-44%, total fat losses of 14-42%, saturdated fatty acid losses of 14-37% and dietary fibre losses of 15-43%. Generally, except for Croatia, losses were higher in LOW/ORG case schools and when compared to results in existing studies (detailed above), the estimated losses are, for all categories expect for dietary fibre, either within or above, the published ranges. For total carbohydrates and total fat, the losses were found to be to be well above these published ranges. As before, we did not find clear evidence that any differences between cases were caused by the PSFP model.

In terms of the financial impact of waste, across the 5 countries and PSFP cases, the financial loss attributed to plate waste was estimated to be between €0.04 and €2.79 per average meal served, representing a loss of between 3% (Croatia, LOW case) and 56% (Italy, ORG case) of the full price paid per meal and between 3% (Croatia LOW case) and 54% (Greece LOC case) of the total food supply budget per case. The cost impact of the waste was strongly related to the quantities of waste produced in each case.

In terms of the estimated embodied carbons emissions attributed to plate waste, across the 5 countries and PSFP cases, these were estimated to be between 0.05 $kgC0_2eq$ and 1.53 $kgC0_2eq$ per average meal served or 5-63% of the total embodied emissions of the food procured per case, with significant differences observed between cases, according to the quantities of waste produced in each case, and also the choice of waste disposal method. As the amount of waste generated in Croatia LOW case was very low, the proportion of embodied emissions to total emissions was also very low at 5%. However in Greece cases, where waste quantities were very high and the waste disposal method is landfill, which has a high carbon burden, the embodied emissions in the waste represented a very high proportion of total case emissions (62-63%). In Italy, Serbia and UK cases, the contributions of the embodied emissions in the waste to total emissions were estimated to be from 17-35% of total emissions.

The following set of recommendations are proposed across our 5 countries, and different PFSP models investigated. They articulate the clear need for a systems based approach to reducing plate waste (and associated nutritive, financial and carbon losses), optimising the nutritive intake of primary school children and explicitly acknowledging the role and influence of multiple factors and stakeholders, in daily school meal services. Grounded firmly in the observational, nutritive, and plate waste results reported, the recommendations are split into 4 interconnected and interdependent categories which target different level of the school meal management and delivery system: 1. National and Municipal Policies and Practices; 2. Staff Resourcing, Roles, Training and Skills; 3. School based Policies and Initiatives; and 4. Canteen Environment and Layout.

1. ***National and Municipal Policies and Practices***
    a. Development (Greece), implementation (Serbia) and regular reviewing of National Nutritional and/or Food Based Standards for Primary School aged Children (Croatia, Italy, UK), and where possible specific to school meals. This

will, in particular, require consideration, at a national, municipality and school level, to be given to adjusting portion sizes for age and (where considered appropriate) gender.

b. Policies should be put in place to avoid child refusal of whole meal components, and in particular vegetables, during school meal service.

c. Creation, and resourcing of centrally managed (national and/or municipality based), pools of professionally trained nutritionists and/or dieticians who work closely with school based catering teams on menu innovation and development and nutritional analysis for primary school meals.

d. Development of varied, yet nutritionally optimal and seasonally grounded, menu cycles that offer variation and respond to locally available supply (where appropriate and feasible).

e. Development of national, and municipality, led mechanisms for greater, and better, stakeholder engagement and best practice sharing (i.e. stakeholder forums)

f. Integration of the voices and experiences of children and parents into the processes for managing, and reviewing, school meal systems to ensure that the "consumer" voice is listened to, and valued in, the service design and delivery process.

g. Development, delivery and evaluation of national and/or municipality led food, nutritional and sustainability initiatives, including child and parental/wider family targeted educational and cooking skills programmes.

2. ***Staff Resourcing, Roles, Training and Skills***

a. Evaluation of, and investment in, the roles and skills of canteen staff (from Unit Managers to part time assistants) to maximise the positive impact they can have in terms of school meal production (i.e. menu innovation; preparation and cooking techniques; presentation of food) and service delivery where optimal intake and waste minimisation are considered key indicators of good performance

b. Investment in greater canteen supervision capacity (catering and teaching staff) to support and encourage all children, no matter what their age, to eat as much of their lunch and in particular their vegetables as possible.

c. Provision of generic, and onsite, training in how to interact with, and encourage children with optimal eating (given the environmental constraints each will be working under in their schools) to get the best results from increased investment in dedicated, and trained, canteen supervisors.

d. Integration of catering staff into other suitable school based roles (pre or post lunchtime activities) to create better, more attractive mixed full time and part time roles within schools, helping to improve the connectedness and integration of such staff into wider school life.

e. Establishment of food and non-food segregated recycling initiatives and waste stations and monitoring and tracking systems that require regular (daily/weekly) recording, and reporting, of daily plate, other food, and non-food waste (especially single use plastic and packaging) in school canteens to support schools, caterers and municipalities to learn from, reduce rates, and dispose optimally, of the daily plate, other food and non-food waste generated.

3. ***School based Policies and Initiatives***
    a. Schools are strongly encouraged to integrate food, nutritional and sustainability related topics into the broader culture and life of their schools both in terms of on, and extra curricula, activities.
    b. Systemic review (municipality and school based) of the length and positioning of school lunchtimes within the broader school day to ensure children have optimal time for eating (and digesting) their lunch, engaging in very valuable peer to peer and peer to staff (supervisors) interaction, developing good food and eating practices and ensuring they do not feel under pressure to eat fast for fear of missing out on playtime.
4. ***Canteen Environment, Layout and Food Service***
    a. Municipality and school based reviews are recommended regarding how food is ordered by (where pre-ordering is required in the UK), and served to, children in the canteen. This should consider how, and where school food is produced (on-site or central), the impact of central kitchen production on the appearance, taste and temperature of served food, what items are served, and in what order, whether all main meal components (including dessert as happens in the UK) are served together, where children are served their food (service counter, from serving carts, at their tables), on what food is served (i.e. multi-compartment trays; plates; bowls) and how canteen supervision interacts with this process to optimise food intake and reduce plate waste.
    b. Review and investment in optimising, given school specific constraints, canteen layout and lunch service management. This should include reviewing how to optimise: the type and use of available canteen space (dedicated or multiuse); the height, and visual accessibility of the food service counter (where used); the canteen layout including the number, and type of seats and tables available; the type and number of segregated waste stations (to maximise waste recycling); noise levels during service; and the available light and decoration of school canteens

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List of Abbreviations and Acronyms

PSFP- public sector food procurement

LOC MODEL – School with an Alternative model of public food procurement

LOW MODEL – School with a model of LOW cost public food procurement

-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)

b-model 2- school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

FCA - food composition analysis

HR – higher than recommended

AV- adequate value

LR – lower than recommended

SATFAT-saturated fatty acids

1. INTRODUCTION

This report presents the findings of S2F 6.2 workpackage into nutritional and plate waste outcomes of primary school food chains across 5 european countries namely Croatia, Greece, Italy, Serbia and UK. Using case studies, pairs of contrasting procurement models were analysed. For Croatia, Greece, Serbia and UK, the contrasting procurement models were: (i) a local model (LOC), in which the procurement contract encouraged local sourcing of foods, and/or a proportion of the suppliers were local, and (ii) a low cost model (LOW), in which the procurement contract made no reference to local sourcing. For Italy, the contrasting procurement models were: (i) a local and organic (LOC-ORG) model, in which the procurement contract specified a minimum amount of food from organic agriculture, integrated production, typical or traditional products (in total to comprise at least 70% of all foods); and (ii) an organic (ORG) model, in which the procurement contract specified that the majority of foods must be organic. In each country, and for each case, 2 of the 5 case schools described in D6.3 were selected to participate with school selection driven by specific criteria to allow a meaningful comparison with the other European case studies selected within this task, including: a minimum pupil roll of 100 pupil; the presence of a distinct meal preparation and delivery model (e.g. food prepared and distributed from central or school based in house kitchen), and different distances between the schools and the cooking centre if a unique meal-delivery model was applied and/or different socio-economic school profiles.

The nutrition of primary-school children is one of the most significant public health issues facing almost every country in the world. School nutrition should provide an adequate range of food for children, supporting a a child’s physical growth and development, educational attainment and the establishment of healthy and proper eating habits. Although many countries have developed national nutritional guidelines for primary school meals, child nutritional intake of institutionally organized diets can be influenced not only by food standards and nutritional guidelines but also the criteria set by food procurement policies, the school food facilities and the processes and practices for delivering school meal services. Therefore, our goal was to undertake food composition analysis (FCA) of daily lunch menus at selected primary school canteens belonging to contrasting models of food procurement, in order to evaluate the nutritive values of the selected menus. In addition, we recognised that no matter the national guidelines or PSFP model used, children sometimes do not like to eat some food resulting in child refusal and plate waste. These refusal and wastage rates result in a lower than planned actual nutritional intake for children from school meals, compared with what is intended by the menu design. Therefore, as well as calculating the nutritive values of menus via FCA, we also collected and evaluated plate waste from the same selected school canteens, to reveal the associated nutritional losses as well as the financial loss, and embodied carbon burden, associated with the collected plate waste.

Therefore in summary, in all cases, and across all 5 countries, our research involved collecting and analysing plate waste, measuring the nutritional composition of planned school lunch menus and calculating the estimated nutritional and finanical losses, and embodied carbon within, the collected plate waste.

1.1. The Case PSFP Models

The location of the case PSFP models included in this research are shown in Figure 1, followed by an explanation of the selection of the cases, and how they were defined, in each country.

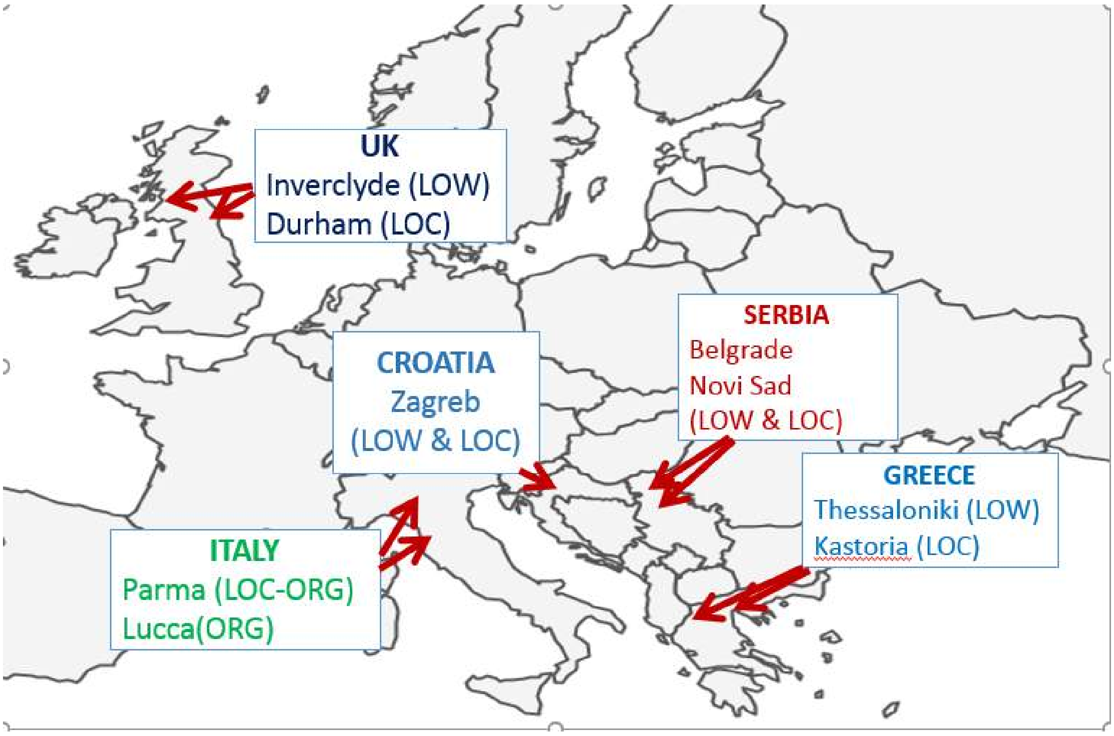

Figure 1. Location of Case PSFP Models

Croatia

Both case studies are located in Zagreb City, the capital of Croatia. In Croatia, procurement contracts are normally tendered and managed by individual schools, not municipalities, and the first criterion for contract award is safety (pass/fail), and the second is price. Therefore, the dataset for the LOW case model in this research consists of five primary schools who each undertake their own procurement according to this typical context and contracting criteria. The other case model is based on a hub school with a big central kitchen, which prepares meals for 12 other schools in Zagreb City, in addition to its own pupils. Due to its large budget and bargaining power in the supply chain, the hub school has more flexibility to contract additional, usually local, organic and/or family-owned suppliers, at least some of whom supply healthier products. This model is therefore described as a LOC model, and the dataset consists of the hub school plus four out of the 12 schools it distributes meals to.

Greece

School meals were first introduced into Greece in 2016-17 by the Ministry of Labour, Social Insurance and Social Solidarity, and the Ministry of Education, in a fully funded program ("School Meals") to address social inequality risks. Within this context, the PSFP models selected were one LOW and one LOC model. The LOW case was the implementation of the School Meals programme in the urban municipality of Evosmos – Kordelio, Thessaloniki. The contract was awarded according to the Most Economically Advantageous Tender (MEAT) framework, and most of the catering firm’s first tier suppliers were located outside the municipality or abroad. Hence, this case was defined as a LOW PSFP model. The LOC case was the implementation of the School Meals programme in the rural municipality of Kastoria, northwestern Greece. Although in this case the contract was also awarded according to the MEAT framework, a larger proportion of first tier suppliers, and also upstream producers, were located in the prefecture of Kastoria. Hence, this case was defined as a LOC PSFP model.

Italy

In Italy, school meals are normally organised at the municipal level. The research was conducted in two municipalities, which are also administrative centres of their provinces: Parma, located in Emilia-Romagna Region in the North of Italy, and Lucca in Tuscany Region, in the Centre of Italy. The two case procurement models were (i) a local-organic (LOC-ORG) model (Parma), in which the procurement contract encouraged sourcing of foods from within a local/regional area, and a minimum amount from organic agriculture, integrated production, typical or traditional products (in total to comprise at least 70% of all foods employed for meal preparation); and (ii) an organic (ORG) model (Lucca), in which the procurement contract specified that the majority of foods used in meal preparation must be of organic origin.

Serbia

The Serbian context for school meals provision is similar to Croatia, to the extent that individual schools are normally responsible for contracting and managing their own food supplies/meals, and are obliged to accept lowest cost tenders. In practice however, there is some variation in the geographical distances between schools and the first tier suppliers they contract with, which formed the basis of the case model definitions. Specifically, the first PSFP model was defined as a LOC model, and consisted of schools which procured more than 70% of their food (by value) from suppliers less than 15 km distant from the school. The second PSFP model was a LOW model, in which at least 30% of food (by value) was procured from suppliers at least 15 km distant from the schools. In reality, the procurement decisions of schools in Serbia take place in a fluid manner on an annual basis, which means the stability of models over time is rather weak. For the purposes of this study, both LOC and LOW models were defined according to the suppliers contracted at the commencement of data collection, early in the 2017-18 school year. In terms of location, the dataset for the LOC case consisted of the supply chains to two Belgrade and two Novi Sad primary schools, respectively, whilst the dataset for the LOW case comprised the supply chains to an additional three Belgrade primary schools and one Novi Sad primary school.

UK

The research was conducted in two regions: County Durham in north east England and Inverclyde in west central Scotland. In both these areas, as elsewhere in the UK, school meals are generally organised at municipal or Local Authority (LA) scale. In Durham, the PSFP model was defined as LOC, because the procurement contract specifies a number of sustainability criteria as part of the award, including encouragement of local sourcing. Inverclyde was defined as a LOW PSFP model, as the procurement contracts are awarded primarily on the basis of lowest price bids, with no specific reference to local sourcing.

2. PROFILE OF THE CROATIAN CASE SCHOOLS AND THEIR SCHOOL MEAL SERVICE

2.1. Croatia

Both cases are located in Zagreb city, the capital of Croatia. Zagreb City has 144 primary schools, with a total of 59756 (2017/2018) pupils and average pupil roll of 414[1], considerably higher than the Croatian national average of 150.[2] In Croatia, all primary schools must provide school meals to their children. Where school nutrition is organized at the municipality level, funds are provided from the state budget and the budgets of local and regional self-government units, while part of the costs are also covered by parents. In Zagreb primary schools, meals are co-financed for 68% of children (approximately 43,000). For students in day care (from 8 am to 4 pm), approximately 24% of all Zagreb primary school children, the school must plan to, and serve them, three meals per day (a milk meal, a lunch and a snack). There is only one lunch dish prepared per day and all children are served with this (i.e. there are no multiple options between dishes on the same day). The price of the daily lunch €1.20 (9.00 HRK) with pupils entitled to subsidized meal prices, in accordance with the established criteria and benchmarks of this program. The difference in funds between the subsidized price and the established full price of school meals is made payable to the school from the budgetary funds. Parents are charged on a monthly basis calculated from school records of the number of consumed meals/child with monthly invoices issued by the school to parents. In Zagreb, as in Croatia more widely, food procurement contracts are tendered and managed by individual schools, not the municipality, and the process is conducted annually.

2.1.1. LOC Schools

The two selected LOC Case schools are: LOCSchool A (the hub school) and LOCSchool E. Both schools are big (719 and 803 respectively), with 48% and 36% meal uptake respectively. LOCSchool A, a hub school, sets the seasonal menus for itself and the 12 other Zagreb primary schools it prepares school meals for. Lunches are prepared in LOCSchool A and delivered daily to LOCSchool E. LOC School E has limited input into, and impact on, lunch menu planning, though they can, and do, communicate with LOC School A providing feedback about the lunches which LOC School A takes into consideration and responds to where possible. The daily menu comprises a single option meal (hot main dish plus a salad or dessert). The main dish is typically a meat and vegetable stew accompanied by bread or potatoes, although pasta, gnocchi and polenta-based dishes also feature. Salads most often comprise beetroot, cabbage, lettuce or tomato. Desserts can be milk-based puddings or juice. The weight of the average cooked LOC school lunch is 472g. Both schools have large canteens with tables set out in long rows (See Figure 2).

[1] https://www.dzs.hr/Hrv_Eng/publication/2018/08-01-02_01_2018.htm
[2] https://eclectica.hr/2015/07/13/hrvatsko-skolsto-u-brojkama

Figure 2: School canteen and serving counter in LOCSchool A (Croatia)

2.1.1.1. Menu Planning, Lunchtime service and Waste Management

LOCSchool A has 7 staff members (3 chefs and 4 assistants) preparing schools meals for 13 schools (including itself). Menus are planned one month in advance (See Table 1 for a sample LOC menu). For lunch service, the youngest children are treated differently to the older children as they are served food at the tables, by kitchen staff, with cutlery, glasses, bread and salad all laid out for them. Teachers sit with them and "half of the teachers" encourage them to eat more/finish up. Older children come in adhoc, are served their meal on tray at the counter, and left alone by teachers to eat their lunch with no additional encouragement provided. Each child has 15-20 mins, in practice, to eat lunch and when finished children clear their own plate waste into single dedicated food waste bin. Of the food waste collected, 70% is sent to a local farm (for use as animal feed) and 30% goes to a commercial waste plant for processing via an anerobic digester unit.

Figure 3: School canteen and serving counter in LOCSchool E (Croatia)

LOCSchool E has 2 female cooks with each child, in practice, getting 20 mins to eat lunch. The youngest children are served first collecting their main meal from the canteen counter and sitting down in class groups at prepared tables (with bread, salad laid out in advance) (Figure 3). While their teachers sit in the canteen at separate tables eating their lunch, they do not provide encouragement to the children to eat their food and/or try new foods. They do, however, check the finished plates as the youngest children need to get permission to take their dessert.

Older children come in adhoc and collect their whole meal (main and dessert) on a tray from the canteen counter. All children are responsible for taking their finished plates to the waste hatch where kitchen staff take the tray from them and are responsible for disposing of the associated food and non food waste. 70% of the collected food waste goes to a local farm for use as animal feed while the remaining 30% is sent for a commercial waste organisation for processing via anerobic digestion.

Season	Monday	Tuesday	Wednesday	Thursday	Friday
AUTUMN/WINTER	Polenta, pork goulash, pickled beetroot, bread	Bean stew with pasta and sausages, rye bread	Soup with noodles, vegetable risotto, corn bread, biscuit chocolate cake	Potato stew with beef, bread, biscuit cake with dried cranberries	Boiled brussels sprouts with potato, breaded hake, bread with sunflower seeds, juice made from syrup
	Green beans stew with beef, bread, dairy dessert “Euforia”	Cooked potato, meatballs in tomato sauce, bread	Vegetable stew with turkey, corn bread, biscuit cake with chocolate and coconut	Bean stew with pasta and sausages, bread with sunflower seeds, juice made from syrup	Mashed potato, spinach with milk, cooked eggs, bread with pumpkin seeds
SPRING/SUMMER	Peas stew with gnocchi and beef, bread, chocolate pudding	Pasta, chicken fricassee, lettuce salad, rye bread	Vegetable stew with turkey, corn bread, vanilla shake	Rice with peas, breaded chicken, cabbage salad, graham bread	Pasta with tuna sauce, cucumber or pickled beetroot salad, bread with sunflower seeds
	Tomato soup, risotto with vegetable and turkey, bread with pumpkin seeds, juice made with syrup	Cabbage stew with beef, graham bread, biscuit cake	Mashed potato, breaded turkey, tomato salad, corn bread	Bean stew with barley and smoked meat, bread, chocolate pudding	Boiled chard with potato, breaded hake, bread with sunflower seeds

Table 1: Sample Croatian LOCSchools A and E Menu

2.1.2. LOW Schools

The two LOW case schools are LOWSchool A and LOWSchool C. Both are smaller than LOC case schools (390 and 368 respectively), with uptakes of 37% and 58%. Like LOCSchools, the LOW schools are actively involved in school based food, health and sustainability initiatives, both externally driven and homegrown. It is noteworthy that LOWSchoolC has a school garden where pupil involvement in growing is encouraged (it also seemed to be the case for LOCSchoolE) and quite a high meal uptake % (58% compared to 24% in LOWSchool A) from a relatively small pupil roll.

2.1.2.1. Menu Planning

LOWSchool menus are quite a bit similar to those of LOCSchool though pasta seems to appear more frequently in LOWSchool dishes (bread/potatoes definitely the dominant carb in LOC case) (See Table 2). Like LOCSchools, the dishes are very traditional "meat and two veg" meals though the cooked weight of on average LOWSchool lunch is 179g less than LOCSchools at 293g/average lunch meal served.

Season	Monday	Tuesday	Wednesday	Thursday	Friday
AUTUMN/WINTER	Polenta, sauerkraut goulash, bread	Bean stew with sausages, bread	Soup with noodles, mashed potato, turkey burger, pickled peppers, bread	Peas stew with chicken, bread	Risotto with tomato and hake, lettuce salad, bread
	Risotto with turkey, pickled beetroot, corn bread	Green beans stew with chicken, corn bread	Polenta, beef goulash “pašticada”, corn bread	Peas stew with turkey, corn bread	Spaghetti with shrimps and tomato sauce, lettuce salad, corn bread
SPRING/SUMMER	Polenta, beef goulash, pickled mixed vegetable, bread	Green beans stew with chicken, bread	Domestic pasta “Mlinci”, roasted chicken, lettuce and chicory salad, bread	Bean stew with barley and smoked meat, cabbage salad, bread	Potato stew with haddock, bread
	Mashed potato, roasted turkey, cabbage salad, bread with sunflower seeds	Peas stew with turkey, corn bread	Spaghetti with chicken sauce, corn bread	Polenta, beef in mushroom sauce, corn bread	Pasta with cottage cheese, corn bread

Table 2. Sample of school meals in LOWSchool A and LOWSchool C

2.1.2.2. Kitchen and Canteen, Lunctime Service and Waste Management

LOWSchool A has 3 staff members (1 female chef, 2 male assistants). The canteen is quite small and some pupils will stand to eat their meal, at high tables. The other tables seem to be arranged in rows, but are somewhat shorter than in the (larger) LOC schools (Figure 4).

Figure 4: School canteen and serving counter in LOWSchool A (Croatia)

Service is from 12.00-1.30pm, each student gets 15mins for lunch. The youngest children come in as come in as a group, while all other children comes in adhoc. All meals are served from the counter and children get all lunch components on their tray at once picking up their salad, cutlery and/or bread at the end of the serving counter where children can take as much bread/salad as they want. While the teachers can decide where they want to sit, in practice they were not observed sitting with the children nor providing additional encouragement. Instead, the kitchen staff encourage the children to eat up their meals and/or try new foods. After lunch, all children are responsible for taking their trays back to the counter for waste processing and washing. The kitchen staff throw away the plate waste into a single (aggregate) food waste bin, and put the cutlery and plates into a dishwasher. The collected food waste is sent to a locally owned family farm known to school staff as well as an official company, Agroproteinka, who specialise in waste disposal.

LOWSchool C has 3 staff members (1 chef, and two assistants, one of which is part-time - though recall this is also the school where 2 science teachers are part of the wider meals "team"). LowSchoolC kitchen staff serve, from the canteen counter, the main dish and salad on a serving tray (the same size portion whatever the child’s age) and, after children take their lunch, they sit at tables of 4, which is a strikingly different arrangement to other canteens. On every table, the kitchen staff put a basket with bread and cutlery (Figure 5).

Figure 5: School canteen and serving counter in LOWSchool C (Croatia)

LOWSchoolC lunch service lasts for 2.5 hrs between 11.30am and 2pm. Each child has up to 45mins to eat their lunch, significantly longer than in any other Croatian case school. In practice, the children were observed spending on average 30 minutes eating lunch. The big canteen space, food service organisation and the number of students having lunch in LOWSchoolC all appear to combine to facilitate this longer lunchtime period. Both teachers and kitchen staff check plates, encourage children to eat up and/or try new foods. After lunch, all children are responsible for putting their trays on the window ready for washing. The kitchen staff throw away the plate waste into a single (aggregate) food waste bin, and put the cutlery and plates into a dishwasher. The collected food waste is sent to a locally owned family farm known to school staff as well as an official company, Agroproteinka, who specialise in waste disposal.

2.2. Greece

In the 2016-17 school year, due to concerns for socio-economic inequality, the Greek Ministry of Labour, Social insurance and Social solidarity (LSS), in collaboration with the Ministry of Education, launched the "School Meals" program in 38 primary schools, selected from specific Municipalities based on deprivation criteria. In 2017-18, the program was expanded to 798 public primary schools. None of the participating public schools in Greece have kitchen and/or canteen facilities and thus private catering enterprises were contracted to prepare and deliver meals to schools. The two models selected were a low-cost model (LOW) and a local procurement model (LOC). All schools meals are delivered and served in black platstic (PET) containers (like those used for ready made meals) and pupils are allowed to consume them either at the school, or to take them home to eat, during the daily lunch break.

2.2.1. LOW Case

The LOW case is located in west side of the city of Thessaloniki, and specifically in the municipality of Evosmos-Kordelio. The Municipality runs 33 primary schools all of which are participating in the national pilot program "School meals". While all pupils in participating schools are eligible to receive a free school meal, on average 235 pupils/school are receiving a free school meal across the 33 registered primary schools equating to a meal uptake rate of 71%. The duration of the school meals program was 24 weeks, starting in the second week of January (8th of January) until the end of the school year (13th of June). Very limited school based food, nutrition and sustainability initiatives were identified in LOW Schools though teachers in LOW schools have initiated a voluntary recycling program (very usually within Greece) in which children are educated about recycling and children's daily participation in recycling is monitored by an assigned pupil (rotates daily) who is responsible for managing the proper implementation of the school recycling initiative. LOW school meals are prepared and delivered by the LOW caterer (D6.3 Greece Country Report) at a cost of €2.23/school meal which is fully covered by the Greek government.

2.2.1.1. Menu Planning

Each school meal consists of a main meal, a salad, a piece of bread, and a dairy product once per week (FETA cheese) (See Table 3). The menu was planned by the caterer and while the school had no input in menu design, headteachers are responsible for providing regularly feedback to the the caterer in order to improve the school meal service.

Day & Participation (%)	Meat & Fish	Starchy food		Vegetables	Mixed	Other (egg, FETA cheese)
Monday (80%)	Beef chicken	Rice	Bread	Salad (boiled beetroot)	-	-
Tuesday (65%)	-	-	Bread	Salad (boiled carrot)	Pasta with minced meat	-
Wednesday (72,5%)	Fish	Potatoes (oven)	Bread	Salad (fresh carrot & cabbage)	-	-
Thursday (70%)	Beef	Barley	Bread	Salad (Fresh Cucumber-Carrot)	-	-
Friday (65%)	-		Bread	Salad (boiled beetroot)	Boiled Peas with Carrot and potatoes (main meal)	FETA cheese

Table 3: School menu for LOW Schools

2.2.1.2. Kitchen and Canteen, Lunchtime Service and Waste Management

School meals are delivered, by LOW Caterer, to the school facilities between 12:15-12:30 in thermal incubators using LOW Caterer owned vans. Lunch starts at 13:15 when meals are served to children in their classrooms or the school halls as neither of the LOWSchools have dedicated school dining facilities. In LOWSchool A, teachers used a computer classroom as dining room (figure 6) while in LOW School B students, who choose to eat their lunch in school, were served, and ate lunch, in their classrooms. Some children choose to take their school meal home to eat it there during the daily lunch period. The children who did not accept the offered school lunch (approximately 30%) brought their own lunch into school and consumed it in the classroom alongside the other children. No drinks were provided with pupils bringing in their own water in reuseable water bottles. Lunchtime ends at 14:00 and the teachers cleared away the pupils' dining tablecloths and clean the desks while LOW caterer staff return to pick up the empty incubators. Normally, the plate waste is put into non-segregated bins by children for disposal in landfill while the PET containers are recycled in special recycling bins.

2.2.2. LOC Case

The LOC Case, Kastoria, is located in the Municpality of Kastoria, a rural region of North West Greece (with part of the prefecture in neighbouring Albania). The municipality of Kastoria has a population of 35,874 citizens covering an area of 763,3km^2 (ELSTAT, 2011). It is comprises of the towns of Kastoria and the villages of Aposkepos, Kefalari and Chloi. The municipalities economy is oriented to fur production, tourism and agriculture (Municipality of Kastoria, 2018). Agriculture is the single main employer in the region with 17,77% of the workforce followed by the Public Sector with 10.96% of labour (ELSTAT,2018)[3]. Kastoria Municipality has a total of 30 primary schools (Primary education office, 2018) with 15 (50%) registered on the school meals program. On average, 77 pupils per school are receiving school meals through the program representing an meal updake % of 81%. As for LOCSchools, the duration of the school meals program was 24 weeks, starting in the second week of January (8th of January) until the end of the school year (13th of June). On average, the two selected LOCSchools have 81 pupils/school receiving schools meals, an maeal uptake rate of 83.3%, slightly higher than the Municiality's average. No food and sustainability inaitives have been developed and/or delivered in LOC schools.

2.2.2.1. Menu Planning

The LOCSchool meals were prepared and delivered by the LOC caterer (D6.3 Greece Country Report) at a cost of €2.22/school meal which was fully subsidised by the Greek government. Each school meal consisted of a main meal, a salad, a piece of bread, and two day per week, a dairy product (FETA cheese) or a boiled egg (See Table 4). As per the LOW schools, the menu was planned by the caterer and headteachers were responsible for providing feedback to LOC caterer to help improve the school meal service.

[3] http://www.statistics.gr/el/statistics/-/publication/SAM04/-

Day & Participation (%)	Meat & Fish	Starchy food		Vegetables	Mixed	Other (egg, FETA cheese)
Monday (80%)	Roasted chicken	Rice	Bread	Salad (boiled carrot)	-	-
Tuesday (65%)	-	-	Bread	Salad (fresh cabbage)	Pasta with minced meat	-
Wednesday (72,5%)	-	Lentil soup	Bread	Salad (broccoli)	-	Cheese feta
Thursday (70%)	Roasted chicken	Groats	Bread	Salad (fresh carrot & cabbage)	-	-
Friday (65%)	-		Bread	Salad (fresh cucumber)	Spinach with rice	Boiled Egg

Table 4: School menu of LOC Schools

2.2.2.2. Kitchen and Canteen, Lunctime Service and Waste Management

The school meals were consumed by the pupils in the classrooms or the school halls, were teachers installed dining tables with tablecloths for the pupils. The lunchtime service applied in Kastoria (LOC case) was similar to that in the LOW case. The LOC school meals were delivered to the school facilities at approximately 12:15-12:30 in thermal incubators (figure 6a, 6b) using a LOC Caterer owned van. Lunch service started at 13:15 and the meals were served in the classrooms and the school halls. As per LOW case, while some pupils consumed their school meal in school during lunch, others chose (and were allowed) to take the meal home and consume it there. The children who did not accept the offered school lunch (approximately 28%) brought their own lunch into school and consumed it in the classroom alongside the other pupils. No drinks were provided and thus the pupils bring in their own water in reuseable water bottles. The lunchtime lasted for 45 minutes, ending at 14.00 when the teachers cleared away the pupils' dining tables and tablecloths and cleaned the desks while LOW caterer staff returned to pick up the empty incubators. While normally the plate waste were put directly into bins by the pupils for disposal via landfill, it was observed that sometimes plate waste was taken by the teachers and given to stray animals in Kastoria. The PET containers were recycled by the pupils in special recycling bins.

Figure 6: (a) Thermal incubators that are used for the transportation of the school meals and the salads, (b) the school meals in the termal incubators, (c) a typical school mail in Kastoria, and (d) Lunch preparation in LOC case school (Greece)

2.3. Italy

2.3.1. LOC-ORG Case

Parma is wealthy city (13/111) with a total 33 primary schools, an average pupil roll of 200 and an average regional meal uptake rate of 47%. All schools must offer a school meal, and the same standard menu that is delivered in every Parma school. The cost of lunch to parents is €6.18, and state subsidy starts for annual family incomes below €12,000 though only 1-3% of pupils are eligible for free school meals. The School meal service contract is retendered on a 6 year cycle and has been held by the current incumbent (ParmaCater) since 1995. The LOC-ORG contract specifies 70% of all foods procured must be organic, plus preference is given for local sourcing and other sustainability criteria. There are 29 supplier subcontracts in place (10 main ones) and suppliers are typically large-scale, with turnovers of >€100m. ParmaCater use a central kitchen to cook and distribute meals to 25 schools, cooking meals in onsite kitchens in the remaining 8 schools. All canteen staff, both central (32) and on-site (181), are ParmaCater employees (approx. 5-6 staff members per school, depending on numbers of meals served). The two selected LOC-ORGSchools are ParmaSchool One (located very close to municipality office, 215 pupils, 90% uptake), and ParmaSchool Two (located 10km from Parma centre, 239 pupils, 95% uptake).

2.3.1.1. Menu Planning

For LOC-ORG municipality schools, a set school lunch menu is carefully designed and approved by municipal dieticians (See Table 5 for a sample weekly LOC menu). The LOC-ORGSchool lunch menu runs on a 4 week cycle and is differentiated in 4 periods (autumn;winter; spring and summer) to guarantee the supply of seasonal fruit and vegetables. All LOC-ORGSchools have a canteen commission composed of nominated parents (of children attending the school) and school teachers who meet twice annually and whose the purpose is to verify the food and school canteen service quality. The lunch is made up of two courses (first course = starchy carbs like soup, gnocchi, pasta; second course = protein-based with side veg like fish with salad, beef/chicken with cooked veg; plus bread; plus fruit). The only drink served is water, while desserts are only served on special occasions. Occasionally, first and second courses are substituted by 'unique dish', e.g. lasagne. All schools in municipality take part in multiple food, nutrition and sustainability related educational initiatives and according to the Parma public tender specifications, ParamCater is required to provide financial support (corresponding to 0.6% of the annual value of the primary school food procurement).

Monday	Thursday	Wednesday	Thuesday	Friday
Pasta with EVO and Parmigiano cheese	Pasta in meat-soup	Egg-pasta with ricotta cheese and herbs	Pasta with clam sauce	Rice with tomato sauce and basil
Baked omelette with vegetables	Boiled meat with sauce	Vegetable pie	Cannellini beans with flavourings	Plaice fillet cooked au gratin
Green beans with EVO oil–tomatoes / fennels	Salad with mixed vegetables	Tomatoes/ julienne fennel	Julienne carrots	Salad with corn
Bread	Bread	Bread	Bread	Bread
Seasonal fruit	Seasonal fruit	Seasonal fruit	Seasonal fruit	Seasonal fruit

Table 5: A weekly standard menu planned by ParmaCater for LOCSchools

2.3.1.2. Kitchen and Canteen, Lunchtime Service and Waste Management

In both LOC-ORGSchools, the school lunch service lasts 60 mins and is split into 2*30min sittings. The two sittings are distinct only in LOC-ORGSchoolTwo where 1st and 2nd graders are always served first. In both LOC-ORGSchools, the canteen is arranged with 6 seater tables set out in advance by staff with cutlery, napkins, and water jugs, according to the number of students who are taking school meals (See Figure 7). Modification of the standard portion sizes only takes place if requested by the children. Teachers and kitchen staff supervise and encourage the children to eat what they have been served and/or to try new foods, especially encouraging increased vegetable consumption. When they have finished their lunch, the children are responsible for disposing of their plate waste in a single (aggregate) food waste bin, and putting their cutlery and plates into separate plastic containers located in the canteen. Interestingly, once a month, the children are asked to separate their plate waste into specific boxes allocated near their tables, as kitchen staff are required to record, once a month, the amount of food waste per food component in order to help optimize food production, reduce waste and minimize surplus.

A  B

Figure 7. LOC-ORGSchool Canteens Note: One of the three rooms where the pupils eat in ParmaSchoolOne (A) and the big school canteen hosting all the pupils at lunch time in ParmaSchooTwo (B), LOC-ORG case (Italy)

2.3.2. ORG CASE

Lucca is also a wealthy Italian city (39/111) with a total of 29 primary schools, averaging 100 pupils/school. All schools must offer meals with a full price of €5/meal, where annual family incomes are over €30,000. Under this income threshold, families are entitlted to state subsidy and across the 5 ORGSchools, the % entitled to free meals is 6-29%, much higher than in LOC-ORG Schools. The ORG contract is retendered on a 9 year cycle, and the current incumbent, LuccaCater, who is part of regional corporate enterprise, has held it since 2002. It subcontracts to 9 suppliers, and uses a central kitchen to cook and distribute meals to all LuccaSchools. All staff, central and school based, are LuccaCater employees (3-4 staff members per school). Around half of the ORGsuppliers are large enterprises with turnovers in excess of >100m euros who are located inside the region, while others are located upto 60km away (whereas many for Parma are >100km). The selected ORGSchools are: LuccaSchoolOne located close to the historical city centre and LuccaSchoolTwo, located 3.5 km far from the city centre. The pupil roll and daily average uptake of school meals were 168 and 90% (151) for LuccaSchoolOne and 212 and 88% (186) for LuccaSchoolTwo. This is slightly above the regional average of 80% and on average across the 27 state primary schools, 115 lunches are served per school per day with a min of 40 and maximum of 316.[4].

2.3.2.1. Menu Planning

For all schools in the Lucca municipality, a set menu is carefully designed and approved by municipal dieticians. Like Parma, there are two courses (first course = starchy carbs like soup, gnocchi, pasta; second course = protein-based with side veg like fish with salad, beef/chicken with cooked veg; plus bread; plus fruit/dessert) (See Table 6). Only water is served, and desserts (yoghurt, choc pudding) are served 1-2 times per week. Occasionally, first and second courses are substituted by a 'unique dish' such as pizza. LuccaCater prepares all meals in their central kitchen. The ORGSchool lunch menu runs on a 7-8 week cycle and is differentiated in two periods (autumn-winter; spring-summer) to guarantee the supply of seasonal fruit and vegetables. All ORGSchools have a canteen commission composed of nominated parents (of

[4] The reported numbers refer to the sum of children and teachers who daily receive the school lunch.

children attending the school) and school teachers who meet twice annually to verify the food and school canteen service quality. All Lucca schools have taken part in educational initiative to improve pupils' appreciation of food and healthy eathing. The regional guidelines also specify the importance of developing educational programs targeting teachers, parents and students, aimed at educating these groups towards conscious consumption and the value of food, taking into consideration the environmental compatibility of food production. As specified in the contract tender, the services provided by the catering firm engaged in preparing, and delivering, school meals to the children have to refer to a quality project. This project has to involve all the services included in the tender and has to comprise a program of food education. Specifically, 13 primary schools in Lucca, including LuccaSchoolTwo, are involved in a project named "Orti in condotta" (literally, "ongoing gardens") started in 2015 in the framework of "Centomila Orti in Toscana" (literally "one hundred thousand vegetable gardens in Tuscany"). It is based on the development of educational vegetable gardens using areas outside the school. It is a national project promoted by Slow Food in which some training initiatives are planned for, and delivered to, teachers.

Monday	Thursday	Wednesday	Thuesday	Friday
Strained cream soup	Rice with EVO	Pulses soup with spelt	Pasta with tomato sauce and basil	Lasagne with pesto
Chicken cutlet	Squid with green peas	Pecorino cheese	Roast veal	Cooked ham
Salad		Courgettes cooked in oil with parsley and garlic	Mashed potatoes	Salad with tomatoes
Bread	Bread	Bread	Bread	Bread

Table 6. A weekly standard menus planned by the catering service for Lucca's primary schools.

2.3.2.2. Kitchen and Canteen, Lunctime Service and Waste Management

In ORGSchools, the school lunch service is between 60-90mins in length split across 2*30min time periods with younger children always served first. Every day a set menu is delivered pre-cooked and prepared by the central kitchen to ORGSchoolOne and Two, with the exception of the starchy food components and sauces (such as pasta, rice and other cereals) which are assembled on site. In both schools, 6 seater tables are arranged in the canteen with kitchen staff setting the tables by laying out glasses, steel cutlery, and reusable plastic containers containing grated cheese (i.e. Grana PDO) (Figure 8). All children are accompanied to the canteen by their teacher with the youngest children coming first (1st-3rd grades) while older students get lunch during the 2nd service. In ORGSchoolOne, the kitchen staff clear and reset the canteen between 1st and 2nd service. The school kitchen has facilities only to wash plates, cutlery and glasses, with ceramic dishes used for main meals. Bread is freely available on a distinct table. Kitchen staff serves meals from serving carts bringing the meals directly to the tables where children are sitting. Teachers supervise and encourage the children not to waste foods and when the children are finished all leftover food waste is collected in single aggregated food waste bin. Lucca municipality requires LuccaCater, and ORGSchools, to have adequate differentiated waste collection throughout the supply chain. Food and non-food generated in the schools must follow the same separate waste collection already applied more generally in the municipality.

In addition in 7 of the Lucca primary schools, including both ORGSchoolOne and Two, a pilot project is in operation to donate uneaten food (e.g. bread and fruit) to a third sector association. For schools not involved in the project, the leftover bread and fruit distributed but not consumed at lunch time can be brought to the class, at the discretion of the pupils. The rest of the prepared and not consumed food is not recycled for human consumption but is instead disposed of following the Lucca's separate food waste collection system.

B

Figure 8. ORGSchool Canteens Note: The school canteens present in LuccaSchoolOne (A) and LuccaSchoolTwo (B), ORG case (Italy)

2.4. Serbia

As the school meal service is managed uniquely in each school, details are provided below, by case school, for the school profile, menu planning, kitchen and canteen facilities, lunchtime service and waste management.

2.4.1. LOC Schools

LOCSchool1 is one of the oldest primary schools in Belgrade. It is located in Voždovac municipality, one of the biggest and most developed Belgrade municipalities whose inhabitants average net monthly salary, having seen positive growth over the last 5years, currently equates to €418/month, in line with the average national monthly income of €421. This school has a pupil roll of 471 children with 38% (83) of 1st-4th graders using the daily extended stay service during which they can receive breakfast, lunch and/or one snack. The snack and breakfast are both priced at €0.58 (0.70 RSD), while the daily cost of lunch is €1.67 (200 RSD) and generally parents are responsible for paying the full cost.

Throughout its long history, LOCSchool2 has changed its appearance as well as its location. Currently, it is located in one of Belgrade's largest municipalities, Čukarica, whose inhabitants average net salary, having seen positive growth over the last 5years, equates to €382/month, slightly below the national average (€418/month). LOCSchool2 belongs to a group of bigger schools with a current pupil roll of 1204 students providing extended stay for 180-200 (62-69%) 1st and 2nd grade children[5] though uptake can, and does, vary significantly from one day to another. Parents are required to notify the school 1 day in advance if their child will be absent from school the next day and if advance notice is not provided a charge for lunch is made. As part of the extended stay service, a daily breakfast, lunch and 1 snack is prepared and served. There are two shifts of extended stay children: one shift starts at 07.00 and end at 13:45, while

[5] Although students from third and second grad may apply for extended stay, number of children who apply is insignificant.

the second shift starts at 11:30 until 17:30. Depending on different shifts, children take breakfast and lunch or lunch and snack as a combination. Lunch is the only mandatory meal for extended stay pupils in LOCSchool2 priced at €1.42/day (170 RSD). The school has not been involved in any food or sustainability initiatives in the past. Each year, the school devotes a number of days to food and health education, including lessons on nutrition and healthy eating, recipe development and exhibitions/displays. The biology and chemistry teachers in the school take a leading role in these.

2.4.1.1. Menu Planning

In LOCSchool1, the school catering staff (n=2), helped by a health inspector (who advises on healthier product swaps and cooking methods), draw up the daily menus on a monthly basis 5 days before the start of each month. Kitchen staff are responsible for hygiene and safety, all cleaning, and all communication between, and taking deliveries from, suppliers. The menu changes according to seasonal availability of produce. The lunch consists of three courses: first course is the soup, second one is the main dish (e.g. meat and vegetables) while the third course is a dessert (e.g. fruit or cake). Additionally, children have bread and drinks (usually lemonade) as well.

In LOCSchool2, menus are planned on weekly or biweekly basis, by catering staff (n=2, one cook and one assistant) with support from the schools chemistry and biology teachers who advise on health aspects. Kitchen staff are responsible for health and safety in kitchen, cleaning kitchen and canteen, and all procurement and communication with suppliers. The menu change seasonally according to seasonal availability of produce. The daily menu usually consists of three courses: soup, main dish (e.g. meat and vegetables or some cooked meal) and dessert (See Table 7). When it comes to dessert, according to employees, children are mostly served with fruit rather than cake. Kitchen facilities were observed as old and in need of upgrading, while the canteen is a multi-use space. Tables are designed to sit 4 pupils, but often staff arrange them in long rows as it makes the space less crowded.

Season	Monday	Thursday	Wednesday	Thuesday	Friday
AUTUMN/WINTER	Soup, french fries, sausage, salad, cookie	Green beans with chicken, sour cream, fruit cake	Goulash with pork meat, mashed potatos, salad, fruit	Soup, lasagna, a galette	Potato stew with chicken meat, salad, cookie
SPRING/SUMMER	Vegetable pottage, macaroni and cheese, mandarin	beef steak, peas side dish, cucumber salad, pudding	Chicken soup, potato stew with chicken meat, beet salad, sweet pie	gulas with beef meat, macaroni, mixed salad, banana	Bean with smoked meat, cabbage salad, juice, fruit cake

Table 7. Sample of school meals in LOCSchool2

2.4.1.2. Kitchens and Canteen, Lunctime Service and Waste Management

LOCSchool1 has a well equipped onsite kitchen and the employees have at their disposal a significant array of equipment including: seven professional tables for food preparation, two dishwashers, three refrigerators (one large and two smaller ones)[6], freezer, professional stove, five ovens, as well as many small kitchen appliances, which make the children meals preparation process more efficient. Food ingredients preparation is done manually (peeling, chopping etc.). The school kitchen is used exclusively for food preparation and meal serving having no additional purpose. After the work is done, the kitchen is closed. Currently, two cooks work full time in this school kitchen. Beside food preparation, their responsibilities also include hygiene maintenance, disinfection of tables, direct communication with suppliers, and classification of food ingredients from supplier's deliveries. Both cooks have passed HAACP training and undergo regular smear sample test every six months to ensure quality and safety improvement in food preparation process. The canteen walls are brightly painted.

LOCSchool2 has an onsite kitchen with two entrances, one from the school building and one through the back entrance. Kitchen facilities are comprised of working area where the food is prepared, the canteen area where children eat meals and two toilets. The working area is equipped with quite old kitchen equipment and appliances including: refrigerator, stove, kitchen sink, plates and cutlery. There is also potato peeler machine, but it is currently not in use as their is not enough space in the kitchen for the machine and no drain, which the machine requires. The kitchen owns a fryer, but 13L of oil is required for frying whihc has to be replaced after each frying. This is too expensive for the school, and therefore, the fryer is not in use. The kitchen employs one full time cook and one full time cook assistant, whose main roles include food preparation, kitchen cleaning, food procurement and primary communication with suppliers. According to the kitchen staff, kitchen equipment has not been renewed for a long time (from time to time someone donates used appliances which are newer than the existing ones, but are still outdated). LOCSschool 2 canteen has tables with four stools which the kitchen staff often rearranges into rows of tables to make lunch rush less crowded (Figure 9). Beside its main purpose, the canteen space is used for parent-teacher meetings, diploma giving ceremonies, student award presentations etc. The school is outgrowing its current space, is struggling to accomodate its growing number of pupils and is having to make temporary adjustments to cope.

Figure 9: Table arrangement in LOCSchool2 (Serbia)

[6] All food items are stored separately, more precisely, every refrigerator is used for specific food category.

In LOCSchool1, lunchtime service takes place from 12.30-1pm. If meal is classified as 'dangerous' (e.g. hot soup), then staff serve pupils at the tables, otherwise pupils queue up and take their meals from service counter. On 2 days p/w children have an option (e.g. rice instead of potato salad), otherwise there is one set menu per day. Kitchen staff encourage the children to finish meals and make servings of fruit and vegetables appealing (e.g. make into smiley faces). To help manage the flow of children through the canteen, teachers stagger their arrival. At least one teacher is present during every lunch service and he/she is responsible for maintaining order in the canteen. Kids take their own trays to the waste station and it was observed that students have an excellent relationship with kitchen staff, and that lunchtime in the canteen is a positive experience. All food prepared for that day is kept in large containers from which the cooks fill the childrens plates using standard measurement utensils (glasses, ladles, spoons etc.) to serve portions approximate to the predefined portions. Portion sizes are not varied based on childrens age, however, they may differ depending on the children‘s appetite. When pupils finish their meal, they are responsible for taking their tray to the waste station themselves. The entire process is managed in a pretty organized manner, since the cooks as well as the children are familiar with their responsibilities.

In LOCSchool2, lunchtime service lasts for one hr (12.00-1pm). As in LOCSchool 1, LOCSchool2 kitchen staff use measurement tools (ladle, spoon, etc.). To help manage the flow of children through the canteen given that approximately 180-200 chdilren eat lunch daily, the lunch service is broken up. Groups are not formed based on the class, but instead by the teacher who takes the children to lunch (when one group of students finish the lunch, next class starts the lunch). Like LOCSchool1, when soup is served which kitchen staff bring to the children at the tables. Otherwise, the children pick up the main meals from a serving table themselves, returning to this table after they have finished their main course to pick up fruit/dessert. Bread and salad is served in baskets on the canteen tables. Children do not get trays with full lunch content instead each course is served separately. Children were observed not eating much of the bread and/or salad provided. Children were also observed often returning their soup immediately or half eaten before getting and carrying their main meal to the table. If someone wants more food, he/she can ask the cooks for another portion. Drinks (usually fruit juice or tea) are located on the seperate table and children can take them during the lunch (Figure 10). The teachers are present during the lunch breaks, while the kitchen staff were not observed communicating deeply with the children. Sometimes, children are encouraged by teachers and/or kitchen staff to eat more or try something new, but they do not insist on it.

Figure 10: LOWSchool2 Main table, from which the children can take fruit or dessert (Serbia)

During interviews, LOC school officials estimated that less than 10% of food is left-over after the lunch and significantly less than 10% is wasted due to inadequate food orders and not consuming ordered food items. Often left over prepared food is served to cleaning staff or underprivileged students (two to three students). The remaining food left-overs and plate waste is disposed of to landfill. Reuseable plastic containers are used only for a short periods of time e.g. large containers in which side dishes are served or the containers for fruit. Some use of single use plastic cups to serve some puddings was observed and these are not recycled. Instead they are disposed of to landfill with the rest of waste.

2.4.2. LOW case schools

LOWSchool1, is located in the Municipality of Zvezdara, inside the region of the capital of Serbia. The Municipality of Zvezdara covers an area of 3,165 hectares (about 1% of total Belgrade area), with a population of around 150,000 (about 10% of total Belgrade population). According to Statistical yearbook, 38,982 of the population were employed in 2012 (~26%), while the active population is 47,297 persons. Zvezdara remains to be one of the most densely populated municipalities in Serbia, with a positive birth and migration rate. As many areas of modern Zvezdara municipalities were villages and rural areas annexed to it in the 1950s, the entire southern and eastern sections are without industry, while industrial facilities are mostly grouped in two sections. The average salary in Zvezdara is significantly higher than national average and there are 14 elementary and 9 secondary schools in Zvezdara municipality.

LOWSchool1 is attended by approximately 1730 pupils and lunch is the only meal served. During the data collection period, the number of served lunches/day varied from 62 to 91 per day, with a daily average of 80. Uptake from all 1st to 4th graders was estimated at 18.5% with 64% of extended stay pupils taking lunch. The average price of a lunch is €1.75 (210 RSD) which is fully paid by parents.

LOWSchool2, is located in Zemun municipality which covers an area of 15,356 hectares, and is inhabited by a population of 152,950. Zemun is one of the most developed municipalities in the country, with developed industries in almost every section. Average monthly net salary is €460, above the national average (national average is €421). Zemun has two large and growing industrial zones. Industries include: heavy agricultural machines and appliances, precise and optical instruments and automatized appliances, clocks, busses and other heavy vehicles, pharmaceuticals, plastics, shoes, textile, food, candies and chocolate, metals, wood and furniture, recycling, beverages, chemicals, building materials, electronics, leather, etc. Approximately 840 children who attend LOWSchool2 which provides upto 2 meals per day namely: snack and lunch. Lunch is served to about 145 children, with a 34% uptake for grade 1-4 children. Neither LOWSchools reported invovlement in specific food and sustainability actions and/or initiatives.

2.4.2.1. Menu Planning

As previously noted, the number of meals served per day LOWSchool1 varies, mostly due to illness and/or absence of children. Therefore, each evening, around 6 p.m., the cooks get the planned number of children who will take lunch the following day. Cooks multiply the number of meals with the size of a portion and get the total quantity of food that should be prepared. Using this information, they contact their suppliers nightly for procurement of necessary ingredients. The average price of a lunch is €1.75 (210 RSD) which is fully paid by parents.

Menus are planned on the weekly basis by the cooks, according to the normatives (See example in Table 8) and guidelines prescribed by a contracted and qualified nutritionist.

Season	Monday	Thursday	Wednesday	Thuesday	Friday
AUTUMN/WINTER	Vegetable soup, macaroni and cheese, bread, salad, fruit	Peas with beef meat, bread, fruit	Tomatoe soup, baked fish, rice, salad, bread, fruit	Chicken soup, potatoe moussaka, salad, bread, fruit	Cooked pork meat, cooked carrot, sour cream, bread, fruit
SPRING/SUMMER	Beans, cabbage salad, bread, fruit	Vegetable soup, pilaf of whole grain rice and chicken breasts, sadald, bread, fruit	Stew with potatoes and beef meat, salad, bread, cake	Chicken soup, sarma of sauerkraut, bread, fruit	Schnitzel in the sauce, cooked green beans, bread, cake

Table 8: Sample of a weekly school meals in LOWSchool1

2.4.2.2. Kitchen and Canteen, Lunchtime service and Waste Management

In LOWSchool2, lunch is served to 145 children, at a price of €1.67 (200 RSD) which is fully paid for by parents. Lunch is prepared daily for all children (145 children), no matter how many of the 145 children are in attendance and come to lunch. In accordance with the normative, meal portions are standardized per meal component and quantity. Meat is served on 4 out of 5 days with some Mondays offering a meat-free dish. The menus are prepared by a contracted nutritionist on the weekly basis (See Table 9). Besides the list of the dishes served, each meal provides specification on the ingredients and allergens present in the lunch.

Day	Menu 1 Autumn-Winter 2017	Menu 2 Spring-Summer 2018
Monday	Vegetable soup, macaroni and cheese, bread, salad, fruit	Beans, cabbage salad, bread, fruit
Tuesday	Peas with beef meat, bread, fruit	Vegetable soup, pilaf of whole grain rice and chicken breasts, sadald, bread, fruit
Wednesday	Tomatoe soup, baked fish, rice, salad, bread, fruit	Stew with potatoes and beef meat, salad, bread, cake
Thursday	Chicken soup, potatoe moussaka, salad, bread, fruit	Chicken soup, sarma of sauerkraut, bread, fruit
Friday	Cooked pork meat, cooked carrot, sour cream, bread, fruit	Schnitzel in the sauce, cooked green beans, bread, cake

Table 9. Examples of menus in LOWSchool2

In LOWSchool1, meals are prepared in the onsite school kitchen, which is very modestly equipped with a boiler, a stove, a refrigerator and three ovens. The school kitchen has no specialist equipment for food preparation except a mixer, food preparation is done manually (peeling, chopping, etc.) and the kitchen has no heating system. There is also a storage space equipped with a dozen shelves. Canteen walls are brightly painted. Tables in the canteen seat four persons, are made of wood and are accompanied by 4 children-size chairs (Figure 11). Considering the children are divided in groups during the lunch, according to school employees, organization is fairly good and there is no crowding in the canteen.

In LOWSchool2, meals are prepared in the onsite school kitchen which is equipped with machines for peeling potatoes, cutting cabbage and salads and a mixer. The school canteen is child friendly, very colourfully decorated and contains children-size-adjusted elements and furniture. All tables seat 4-6 children at any one time and there is plenty of space between tables so that children can easily pass by and move around the canteen.

Figure 11: Canteen in LOWSchool2 school (Serbia)

In LOWSchool1, a set lunch menu is served daily between 11:30 to 13:00 (90mins). Children are divided into two groups, with each group having on average 45 minutes to eat their lunch. Using normative guidelines, the cooks try to serve standardised meal portions across all children though children can request extra portions if they are hungry. Children do not get trays with full lunch content. Firstly, soup is served to children at their canteen tables after which cooks serve the main meal with bread and salad followed by dessert (usually a piece of fruit). Pieces of bread are provided per 4 children on the same plate, while salad and meals are served individually. No drinks are served during the lunch. During the soup and fruit servings, cooks interact with the children encouraging children to eat everything served, frequently using the argument that their parents have paid for it.

Similarly in LOWSchool2, one set lunch menu is served daily. Cooks serve soup (if it is on menu), main meal with bread and salad on tables, before lunch has been started. Dessert (cookies or fruit) is served on common plates, so one plate belongs to one class. In this school, drinks are served during the lunch. The type of drink served depends on the season (tea or hot milk during the winter and juice during the summer). Drinks are located on a separate table and children are free to take them. Lunch is organized from 12:00 to 13:15 (75mins) in two services, each lasting 35 min. Children in extended stay start their lunch at 12:35. Teaching staff usually do not provide suggestions or encouragement to children during lunchtime. In both LOWschools, when children have finished their lunch they move their plates and cutlery from their table and the kicttchen staff clean the canteen (and the associated dishes and cutlery).

Across both LOWSchools, kitchen/plate food waste is disposed of in containers together with general non food waste, and sent to landfill. In LOWSchool2, it was observed that sometimes the food waste is collected separately by kitchen staff and given to the nearby neighbour who feeds the dog with it.

2.5. UK

2.5.1. LOC CASE

LOCSchoolD and E participated in the plate waste study. Table 10 outlines their profile in terms of size, average % of school roll taking school meals, average number of school meals served/day, and % of children in receipt of free school meals.

	School Roll	Average % Uptake of School Meals (n/day)	% of children in KS2 receiving free school meals
LOCSchoolD	178	60% (107/day)	16%
LOCSchoolE	303	55% (167/day)	34%

Table 10: LOC School Profile

LOCSchoolD is located in a rural market town in the far south west of County Durham. A relatively affluent area serving a predominantly rural hinterland with a high proportion of children coming from farming/agricultural backgrounds. The school has 178 pupils, slightly above the municpality average, with 16% claiming free school meals and a 60% meal uptake rate, slightly below the municipality average. The school has pursued, and is, pursuing several food and health related initiatives, including gardening and cooking clubs, however these were very dependent on the voluntary input of specific staff members, and ceased when those staff left.

LOC School E is located 3kms from Durham city in an area of relatively high deprivation, with 34% of pupils claiming free school meals. The pupil roll is 303, making it one of the larger schools in the municipality and during plate waste data collection, the average meal uptake was 55%. The school has an active list of food, health and sustainability intiautive including a gardening club, an active Outdoor Play and Learning Programme (OPAL), weekly access for all children to an onsite swimming pool, a suite of daily/weekly sports clubs and an all school weekly health club on Friday afternoons

2.5.1.1. Menu Planning

SchoolCater delivers all school catering services across LOCSchools. For each academic year, two 3 week menu cycles for Spring-Summer (April – Oct) and Autumn-Winter (Oct – March) are served. In line with statutory school food standards for England and Wales (and the associated food-based standards), SchoolCater develops new and revised nutritionally compliant and cost analysed hot meal, sandwich and dessert options per menu cycle. Daily, LOCSchool children choose from 2-3 hot meal options (including one vegetarian hot meal (where required) and occassionally Jacket Potatoes (LOCSchool D&E)). As an alternative to a hot meal, some LOCSchools children (including LOCSchool D&E) can select a sandwich option (bread; rolls or baguettes) with between 1-3 filling options (usually egg mayo, ham, turkey, cheese or tuna mayo).

Depending on the main meal option chosen, children select from the available daily (stratchy) carbohydrates options including: mashed, creamed, roast or boiled potatoes; jacket potato wedges; chips; rice; pasta; pastry (i.e. quiche; pie) or garlic bread. All LOCSchool children must accept at least one portion of hot vegetables onto their plates/trays. In addition, LOCSchoolE children are actively encouraged to take two or more portions with those selecting the sandwich option (approx. 50%) required to accept two portions of hot/cold vegtables. Daily, all LOCSchools prepare homemade freshly baked bread (plain; wholemeal; cheesy) which children are free to help themselves to at lunchtime.

All LOCSchool children are entitled to take a dessert and can choose from upto 3 daily dessert options: 1) homemade cake or ice cream related options (i.e. apple crumble and custard; Rice Krispie cakes; Fruit salad and Vanilla Ice Cream); 2) Low Fat/Fat free fruit yoghurt (strawberry; peach and passion fruit); or 3) Fresh fruit (i.e. whole apples (red and green); bananas; whole kiwis; whole mandarin oranges; raisins). While LOCSchoolD buys premade yoghurt in single serve plastic yoghurt pots, LOCSchool E produces most of its own yoghurt in house using EasiYo powder and equipment (rented annually via SchoolCater) serving their yoghurt in reuseable plastic bowls (https://uk.easiyo.com/) reducing waste from single use plastic yoghurt pots.

Tapwater is the only drink option available in LOCSchools with reusable plastic cups pre-poured which children pick up at the end of the food service line. Additional jugs of water are available during service and children can serve themselves or request more water from their lunchtime supervisors.

2.5.1.2. Kitchen and Canteens, Lunchtime Service and Waste Management

All LOCSchools have onsite school kitchens equipped and maintained by the municipality. Each LOCschool kitchen is defined as a unit and SchoolCater operates approximately 203 units. SchoolCater employs all the school based catering staff (between 1-5/school) with a unit manager in each responsible for the financial and operational unit management including all ordering/stock management, deliveries, waste management, unit adminstration and production and service of daily schools meals. At least one lunchtime supervisor is employed by each LOCSchool to: 1) manage the flow and behaviour of children, the canteen side service line and the waste station; and 2) provide encouragement and support to the children to eat their school lunches. Class teachers, special needs assistants and/or teaching assistants also provide additional support for, and encouragement to, the youngest children (Nursery and Reception, 3-5yr olds) or children with special educational needs. Table 11 outlines staffing provision and how lunchtime service is managed (time and number) in LOCSchool D&E.

	Average No. of School Meals served/day	**Lunch Time Service Period**	**School based School Cater Canteen Staff (including Unit Manager)**	**Lunchtime Supervisors (LOCSchool employees)**	**No. of Staff on Hot Counter**	**No. of Staff on Cold Counter**	**No. of Daily Lunchtime Services (approximately 15 mins/service)**
LOCSchoolD	107 (60%)	Approx. 11.45-1pm	2	2-3 + teaching staff with nursery and reception kids only	1	1	5
LOCSchoolE	167 (55%)	Approx. 11.15-1pm	3-4	1 + teaching staff with nursery and reception kids only	2	1	5

Table 11: LOCSchool D&E Canteen Staffing

In LOCSchoolD, the canteen is a multi-use space used daily for school assemblies, physical education, drama, exhibitions and reading. All children eat their lunch in this canteen including those with school lunchboxes. This space is usually handed over to SchoolCater staff by 11am who then set it up as a canteen putting out nine 12 seater rectangular tables, the waste station and the food service line. The open food service line, the space and number of seats available, how child flow is managed and the extensive outdoor playground all combine to faciliate a calm, unrushed canteen environemnt in which LOCSchool D as children have plenty of space and time to eat their lunch, don’t have to worry about finding a seat, are very sociable with each other, are relaxed about finding space and equipment, and have plenty of time, and space, to play outside.

Figure 12: Canteen Images from LOCSchoolE (UK)

LOCSchoolE has a light, airy single use canteen (See Figure 12 and 13) permanently set up with an open canteen service line. LOCSchoolE uses trays with multiple compartments which children receiving on the tray, at the same time, their main course and dessert. In LOCSchoolE, 3 SchoolCater staff manage the food service line. All children use the canteen for their lunch (school meals or lunchboxes) though in dry weather children are permitted to eat their lunch outside in a covered terrace area with outdoor seats and tables. There are thirteen 8 seater round tables (total of 104 seats for a school roll of 303). Space is limited as only 104 (35% of pupil roll) can be accomodated in any one sitting. There is strict management of the sittings by the lunchtime supervisor and year groups need to be ready, and lined up outside, the canteen in advance of their timeslot.

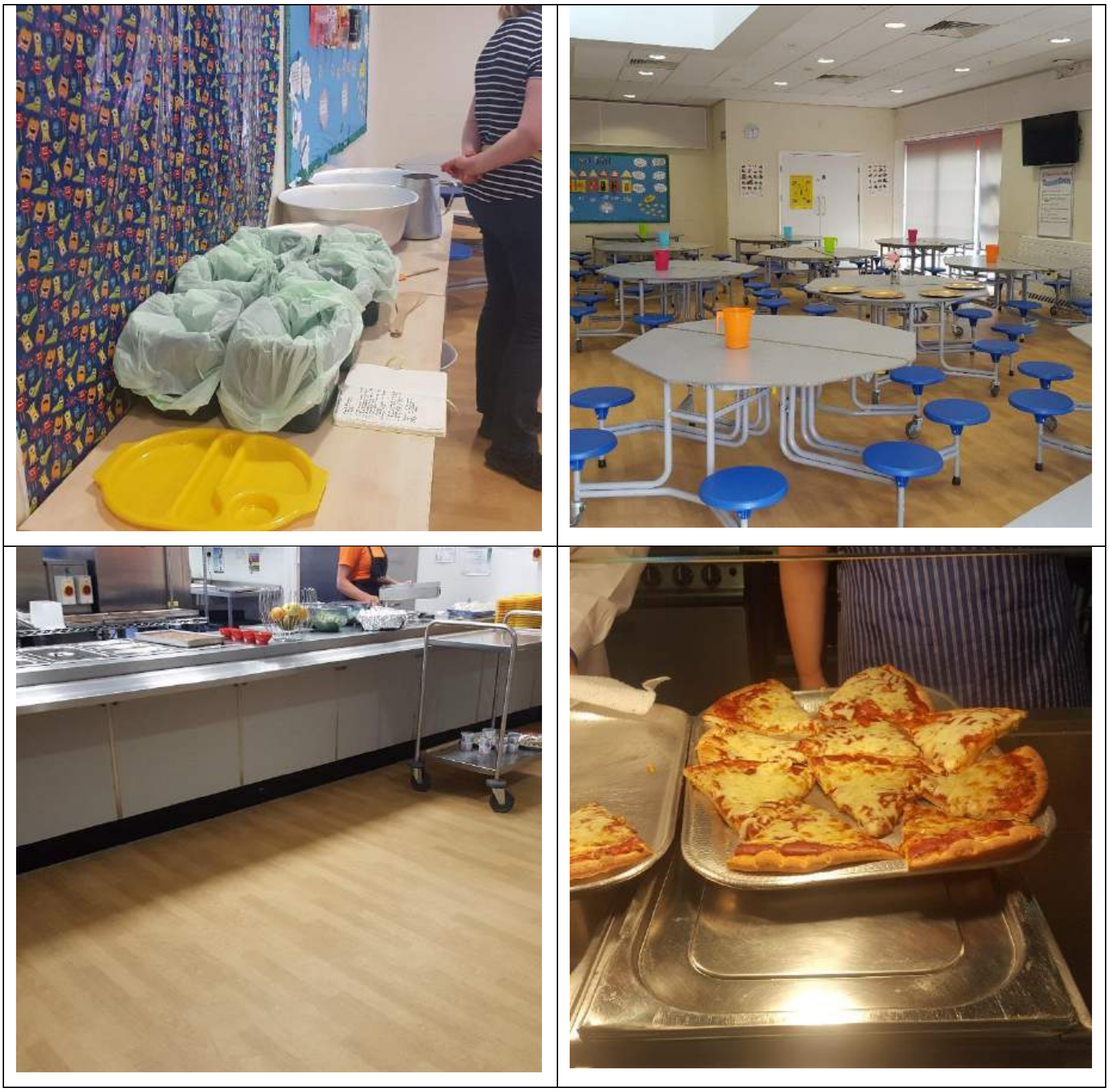

Figure 13: Canteen Images from LOCSchoolE (UK)

Different school meal ordering systems are in operation across LOCSchool ranging from: no pre-ordering (LOCSchool D), on the day pre-ordering (children select lunch first thing in the morning – paper or electronic based system; LOCSchool E) and paper or electronic based parental pre-ordering system (other LOCSchools). Where payment is required (those children in KS2 and above who are not eligible for free school meals), parents are required to register for, and pay, via the online ParentPay system as cash payments were phased out in 17/18.

In LOCSchoolD, all children are greeted individually by the Unit Manager who explains the available choices serving them and they are given, if selected, their choosen hot/cold main meal option and hot vegetables. The Unit Manager then passes this plate along the service line to her catering assistant who manages cold vegetables and dessert sections. After completing the order, the catering assistant places the main plate and selected dessert (bowl, yoghurt pot or whole piece of fruit) onto the tray and the children take their tray picking up their cup of water and cutlery as they go to sit down. In LOCSchoolD, the nursery and reception classes arrive first at 11.45am and generally take 15-20 mins to eat their lunch (with support from the lunchtime supervisors, their class teacher and teaching assistants). Year 1-6 start arriving in random order depending on what they have been doing prior to lunchtime, when they want to play and how quickly they can get from their classroom to the canteen. They are free to come to the canteen as they please and do not have to line up in year group order. Between 12.05-12.30pm, there is a steady stream of year 1-6 children through the canteen and all children have received and eaten their lunch by 1pm at the latest.

In LOCSchool E, an new electronic pre-ordering system was introduced in July 2018 through which the children make their lunchtime choices each morning using a classroom based IPad/tablet. The choices are linked uniquely to each child and the data is transferred to both Parent Pay (where appropriate to calculate bill) and the kitchen (by 10.30am at the latest) who are also connected to the CYPad system. Children line up in their year group order picking up a compartentalised tray and their cutlery (reusable plastic for younger children; metal for older children). Three SchoolCater employees (including the unit manager) manage the service line starting with meal choice confirmation. Lunchtime is staggered in LOCSchool E starting with the nursery class at 11.15am followed by reception at 11.30am. Both nursery and reception must be finished and left the canteen by 11.55am. At 12 noon, year 1 and 2 start their lunch break and arrive in the canteen where they are served in their year groups. They have approximately 15 minutes to queue up for, select and eat their lunch. Year 3-6 start to come through in their year groups between 12.15-12.45. All children have received their school lunch by 12.45pm and normally lunch service is completed, and the canteen emptied, by 1pm.

In LOCSchool D&E, portion size adjustment of the stratchy carbohydrate option was observed and confirmed by the unit managers with the youngest children receiving smaller portions of carbohydrates as per the national portion size recommendations. There is no obvious adjustment of other main meal component portions as these are carefully prepared in accordance with approved SchoolCater recipes and portion normatives.

In LOCSchool D, a team of 2-3 lunchtime supervisors help manage the canteen and provide support and encouragement to children. The younger children must confirm with a lunchtime supervisor that they have eaten sufficient amounts of their main meal, request approval to move onto dessert, obtain permission to go to the waste station and head out to play. In LOCSchoolE, one lunchtime supervisor manages the canteen side lunch service and she is supported during 1st service by class teachers, special needs assisstants and/or teaching assistants. In both LOCSchools D&E, lunchtime supervisors provide support throughout service though supervision is lighter for older children. While all LOCSchoolD children and all young children in LOCSchoolE must confirm with a lunchtime supervisor that they have eaten sufficient amounts of their main meal, and request approval to move onto their dessert, go to the waste station and head out to play, older chidlren (aged 8 and above) at LOCSchoolE are free to decide themselves when they have eaten enough.

In LOCSchool D&E, the children are responsible, no matter what their age, for bringing their trays to the waste station. In LOCSchool E, all children self-manage the disposal of their food, non-food waste, reuseable plates, cups and cutlery, while in LOCSchoolD Year 5 children (9-10year olds) work on a rota providing support, and managing the, waste station. All plate waste is collected in a designated food waste bin which is weighted and recorded daily (as is associated counter and kitchen waste). All food waste (plate; counter; kitchen) is disposed of via anerobic digestion. No sorting of non-food waste for recycling was observed and non-food waste is generally disposed of via landfill. It is worth noting though that very little non-food waste was observed in LOCSchools as SchoolCater practices minimise waste by using reuseable cups, not serving milk in cartons, limiting the use of single use plastic yoghurt pots and not wrapping (with paper or plastic) sandwiches, burgers or fruit. In fact, most non food waste observed was actually generated by lunchbox children.

2.5.2. LOW Case

LOWSchools A&E participated in the plate waste study. Table 12 outlines their profile in terms of size, socio-demographic profile, average % of school roll taking school meals, the average number of school meals served/day, and % of children in receipt of free school meals.

	School Roll	Average % Uptake of School Meals (n/day)	% of children in KS2 receiving free school meals
LOWSchool A	229	71% (162/day)	51%
LOWSchool E	200	61% (122/day)	14%

Table 12: LOWSchool Profile

LOWSchoolA is a co-educational, denominational (Catholic) primary school located in the large town of Greenock, in central Inverclyde in an area of high deprivation with 51% of pupils receiving free school meals. LOWSchoolA runs a number of food, nutrition and sustainability initiatives, including the "Daily Mile" walk/run for all pupils, a health group promoting healthy lunch/snack choices, and a well attended breakfast club (upto 80 children get breakfast every morning for a cost of £1/child). However, the headteacher notes that they have not placed a huge priority on such issues in the past due to more pressing concerns regarding pupil attainment.

LOWSchoolE is a co-educational, non-denominational primary school serving a local village, and surrounding rural communities, in the east of Inverclyde serving an affluent area, with low levels of deprivation. Only 14% of pupils receive free school meals. The headteacher has a strong personal enthusiasm for, and professional interest in, food, nutrition and sustainability related issues placing importance on the development, and delivery of a diverse range of food, nutrition and sustainability related initiatives.

2.5.2.1. Menu Planning

The LOWSchool municipality have delivered an in-house school meal service since its creation on 1996, employing all school kitchen staff, and contracting directly, via national and local framework procurement contracts, with suppliers. Eighteen out of the 20 LOWSchool primary schools have on-site kitchens with the remaining 2 served by their next nearest school with a kitchen. In 17/18 all LOWSchools develop their own bespoke school lunch menus. In 18/19, this was changed in an attempt to bring greater consistency across LOWSchools and manage the increasing regulatory burden associated with meeting statutory food-based and nutrient standards in Scotland in particular in relation to providing for special diets. From 18/19, one menu is served across all 20 LOWSchools with some flexibility in terms of the number of daily options served and all LOWSchools received a common recipe book of nutritionally compliant recipes which head cooks are expected, where feasible, to follow.

Daily, LOWSchool children choose from either soup and main meal or main meal and dessert with most opting for the latter. They can choose from upto 9 main meal options including up to 3 hot meal options (including one vegetarian hot meal (where required), Jacket Potatoes with up to 3 filling options (cheese; tuna mayo; chicken mayo; beans) or a sandwich option (sandwich; wrap; baguette; toastie) with up to 3 filling options (ham; cheese; tuna). Depending on which main meal option is chosen, children select from the available daily carbohydrates option including: mashed, boiled or roast potatoes; chips; rice; pasta; noodles or garlic bread. A good range of hot vegetables are offered daily in all LOWSchools and children are free to ask for multiple portions of vegetables if they choose. In accordance with the Scottish School Food Standards, a minimum of 2 types of fruit and vegetables (hot or cold) must be made available daily in all LOWtSchools but LOWSchool children are not required to accept any fruit and/or vegetables (hot or cold) with their school lunch. High refusal rates for fruit, and in particular hot and/or cold vegetables, were observed in both LOWSchools A&E, though it was not possible to systematically record the level and type of refusal due to time and personnel contraints. While a soup or dessert option is offered to ScotSchool children, most choose dessert selecting from up to 3 daily dessert options including: 1) cake or ice cream related options (i.e. apple crumble and custard; Iced sponge; Fruit salad and Vanilla Ice Cream) (offered on 2 of 5 days/week); 2) Fat free fruit yoghurt (strawberry; peach and passion fruit) (offered ever day); and/or 3) Fresh fruit (i.e. whole apples (red and green); bananas; whole kiwis; whole mandarin oranges; raisins) (offered every day). All LOWSchools serve pre-made yoghurt in single use plastic pots. Tap water, served in single use plastic cups, and single serve plain and flavoured (chocolate and strawberry) milk cartons (189ml) and 50/50 juice cartons (200ml; 3 flavours) are provided in LOWSchoolA. In LOWSchoolE, only single serve plain milk cartons and tap water (jugs on the table with some reuseable plastic cups) are available after the parents council requested the removal of flavoured milk and 50/50 juice in 17/18.

2.5.2.2. Kitchen and Canteens, Lunctime Service and Waste Management

All LOWSchool based catering staff (between 1-5/school) are employed by the municipality with each kitchen managed by a Head Cook who is responsible for the operational management of their kitchen including all ordering/stock management, receiving deliveries, managing waste, unit adminstration and production and service of school lunches for their unit. LOWSchool head cooks, unlike LOCSchool unit managers, are not financially responsible for their kitchens nor are they required to keep daily/weekly paperwork on how much is spent per meal served. In most LOWSchools, the head cook is responsible for the primary preparation of hot meals. Other preparation work, such as making, and wrapping, of sandwiches, chopping up fruit, preparing salad items, setting up food service counter, washing up, is undertaken by a team of catering assistants (number depends on school size). It is worth noting that most LOWSchool catering assistants work part-time with many holding down multiple jobs (within and outwith of the school) including running the school breakfast clubs and/or cleaning the school. Table 13 outlines staffing provision and how lunchtime service is managed (time and number) in ScotSchool A&E.

	Average No. of School Meals served/day	Lunch Time Service Period	School Canteen Staff (School Cater Enployees)	Lunchtime Supervisiors (LOCSchool employees)	No. of Staff on Hot Counter	No. of Staff on Cold and Desert Counter	No. of Daily Lunchtime Services (approximately 15 mins/service)
ScotSchool A	162	Approx. 75 mins including Year 1 children	5 (including unit manager)	No lunchtime supervisors; School Janitor is present during lunch and manages the waste station; Teaching staff with nursery and reception kids only	2	2	4
ScotSchool E	122	Approx. 60 mins including Year 1 children	3-4 (including unit manager)	No lunchtime supervisors; Teaching staff with nursery and reception kids only; Head and Deputy Head have lunch most days in canteen towards the end of service	2	2	4

Table 13: LOWSchool A&E Canteen Staffing

In LOWSchool A, a dedicated single use canteen is permanently set up, has an open and low canteen service line and is used daily for the breakfast club. For LOWSchool E, the canteen is made up of two distinct spaces, a single use canteen with an overflow area in the next door mixed use assembly hall (See Figure 14). The overflow area is completely unsupervised and usually there is a 2nd waste station in this area. During our plate waste data collection, this overflow waste station was closed and all students handed their trays to the research team for processing.

The LOWSchoolE service line is higher than LOWSchoolA and is very tightly packed in the cold section with salad vegetables, fruit, yoghurt, dessert and the daily sandwich option competing for space and the children‘s attention. Interestingly, on days when hot desserts were served in LOWSchoolE, the desserts were positioned before the hot main option in the service line and on these daysvery few children were observed considering the alternative yoghut or fruit dessert options.

Figure 14: Canteen Images from LOWSchool E (UK)

In 17/18, a new daily pre-ordering system was implemented. Where payment is required, LOWSchool parents must register for, and pay, via the online Parent Pay system. In both LOWSchool A&E, an electronic pre-ordering system was introduced in 17/18 where each child selects their lunch choice in their classroom every morning with choices electronically recorded and passed onto the kitchen by 10am. The children are given a coloured band to denote which main meal they ordered.

In LOWSchool A, the canteen has six 12 seater rectangular tables, three 8 seater round tables and a 12 seater high stools counter giving a total of 108 seats for a school roll of 229. As space is limited, service is carefully managed and broken into 4*15min sittings. The youngest children always have lunch first with nursery and P1 children arriving between 12-12.15pm. A rota system operates from P2 upwards splitting the year groups across the remaining sittings and there is a continuous turnover of children through the canteen between 12.15-1pm with the last children finishing at approximately 1.15pm. In LOWSchool E, there is a mix of seating with seven 12 seater rectangular tables (84 seats) in the main canteen and one 12 seater rectangular table and six 8 seater round tables (60) in the overflow area giving a total of 144 seats for a school roll of 200. In LOWSchool E, service is split into 4*15min sittings. The nursery and P1 children alwasy arrive first at 12noon. A rota system operates from P2 upwards splitting the year groups across the remaining sittings with a continuous turnover of children through the canteen between 12.15-1pm. Monday and Friday's are the busiest days in ScotSchool A&E with the canteen noticeable busier.

Children line up in their year group, pick up a compartmentalised tray and their cutlery (reusable plastic for younger children; metal for older children). Catering staff (including the head cook) manage the food service line in LOWSchool A&E. Hot food (main meal and vegetables) is served first with the tray passed along the food service line. The staff interact with each child individually helping them to choose vegetables, salad and dessert options. In LOWSchool A&E, 3, and 4, catering staff, respectively, manage the food service line (2-3 kitchen side; 1 canteen side) with 1-2 on hot main option and hot veg; 1 on cold main option and 1 on the canteen side serving desert. The catering assistants are also responsible for washing up, and cleaning, during, and after, service.

While LOWSchoolA makes some portion size adjustments between younger and older children especially for the carbohydrate option, no such adjustment was observed in LOWSchool E. No obvious adjustment of main meal portions was observed as main meal component portions are produced in accordance with the new municipality approved recipes.

Due to budgetary constraints, lunchtime supervisors are no longer employed in LOWSchools. As a result, catering and school staff work together to manage flow and behaviour in the canteen and along the service line. In LOWSchool A&E, encouragement and support with eating lunch is only provided to the youngest children (under 6) via class teachers, special needs assistants and/or teaching assistants. The Head and/or Deputy Head teachers visit the canteen daily, providing ad hoc support and encouragement and in some cases (LOWSchoolE in particular) eating their lunch with the children during the latter part of service.

In LOWSchool A&E, the children are trained to use the waste stations. In LOWSchool A only, the school janitor provides extra oversight of, and support at, the waste stations helping the children, where required, with waste disposal. Both LOWSchools have multiple waste stations to dispose of plate waste (i.e food and non food (yoghurt pots)), lunchbox leftovers, and non food waste (i.e. milk cartons, juice cartons; polystrene cups; plastic cutlery; plastic wrapping), and to stack reuseable plates, bowls and cutlery ready for washing. All plate food waste is collected in designated food waste bins though unlike LOCSchool the collected food waste is not weighed and recorded on a daily basis. All plate, counter and kitchen food waste is transfered to large outdoor food waste bins for disposal via anerobic digestion. No sorting of non-food waste for recycling was observed and all non-food waste is disposed of via landfill. Significant single use plastic waste was observed daily in ScotSchool A&E due to the use of single serve milk, juice and yoghurt cartons (including plastic straws); polystrene cups for soup; plastic wrapping for prepared sandwiches, burgers and cut fruit, and single use plastic cutlery (spoons only).

2.6. Summary

In this section, a series of summary tables are presented (Tables 14-17) which drawn both from this and the more detailed 6.2 country reports, which synthesis the key insights into, and observations made about: 1) school meal uptake, price, subsidies and payment systems, and contract arrangements (Table 14); 2) menu planning, meal options and meal ordering systems (Table 15); 3) kitchen staffing and lunctime service (Table 16); and 4) canteen environment, supervision and waste management (Table 17). These synthesis tables highlight all the key variables, which based on our detailed observations, are shaping, and influencing, school meal services across out 5 countries and which we believe must be considered when developing school meal policy and services as they are impacting, to varying degrees, the nutritional quality, economic and service efficiency, lunctime experience, waste management and consumption patterns of primary school lunches. Across the tables, similarities and differences are evident between the countries and their different approaches to, resourcing of, and daily delivery of school meal services.

School Meal Service and Canteen Environment Characteristics	Croatia	Italy	Greece	Serbia	UK
School Meal Uptake in Case Schools	37-58%	80-90%	Approx. 70%	36-61% of extended stay 1st-4th grade ((80-145) children	55-71%
Daily Full Price of School Lunch/Pupil	€1.20	€5-6.18 (adjusted for, and subsidies available)	€2.33 (Fully subsidised as part of Pilot Project in 17/18 by Greek Government)	€1.42-€1.75	Approx. €2.30
Free or subsidised schools meal in case schools	0.5-5% (free); 68% eligible for subsidised meals	% not known (€ 2.30/meal (ISEE € 0-6,360.17); € 4.12/meal (ISEE € 6,360.18-11,764.89); or € 6.18/meal (ISEE above € 11,764.90).	100%	Very limited; Vast majority are fully paid for by parents	14-51% (free school meals)
Free or subsidised schools meal in case schools	0.5-5% (free); 68% eligible for subsidised meals	% not known (€ 2.30/meal (ISEE € 0-6,360.17); € 4.12/meal (ISEE € 6,360.18-11,764.89); or €	100%	Very limited; Vast majority are fully paid for by parents	14-51% (free school meals)

		6.18/meal (ISEE above € 11,764.90).			
Payment System	Monthly invoices issued to parents by school	Monthly invoices issued by the municipality	Fully subsidised; No charge to parents	Monthly invoices issued to parents by school	Online Parent Pay system
Contract Arrangements	In-house school service	Private Caterer	Private Caterer	Mixed LOC: Private Caterer; LOW: In-house school service	Mixed LOC: Private Caterer; LOW: In-house municipality service

Table 14: Cross Case Synthesis of school meal uptake, price, subsidies and payment systems

School Meal Service and Canteen Environment Characteristics	Croatia	Greece	Italy	Serbia	UK
School Meal Production	Onsite School Kitchens except for one school who receives meals produced in other school (hub school)	Central Kitchen, Delivered daily to schools	Onsite School Kitchens (1 school) Or Central Kitchen (3 schools); Delivered daily to schools	Onsite School Kitchens	Onsite School Kitchen
Menu Planning and/or Cycles	Monthly Menu Planning	1 menu across 24 week pilot project;	2-4 menus per year; Rolling 4-8 week cycle	Weekly/Bi-weekly menu planning	1-2 menus per year; Rolling 3 week cycle
School Input in menu planning and school meal service	Head Teacher and/or key subject teachers involved in menu planning	Developed by the Private Caterers; No school involvement	Developed by the Private Caterers and approved by municipality;	Head Teacher and/or key subject teachers involved in menu planning	Head teachers consulted
Child and/or Parental input into School meal planning and service	No formal child/parental involvement though each school has a parent council that can provide feedback.	No formal child/parental involvement.	Each school has a Canteen Commission made up of parents and teachers who inspect the canteen ad hoc during the year and provide feedback on the schools meals and canteen service.	No formal child/parental involvement.	• SNAG groups (School Nutrition Advisory Groups) – Child members only • Parents Council
Number of Menu Options	1 daily meal option	1 daily meal option	1 daily meal option	1 daily meal option	Up to 9 different main meal and 3 different dessert options per day

Lunch Ordering system	Teachers confirm the number at the beginning of each month	Available to all though must sign up at start of programme;	Children are signed up in advance for school lunch	Numbers confirmed daily the night before for cooks	At canteen service line or first thing each morning (choices submitted to kitchen by 10am)
Other snacks/food offered (for separate payment) during school day	Breakfast and/or Snack (extended stay children)	No other snacks provided	No other snacks provided apart from fruit through the EU Fruit Scheme	Breakfast and/or Snack (extended stay children)	Breakfast Club Fruit through the EU Fruit Scheme
Lunchbox Children	Eat their lunch at the same time and in the same canteen space	Eat their lunch at the same time and in their classrooms	Eat their lunch at the same time	Eat their lunch at the same time	Eat their lunch at the same time and in the same canteen space

Table 15: Cross Case Synthesis of Menu planning, Meal options and Meal Ordering Systems

School Meal Service and Canteen Environment Characteristics	Croatia	Greece	Italy	Serbia	UK
No of Catering Staff	2 – 7 where 7 are employed in the Hub school who prepare and supply meals to 12 other schools.	Central Kitchen: ?? No in school catering staff as Teachers distribute meals in schools	Central Kitchen: 25-32 In School: 3-6	2	2-5 depending on school size (approx.. 1 member of staff per 50 meals served)
Length of Time available for Eating lunch/child	15-45mins	45 mins	25-30 mins	Approx.. 15-20mins	Approx. 15 mins
Number of lunch sittings	Upto 5 with sitting varying from 15-45mins	1*45min	2 * 30mins	Upto 2 with each sitting approximately 30-35mins	Upto 5 with each sitting approximately 15 mins
Order of Service	Youngest children are always served first; Mixed order thereafter	No stated order as children served by their teachers in their class or computer room;	Youngest children are always served first; Mixed order thereafter	Youngest children are always served first; Mixed order thereafter	Youngest children are always served first; Mixed order thereafter
How is food served	Mixed ; Kitchen staff serve children at the tables from a serving cart at the canteen service line where children queue up and receive their lunch	Meals are delivered pre-packaged and served via serving carts to children in their class rooms/assembly hall	Kitchen staff serve children at the tables from a serving cart	Meals are served up and laid out in advance on tables; Dessert, when served, is laid out on a special dessert table	At the canteen service line; Children queue up and receive their lunch

Requirement for Children to accept vegetable side dishes	Every child gets his portion of meal on a plate (no choice of vegetables)	Children required to accept vegetable side dishes	Children required to accept vegetable side dishes	Children required to accept vegetable side dishes	• LOC: All children must accept a minimum of 1 portion of vegetables as a side dish • LOW: Children are not required to accept any vegetable side dishes
Items available for children to freely choose	• Plates of Bread on tables • Bowls of Salad on tables • Jugs of water	• No additional items provided; Meals come with bread and salad included; Children bring their own water in water bottles.	• Plates of Bread on tables • Bowls of Salad on tables • Cheese in bowls on tables	• Plates of Bread on tables • Bowls of Salad on tables • Drinks in some schools (water; tea; lemonade)	• Bread and Salad at service counter • Trial of cut fruit on platters on tables in LOWSchool in Oct 2018 • Jugs of water
Are multiple courses served together?	No	Yes	No	No	Yes
What are school lunches served on?	Trays (canteen service) and plates/bowls	In PET pre-packaged containers	Plates and Bowls	Plates and Bowls	Trays and plates/bowls OR Multi-compartmental trays
Portion Size Adjustment	No formal portion size adjustment observed	No formal portion size adjustment observed	No formal portion size adjustment observed	No formal portion size adjustment observed	Only Starchy food portions are formally adjusted based on age of child in 3 of 4 case schools
Are extra portions of food available upon request from children?	Yes	No	Yes	Yes	No
What drinks are provided (if any)?	Only water provided	Children bring their own water bottles into school	Only water provided	Only water provided	• LOC Schools: Only water provided in jugs and pre-poured cups • LOW Schools: Cartons of Plain and/or Flavoured Milk; Cartons of Juice drinks and jugs of water are available

Table 16: Kitchen Staffing and Lunchtime Service

School Meal Service and Canteen Environment Characteristics	**Croatia**	**Greece**	**Italy**	**Serbia**	**UK**
Single or Mixed Use Canteen Facilities	Single use though can be used for special occasions	Mixed Use – Lunch served in classrooms or school assembly hall	Single use though can be used for special occasions	Single use though can be used for special occasions	Mixed Use (school assembly hall) and Single use (dedicated canteen)
Canteen Layout and space	Mix of long rectangular tables with upto 24 seats and smaller 4 seater tables; Depending on the school (in LOC School A there are about 140 seats, LOW A approx 50 seats + 10 stands for high tables, LOC E 120 seats, LOW C 76 seats)	Classroom based	Can accommodate between 90-100 per lunch sitting	Mix of long rectangular tables with upto 24 seats and smaller 4-6 seater tables;	Rectangular and/or round 8-12 seater tables; Can accommodated between 35-72% of total pupils in one sitting
Supervision and Encouragement	Some encouragement provided by teachers and canteen staff to encourage children to try new foods and eat more of their meal; Levels of encouragement vary across the schools	Overall limited supervision and encouragrement provided though teachers in some schools do ask students what were the reasons for not finishing the mea and tryto encourage them to eat something	Some encouragement provided by teachers and canteen staff to encourage children to try new foods and eat more of their meal; Levels of encouragement vary across the schools	Some encouragement provided by teachers and canteen staff to encourage children to try new foods and eat more of their meal; Levels of encouragement vary across the schools	Provided by lunchtime supervisors and some teachers; In LOC schools only, young children must request permission to move onto their dessert and to confirm that they have eaten enough food; Levels of encouragement vary across the schools
Do teachers get, and eat, their lunch from, and in, the canteen	Yes – teachers eat in the canteen with some sitting with children and others sitting on a separate staff table.	No	Yes – teachers eat in the canteen with some sitting with children and others sitting on a separate staff table.	Yes – some teachers eat in the canteen with some sitting with children and others sitting on a separate staff table.	No - Very few teachers get, and/or eat their lunch from, and in, the canteen.
Waste Disposal after lunch service	The children, with some help from school staff and/or older children, are responsible for taking	Teachers are responsible for clearing away left overs and waste packaging.	The children, with some help from school staff and/or older children, are responsible for taking their plates/trays to the	The children, with some help from school staff and/or older children, are responsible for taking their plates/trays to the	The children, with some help from school staff and/or older children, are responsible for taking their plates/trays to the waste station and

	their plates/trays to the waste station and putting their food and non-food waste into the appropriate bins and putting their dirty plates and cutlery in the bowls ready for cleaning.		waste station and putting their food and non-food waste into the appropriate bins and putting their dirty plates and cutlery in the bowls ready for cleaning.	waste station and putting their food and non-food waste into the appropriate bins and putting their dirty plates and cutlery in the bowls ready for cleaning.	putting their food and non-food waste into the appropriate bins and putting their dirty plates and cutlery in the bowls ready for cleaning.
Is food waste collected in separate food waste bins?	Yes	No	Yes	Not routinely	Yes
Are there separate bins for recycling non-food waste?	Yes	For PET containers only	Yes	No	No
Curricula and Other Food, Nutrition and Sustainability Initiatives	Multiple	Limited	Multiple	Limited	Multiple
When do children get playtime?	Depends on when they are brought to the canteen. Some play before their lunch and others after.	After the the 45min lunchtime.	Not clear from observations	Not clear from observations	Depends on when they are brought to the canteen. Some play before their lunch and others after. Lunchtime clubs run on some days which can impact the ordering for some children.

Table 17: Canteen Environemnt, Supervision and Waste Management

3. NUTRITIONAL COMPOSITION OF SCHOOL MENUS IN DIFFERENT PSFP MODELS

3.1. Methodology to measure nutritional composition of menus

The methodology used for the FCA and nutritive evaluation of daily school lunch menus is as follows. From each partner (Croatia, Italy, Greece, Serbia, and UK) across the two PSFP models, daily menus were collected for a period of 5 consecutive school days (Monday to Friday) during 2 seasons (autumn/winter and spring/summer) in the school year 2017/2018. In total, 40 daily menus (20 for Greece) were analysed, 20 for each model (10/model in Greece). Menus were obtained from the school staff while normative provisions (standard quantities of ingredients) were obtained (where required) from direct conversation with the cooks or with catering staff/responsibles. The nutritive values of school lunch recipes were calculated using national composition tables for each country (for Croatia-National food composition tables Kaić Rak and Antonić; for Italy-Food Composition Database for Epidemiological Studies in Italy , IEO; for Greece- Composition tables of foods and Greek dishes, HHF; for UK-McCance and Widdowson's The Composition of Foods integrated dataset, IFR; for Serbia-Serbian Food and Nutrition Database, IMR). Thus, for each recipe offered on the schools' daily menus, the total energy (calories), macronutrients (proteins, fats, carbohydrates, dietary fibres and saturated fatty acids) and selected micronutrients (all countries except UK) from a full consumed portion was calculated (See Table 20). For those foods not in national food composition database, energy and nutritive values were obtained, where possible, from the food labels. Whilst significant consideration, and effort, was given to, exploring possible nutritive differences between organic and conventional food, for those countries where organic supply was identified (specifically Italy), we were unable to find comprehensive, nor scientifically accepted, nutritive data that would support a comprehsnive and meaningful organic vs conventional nutritive analysis of schools meals. Reanalysis of the collected data, at a later date during the remainder of the S2F project is possible if more comprehensive, and scientifically accepted, data for the nutritive values of organic food stuffs, especially fruit, vegetables, meat and dairy becomes available.

Unlike other countries where participating schools only offer one set meal combination (one main and one soup/dessert) per day, the UK case schools offered upto 9 different daily meal options. Daily, across both LOC and LOW Schools, up to 27 different meal combinations are offered including up to: 3 hot meal options; 3 baked potato filling options, 3 sandwich filling options and 3 dessert/soup options. Multiple daily hot and cold vegetables options (up to 8 different types) are available though only LOCSchool children are required to accept at least one portion of hot/cold vegetables. For the purposes of nutritional composition analysis, and in order to calculate the planned energy and nutritive profile for both cases, it was assumed that all children, irrespective of the high observed hot/cold vegetable refusal rates in LOWSchools, accepted at least one portion of hot vegetables/main option chosen (including sandwiches) and as such, all nutritive calculations include energy and nutrient data for one portion of hot vegetables/main option served. Supplementary data was required when preparing the data, for LOWSchool recipes in particular, as the available recipes did not cover all components served and thus the available menus were supplemented with portion size recommendations from the Heathy Eating in Schools Guide, Scotland (2008). After entering all ingredient data for the selected menu options per region (approx.. 33 per region) into the Food Explorer database, a full energy and macronutrient profile for a standard portion/child for each menu option (soup, main or dessert) was calculated. For reporting purposes, only energy and macronutrient profiles are presented for the UK due to breadth of choice offered, and the high vegetable refusal rates observed in LOWSchool. For LOCSchools and LOWSchools respectively, drawing on the calculated energy and macronutrient profile from the main menu (22 and 28 respectively) and soup/dessert options (11 and 5 respectively) selected, a daily average energy and macronutrient profile for a 2 course school lunch, was calculated. For both LOC and LOWSchool, table 20 presents average daily energy and macronutrient profiles for an average 2 course school lunch including the range for each energy and macronutrient category.

The energy and nutrient values of the offered meals were evaluated with regard to referent national guidelines for primary school meals each country. All partners (except Greece and Serbia) had set up national standard for school lunches at time of analysis. National guidelines for school catering set out the mandatory standards that all municipalites and schools must meet. National dietary standards therefore specify the recommendation for school lunches considering both energy and nutrient intakes and food groups (See Table 18). Specific recommendations especially for lunch are also available in Italy and UK. For Croatia and Serbia recommendation are presented as total daily recommendation but specify that lunch should provide 35 % of total daily energy, therefore all other macro and micronutrients could be recalculated.

Table 18 summarises the recommendation used across our 5 countries. Since Greece and Serbia (at the time fo the FCA) did not have national recommendations for school lunches, for the purpose of this research, it was agreed that WHO (Food and nutrition policy for schools) recommendations should be used for Greece and Serbia. Therefore, for each recipe on the daily menus, we evaluated the extent to which a full consumed portion could contribute to a child's recommended daily intake of energy and nutrients. In undertaking the FCA, we also explored the possibility of making adjustments to reflect how food procured through alternative models may possess different nutritional outcomes. Data gaps for some micronutrients in the national food composition tables for Croatia, Serbia, Italy and Greece mean that the FCA micronutrient estimates are likely to be an underestimation. Results are described using descriptive statistical methods. Results were not normally distributed and therefore the difference between the two models were assessed using ANOVA ω2. ANOVA ω2 statistics was selected because of low bias and non-parametric correlation showing true relationship between data sets. ANOVA ω2 significance values are in the following ranges: 0 - 0.063 not significant differences (no effect); 0.063 – 0.14 significant differences (medium effect) and >0.14 significant differences (high effect).

Country	Croatia	Greece	Italy	Serbia	UK
Guidelines	National guidelines for school meals for children in primary schools	WHO - Food and nutrition policy for schools	Dietary Standards for school meals for children	WHO - Food and nutrition policy for schools	Scottish Nutrient Standard for School Lunches
Age group	**7-9 years**	**7-9 years**	**6-11 years**	**7-9 years**	**4-11years**
Energy	35% of daily energy	30 % of EAR	35% of daily energy	30 % of EAR	
	649 (584-714) kcal	501-612 kcal	520-810 kcal	501-612 kcal	557 kcal
Proteins	10-15 % of meal energy	not less than 30% of the RNI	10-15% of the meal energy	not less than 30% of the RNI	
	16.2 – 24.3 g	>8.49 g	13-30 g	>8.49 g	>8.5 g
Animal-Plant Proteins Ratio	/	/	0.66	/	/
Total fat	30-35% of meal energy	not more than 30% of food energy	30% of the meal energy	not more than 30% of food energy	
	21.6 – 25.2 g	17-20 g	18-27 g	17-20 g	<21.7 g
Saturated fatty acids	≤10% of meal energy	not more than 10% of food energy		not more than 10% of food energy	
	≤7.2 g	6-7 g	6-9 g	6-7 g	<6.8 g
Carbohydrates	>50% of meal energy	not less than 55% of food energy	75-120 g	not less than 55% of food energy	not less than 50% of food energy
	>81 g	69-84 g		69-84 g	>74.3 g
of which sugars			13-30 g		

Fibre	>10 %	not less than 30% of the reference value		not less than 30% of the reference value	
	>6.5 g	>4,47 g	6 g	>4,47 g	>4. 5 g#
Iron	35 % of daily recomm. 3.5 mg	not less than 40% of the RNI >3.48 mg	6 mg	not less than 40% of the RNI >3.48 mg	>3 mg
Calcium	35 % of daily recomm. 315 mg	not less than 35% of the RNI >245 mg	350 mg	not less than 35% of the RNI >245 mg	>165 mg
Vitamin A	35 % of daily recomm. 0.3 mg RE	not less than 30% of the RNI >150 µg	/	not less than 30% of the RNI >150 µg	>150 µg
Folate	35 % of daily recomm. 105 µg	not less than 40% of the RNI >120 µg	/	not less than 40% of the RNI >120 µg	> 45 µg
Vitamin C	35 % of daily recomm. 28 mg	not less than 35% of the RNI >10.5 mg	/	not less than 35% of the RNI >10.5 mg	>9 mg
Sodium (salt)	1380 mg per day	1380 mg (3.6 g) per day	2750 mg (1.1 g) per day*	1380 mg (3.6 g) per day	686 mg per lunch

Table 18. National or WHO Reference ranges or values for energy and nutrients of lunch

EAR- Estimated average requirement
RNI- Recommended Nutrient intake for Children and Adolescents
*Daily recommended values of sodium and salt intake provided by Parma municipality to children aged 7-10 years
#NSP- non-starch polysaccharides

3.2. Nutritional composition of School Lunch Menus

The following sections reports the results of the FCA and nutritive evaluation of daily school lunch menus within, and across, countries, both descriptively and via a synthesis tables. Table 19 and 20 present the energy, macro-, and micronutrient profile of the average lunch/PFSP model across the 5 countries. Figures 15-21 and Table 21 presents the proportional breakdown within, and across the 5 countries, of how many menus deliver above, within or below national recommendations for total energy and macronutrient categories. This is followed by short country summaries of the key nutritional compositional results.

Parameter*	PFSP model	Croatia	Greece	Italy	Serbia	United Kingdom
Energy (kcal)	Model 1[a]	525 ± 115	815 ± 109	706 ± 93	561 ± 186	625 ± 159
	Model 2[b]	352 ± 124	759 ± 119	698 ± 68	546.1 ± 113	576 ± 71
Total proteins (g)	Model 1	18.0 ± 5.4	34.8 ± 6.1	30.5 ± 5.9	22.5 ± 5.1	25.0 ± 4.2
	Model 2	19.8 ± 742	29.9 ± 6.5	27.4 ± 5.0	21.9 ± 6.2	29.7 ± 3.18
Total carbohydrates (g)	Model 1	66.4 ± 14.8	87.6 ± 14.7	104.2 ± 12.1	72.0 ± 20.2	69.9 ± 20.7
	Model 2	48.8 ± 19.5	79.9 ± 15.6	104.5 ± 12.0	64.2 ± 17.2	66.1 ± 10.9
Dietary fibre (g)	Model 1	4.6 ± 2.7	7.5 ± 5.3	12.9 ± 3.5	6.8 ± 3.7	6.3 ± 1.5
	Model 2	3.3 ± 3.0	4.4 ± 0.9	10.2 ± 4.7	5.7 ± 1.6	6.0 ± 0.6
Total fat (g)	Model 1	21.7 ± 9.4	36.2 ± 7.4	20.4 ± 7.2	19.6 ± 11.8	26.7 ± 8.4
	Model 2	9.2 ± 5.1	35.3 ± 7.9	20.9 ± 4.4	22.1 ± 7.9	22.2 ± 4.8
Saturated fatty acids (g)	Model 1	4.6 ± 2.7	8.6 ± 2.2	7.0 ± 6.4	4.8 ± 3.2	12.2 ± 4.2
	Model 2	2.7 ± 2.0	9.7 ± 4.4	5.7 ± 3.1	4.8 ± 2.6	10.9 ± 2.4

Table 19. Energy and macronutrient values in the average lunch at five countries according to PFSP model

*All values are mean ± standard deviation
[a]-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)
[b]-model 2- school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

Table 20 presents the micronutrient profile of the average lunch/PSFP model across four countries (Micronutrient analysis was not performed on UK data due to the complexity of the number of daily menu options offered).

Parameter *	PFSP model	Croatia	Greece	Italy	Serbia	United Kingdom
Vitamin A (RE)+	Model 1[a]	0.16 ± 0.19	*na*	909.13 ± 672.66	56.9 ± 58.5	anp***
	Model 2[b]	0.09 ± 0.07	*na*	522.32 ± 339.31	124.4 ± 260.4	anp
Vitamin B1 (mg)	Model 1	0.25 ± 0.15	0.49 ± 0.14	0.52 ± 0.19	0.42 ± 0.18	anp
	Model 2	0.19 ± 0.10	0.48 ± 0.12	0.48 ± 0.15	0.49 ± 0.27	anp
Vitamin B2 (mg)	Model 1	0.22 ± 0.14	0.56 ± 0.25	0.44 ± 0.14	0.29 ± 0.09	anp
	Model 2	0.17 ± 0.07	0.41 ± 0.28	0.39 ± 0.10	0.32 ± 0.16	anp
Niacin (mg)	Model 1	3.71 ± 2.69	*na*	1.22 ± 0.82	6.1 ± 3.4	anp
	Model 2	5.14 ± 3.62	*na*	1.28 ± 0.61	6.4± 3.7	anp
Vitamin B6 (mg)	Model 1	0.32 ± 0.25	0.42 ± 0.25	0.79 ± 0.34	0.49 ± 0.27	anp
	Model 2	0.27 ± 0.19	0.73 ± 0.26	0.80 ± 0.23	0.43 ± 0.30	anp

Folate (µg)	Model 1	*na*	*na*	118.81 ± 38.73	79.0 ± 37.5	anp
	Model 2	*na*	*na*	96.97 ± 42.83	88.9 ± 59.9	anp
Vitamin B12 (µg)	Model 1	*na*	*na*	2.53 ± 4.27	1.2 ± 1.3	anp
	Model 2	*na*	*na*	1.43 ± 0.76	1.1 ± 0.9	anp
Vitamin C (mg)	Model 1	25.36 ± 23.64	58.10 ± 50.76	82.20 ± 37.12	38.4 ± 24.1	anp
	Model 2	15.98 ± 16.13	65.32 ± 44.54	55.70 ± 46.16	41.6 ± 42.4	anp
Vitamin D (µg)	Model 1	*na*	*na*	0.32 ± 0.36	0.42 ± 0.33	anp
	Model 2	*na*	*na*	0.86 ± 1.81	0.26 ± 0.25	anp
Sodium (mg)	Model 1	1086.57 ± 331.50	1492.97 ± 627.74	630.10 ± 142.47	661.5 ± 310.5	anp
	Model 2	878.15 ± 521.87	1695.35 ± 585.10	647.19 ± 324.31	748.0 ± 281.8	anp
Potassium (mg)	Model 1	645.11 ± 482.09	1125.30 ± 363.80	1335.53 ± 389.99	922.1 ± 330.0	anp
	Model 2	564.08 ± 427.32	1144.04 ± 353.58	1064.85 ± 295.89	850.3 ± 358.3	anp
Calcium (mg)	Model 1	49.46 ± 36.76	300.42 ± 117.31	368.03 ± 212.70	148.1 ± 61.8	anp
	Model 2	45.99 ± 28.45	366.62 ± 139.93	302.66 ± 131.34	112.6 ± 55.1	anp
Magnesium (mg)	Model 1	34.38 ± 28.33	129.38 ± 37.86	45.91 ± 22.89	88.0 ± 22.6	anp
	Model 2	31.19 ± 22.35	130.06 ± 50.77	43.40 ± 18.87	75.3 ± 25.2	anp
Phosphorus (mg)	Model 1	171.32 ± 89.93	510.20 ± 280.09	510.75 ± 103.20	307.2 ± 97.2	anp
	Model 2	227.57 ± 100.74	439.07 ± 326.32	424.39 ± 67.57	289.7 ± 79.9	anp
Iron (mg)	Model 1	2.27 ± 1.10	7.45 ± 3.23	5.41 ± 1.83	3.3 ± 1.3	anp
	Model 2	2.25 ± 1.12	5.76 ± 2.06	4.10 ± 1.30	3.5 ± 0.8	anp
Zinc (mg)	Model 1	0.68 ± 0.50	6.11 ± 1.75	3.30 ± 0.80	2.9 ± 1.4	anp
	Model 2	0.65 ± 0.51	6.15 ± 2.75	3.39 ± 1.13	3.0 ± 1.3	anp
Copper (mg)	Model 1	0.32 ± 0.35	0.66 ± 0.40	0.31 ± 0.24	0.22 ± 0.12	anp
	Model 2	0.21 ± 0.19	0.53 ± 0.15	0.35 ± 0.31	0.19 ± 0.09	anp

Table 20. Micronutrient values in the average lunch across five countries according to PFSP model

*All values are mean ± standard deviation
**na-data not available from the national food composition database
***anp-analysis not performed
[+] Croatia REµg, Serbia and Italy REmg
[a]-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)
[b]-model 2 - school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

Figure 15: Proportion of daily menus across both cases/country that met National recommendations for total energy (Kcal)

HR – higher than recommended, AV- adequate value, LR – lower than recommended

Model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)

Model 2 - school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

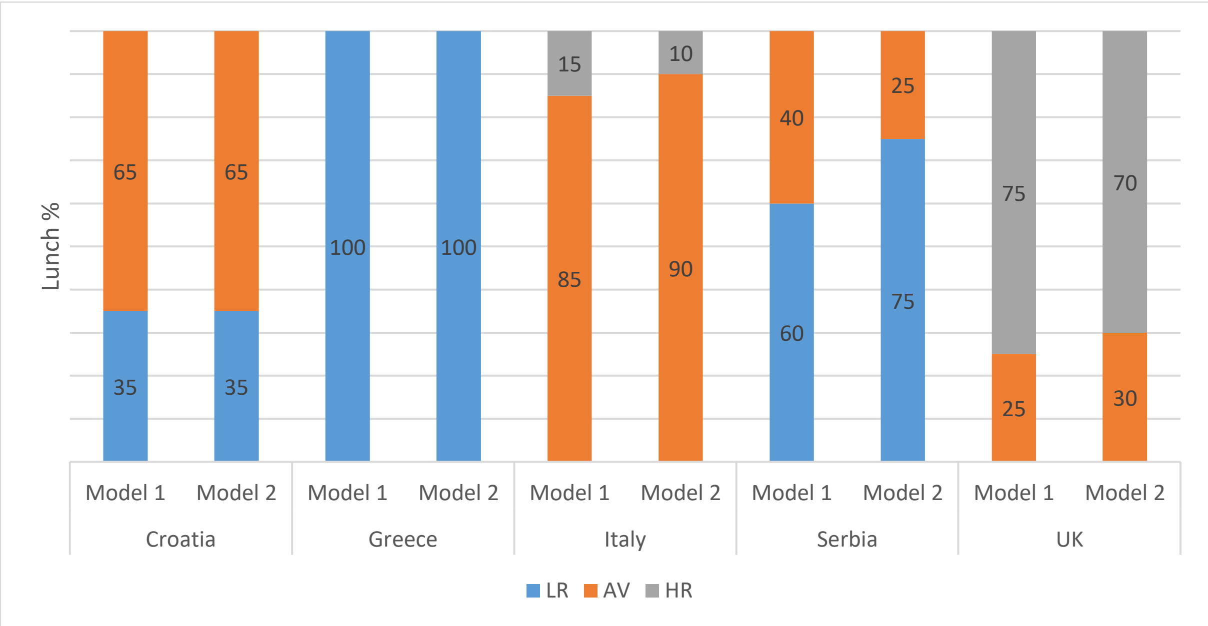

Figure 16: Proportion of daily menus across both cases/country that met National recommendations for total carbohydrates (g)

HR – higher than recommended, AV- adequate value, LR – lower than recommended

Figure 17: Proportion of daily menus across both cases/country that met National recommendations for total protein (g)

HR – higher than recommended, AV- adequate value, LR – lower than recommended

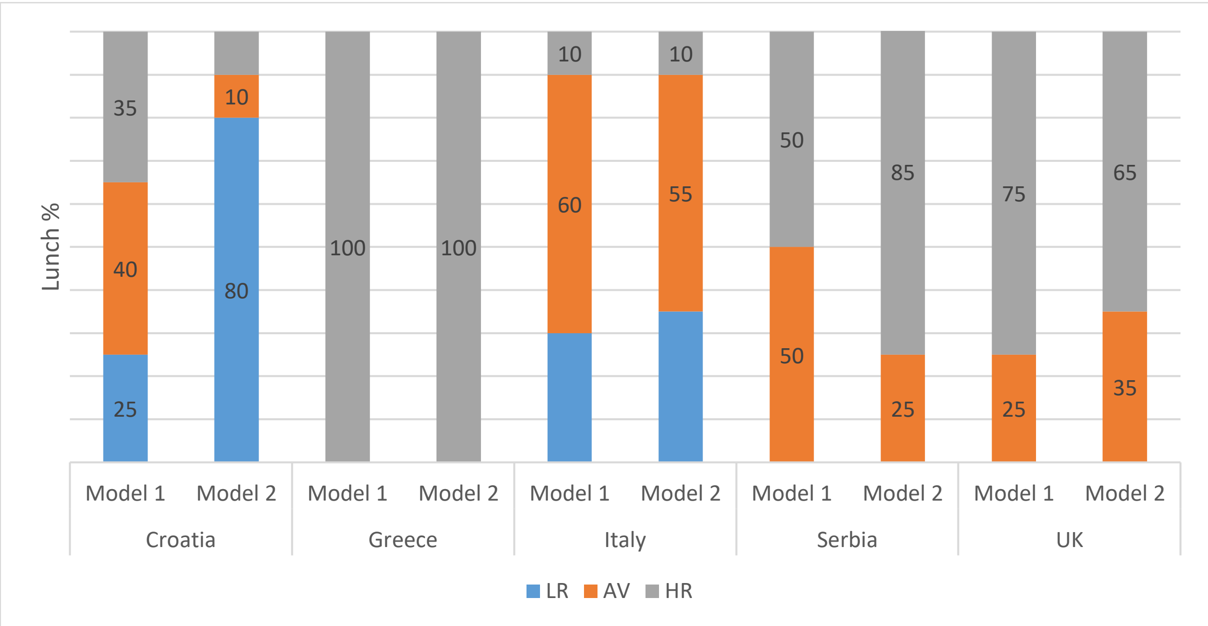

Figure 18: Proportion of daily menus across both cases/country that met National recommendations for total fat (g)

HR – higher than recommended, AV- adequate value, LR – lower than recommended

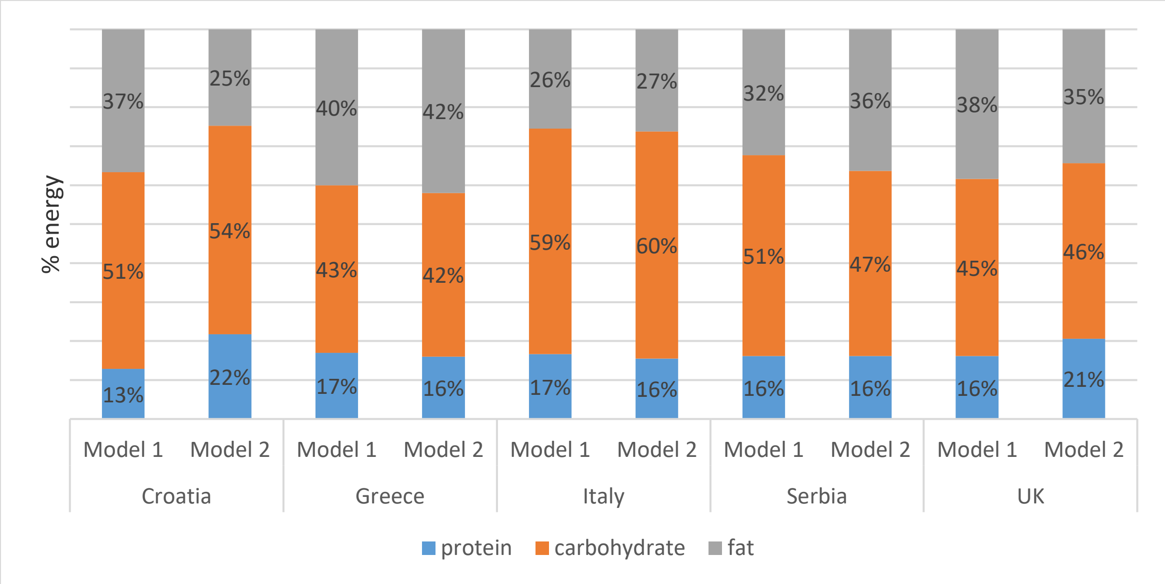

Figure 19: Average proportions, per case, of macronutrients in terms of % meal energy in daily lunch menus

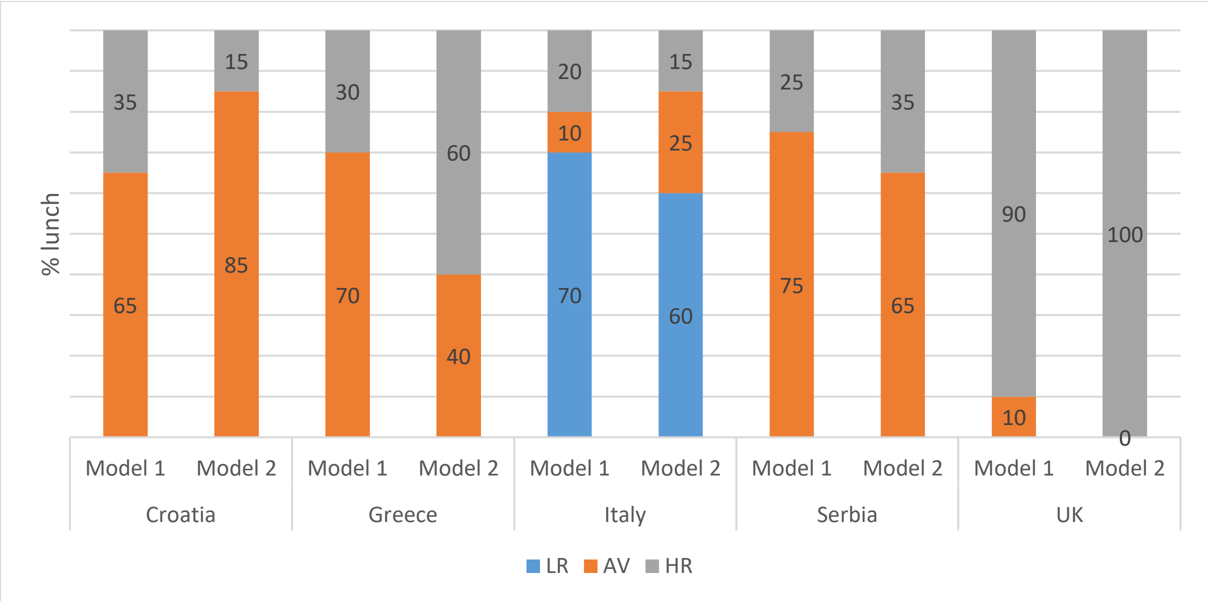

Figure 20: Proportions of daily menus across cases, and countries, that met National recommendations for saturated fatty acids

HR – higher than recommended, AV- adequate value, LR – lower than recommended;

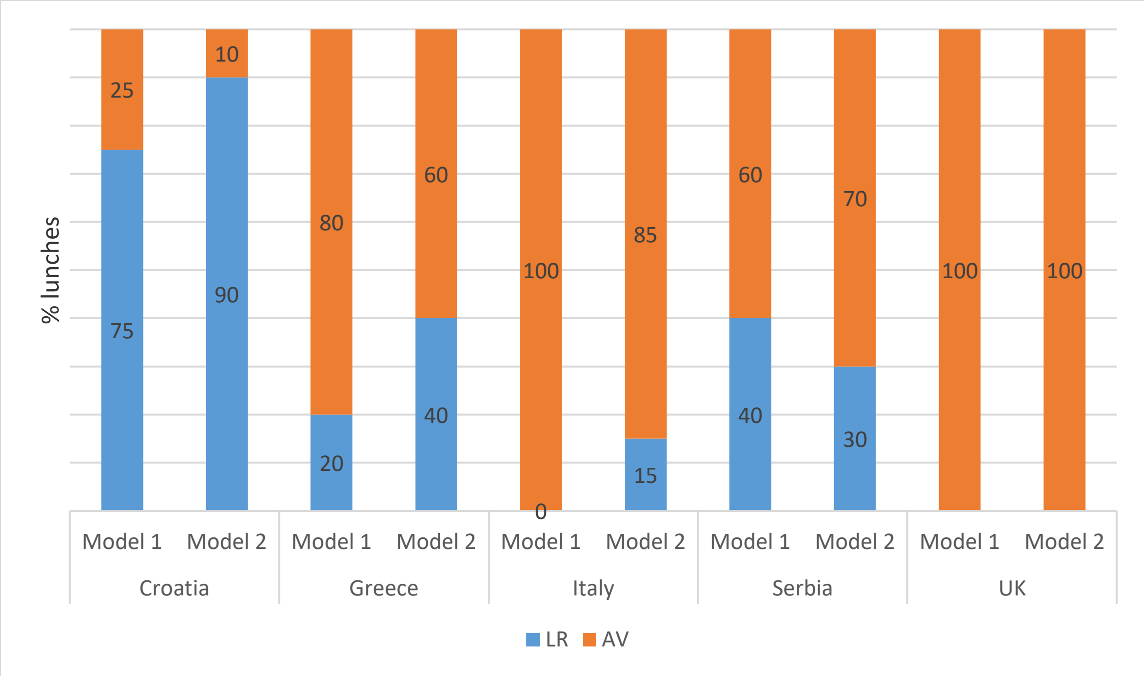

Figure 21: Proportions of daily menus across cases, and countries, that met National recommendations for dietary fibre

AV- adequate value, LR – lower than recommended;

% Menus within (above min) Recommended Levels	PFSP model	Croatia	Greece	Italy	Serbia	United Kingdom	Cross Case Range
Energy	Model 1[a]	35	0	85	40	25	0-85 within recommended levels
	Model 2[b]	35	0	90	25	30	0-90 within recommended levels
Total protein (%) Within (above) min threshold	Model 1	70 (25)	100	30 (70)	100	100	95-100% within or above recommended levels
	Model 2	5 (95)	100	40 (60)	100	100	100% within or above recommended levels
Total carbohydrates (%)	Model 1	65	0	85	40	25	0-85 within recommended levels
	Model 2	65	0	90	25	30	0-90 within recommended levels
Dietary fibre Within (above) min threshold (%)	Model 1	75 (25)	20 (80)	100	40 (60)	100	100% within or above
	Model 2	90 (10)	40 (60)	15 (85)	30 (70)	100	100% within or above
Total fat (%)	Model 1	40	0	60	50	25	0-60 within recommended levels
	Model 2	10	0	55	25	35	0-55 within recommended levels
Saturated fatty acids (%)	Model 1	65	70	10	75	10	10-75 within recommended levels
	Model 2	85	40	25	65	0	0-85% within recommended levels

Table 21. Proportions of daily menus across cases, and countries, that met National recommendations for dietary fibre

Model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)

Model 2 - school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

Drawing on tables 19-21, and figure 15-21, short country specific overviews of the key nutritional compositional results are presented below.

3.2.1. Croatia

Energy and macronutrients

In LOCSchools, the standard lunch portion provides more energy (kcal) than the standard lunch portion in LOW case (547 kcal and 363 kcal, respectively), which is unsurprising given the average portion size of school lunches in in LOC Schools is 179g greater (472g) than in LOW Schools (293g). Also, the results show that only 10% of LOC school lunches, and 5% of LOWSchool lunches meet the recommended energy thresholds, with the majority of analysed school lunches acros both LOC and LOW schools below recommendation. The energy contribution from carbohydrate reached 50% of energy for both models, which is line with national recommendation. While LOC School lunches acquired on average 37% of food energy from total fat which exceeds national recommendation, LOW School lunches acquire only 25% of food energy from total fat which is below the recommendations. Finally, in terms of protein, while LOC school lunches are within national recommendation for total proteins (on average 13% of food energy) LOW school lunches exceeds the recommendation (on average 22% of food enregy). The majority of LOC (65%) and LOW (85%) school lunches in are within the recommendation for amount total amount of saturated fatty acids, therefore, only 35% o and 15% of LOC and LOW school lunches were found to have excessive levels of saturated fatty acids. The dietary fibre content of analysed LOC and LOW school lunches was found to be concerningly low. Only 25% of LOC, 10% of LOW school menus, were estimated to offer the recommended amount of dietary fibre.

Micronutrients – Although, no statistically significant difference was detected between the micronutrient profile of LOC and LOW school lunches, it is worth noting that LOC school lunches are higher for 3 of the 6 vitamins, and 6 of the 8 minerals analysed. For vitamins, the majority (50% or more) of both LOC and LOW menus provide lower than recommended national guidelines for Vitamin A, Vitamin B1, Vitamin B2 and Vitamin C. The only vitamin where the majority of menus across the cases achieve or exceed national recommendations was Vitamin B6. For minerals, the majority (50% or more) of menus across both LOC and LOW cases provide lower than the nationally recommended levels for 7 out of the 8 minerals analysed, and in 6 of these (Potassium, Calcium, Magnesium, Phosphorus, Iron and Zinc), the proportion of deficient menus was 70% or more. The average sodium composition of lunch for the LOC and the LOW models was 1077 mg and 919 mg respectively, both exceeding lunch recommendation of 482 mg. In summary, there is no detectable pattern of LOW or LOC menus 'performing' better or worse in terms of micronutrient status.

3.2.2. Greece

Energy and macronutrients - The average weight of a school lunch portion is 437 g, and 507 g, in LOC and LOW schools respectively, a difference of 69.5g. In term of energy, the standard lunch provides 815 kcal in LOC case and 759 kcal in LOW case, a difference of 56kcal. According to WHO recommendations, in both cases, all the analysed school meals are higher than the recommended in terms of total energy. The average energy provided from carbohydrates were less than 55 % of food energy, in line with WHO recommendations. For protein, the average amount of proteins provided by the analysed menus across both cases was in line with WHO recommendation (>8.49 g). The average total fat content was 40% of food energy for LOC case and 42 % of food energy for LOW case much higher than the WHO recommendation (lower than 30% of food energy). In terms of saturated fatty acids, according to WHO recommendation, a school lunch should provide less than 10% of lunch energy, and 70 % of LOC cases and 40 % of LOW cases met this recommendation. In LOC case more luches provided adequate amounts of dietary fibres than in LOW case (80% and 60%, respectively).

Micronutrients - Generally, no significant difference were found between the analysed menus. In terms of vitamins, while in LOC school lunches levels of Vitamins B1 and B2 levels were found to be higher than in LOW schools, the reverse was found for Vitamins B6 and C which was found to be higher in LOW school lunches. All analysed LOC and LOW menus were in line with the WHO recommendation for vitamin C. The minerals Phosphor, Iron and Copper are lower in LOW compare to LOC school meals which alos had lower concentration of Sodium, Potassium, Calcium, Magnesium and Zinc. All LOW (100 %) and 90 % of LOC school menus were found to be in line with WHO recommendation for Iron, while for calcium, across both cases, 60 % of lunches were found to be in line with WHO recommendation.

3.2.3. Italy

Energy and macronutrients – An average weight of a lunch portion in LOC-ORG case is 529 g, 31g more than the average weight of an ORG lunch portion, 498 g. In terms of energy, a standard lunch provides 706 kcal in LOC-ORG case and 698 kcal in ORG case and the vast majority of the analysed school lunches (LOC-ORG case (90%) and ORG case (95%)) meet national recommendations for energy. For both cases, the energy provided from carbohydrates were less than 60% of the lunch energy content which is also in line with the National recommendation. For protein, the average % of energy provided by proteins was slightly higher than the National recommendation (17% and 16% respectively for LOC-ORG and ORG model) for both cases. Total fat content was estimated to be providing 26%, and 27%, of energy content for the LOC-ORG case and ORG case, respectively, slightly below the national recommendation. In terms of saturated fatty acids (SFA), according to the National recommendation, a school lunch should provide between 6 and 9 g of SFA, and only 10% of LOC-ORG lunches and 25% in ORG lunches were found to meet this recommendations. In fact, while 20% of LOC-ORG and 15% of ORG lunches were found to have higher than recommended levels of SFA, the majority (70% LOC-ORG and 60% ORG lunches) were below national recommendations. All LOC-ORG, and 85% of ORG, lunches were found to align with dietary fibre recommendations.

Micronutrients - Generally, for micronutrietns no significant difference were found between the cases. In terms of vitamins, for LOC-ORG menus the average meal has found to have higher contents of 6 out of the 9 vitamins tested (A, B1, B2, folate, B12 and C), whereas ORG menus contained more Niacin, Vitamin B6 and Vitamin D). For minerals, the average LOC-ORG lunch was found to have a higher content 5 out 8 minerals analysed (Potassium, Calcium, Magnesium, Phosphorus and Iron), while ORG lunches were found to be higher in Sodium, Zinc and Copper. Only Iron and Calcium have national recommendations, with 80% of LOC-ORG lunches found to be below the recommendation for both minerals, while 90% , and 75%, of ORG lunches were found to be below recommendations for Iron and and calcium respectively.

3.2.4. Serbia

Energy and macronutrients - The average weight of a lunch LOC 495 g, 78g more than LOW lunches (417 g). For energy, only 25% menus, across both cases, meets recommendations, with two thirds of menus being found to be either too low or too high in energy. Across both cases, while the analysed menus met the WHO standard for protein content, many were too high in fat and low in carbs. For SFA, 25% of LOC and a third of LOW lunches were found to be above maximum recommended levels. Finally for fibre, 40% of LOC menus and 30% of LOW were found to be below recommendations.

Micronutrients - No statistical differences were found for micronutrient content across the cases. LOW menus were found to have greater contents of 7 out of 9 vitamins analysed, while LOC menus were found to have slightly higher contents of B6, B12 and D. LOC menus were found to have higher contents of 5 out of 8 minerals, with only sodium, iron and zinc higher in LOW. According to recommmnedation, the vast majority of boht LOC and LOW (90-95%) were found to be in line with recommended Vitamin C recommendations. However, both cases performed poorly in terms of Folate and VitA, where 80-95% of all menus fell below recommended levels. Recommended levels for Iron were found for 50% and 45 % of LOC and LOW menus respectively. No LOW and LOC lunches were found to meet recommended Calcium levels.

Since completion of the Serbian FCA of school menus reported above, the Ministry of Education, Science and Technological Development (a Strength2Food partner) introduced, for the first time (September 2018) Serbian specific regulations for meal nutrition in primary schools (MPNTR, 2018[7]) (See Table 4). These regulations were developed by a Ministry working group who took advice from Strength2Food project partners. In response, a 2nd stage analysis, led by BEL, with support from ZAG, is underway which will apply these new national Serbian nutritional guidelines for school food to the already collected menu data. In addition, BEL and ZAG plan to request a formal explanation from EUROFIR regarding the data gaps in the most upto date EUROFIR Serbian database. This 2nd stage analysis will be reported in subsequent scientific publications post submission of this deliverable.

3.2.5. UK

Energy and macronutrients - The average weight of an LOCSchool lunch (329g) is 78g more than LOW (252g) providing slightly more energy (49kcal) per average lunch portion (625kcal±159 – LOC; and 576±71), LOW). Overall in terms of energy, 45%, and 60%, of LOC and LOW school lunches respectively, were found to meet the recommended energy thresholds while 35% (LOC), and 25% (LOW) were below and 20% (LOC), and 15% (LOW), above recommendation. The average energy contribution from carbohydrate was 45% for LOC, and 46% for LOW, which is slightly below national recommendation. Both LOC and LOW School lunches were found to acquire on average 38% (LOC), and 35% (LOW) of food energy from total fat which slightly exceeds national recommendation. In terms of protein, both LOC and LOW school lunches excced national recommendation for total proteins with on average 25± 4.2 (LOC) and 29.7 ± 3.18 (LOW) grms of total protein per lunch menu analysed. This is well in excessive of the recommended minimum of 8.5g and equates to 16%, and 21% of food energy coming from proteins. The majority of LOC (90%) and LOW (100%) school lunches were estimated to exceed recommended levels for saturated fatty acids. All LOC and LOW menus analysed were found to be in line with recommended dietary fibre content. It is worth noting that while little or no refusal of meals components at service was observed in LOCSchool, significant refusal of meal components, especially of hot/cold vegetables, was observed in LOWSchool and as such the actual school lunch energy and nutritive intake of LOWSchool children is highly likely to be lower than that presented in Table 20.

[7] Rulebook on Detailed Requirements for Organizing, Implementing and Monitoring Nutrition of Pupils in Elementary School. "Official Gazette of RS", no. 68/2018 of 7.9.2018

4. SCHOOL MEAL PLATE WASTE IN DIFFERENT PSFP MODELS

According to the Food and Agriculture Organisation (FAO), the term "food loss" refers to the decrease in quantity or quality of food (FAO, 2011) while the related term, "food waste", considered part of food loss, refers to the discardment of food or using it for alternative (non-food) uses (FAO, 2011). Food loss can occur throughout the supply chain including during storage, preparation, and/or serving, as well after eating, with the latter attributed as the largest contributer to total food waste volumes (Engström and Carlsson-Kanyama, 2002). The term "plate waste" is a part of food waste referring to the weight or percentage of served food that people (including children) discard. Plate waste can also serves as a marker to determine food intake or the impact of implemented interventions to improve healthy eating behaviour in school meals (Buzby and Guthrie, 2002, Niaki et al., 2017).

While reviewing peer reviewed articles on different methods used to measure plate/tray waste in school meals, a significant number of articles quantifying fruit and vegetable (F&V) intake, F&V waste, and F&V selection or consumption were found. According to this literature, a significant amount of F&V served in school lunches is wasted and it is well established that regular consumption of F&V is connected with prevention of chronic diseases (WHO, 2003; Wang et al., 2014), thus, wasting F&V is concerning. Plate waste in primary school aged children is influenced by numerous factors including dietary habits and ignorance of food production (Yao Liu et al., 2016, Casmir, 2014), availability of substitute foods or competitive food items (Marlette et al., 2005), discrepancy between meals served and student preferences (Bontrager et al., 2016; Zhenru et al., 2017), elimination of F&V choice (Kessler, 2016; Marc et al., 2005), energy needs/portion size vs. age (Niaki, 2017, Wansink et al., 2014), short lunch period (Cohen et al., 2017, Pellegrini & Bohn 2005), lunch before recess, meals being served when children are less hungry (Murray et al., 2013), variation in students' appetite (Cohen et al., 2005), position of salad bar in school's lunchroom (Kessler, 2016), default options, and incentives and food choices (Just & Price, 2013). Determining food waste is very useful for policy-makers, school-cafeteria managers/administrators (e.g. how much food to order and prepare), and parents in order to know how much, and what, food children are eating, as well as for dieticians to calculate average energy and nutrients lost through waste. This all becomes even more relevant when you factor in the associated economic losses and embodied carbon also associated with plate waste (Cohen et al., 2013).

Section 4 presents a detailed synthesis of the plate waste study conducted across different PSFP models, and 5 european countries (Croatia, Greece, Italy, Serbia and UK). Firstly, the common methodology selected, and used, for plate waste collection is described (Section 4.1.). Secondly, the weights of collected plate waste, in total and by food category, are presented as total weight per catgory (kg), average weight/served meal (g) and as a proportion (%) of total planned food served (Section 4.2). The compositional breakdown of collected plate waste is presented as a % of total collected plate waste (by the amount of waste each food category contributes), and, as proportion (%) of planned food served/category (Section 4.2). Thirdly the calculated nutritional and financial losses (Section 4.3 and Section 4.4), and levels of embodied carbon, attributed to the collected plate waste is presented (Section 4.5). This section concludes with a synthesis of key plate waste results across the different PSFP models and 5 countries is (Section 4.6).

4.1. Selecting a methodology to measure plate waste

Identifying an appropriate method for measuring plate waste in school canteens or other food service settings is not a trivial matter (Hanks et al., 2014). For this study, the method selected needed to be appropriate to allow links to be made between collected plate waste and the different food procurement models, and to facilitate the calculation of the nutritive and financial losses, and embodied carbon emissions, attributed to the collected plate waste. To meet these requirements, the method chosen needed to be appropriate for each school in terms of: school size, ordering and serving system, different menu items, and child profile. In addition, the method needed to minimise the costs and time required while still being reliable and valid. Based on a comprehensive review of the literature, 3 different plate waste collection methods (1 direct; 2 indirect) were reviewed and considered: (1) the direct weighing method; (2) indirect visual estimation by trained observer, and (3) indirect visual assessment by digital photography (Martinis et al., 2014). Interestingly in some reported studies, a combination of direct and indirect methods are often used (Hanks et al., 2014).

4.1.1. Direct Weighting Methods

For direct weigthing, three approaches were identified: a) aggregate non selective plate waste, b) aggregate selective plate waste, and c) individual plate waste. Precisely weighting the residues of edible food is the most accurate way of measuring plate waste, and is considered the “gold standard” (Buzby and Guthrie, 2002). Moreover, other alternative methods (e.g. visual assessment method) are usually validated against direct weighting. (Niaki et al., 2017; Martins et al., 2014; Hanks et al., 2014; Parent et al., 2012; Dhingra et al., 2007; Connors and Rosell, 2004; Comstock et al., 1981; 1979). There are three detection methods for measuring plate waste by weighting, including: a) aggregate non-selective plate waste; b) aggregate selective plate waste; and c) individual plate waste.

a. <u>Aggregate non-selective plate waste</u> is used when the objective is to estimate the average food waste per subject and where it is enough to weigh the waste from all the plates together and divide by the number of subjects to get an average weight of waste per subject (USDA, 2002). This method has a lot of advantages as it minimizes student contact, and thus minimizes the need for informed consents, and limits interaction with, and/or distribubance of the kitchen staff during daily presusurised food service delivery periods. The primary disadvantage is that it does not provide essential information on what actual foods have been wasted. Therefore, this method was deemed unsuitable for this plate waste study.
b. <u>Aggregate selective plate waste</u> is used in order to accurately determine how much (by weight) of each item/food category is thrown away and accumulated across multiple plates. Mean aggregate plate waste equates to mean individual plate waste, as long as the samples are representative (USDA, 2002). The different components of the meal may be separated, and, the total amount of each component weighed (Byker et al., 2014). This measurement involves collecting trays/plates from all, or a sample, of individuals, taking lunch and separately scraping the waste for each food category into dedicated tubs/bins. Waste is accumulated across the students before being weighted, for each tub/bin after all plates have been scrapped and the school meal service is completed. This method is considered appropriate for institutional level data collection, is flexible enough for use when individuals have no/limited choice in menu items being measured (Robinson, 1978) and is found to be fast, accurate, and easy to conduct.

c. Individual plate waste is measured by weighing the leftovers from separate food items on the trays of individual students. Individual plate waste is the criterion against which other estimates from indirect measures of waste have traditionally been compared. It is worth noting that many investigators have also attempted to use individual plate waste to calculate individual consumption. If the mean serving size of each food is desired, it is usually estimated based on four or five servings. This method is used when vegetable acceptance is measured though it is considered costly and time-consuming. Interestingly, Hoffman et al. (2007) who for the first time validated the aggregated plate waste approach as a method to measure actual dietary intake using individual plate waste method in two elementary schools, found that the aggregated plate waste method was as accurate, and more easily implemented, than actual weighed food measurements (Hoffman et al., 2007).

4.1.2. Visual assessment method

Unlike direct weighing, the visual assessment method does not distort significantly the lost meals (and food items), takes less time, is cheaper, does not require much additional space, and provides detailed information about the meal (Martins et al., 2014; Williamson et al., 2003; Hanks et al., 2014). For the visual assessment, trained observer(s), or trained researchers are needed.

a. The visual assessment method by trained observers: In this method, at the end of the meal, a trained researcher estimates the food remained on the plate in comparison to the original or standard portion.
b. The visual assessment method by digital photography
   Digital photography can be used most effectively in dining facilities where the preparation and serving of food can be measured. It is useful for a variety of purposes including: obtaining food intake data for nutrient analysis; to study food consumption patterns at senior nutrition centres, university dining halls, and school lunch or school breakfast programs; to determine food waste of specific menu items; to spot trends in acceptability and other quality control issues; and to check quality control of serving portions for appearance in both commercial and non-commercial food service operations (Williamson, 2013). Digital images are less costly and less labour-intensive to collect while still being valid alternative data for assessing schoolchildren's mean F&V consumption during lunch. Taking photographs is an accurate, reliable, and precise method for measuring residual food after a meal in children and adults diet (Swanson, 2008; Williamson, 2013). Taking photographs of meals before, and after, consumption takes the least time, and minimizes disruption to, food consumption compared to previously described methods, which is a great advantage for on-site practitioner and researchers. There is also no need for a large number of observers/researchers to take pictures (Bontrager, 2014; Hanks, 2014; Pouyet, 2014). After the photographic data has been collected, and in laboratory conditions away from the canteen environment, researchers can assess photos and compare the initial and final amount of food with a reference-picture serving and express them in units of 10% (Swanson, 2008). For simplicity, the rest of the meal on the plate can be compared only to photo reference portions (Hanks et al., 2014). The difference compared to the standard ration can be expressed in units of 10 %, where it was possible to determine whether the initial serving was larger than the standard (e.g. 90%, 100%, or 110% of the prepared reference portion of each food) (Williamson et al., 2003; Williamson et al., 2004).

4.1.3. Selected Plate Waste Methodology

Drawing on this state of the art literature review of current direct and indirect methods for measuring plate waste, the experiences of the UNED (Deliverable No: D3.4; report of WP6 pilot study) pilot plate waste study in which the visual estimation method by digital photography was trialled, and the practical and resource constraints under which partners were working, a modified aggregate selective plate waste method was chosen (Comstock et al., 1979) which is both empirically reliable, supported the collection of actual weights of collected plate waste by food category whilst also minimising disruption in school canteens and the personnel, financial, and time input required from partners. Table 22 outlines the plate waste data collection by country, and season. In four countries, (Croatia; Italy, Serbia and UK), plate waste data was collected in each school for five consecutive days in autumn/winter and spring/summer season (UniPR lost one day of data collection in LOW schools due to extreme winter weather which closed all primary schools in Lucca). Due to the nature of the pilot school food programme in Greece where the same menu is repeated weekly throughout the 24 week programme, the AUTH team recorded plate waste for one season only and for 10 days/case and 20 days in total.

	Croatia		Greece		Italy		Serbia		UK	
	LOW	LOC	LOW	LOC	LOW	LOC	LOW	LOC	LOW	LOC
Autumn/Winter Data Collection	10	10	10	10	10	9	10	10	10	10
Spring Summer Data Collection	10	10	n/a	n/a	10	10	10	10	10	10
Total No. of days of Data Collection	40		20		39		40		40	

Table 22: Plate Waste Data Collection by Country and Season

In advance of starting the plate waste data collection, all partners conducted in-depth interviews with key municipality, school and/or catering staff (linked to D6.3), observed lunchtime service in selected schools and confirmed the weekly menus being offered during the confirmed data collection periods. Throughout the data collection process, partners continued to make observations, make field notes and take photographs of the school meal service including conducting additional informal conversations with school and canteen staff. On each day of data collection, the first step was to weight a minimum of 3 randomly chosen portions of offered daily meal and an average from these was calculated as a reference point for the average weight of the served meal (and its associated components). Due to the complexity, and number of, menu options offered in the UK schools (upto 9 main meal and 3 dessert options per day), it was not possible to undertake this stage as described. Instead reference weights were drawn from the normative portion sizes presented in the carefully developed, and nutritionally analysed, recipes supplied by catering staff. The second step was the collection, at researcher manned waste stations, of finished plates/trays from all children taking school lunch (generally from 1st to 4th grade) on each data collection day. The research team noted the total number of meals served per day and in the UK how choices were distributed across the offered menu options. The leftovers were separated into 6-8 different bins (depending on the menus offered) defined according to the nutritive value of the food category: vegetables, fruit, starchy food (split into Bread and other in some countries), meat and fish, dessert and other food. At the end of the lunch service, the total weight of each bin was recorded. The aggregate plate waste method did not require direct contact with children aside from receiving they finished tray/plates. After data collection the plate food waste was calculated using the following formulas:

$$\%\, waste = \frac{edible\ waste\ weight}{weight\ of\ mean\ serving\ size\ of\ edible\ food}\, x\ 100 \qquad [1]$$

$$\%\, of\ plate\ waste\ of\ food\ category = \frac{\frac{total\ plate\ waste\ of\ each\ category}{no.of\ students}}{sample\ weight\ of\ each\ food\ category}\, x\ 100 \qquad [2]$$

$$\%\, of\ plate\ waste = \frac{\frac{total\ plate\ waste}{no.of\ students}}{sample\ weight\ of\ each\ food\ category}\, x\ 100 \qquad [3]$$

$$food\ intake\ per\ student\ (g) = sample\ waight\ (g) - \frac{total\ plate\ waste}{number\ of\ students} \qquad [4]$$

After measurements were finished all partners gave the results (description of food in each food category, total amount of plate waste for each food category, average serving size of each item in food category and number of served items of each food category) to ZAG team. ZAG team estimated the nutritional composition of the collected plate waste/day for each food category. The nutritional composition for each food category was produced as described in section 3.1. Using this, the nutritional composition of the collected plate waste for food category was calculated by multiplying estimated nutritional composition of each food category with the percentage of plate waste/planned food served per category. The estimated actual nutritional intake was then obtained by calculating the difference between estimated planned nutritional composition of each food category and the nutritional composition of collected plate waste per food category. The amount of energy and nutrients were summed at a daily level and average values calculated across the full data collection period. The ZAG team produced the following results by school and case for all partners: (i) a summary of the energy and nutrient profile of served lunches, (ii) a summary of the energy and nutrient profile of plate waste, (iii) a summary of the estimated actual energy and nutrient intake from the eaten food (i.e. planned less collected plate waste) (iv) percentages of consumed macro and/or micro nutrients, and (v) percentages of energy and macro and/or micro nutrients losses.

In order to link the plate waste results to the carbon footprint results and total supply budgets reported in D6.3, estimation of embodied carbon in, and financial loss attributed to, collected plate waste were made not just on two, but all five schools comprising the 6.3 samples in LOC and LOW for Croatia, Greece, and UK and LOC-ORG and ORG for Italy. In Serbia, the analysis was conducted only on 6.2 case schools 92/case) due to significant difference sin the size, uptake and school food practices in the other 6.3 schools. We also made estimates for the whole academic year, rather than the specific plate waste data collection weeks. For all countries, and both cases, we made the calculations by aggregating pro rata the weight of plate waste recorded during the full data collection period. Therefore, the total weight of plate waste reported in this section is higher than the weights reported in the other sections in deliverable 6.2 The waste rates of individual food items within each food category were estimated either via direct observation by the food waste collector (when this was possible) and/or by inspecting the relevant ratios of the food procurement data collected as part of D6.3 (guided by the menus/recipes). Having determined which food items comprised the categories of collected plate waste for each case, and in which proportions, an average emissions factor per kg (EF) for each food category was calculated by dividing the total production emissions generated by all the food items under each waste food category (in kgs CO2eq) by the total weight of those items procured across the five schools for each case. In this way, the average EF for each food category took account of the varying proportions of specific food items within the waste category, and their specific EFs. If the waste food category only included one item (e.g., milk), the actual EF for this item was used as the category EF. Next, by multiplying the average EF for each food category by the total volumes of waste recorded for those food categories in each case, the total production-related embodied carbon emissions for each food waste category were calculated. The same methodology was followed to calculate the transport-related embodied carbon emissions for each food waste category. Finally, the embodied emissions relating to the food waste itself (i.e. transportation and handling of the waste) were added. All three components of the embodied carbon emissions (food production, transportation and waste disposal) were then summed to get the total embodied carbon emissions of the collected plate waste for each case in each country.

To link, and estimate, the financial loss associated with the collected plate waste, an average price per kg of each waste per food category was calculated by dividing the total supply budget related to this category by the volumes of specific items procured within that category, in proportion to each other (the sources for the values were the procurement data collected for D6.3). In this way, the average prices per kg reflected the varying volumes of different food items procured within each category, and their specific prices. The total cost of waste for each food category was then summed to derive an estimate of the total cost of plate waste for each case.

4.2. Plate waste volumes and compositions in different PSFP models

According to the available literature, levels of school canteen plate waste (as a proportion of food served) vary from 9% to 45%, with the main reasons given for such discrepancies being age of students, duration of the lunchtime, timing of the lunchtime, encouragement of the students by the school and canteen staff to finish their meals, education activities in school, and methodology used for plate waste estimation (Bergman et al. 2004; Byker et al. 2014; Engstrom and Carlsson-Kanyama, 2004; Liu et al., 2016; Liz Martins et al., 2015; Thorsen et al., 2015). In terms of plate waste composition, as a proportion (%) of total collected plate waste (by the amount of waste each food category contributes), previous studies have shown that in Beijing primary schools, 43% of collected plate waste comes from staple food, 42% from vegetables, 10% from meat, and 5% from the other food category (soups) (Liu et al., 2016). According to Engström and Carlsson-Kanyama (2004), in a Swedish primary school, half of collected plate waste came from starchy food (potato, pasta, rice) and fish, 29% from vegetables and 20% from meat or fish. Considering the composition of plate waste as a proportion of the total weight of served food per category, studies show that the % of waste from vegetables ranges from 34% to 73%, from fruit food ranges from 24% to 47%, from starchy food category or entree ranges from 27% to 45%, and from meat category ranges from 1% to 32% (Byker at al. 2014; Cohen et al. 2013; Dinis et al. 2013; Niaki et al. 2017).

Table 23 presents the cross country synthesis of the key plate waste results by PSFP model followed by a compositional breakdown by food category (Table 24 and 25). In total, across 5 countries and 179 primary school lunch services, plate waste was scrapped, separated, collected and weighted from 22,529 plates. For LOC/LOC-ORG schools, 19 (Serbia, LOC) -38% (Greece, LOC) of planned food served was collected as plate waste with an average weight of plate waste/meal served of between 87g (UK, LOC) - 164g (Greece, LOC) while for LOW/ORG schools, 12 (Croatia, LOW) - 38% (Italy, ORG) of planned food served was collected as plate waste with an average weight of plate waste/meal served of between 36 (Croatia, LOW) - 220g (Greece, LOW) (See Table 23 and Figure 24).

Parameter	PFSP model	Croatia	Greece	Italy	Serbia	United Kingdom	Cross Case Comparsion
Total no. of served meals (n)	Model 1[a]	3793	452	3897	1360	2624	12,126
	Model 2[b]	2183	495	2897	1995	2833	10,403
	Total	**5976**	**947**	**6794**	**3355**	**5457**	**22529 plates scrapped**
Average planned weight of food/meal served (g)	Model 1	472	438	527	495	329	329-527g
	Model 2	293	507	498	417	252	252-507g
Average collected plate waste/meal served (g)	Model 1	130	164	140	89	87	87-164g
	Model 2	36	220	191	132	64	36-220g
Estimated Consumed Weight of Food/Meal served (planned–waste) in grms and as % of planned food served	Model 1	342 (73%)	274 (63%)	389 (74%)	406 (82%)	265 (81%)	63-82%
	Model 2	257 (87%)	287 (57%)	307 (62%)	285 (68%)	188 (75%)	57-87%
Collected plate waste as a proportion of planned food served (%)	Model 1	28	38	26	19	26	19-39%
	Model 2	12	43	38	32	25	12-43%

Table 23: Cross Country Synthesis of key Plate Waste results by PSFP model

[a]-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)
[b]-model 2- school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

Between case differences were found for all countries except the UK (See Figure 246 While collected plate waste as a proportion of planned food served is higher in Greece, Italy and Serbia in the LOW model (5.8%, 12.7%; 12.8% respectively), it is 16%, and 1%, higher in the LOC model for the Croatia and the UK respectively.

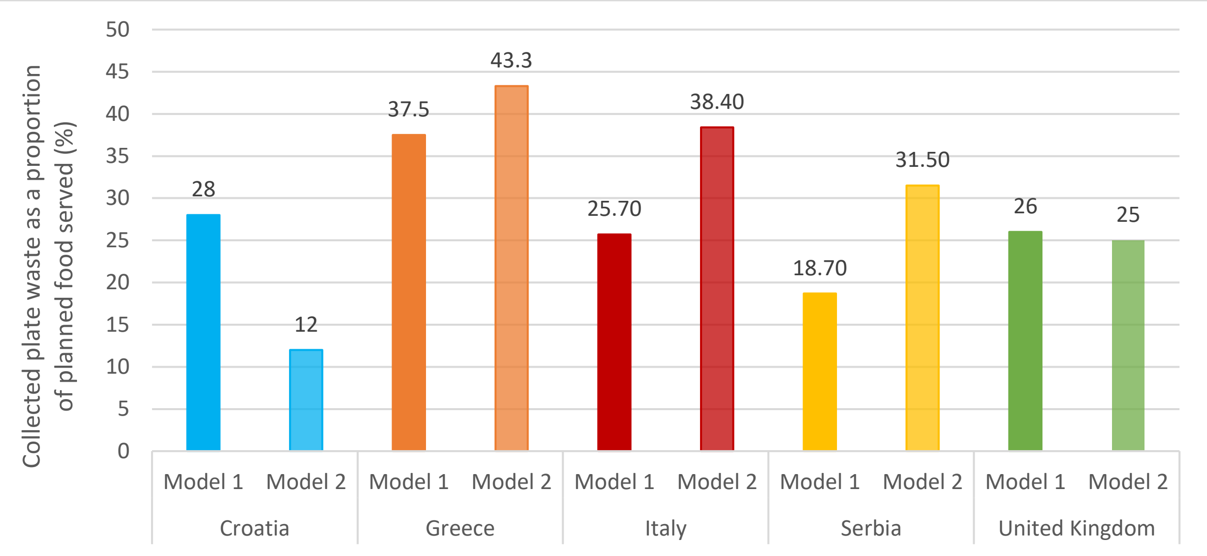

Figure 22: Total Collected Plate Waste as proportion of Total Planned Food Served (%)

Table 24 present the compositional breakdown of collected plate waste by food category across all countries and by PFSP model (Table 24). and by proportion of food served per catgory (Table 25).

Food Category*	PFSP model	Croatia	Greece	Italy	Serbia	United Kingdom
Starchy food	Model 1[a]	133.4 (27)	17.2 (23.1)	162.59 (30)	7.2 (6.4)	85.6 (37)
	Model 2[b]	35.1 (45)	38.46 (35.3)	191.53 (35)	38.1 (13.9)	110.4 (61)
Vegetables	Model 1	276.6 (56)	22.9 (30.8)	98.71 (18)	38.8 (34.4)	62.3 (26)
	Model 2	35.1 (45)	24.35 (22.4)	68.14 (12)	43.1 (31.0)	11.6 (6)
Fruit	Model 1	Not served	-	163.61 (30)	5.9 (5.3)	28.1 (13)
	Model 2	Not served	-	180.81 (33)	35.4 (12.9)	18.1 (10)
Meat and fish	Model 1	64.2 (13)	6.4 (8.6)	39.45 (7)	19.0 (16.9)	22.3 (11)
	Model 2	6.2 (8)	13.13 (12.1)	60.18 (11)	46.3 (16.9)	25.9 (15)
Desserts	Model 1	9.9 (2)	-	Not served	1.6 (1.5)	26.9 (12)
	Model 2	Not served	-	13.71 (3)	9.5 (3.5)	13.0 (7)
Other food	Model 1	9.9 (2)	-	22.62 (4)	-	1.9 (1)
	Model 2	0.8 (1)	-	3.28 (0.6)	-	2.6 (1)
Soups	Model 1	-**	-	-	12.5 (11.1)	-
	Model 2	-	-	-	18.7 (6.8)	-
Bread	Model 1	-	4.6 (6.3)	53.57 (10)	16.3 (14.4)	-
	Model 2	-	12.21 (11.2)	34.12 (6)	24.1 (8.8)	-
Salads	Model 1	-	-	-	11.3 (10.0)	-

	Model 2	-	-	-	16.8 (6.1)	-
Mixed food	Model 1	-	19.1 (25.7)	-	-	-
	Model 2	-	18.71 (17.2)	-	-	-
Dairy products	Model 1	-	4.1 (5.5)	-	-	-
	Model 2	-	1.95(1.8)	-	-	-

Table 24: Cross Country, and PSFP Model, Synthesis of the compositional breakdown of Collected Plate Waste by Food Category

Note: not served – the food category is measured, but nothing was served out of that food category
[+]All values as represent as kgs (%)
** - no measured
[a]-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)
[b]-model 2- school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

Parameter*	PFSP model	Croatia	Greece	Italy	Serbia	United Kingdom
Starchy food	Model 1[a]	28	**31.4**	19.99	8.8	**29**
	Model 2[b]	11	**53.0**	31.74	31.4	**31**
Vegetables	Model 1	**35**	**54.8**	**36.85**	**21.6**	43
	Model 2	**15**	**47.3**	**51.96**	**43.1**	8
Fruit	Model 1	Not served	-	**30.34**		16
	Model 2	Not served	-	**53.36**		9
Meat and fish	Model 1	**35**	**36.0**	17.66	19.2	14
	Model 2	**12**	**40.4**	34.15	31.1	13
Desserts	Model 1	5	-	Not served	7.8	12
	Model 2	Not served	-	17.87	25.8	7
Other food	Model 1	5	-	19.59	-	2
	Model 2	9	-	11.61	-	5
Soups	Model 1	-**	-	-	19.2	-
	Model 2	-	-	-	26.2	-
Bread	Model 1	-	15.7	37.20	**37.1**	-
	Model 2	-	19.7	41.77	**36.7**	-
Salads	Model 1	-	-	-	**23.3**	-
	Model 2	-	-	-	**39.0**	-
Mixed food	Model 1	-	**43.6**	-	-	-
	Model 2	-	**33.3**	-	-	-
Dairy products	Model 1	-	**37.9**	-	-	-
	Model 2	-	**25.5**	-	-	-

Table 25: Cross Country, and PSFP Model, Synthesis of the waste by food category as a proportion of total weight of food served per food category

Note: not served – the food category is measured, but nothing was served out of that food category
[+]All values as represent as %
**** - no measured**
[a]-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)
[b]-model 2- school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

Short summaries of total collected plate waste and the compositional breakdown by country and by PFSP model, are presented below.

4.2.1. Croatia

4.2.1.1. Total plate waste

Using the total number of meals served and total planned weight of served meals, the weight of an average meal was found to be 109 g higher in LOC (472 g) than LOW (293 g). Average plate waste per meal was 130 g (27%) in LOC and 36 g (12%) in LOW, a difference of 94 g per meal served. One plausible explanation for the much smaller weights of plate waste in the LOW case may be the difference in the amount of food served in the first place (109 g less served in LOW than LOC). In the LOW case, children were found to consume 87% of the food served, while in LOC this dropped to 73%. Other possible explanations are that in the LOW schools, kitchen and teaching staff were observed to be more likely to check chidlren's plates and encourage them to finish their meals; the LOWSchoolC canteen has a more spacious and fun layout, and a longer time is allocated for eating lunch in both LOW schools.

4.2.1.2. Composition of plate waste (by the amount of waste each food category contributes, as a % of total food waste)

Very similar plate waste compositional profiles were found for both LOC and LOW schools. In both cases, vegetables and starchy food made up the largest components of collected plate waste. In the LOCSchools, vegetables and starchy food comprised 56% and 27% respectively of total collected plate waste whilst in the LOWSchools, vegetables and starchy food comprised equal proportions (45% each). The next largest waste category, in both LOC and LOW schools, was meat and fish (13% in LOC case, 8% in LOW case). Desserts and other food made up very small components of collected plate waste in both cases. Overall, the Croatian results are consistent with previous studies which show starchy foods and vegetables are main components of plate waste in school meals, with meat and fish being a smaller component.

4.2.1.3. Composition of plate waste (in each food category, by the amount of food wasted as a % of served portion)

Considering the amount of food wasted as a proportion of the planned food served per food catogry, in LOCSchools, where overall levels of plate waste were 28% of planned food served, children rejected in equal proportions their served portions of vegetables and meat (both 35%), followed closely by starchy food (28%). Only 5% of their served portions of dessert and other foods were wasted. In LOW case schools, where overall levels of plate waste were 12% of planned food served, the children rejected 15% of their served vegetables, 12% of served meat and fish and 11% of served starchy foods. Therefore, the rates of plate waste per served food category in LOC schools were comparable to those found in existing studies for vegetables and starchy foods, though were higher for meat and fish. In LOW schools, the rates were considerably lower for all food categories.

4.2.2. Greece

4.2.2.1. Total plate waste

Using the total numbers of meals served and total planned weight of served meals, the weight of an average meal was found to be 65 g higher in LOW (507 g) than LOC (438 g). Average plate waste per meal is 164g (38%) in LOC and 220 g (43%) in LOW, a difference of 56 g per meal served. A plausible explanation for the higher levels of plate waste in LOWSchools may be the difference in the amount of food served in the first place (65 g more served per meal in LOW than LOC). In the LOW case, children were found to consume 57% of the food served, while in LOC this increased to 63%.

4.2.2.2. Composition of plate waste (by the amount of waste each food category contributes, as a % of total food waste)

In LOC schools, the two largest components of plate waste were vegetables (30.8%) and mixed food (25.7%) followed by vegetable (23.1%), meat and fish (8.6%), bread (6.3%), and dairy (5.5%). In LOWSchools, total waste comprised 35.3% starchy food, 22.4% vegetable, 17.2% mixed food, 12.1% meat and fish, 11.2% bread, and 1.8% dairy food category. So, across both cases, approximately three quarters (between 73.9% (LOW) and 79.6% (LOC)) of the collected plate waste, is composed of vegetables, starchy food and mixed food. No dessert or fruit were served in LOC and LOWSchools.

4.2.2.3. Composition of plate waste (in each food category, by the amount of food wasted as a % of served portion)

In LOCSchools, more than half of served starchy food (53.0%) was collected as plate waste followed by vegetable (47.3%), meat and fish (40.4%), bread (39.7%), mixed food (33.3%) and dairy products (25.5%). In LOWSchools, the children wasted 54.8% of their served portion of vegetables, 43.6% of mixed food, 39.9% of dairy products, 36.0% of meat and fish, 31.4% of starchy food and 15.7% of bread.

4.2.3. Italy

4.2.3.1. Total plate waste

Using the total numbers of meals served and total planned weight of served meals, the weight of an average meal was found to be 29 g higher in LOC-ORG (527 g) than ORG (498 g). Average plate waste per meal is 140g (26%) in LOC-ORG and 191 g (38%) in ORG, a difference of 51g per meal served with ORG children consuming 62% of the food served, while in LOC-ORG they consume 74%. A plausible explanation may be the much greater quantity of recognisably locally produce procured, and served, in LOC-ORG model.

4.2.3.2. Composition of plate waste (by the amount of waste each food category contributes, as a % of total food waste)

In LOC-ORG schools, the two largest components of plate waste were starchy food - first course and fruit (both 30%), followed by vegetable (18%), starchy food - bread (10%), protein-based dishes (7%), and other food (4%). No Dessert was served in LOC-ORGSchools. In ORGSchools, total waste comprised 35% of starchy food - first course, 33% of fruit, 12% of vegetable, 11% of protein-based dish, 6% of starchy food- bread, 3% of dessert and 0.6% of other food category. So, in both cases, starchy food (first course) and fruit are the most wasted foods, followed by vegetables and protein-based dishes.

4.2.3.3. Composition of plate waste (in each food category, by the amount of food wasted as a % of served portion)

Considering the amount of food wasted as a proportion of the amount of food served per food category, the most wasted food categories in LOC-ORG schools were bread (both 37%), followed by fruit (30%), other food (20%), starchy food (20%), and meat/fish (18%). In contrast, ORG children wasted half of the served fruit (53.36%) and vegetable (52%) with higher levels of waste in ORG compared to LOC-ORG for starchy food -bread category (42%), meat/fish (34%) and starchy food – first course (32%). The food categories with the lowest % of waste by food served were desserts (18%) and other food (12%). Therefore, across both cases, a lot of served bread is wasted, and in ORG schools specifically the rate of vegetable and fruit wasted per served portion was very high. When compared with existing studies, the rate of vegetables wasted is in line with upper estimated though the rate of fruit wasted is much higher.

4.2.4. Serbia

4.2.4.1. Total Plate Waste

Using the total number of meals served and total planned weight of served meals, the weight of an average meal was found to be 78 g higher in LOC (495 g) than LOW (417 g). Average plate waste per meal is 89g (19%) in LOC and 132 g (32%) in LOW, a difference of 43 g per meal served with LOW children consuming 68% of the food served, while in LOC-ORG they consumed 82%. Therefore, LOCSchools generated considerably less waste, on average per meal served, compare to LOWSchools despite the average weight of meals served being higher in LOC compared to LOW schools. There is no evidence that these differences are associated with, or were influenced by, PSFP model. Instead, based on the detailed observations conducted, lunch service factors including length of lunch break, level and type of staff encouragement of children, and canteen design and layout, are all more likely factors that influence levels, and composition, of collected plate waste.

4.2.4.2. Food Category Composition of Total Waste

Across both cases, when combined, vegetables and salad, by weight, contributed the most to collected plate waste (34.4% (vegetables) + 10.0% (salads) = 44.4%, LOC, and 31.0% (vegetables) + 6.1% (salads) = 37.1%, LOW), generating on average 40.7% of total collected plate waste, over twice as much as any other meal component. The second largest proportion of plate waste was meat and fish (protein) (16.9% for both LOC and LOW) followed by bread (11.6% on average across LOC (14.4%) and LOW (8.8%)) Next followed, soup (11%; 6.8%), starchy food (13.9%; 6.4%), fruit (5.3%; 12.9%) and dessert (1.5%; 3.5%). So, in both cases, vegetables and salad (combined), and meat and fish, contributed over half of the collected plate wate (61.3% in LOC and 54% in LOW).

4.2.4.3. Composition of plate waste (in each food category, by the amount of food wasted as a % of served portion)

Considering the amount of food wasted as a proportion of the amount of food served per food category, LOCSchools children wasted 21.6% and 23.3% of served vegetables and salad respectively followed by bread (37.1%), meat and fish and soup (both 19.2%), starchy food (8.8%), and dessert (7.8%). In contrast, LOW children wasted 43.1% and 39% of served vegetables and salad respectively, 36.7% of served bread, 31.4% of served starchy food, 31.1% of served meat and fish, 26.2% of served soup and 25.8% of served dessert. In summary, the % plate waste differences (in total and by food category) between LOC and LOW case schools are likely, in part, to be due to the variation in vegetables used in main courses, some differences in the length of the lunch times between case schools, as well as differences in social, environmental or organisational factors, including level and type of interactions between kitchen staff and children.

4.2.5. UK

4.2.5.1. Total Waste

Using the total number of meals served and total planned weight of served meals, the weight of an average meal was found to be 77 g higher in LOC (329 g) than LOW (252 g). Average plate waste per meal is 87g (26%) in LOC and 64 g (25%) in LOW, a difference of 23 g per meal served with LOW children consuming 75% of the food served, while LOC children consumed 74%. Based on the total weight of collected plate waste (and associated canteen based observations), it is posited that LOCSchool children received both a greater quantity (weight of food/meal served) and range of food types per meal served due to SchoolCater menu and receipe innovations and the very strong emphasis placed on, and LOCSchool staff skills in, cooking from stratch. In addition, based on the detailed observations conducted, lunch service factors including length of lunch break, level and type of staff encouragement of children, canteen design and layout, and wider school food and caterer policies are all more likely factors that influence levels, and composition, of collected plate waste.

4.2.5.2. Food Category Composition of Total Waste

For LOCSchool, collected plate waste (by weight) was reasonably well distributed across the categories with 37% from starchy food, 26% from vegetables, 13% from fruit, 11% from meat, 12% from dessert and 1% from other (i.e. cheese). On the other hand, LOWSchool collected plate waste (by weight) was much more unevenly distributed with 61% from starchy food, 6% from vegetables, 10% from fruit, 15% from meat, 7% from dessert and 1% from other (i.e. cheese). Large differences in the proportions of collected plate waste by food category were found between the UK cases for Starchy Carbohydrates (LOCSchool: 37%; LOWSchool: 61%; Difference: -24%) and Vegetables (LOCSchool: 26%; LOWSchool: 6%; Difference: 20%). One explanation for these differences is portion size adjustment practices as while starchy carbohydrate portion sizes adjustment depending on the age group served was observed in LOCSchool D&E and LOWSchool A, no such adjustments were observed in LOWSchoolE. All adjustments made were reported to be in line with portion size range recommendations which allow for variation according to age (School Food Plan, (England) (2015); Healthy Eating in Schools (Scotland) (2008)). When the collected starchy carbohydrate plate waste is broken down by school, a very interesting pattern emerges. For LOCSchool D&E and LOWSchool A, on average 29-35g of starchy carbohydrate is wasted/meal served, rising considerably for LOWSchool E, where no portion size adjustment was observed, with on average 53g of starchy carbohydrates wasted per meal served.

4.2.5.3. Composition of plate waste (in each food category, by the amount of food wasted as a % of served portion)

Considering the amount of food wasted as a proportion of the amount of food served per category, in LOCSchools, where overall levels of plate waste were 26% of planned food served, children wasted 43% of estimated served vegetables, 29% of estimated served starchy foods, 16% of estimated served fruit, 14% of estimated served meat and fish, 12% of estimated served dessert and 2 % of estimated other food. In LOWSchools, where overall levels of plate waste were 25% of planned food served, children wasted 31% of estimated served starchy foods, 13% of estimated served meat and fish, 8% of estimated served vegetables, 9% of estimated served fruit, 7% of estimated served dessert and 5% of estimated served other food.

4.2.6. *Summary of Plate Waste Results*

As with total plate waste distribution, within and between case, both similarities and differences are observed in terms of the compositional breakdown of collected plate waste by food category. By composition, the majority of the collected plate waste (upto 90%), across all countries and PFSP models, came from starchy food (Croatia, Italy and United Kingdom), vegetables (Croatia and Serbia), and fruit (Italy category). The clear exception was the LOW UK where only 6% of total waste was vegetables though the explanation for this is unfortunately not high vegetable consumption but instead the complete opposite. In UK LOW schools, very high rates of vegetable refusal were observed at service and thus very little vegetables were being accepted by UK LOW school children explaining the very low proportional rates of vegetable plate waste collected. In all other countries, and across all other cases including UK LOC, children are required to accept at least one portion of vegetables onto their plate and thus proportional rate sof vegetable waste are understandably higher. In terms of fruit waste, it is important to note that not all schools served fruit at lunchtime and thus this has an influence on the proportion of fruit waste collected. For example, in Croatia fruit is only served as a morning snack and in Greece, no fruit at all was served in any of the case schools. Based on the detailed observations and interviews conducted, multiple factors are posited to explain these similariites and differences including: number and size of served portions; children's eating habits, canteen design and layout; level of supervision and encouragement provided by staff to children; wider school and catering food policies; organoleptic appearance of food, a child's previous experience of a food, and the time allocated per child for eating lunch per child.

4.3. Nutritional impact of plate waste in different PSFP models

Levels of collected plate waste can affect the actual nutritional intake of children from school meals, compared to what is intended by menu design and planning. The loss of energy and nutrients (macro and micro) depends on the proportion of energy and nutrients in the meals and the individual components of the meals, as well as of the amount of plate waste of each individual meal component. Within available literature it is shown that students' intake on average 81.1 ± 16.8% of served energy, 79.3 ± 18.1% of served total carbohydrate, 79.9 ± 18.2% of served protein, 86.2 ± 18.2% of served total fat, 85.4 ± 18.8% of served saturated fatty acids, 82.1 ± 20.4% of served iron, 73.1 ± 24.1 of served calcium, 63.7 ± 29.5% of served vitamin A, and 69.5 ± 21.1% of served vitamin C if playtime is before lunch. However, it is noticed that if the playtime is after lunch they take in less energy and nutrients, and it is estimated that their intake, where playtime is after lunch is on average 71.5 ± 20.5% of served energy, 69.2 ± 20.7% of served total carbohydrate, 68.9 ± 22.2% of served protein, 77.6 ± 22.3% of served total fat, 75.0 ± 24.9% of served saturated fatty acids, 73.6 ± 20.4% of served iron, 57.9 ± 29.4 of served calcium, 57.6 ± 27.6% of served vitamin A, and 53.4 ± 27.6% of served vitamin C (Bergman et al., 2004). Cohen et al. (2013), in their recent plate waste study, shown that through whole lunch students can intake 660 ± 13.4 kcal, 9.5 ± 0.4 g of fibre, 18.6 ± 0.7g of total fat, 6.2 ± 0.2 g of saturated fatty acid, 4.4 ± 0.1 mg of iron, 528 ± 11.7 mg of calcium, 1020 ± 118 of vitamin A and 32.0 ± 3.4 mg of vitamin C, but when plate waste was taken into account real intake was 388 ± 8.7 kcal, 4.3 ± 0.2 g of fibre, 13.2 ± 0.5g of total fat, 4.3 ± 0.2 g of saturated fatty acid, 2.7 ± 0.1 mg of iron, 304 ± 8.3 mg of calcium, 321 ± 35.6 of vitamin A, and 9 ± 0.8 mg of vitamin C. Jacko et al. (2007) shown even greater differences in energy and nutrient intake between planned and consumed school lunches where on average their that school lunches provided 722 ± 167 kcal, 31.9 ± 7.1 g of protein, 99.6 ± 26.5 g of total carbohydrate, 22.2 ± 6.2 g of total fat but the students consumed on average 479 ± 147 kcal, 21.4 ± 4.5 g, 59.1 ± 19.2 g, 17.6 ± 7.5 g, respectively. Taking this range of findings into, table 26 presents a summary of the estimated range of possible losses of energy and nutrients through plate waste.

Nutrient Categories	Range of Loss associated with Plate Waste as reported in peer reviewed studies
Energy Lossed (kcal)	19-42%
Total Carbohydrates Lost (g)	21-41%
Total Protein Lost (g)	20-33%
Total Fat Lost (g)	14-29%
Total Saturated Fat Lost (g)	15-30%
Total Dietary Fibre Lost	Aroung 55%
Total Iron Lost	18-38%
Total Calcium Lost	27-42%
Total Vitamin A Lost	36-69%
Total Vitamin C Lost	35-71%

Table 26: Reported Energy and Nutrient Losses from School Plate Waste in Peer Reviewed Studies

Table 27 presents the mean estimated amount of energy and macronutrients consumed by School children across the 5 countries and by PFSP model after adjustments were made for loss of energy and nutrients from plate waste.

Parameter*	PFSP model	Croatia	Greece	Italy	Serbia	United Kingdom
Energy (kcal)	Model 1[a]	448 ± 143	553 ± 140	521 ± 70	448 ± 143	472 ± 60
	Model 2[b]	361 ± 11	445 ± 83	442 ± 80	361 ± 11	515 ± 138
Total proteins (g)	Model 1	18.1 ± 4.4	23.1 ± 7.0	23.6 ± 4.8	18.1 ± 4.4	25.4 ± 2.9
	Model 2	14.9 ± 5.5	18.4 ± 3.5	17.8 ± 4.1	14.9 ± 5.5	20.9 ± 3.8
Total carbohydrates (g)	Model 1	56.4 ± 13.8	62.5 ± 18.1	75.6 ± 10.3	56.4 ± 13.8	50.9 ± 9.4
	Model 2	41.9 ± 15.7	45.9 ± 11.5	66.2 ± 13.5	41.9 ± 15.7	55.3 ± 17.4
Dietary fibre (g)	Model 1	5.3 ± 3.1	5.2 ± 3.8	9.0 ± 2.7	5.3 ± 3.1	4.9 ± 0.6
	Model 2	3.8 ± 1.5	2.6 ± 0.6	5.3 ± 2.0	3.8 ± 1.5	4.7 ± 1.2
Total fat (g)	Model 1	16.3 ± 9.6	23.2 ± 6.3	17.8 ± 9.6	16.3 ± 9.6	19.1 ± 4.2
	Model 2	14.7 ± 6.5	20.6 ± 4.5	13.1 ± 3.5	14.7 ± 6.5	22.9 ± 7.4
Saturated fatty acids (g)	Model 1	4.0 ± 2.6	5.3 ± 1.5	5.6 ± 5.5	4.0 ± 2.6	9.6 ± 2.0
	Model 2	3.4 ± 2.0	5.9 ± 3.0	3.7 ± 2.0	3.4 ± 2.0	10.7 ± 3.7

Table 27. Mean amount of energy and macronutrients consumed by countries and PFSP model

***All values are mean ± standard deviation**
[a]-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)
[b]-model 2- school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

Table 28 presents the mean estimated amount of micronutrients consumed by School children across the 5 countries and by PFSP model after adjustments were made for loss of energy and nutrients from plate waste.

Parameter*	PFSP model	Croatia	Greece	Italy	Serbia	United Kingdom
Vitamin A (RE)[+]	Model 1[a]	0.12 ± 0.17	*na*	0.63 ± 0.45	50.81 ± 54.62	*anp****
	Model 2[b]	0.07 ± 0.06	*na*	0.27 ± 0.17	57.07 ± 70.70	*anp****
Vitamin B1 (mg)	Model 1	0.17 ± 0.13	0.34 ± 0.11	0.38 ± 0.15	0.33 ± 0.14	*anp****
	Model 2	0.15 ± 0.07	0.28 ± 0.10	0.28 ± 0.11	0.31 ± 0.19	*anp****
Vitamin B2 (mg)	Model 1	0.15 ± 0.14	0.40 ± 0.13	0.32 ± 0.11	0.24 ± 0.08	*anp****
	Model 2	0.14 ± 0.06	0.26 ± 0.22	0.25 ± 0.09	0.22 ± 0.10	*anp****
Niacin (mg)	Model 1	2.45 ± 2.25	*na*	0.46 ± 0.64	5.04 ± 2.73	*anp****
	Model 2	4.41 ± 3.28	*na*	0.39 ± 0.55	4.45 ± 2.69	*anp****
Vitamin B6 (mg)	Model 1	0.21 ± 0.21	0.24 ± 0.17	0.58 ± 0.26	0.41 ± 0.23	*anp****
	Model 2	0.22 ± 0.17	0.43 ± 0.21	0.52 ± 0.17	0.40 ± 0.40	*anp****
Folate (µg)	Model 1	*na***	*na*	80.43 ± 29.08	65.27 ± 32.32	*anp****
	Model 2	*na*	*na*	54.33 ± 28.64	53.50 ± 36.71	*anp****
Vitamin B12 (µg)	Model 1	*na*	*na*	2.15 ± 3.73	1.03 ± 1.09	*anp****
	Model 2	*na*	*na*	0.94 ± 0.59	3.63 ± 8.78	*anp****
Vitamin C (mg)	Model 1	15.31 ± 14.75	46.75 ± 27.07	53.75 ± 29.33	32.94 ± 22.45	*anp****
	Model 2	13.91 ± 14.91	38.19 ± 25.04	23.16 ± 12.97	18.88 ± 15.82	*anp****
Vitamin D (µg)	Model 1	*na*	*na*	0.27 ± 0.31	0.34 ± 0.26	*anp****
	Model 2	*na*	*na*	0.65 ± 1.58	1.41 ± 3.73	*anp****
Sodium (mg)	Model 1	733.18 ± 243.79	928.54 ± 357.29	445.07 ± 115.26	496.81 ± 248.03	*anp****
	Model 2	754.11 ± 404.62	1028.27 ± 480.81	406.79 ± 301.93	504.36 ± 233.15	*anp****
Potassium (mg)	Model 1	412.53 ± 395.81	732.89 ± 257.21	951.56 ± 312.85	764.09 ± 272.22	*anp****
	Model 2	473.62 ± 382.12	649.09 ± 213.71	654.47 ± 207.84	552.30 ± 269.45	*anp****
Calcium (mg)	Model 1	34.63 ± 33.25	198.44 ± 74.87	272.85 ± 174.31	117.36 ± 50.93	*anp****
	Model 2	38.59 ± 25.33	213.59 ± 109.00	174.81 ± 84.85	71.70 ± 41.41	*anp****
Magnesium (mg)	Model 1	22.93 ± 22.81	84.51 ± 23.05	34.40 ± 17.28	72.87 ± 19.70	*anp****
	Model 2	26.57 ± 18.70	75.67 ± 33.04	26.18 ± 11.09	49.32 ± 19.67	*anp****
Phosphorus (mg)	Model 1	110.35 ± 75.71	345.20 ± 178.35	389.01 ± 89.50	251.31 ± 81.17	*anp****
	Model 2	192.32 ± 89.99	279.19 ± 250.29	271.02 ± 53.32	194.32 ± 67.80	*anp****
Iron (mg)	Model 1	1.47 ± 0.95	5.32 ± 2.41	3.97 ± 1.55	2.66 ± 1.11	*anp****
	Model 2	1.87 ± 0.91	3.38 ± 1.41	2.44 ± 0.77	2.27 ± 0.65	*anp****
Zinc (mg)	Model 1	0.43 ± 0.34	3.73 ± 0.84	2.57 ± 0.6	2.36 ± 1.14	*anp****

	Model 2	0.56 ± 0.44	3.45 ± 1.61	2.27 ± 0.86	2.06 ± 1.07	*anp****
Copper (mg)	Model 1	0.25 ± 0.31	0.47 ± 0.31	0.25 ± 0.19	0.19 ± 0.10	*anp****
	Model 2	0.18 ± 0.16	0.31 ± 0.12	0.23 ± 0.23	0.13 ± 0.08	*anp****

Table 28. Mean amount of consumed micronutrients

***All values are mean ± standard deviation**
****na-data not available from the national food composition database**
*****anp-analysis not performed**
[+] Croatia and Italy REμg, Serbia mg
[a]-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)
[b]-modle 2 - school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

Figures 23-28 present the proportional loss of energy, macro- and micronutrients from plate waste compared to planned nutritive intake for school lunches (as reported in Tables 19-20) for the 5 countries and by PFSP model.

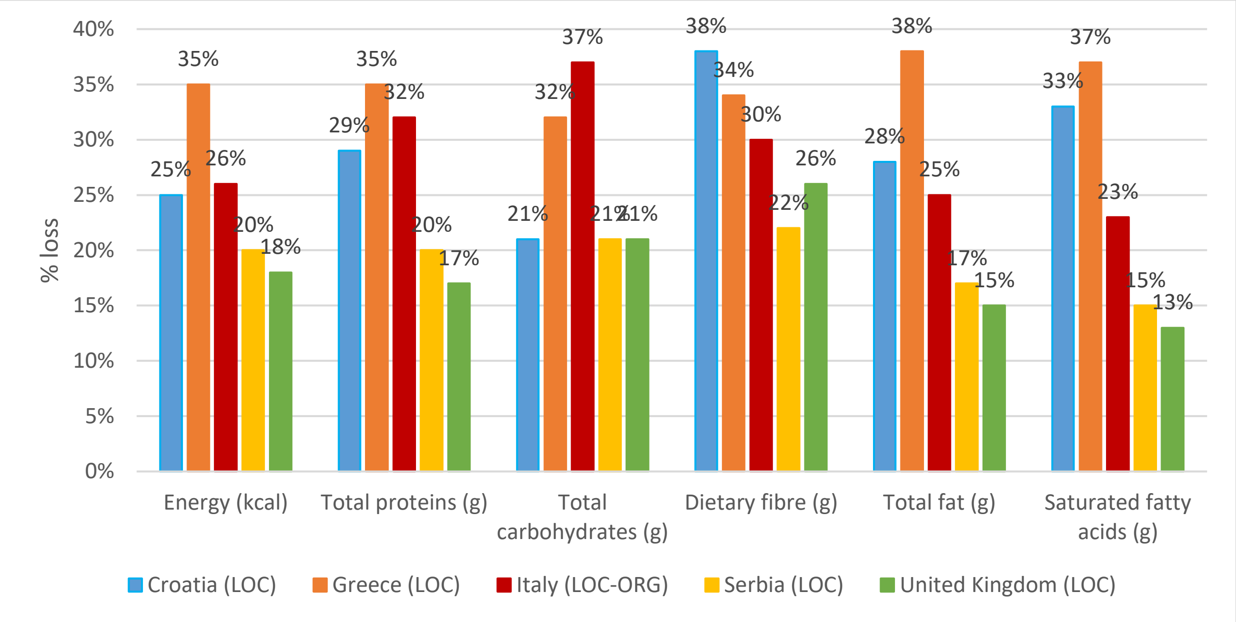

Figure 23. Losses of energy and macronutrient of school lunches (alternative PFSP model)

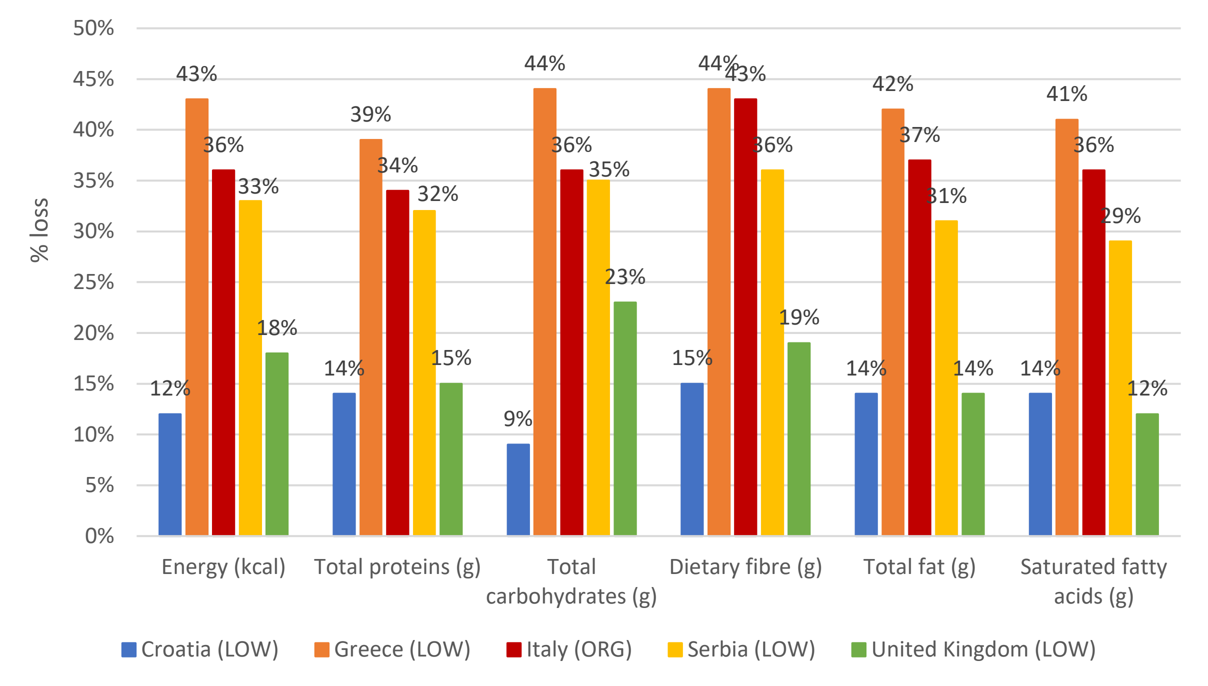

Figure 24. Losses of energy and macronutrient of school lunches (main PFSP model)

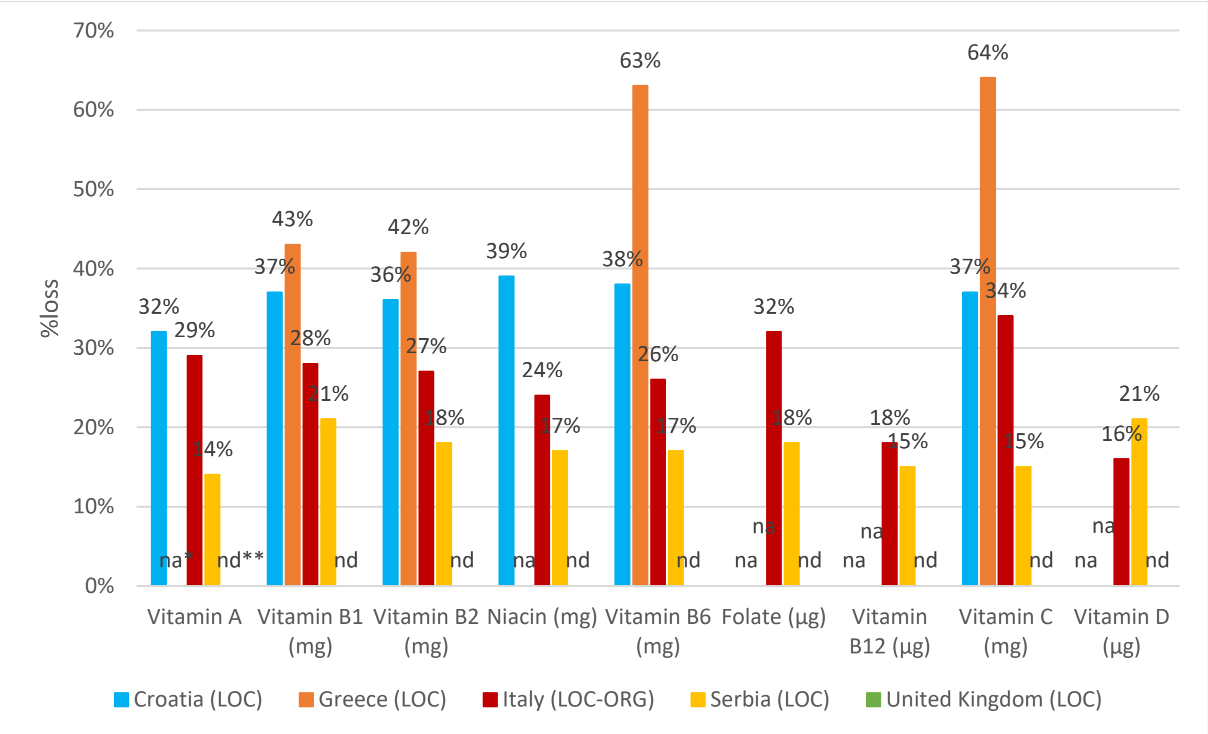

Figure 25. Losses of vitamins in average school lunch due to plate waste in five countries (alternative PFSP model)

*na-data not available from the national food composition database
**nd-not detected

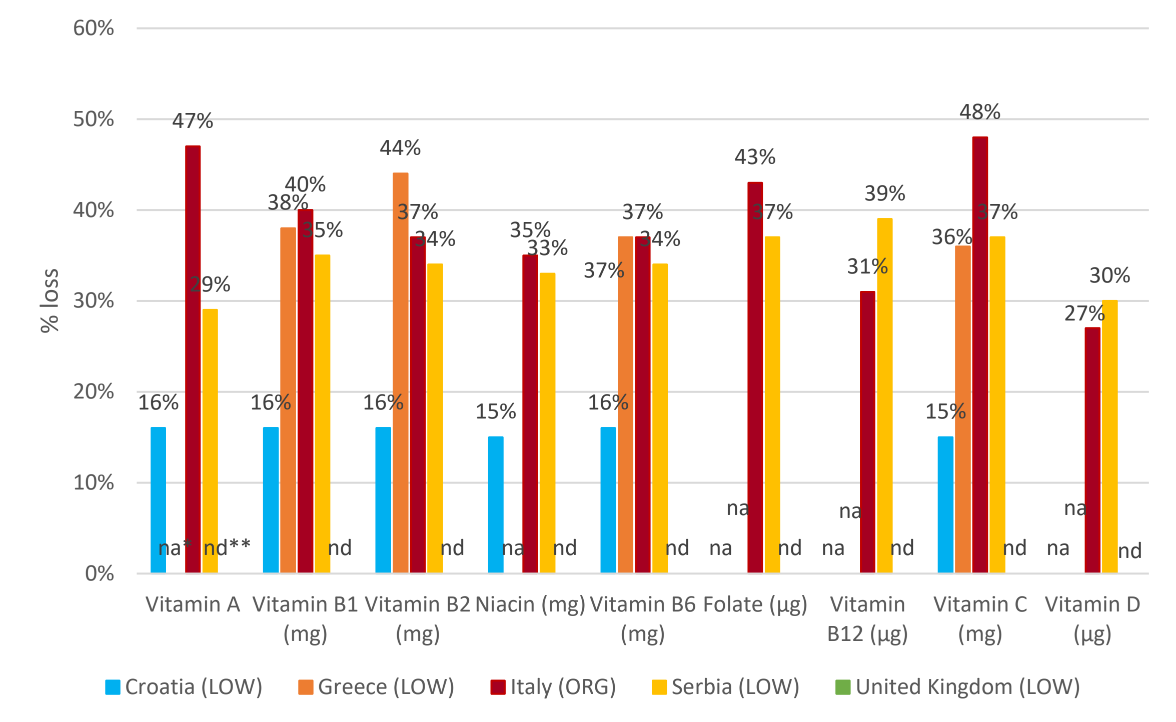

Figure 26. Losses of vitamins in average school lunch due to plate waste in five countries (main PFSP model)

***na-data not available from the national food composition database; **nd-not detected**

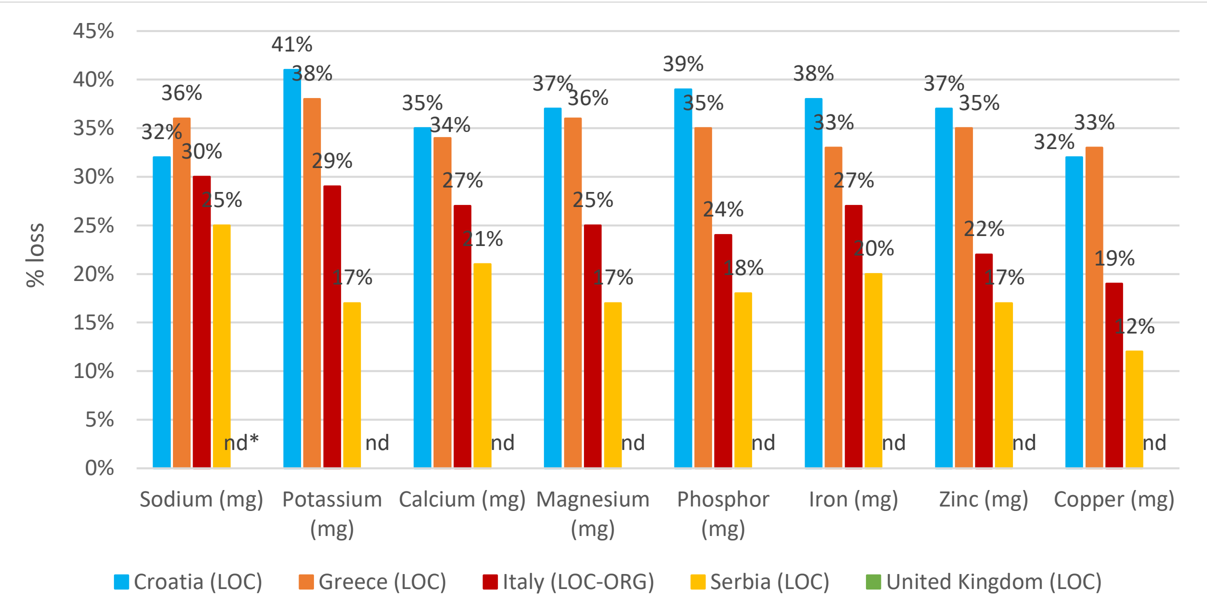

Figure 27. Losses of minerals in average school lunch due to plate waste in five countries (alternative PFSP model)

*nd-not detected

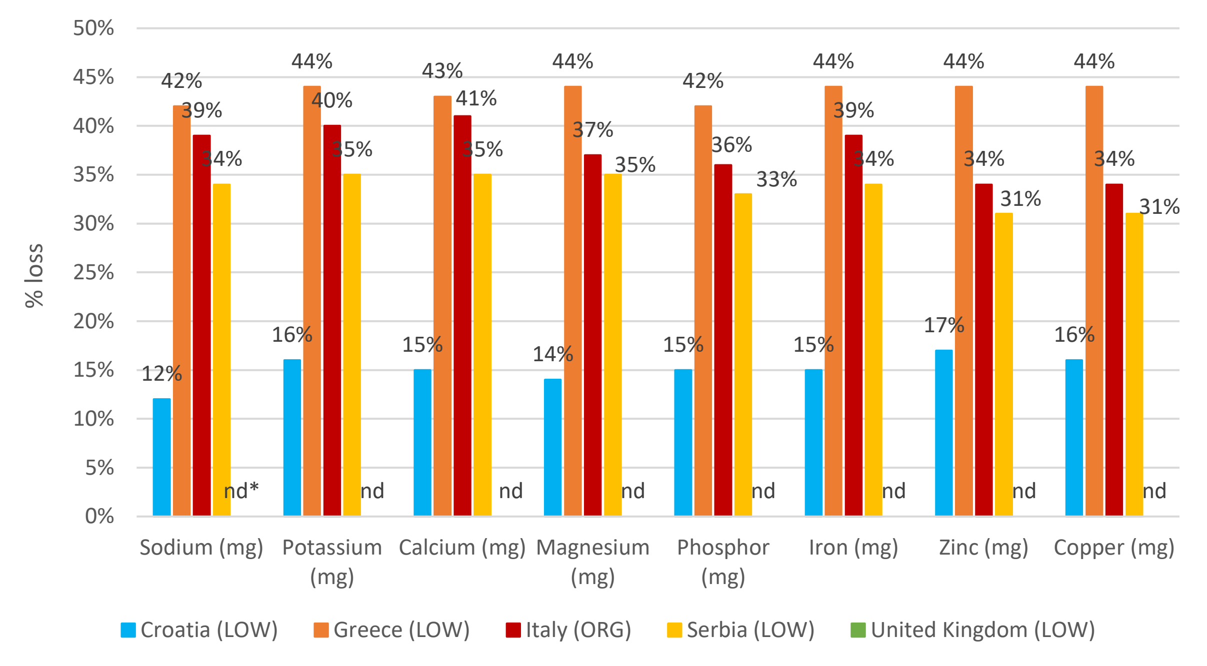

Figure 28. Losses of minerals in average school lunch due to plate waste in five countries (main PFSP model); ***nd-not detected**

4.3.1. Croatia

The energy loss in LOC and LOW schools aligns with the collected plate waste weights with 25% loss in LOCSchool and 12% loss in LOWSchool. Overall, a 9-38% loss across all macronutrients per average meal, as a result of the plate waste, was calculated with losses generally higher in LOCSchools (21-38%) compared to LOWSchool (9-15%). Total protein losses of 29%, and 14%, while total carbohydrate losses of 21% and 9%, were found for LOC and LOW schools respectively. Fibre loss is 38% for LOCSchool and 15% for LOWSchool. A 28%, and 14% loss in total fat was found for LOC and LOW schools respectively. For Saturated fatty acids, a 33% and 14% loss was calculated for LOC and LOW schools respectively. Micronutrients - Overall estimated losses of vitamins and minerals ranged from 32% to 41% in LOCSchools, and 12% to 17% in LOW Schools. The largest loss was found for potassium at 41% in LOCSchools.

4.3.2. Greece

Energy and Macronutrients – The energy loss from plate waste is 35% and 43% in LOC and LOW schools respectively. Overall, losses of 32-44% across all macronutrients categories per served meal were calculated, with generally higher losses in LOWSchool. Total protein loss is 35% and 39% for LOC and LOW schools respectively Total carbohydrate loss is 32% for in LOC school and 44% in LOW school. Fibre loss is 34% in LOC school and 44% for LOW school. Loss of Total Fat is 38% LOC and 42% LOW schools. Loss of Saturated fatty acids 37% loss for LOC school and 41% LOW school. Micronutrients - Overall final losses of vitamins range from 42% to 64% in LOC school cases and from 34% to 45% in LOW school case. Loss of minerals range from 33% to 38% in LOC school,s and from 42% to 44% in LOW schools. The largest losses were recoded for vitamin B6 and vitamin C in LOC school, with estimated losses of 63% and 64%, respectively.

4.3.3. *Italy*

Energy and Macronutrients – The energy losses from plate waste were 26% for LOC-ORGSchools and 36% for ORGSchools. Macronutrient losses range from 23% to 43% per served meal, and as with energy, these macronutrient losses were higher in ORGSchools. Total protein loss is 23% and 34% for LOC-ORG and ORG schools respectively. Total carbohydrate loss is 27% for LOC-ORG school and 36% for ORG school. Fibre loss is 30% for LOC-ORG school and 43% for ORG school. Losses of Total Fat were 25% in LOC-ORG schools and 37% ORG schools. Saturated fatty acids losses were 23% for LOC-ORG schools and 14% ORG schools. Micronutrients – In LOC-ORG schools, the overall a loss of vitamins, and minerals, was between 16-29% and 19-30% respectively. In the ORG school, loss of vitamins, and minerals, was 27-48% and 34-41% respectively. The highest losses were found for vitamin A (47%) and vitamin C (48%) in LOC-ORG schools, and for potassium (40%) and calcium (41%) in ORGSchools.

4.3.4. *Serbia*

Energy and Macronutrients - The energy losses from plate waste were 20% in LOCSchools, and 33% in LOWSchools. Overall, losses of 15-36% were found across all macronutrients per served meal, and were generally higher in LOW compared to LOC schools. Total protein losses were 20% and 32% in LOC and LOW schools respectively. Total carbohydrate loss were 21% and 35% in LOC and LOW schools respectively. Fibre loss was 22% and 36% for LOC and LOW schools respectively. Total Fat losses were 17% and 31% in LOC and LOW schools respectively. Saturated fatty acids losses were 15%, and 29%, for LOC and LOW schools respectively. Micronutrients - Overall losses of vitamins ranged from 14% to 21% in LOC schools and 29% to 39% in LOW schools. Loss of minerals ranged from 12% to 25% in LOC schools, and from 31% to 35% in LOW schools. The highest losses are for potassium (35%) in LOCSchools, and potassium (35%), magnesium (35%), and phosphorous (35%) in LOWSchools.

4.3.5. *United Kingdom*

Energy and Macronutrients – In terms of nutritional losses from plate waste, average energy losses of 18%, and average overall macronutrient losses of 12% to 26% per served meal were calculated. Total protein and carohydrate losses were 17% (LOC) and 15% (LOW) and 21% (LOC) and 26% (LOW) respectively. Fibre loss was 26% and 19% for LOC and LOW schools while loss of total fat was similar between both cases at 15% (LOC) and 14% (LOW) in LOC respectively. Such as with total fat, the losses of saturated fatty acids are similar with 13% and 12% losses in LOC and LOW schools respectively. Micronutrients – Due to the complexity of the UK menu data and the significant number of daily menu options offered, it was not possible to estimate, for the collected data, the losses of vitamins and minerals associated with the collected plate waste.

4.3.6. *Summary of Nutritional Losses from Plate Waste*

Table 29 presents an synthesis of the key overall plate waste waste results and the associated nutritive losses by country, PFSP model and in terms of how they compare to results in existing studies. Across the 5 countries, and different PFSP models, similarities and differences were found in terms of the % lossess across energy, macro-, and micronutrient categories. For LOC schools, across the 5 countries, children were estimated to consume between 63-82% of food served with energy losses of between 18-35%, protein losses of between 17-35%, carbohydrate losses of 21-37%, total fat losses of 15-38%, saturdated fatty acid losses of 15-37% and dietary fibre losses of 22-38%. For LOW schools, children were estimated to consume between 57-87% of food served with energy losses of between 12-43%, protein losses of between 14-39%, carbohydrate losses of 19-44%, total fat losses of 14-42%, saturdated fatty acid losses of 14-37% and dietary fibre losses of 15-43%. Generally, except for Croatia, losses were higher in LOW/ORG schools and when compared to results in existing studies (detailed above), the estimated losses are, for all categories expect for dietary fibre, either within or above, the published ranges with estimated losses for total carbohydrates and total fat found to be well above these published ranges.

	Croatia	Greece	Italy	Serbia	UK	S2F Cross Case Range	Published Literature Ranges
Average Weight of Planned Meal Served (g)	LOC: 472	LOC: 438	LOC-ORG: 529	LOC: 495	LOC: 329	329-529g	
	LOW: 293	LOW: 507	ORG: 498	LOW: 417	LOW: 252	252-507g	
Average Weight of plate waste/meal served (g)	LOC: 130	LOC: 164	LOC-ORG: 140	LOC: 89	LOC: 87	87-164g	
	LOW: 36	LOW: 220	ORG:191	LOW: 132	LOW: 64	36-220g	
Estimated Consumed Weight of Food/Meal served (planned–waste) in grms and as % of planned food served	342 (73%)	274 (63%)	LOC-ORG: 389 (74%)	LOC: 406 (82%)	LOC: 265 (81%)	63-82%	
	257 (87%)	287 (57%)	ORG: 307 (62%)	LOW: 285 (68%)	LOW: 188 (75%)	57-87%	
% Loss of Kcal from Plate Waste	LOC: 25	LOC: 35	LOC-ORG: 26	LOC: 20	LOC: 18	18-35%	19 -42%
	LOW: 12	LOW: 43	ORG: 36	LOW: 33	LOW: 18	12-43%	
% Loss of protein (g) from Plate Waste	LOC: 29	LOC: 35	LOC-ORG: 32	LOC: 20	LOC: 17	17-35%	20-33%
	LOW: 14	LOW: 39	ORG: 34	LOW: 32	LOW: 15	14-39%	
% Loss of Total Carbohydrates (g) from Plate Waste	LOC: 21	LOC: 32	LOC-ORG: 37	LOC: 21	LOC: 21	21-37%	21-41%
	LOW: 19	LOW: 44	ORG: 36	LOW: 35	LOW: 23	19-44%	
% Loss of Total Fat (g) from Plate Waste	LOC: 28	LOC: 38	LOC-ORG: 25	LOC: 17	LOC: 15	15-38%	14-29%
	LOW: 14	LOW: 42	ORG: 37	LOW: 31	LOW: 14	14-42%	
% Loss of Sat Fat (g) from Plate Waste	LOC: 33	LOC: 37	LOC-ORG: 25	LOC: 17	LOC: 15	15-37%	15-30%
	LOW: 14	LOW: 41	ORG: 37	LOW: 31	LOW: 14	14-37%	
% Loss of Dietary Fibre (g) from Plate Waste	LOC: 38	LOC: 34	LOC-ORG: 30	LOC: 22	LOC: 26	22-38%	Aroung 55%
	LOW: 15	LOW: 44	ORG: 43	LOW: 36	LOW: 19	15-43%	

Table 29: Cross Case Synthesis of the impact of Plate Waste on Nutritive Intake (and associated loss

4.4. Financial impact of plate waste in different PSFP models

This sections reports results of the financial loss attributed to the collected plate waste in terms of € loss/meal served and as a proportion of the total food supply budget. As discussed in Section 4.2, this analysis was conducted for all schools (5/case except for Serbia with 2/case) in the LOC/LOC-ORG and LOW/ORG cases across all 5 countries on which nutritional and plate waste analysis has been conducted. Table 30 provides a summary of the total food supply budget, total estimated cost of waste, total cost of waste as a proportion of total food supply budget and average financial cost of waste per meal served in € (and as proportion of food meal price). For each calculation, the analysis is presented by case and country.

Parameter	Model	Croatia	Greece	Italy	Serbia	UK	Cross Case Range
Total cost of waste (€)	Model 1	38,374	16,891	85,000	4,197	21559	21,559-85,000
	Model 2	8,968	60,340	88,000	9,831	40211	8.968-88,000
% Total Waste financial loss from total supply budget	Model 1	22	54	18	20	27	18-54
	Model 2	3	35	34	34	13	3-36
Average financial costs of waste per meal served (€) as a proportion of full price paid	Model 1	0.27 (23%)	0.46 (21%)	1.65 (27%)	0.12 (8.5%)	0.21 (9%)	0.12-1.65 (5-27%)
	Model 2	0.04 (3%)	0.58 (26%)	2.79 (56%)	0.19 (13%)	0.19 (8%)	0.04 – 2.79 (3-56%)

Table 30: Financial Costs of Collected Plate Waste by Country and PSFP model

[a]-model 1 - school case models (LOC school case in Croatia, Greece, Serbia and United Kingdom; LOC-ORG in Italy)
[b]-modle 2 - school case model (LOW school case in in Croatia, Greece, Serbia and United Kingdom; ORG in Italy)

A short overview of the financial losses attributed to collected plate waste per country and by PFSP case is presented below.

4.4.1. Croatia

Across the 5 LOC schools, total annual plate waste is estimated to be 17,158 kgs, with an estimated total cost of €38,374. This equates to €0.27 per average meal served and 22% of the total LOC food suppliers budget. As the price of a school lunch in Zagreb City is set at €1.20, this means that in LOC schools, 23% of the full price paid is estimated to end up as plate waste. Across the 5 LOW schools, total annual plate waste was estimated to be 4631 kgs, with an estimated total cost of €8,968. This equates to €0.04 per average meal and 3% of the total LOW food suppliers budget. As the price of a school lunch in Zagreb City is set at €1.20, this means that in LOW schools, 3% of the full price paid is estimated to end up as plate waste

4.4.2. Greece

Across the 5 LOC schools, total annual plate waste is estimated to amount to 6,029 kgs, with an estimated cost of €16,891 and 54% of the total LOC food suppliers budget. This equates to €0.46 per meal and 21% of the subsidy provided per LOCschool meal by the Greek Government (€2.22). Across the 5 LOW schools, total annual plate waste is estimated to amount to 23,026 kgs, with an estimated cost of €60,340 and 35% of the total LOC food suppliers budget. This equates to €0.58 per meal and 26% of the subsidy provided per LOWschool meal by the Greek Government (€2.23).

4.4.3. Italy

Across the 5 LOC-ORG schools, a total annual plate waste of 51,403 kgs is estimated, with an estimated total cost of €85,000. This equates to 18% of the total school meal budget and €1.65 per average meal. As the price of a school lunch in Parma is set at €6.18, this means that in LOC-ORG schools, 27% of the full price paid ends up as plate waste. Across the 5 ORG schools, a total annual plate waste of 31,600 kgs is estimated, with an estimated total cost of €88,000. This equates to 34% of the total school meal budget and €2.79 per average meal. As the price of a school lunch in Lucca is set at €5.00, this means that in LOC-ORG schools, 56% of the full price paid ends up as plate waste.

4.4.4. Serbia

For LOC schools, the estimated total cost of of total collected plate waste is €4,197. This equates to 20.5% of the total school meal budget and €0.12 per average meal. As the price of a school lunch in LOCSchools is approx. €1.42, this means that in LOCSchools, 8.5% of the full price paid ends up as plate waste. Across the 5 LOW schools, the estimated total cost of of total collected plate waste is €9,831. This equates to 34% of the total school meal budget and €0.19 per average meal. As the price of a school lunch in LOWSchool is €1.75, this means that in LOW schools, 13% of the full price paid ends up as plate waste.

4.4.5. UK

Across the 5 LOC schools, a total annual plate waste of 11,408 kgs is estimated, with an estimated total cost of €21,559. This equates to 27% of the total school meal budget and €0.21 per average meal. As the price of a school lunch in LOCSchools is approx.. €2.30, this means that in LOCSchools, 9% of the full price paid ends up as plate waste. Across the 5 LOW schools, a total annual plate waste of 16,210 kgs is estimated, with an estimated total cost of €40,211. This equates to 13% of the total school meal budget and €0.19 per average meal. As the price of a school lunch in LOWSchool is €2.30, this means that in LOW schools, 8% of the full price paid ends up as plate waste.

4.4.6. Summary

Overall, across the 5 countries and PSFP cases, the financial loss attributed to plate waste was between €0.04 and €2.79 per meal served representing a loss of between 3% (Croatia, LOWSchool) and 56% (Italy, ORGSchool) of the full price paid per meal and between 3 (Croatia LOW School) and 54% (Greece LOCSchool) of the total food supply budget per case.

4.5. Embodied carbon impact of plate waste in different PSFP models

This section presents the results of the embodied carbon emissions analysis of the estimated plate waste in terms of embodied carbon emissions/meal served and as a proportion of the total embodied emissions of total food procured. In line with 4.4, and as discussed in Section 4.2, this analysis was conducted for all schools (5/case except for Serbia with 4/case) in the LOC/LOC-ORG and LOW/ORG cases across all countries, not just the 2 schools/case on which nutritional and plate waste analysis has been conducted. Table 31 presents a cross country synthesis of the estimated embodied carbon emissiosn in collected plate waste by country and across the PFSP models followed by short descriptive summaries for each country.

Parameters	Model	Croatia	Greece	Italy	Serbia	UK	Cross Case Range
Total Estimated Weight of Annual Plate Waste (kgs)	Model 1	17,158	15,736	51,403	7,881	11,408	
	Model 2	4,681	51,570	31,664	16,106	16,210	
Total Estimated Embodied Carbon emissions in Plate Waste (kgsCO2eq)	Model 1	46,968	42,074	90,247	29,930	27,295	
	Model 2	11,845	160,275	46,256	63,919	44,386	
Average Estimated Embodied Carbon in Plate Waste/Meal Served (kgsCO2eq)	Model 1	0.33	1.15	0.34	0.32	0.27	0.27-1.15
	Model 2	0.05	1.53	0.37	0.42	0.21	0.05-1.53
Proportion (%) of Total Embodied Carbon Emissions attributed to Plate Waste	Model 1	39	62	36	31	23	23-62%
	Model 2	5	63	35	31	17	5-63%

Table 31: Cross Country Synthesis of estimated Embodied Carbon Emissions in Plate Waste

4.5.1 Croatia

Across the 5 LOC schools, the total annual plate waste is estimated at 17,158 kgs and to contain embodied carbon emissions of 46,968kgsC02eq, which equates to 0.33kgC02eq per average meal or 39% of total embodied emissions of food procured. Across the 5 LOW schools, the total annual plate waste is estimated at 4,681 kgs and to contain embodied carbon emissions of 11,845kgsC02eq, which equates to 0.05kgC02eq per average meal or 5% of total embodied emissions of food procured. In both cases, meat is highest single contributory category to embodied carbon, although is fairly small component of volume of average meal.

4.5.2. Greece

Across the 5 LOC schools, the total annual plate waste is estimated at 15,736 kgs and to contain embodied carbon emissions of 42,074kgsC02eq, which equates to 1.15kgC02eq per average meal and 62% of total embodied emissions of food procured. Across the 5 LOW schools, the total annual plate waste is estimated at 51,570 kgs and to contain embodied carbon emissions of 160,275 kgsC02eq, which equates to 1.53kgC02eq per average and 63% of total embodied emissions of food procured.

4.5.3. *Italy*

Across the 5 LOC-ORG schools, the total annual plate waste is estimated at 51,403 kgs and to contain embodied carbon emissions of 90,247kgsC02eq, which equates to 0.34kgC02eq per average meal or 36% of total embodied emissions of food procured. Across the 5 LOW schools, the total annual plate waste is estimated at 31,664 kgs and to contain embodied carbon emissions of 46,256kgsC02eq, which equates to 0.37kgC02eq per average meal or 35% of total embodied emissions of food procured.

4.5.4. *Serbia*

Across the 5 LOC schools, the total annual plate waste is estimated at 7,881 kgs and to contain embodied carbon emissions of 29,930kgsC02eq, which equates to 0.33kgC02eq per average meal or 31% of total embodied emissions of food procured. Across the 5 LOW schools, the total annual plate waste is estimated at 16,106 kgs and to contain embodied carbon emissions of 63,919 kgsC02eq, which equates to 0.42kgC02eq per average or 31% of total embodied emissions of food procured.

4.5.5. *UK*

Across the 5 LOC schools, the total annual plate waste is estimated at 11,408kgs and to contain embodied carbon emissions of 27,295kgsC02eq, which equates to 0.27kgC02eq per average meal or 23% of total embodied emissions of total food procured. Across the 5 LOW schools, the total annual plate waste is estimated at 16,210kgs and to contain embodied carbon emissions of 44,386 kgsC02eq, which equates to 0.21kgC02eq per average or 17% of total embodied emissions of food procured.

4.5.6. *Summary*

Overall, across the 5 countries and PSFP cases, the estimated embodied carbons emissions attributed to plate waste were between 0.05kgC02eq and 1.53kgC02eq per average meal served or 5-63% of the total embodied emissions of food procured per case with significant between cases differences observed. While embodied emissions in collected plate waste as a proportion of total embodied emissions of food procured were similar in LOC/LOC-ORG Schools in Croatia, Italy, Serbia and the UK (23-39%), the proportions were very different and much higher for Greece (62%). In LOW/ORG, a slightly different pattern emerged. As amount of waste collected was very low in Croatia LOW schools, the proportion of embodied emissions was also very low at 5%. Italy, Serbia and UK had similar to LOC/LOC-Org proportions ranging from 17-35% with Greece maintaining its outliner status with a much higher proportion of 63%.

4.6. Plate waste in different PSFP models: reflections across the cases

Looking across all the key plate waste results and selected nutritional and financial losses and embodied carbon attributed to collected plate waste, within, and between, country differences across all key dimensions (See Table 32) including: the proportion of planned food served collected as plate waste (12-43%), average plate waste per meal served (36-220g), the most wasted foods (vegetables and starchy food), the proportion of energy lost to plate waste (12-43%), the proportion of total supply budget lost to plate waste (3-54%), financial cost of waste per meal served (€0.04-0.70), proportion of full price paid lost to food waste (3-26%), the average embodied carbon attributed to collected plate waste/meal served (0.05-1.53 kgCO2eq per average meal served) and the proportion of total embodied carbon emissions attributed to plate waste (16-63%). Generally, across these dimensions, the results for the LOW model across all countries except for Croatia and the LOC/LOC-ORG model in Greece and Italy (for some results) are consistently higher than the LOC models in Croatia, Serbia and the UK terms of proportion of served food collected as plate waste and proportional impact of plate waste in terms of nutritive and financial loss and embodied carbon.

	Model	Croatia	Greece	Italy	Serbia	UK	Cross Case Range
Proportion (%) of planned food served collected as plate waste	**Model 1**	**28**	**38**	**26**	**19**	**26**	**19-38%**
	Model 2	**12**	**43**	**38**	**32**	**25**	**12-43%**
Average weight of collected plate waste/meal served (g)	**Model 1**	**130**	**164**	**140**	**89**	**87**	**87-164g**
	Model 2	**36**	**220**	**191**	**132**	**64**	**36-220g**
Top Food Categories as proportion of total food waste collected	**Across both Models**	**1. Vegetables (45-56%)** **2. Starchy Food (27-45%)** **3. Meat & Fish (8-13%)**	**1. Vegetables (31%)** **2. Starchy Foods (25-35%)** **3. Mixed Foods (17-26%)**	**4. Starchy Food (40-41%)** **5. Fruit (30-33%)** **6. Vegetables (12-18%)**	**1. Vegetables (41-44%)** **2. Meat & Fish (17%)** **3. Starchy Food (6-14%)**	**1. Starchy Food (37-61%)** **2. Vegetables (6-26%)** **3. Meat & Fish (11-15%)**	**1. Vegtaebles** **2. Starchy Food** **3. Meat and Fish**
Proportion (%) of planned Energy (kcal) lossed to plate waste	**Model 1**	**25**	**35**	**26**	**20**	**18**	**18-35%**
	Model 2	**12**	**43**	**36**	**33**	**18**	**12-43%**
Proportion of total food supply lossed to Plate Waste (%)	**Model 1**	**23**	**54**	**18**	**20**	**27**	**18-54%**
	Model 2	**3**	**36**	**34**	**31**	**13**	**3-36%**
Finanical cost of waste/meal served (€) (Proportion (%) of full price paid/meal)	**Model 1**	**€0.27 (23%)**	**0.46 (21%)**	**€1.65 (5%)**	**€0.12 (7%)**	**€0.24 (10%)**	**€0.12-0.46 (5-23%)**
	Model 2	**€0.04 (3%)**	**0.58 (26%)**	**€2.79 (14%)**	**€0.19 (11%)**	**€0.21 (9%)**	**€0.04-0.70 (3-26%)**

Proportion of Embodied Carbon in collected plate waste	**Model 1**	**39**	**62**	**36**	**31**	**23**	**23-62%**
	Model 2	**5**	**63**	**35**	**31**	**17**	**17-63%**
Average Embodied Carbon in collected plate waste/ average meal served (kgCO2eq per average meal served)	**Model 1**	**0.33**	**1.15**	**0.34**	**0.32**	**0.27**	**0.27-1.15 kgCO2eq per average meal served**
	Model 2	**0.05**	**1.53**	**0.37**	**0.42**	**0.21**	**0.05-1.53 kgCO2eq per average meal served**

Table 32: Cross Country Synthesis of Key Plate Waste results including selected attributed Nutritional and Financial Loss and Embodied Carbon

5. CONCLUSIONS AND RECOMMENDATIONS

This Synthesis Report has presented the main results of WP6.2 research into the nutritional impacts of PSFP models. In terms of the nutritional composition of menus, the research found large variations across countries and cases. However, many of the sample menus did not offer the planned nutritive values recommended by national or WHO standards. Similarly, although large variations were also found across countries, and cases, in terms of plate waste, the quantities and compositions of waste often translated into considerable nutritional losses compared with the planned intakes, from a third to almost half of many macro and micronutrients lost in the higher waste cases (i.e. Greece LOC and LOW, Italy ORG), to at least 10-20% of nutrients in the lower waste cases (i.e. Croatia LOW, Serbia LOC). Bearing in mind the deficiencies in the planned nutritive value of many case menus, it can be concluded that the actual nutritional intake of children from the sample lunches often fell well below national/WHO recommendations. High levels of plate waste were also found to represent a considerable economic loss for case meal services (as much as 54% of the total supply budget in Greece LOC case), as well as a considerable embodied carbon burden (63% of total emissions in Greece LOW case). We conclude from this that waste reduction is a highly desirable goal, not only to minimise nutritional losses, but also financial loss and unnecessary carbon emissions.

No consistent nutritive value differences were identified between the menus in each PSFP case pair. Instead, factors other than procurement model were more important to explaining these differences. Similarly, apart from a possible link between the location of meal preparation (on-site vs. central kitchen) and the freshness and flavour of the food, the levels of plate waste found in the cases appeared to be unaffected by the procurement model.

To conclude, this section lays out a set of cross cutting recommendations drawing from the detailed country by country and cross case analysis above, and in particular the cross country synthesis tables presented (Tables 14-18, 21, 29-32). The set of recommendations target key parts of the integrated school food system include the PSFP models, with the dual aim of optimising nutritive intake, and reducing plate waste, from primary school lunches. They are inspired by, and grounded in, the observational, nutritional and plate waste results and are proposed as a way of holistically and systematically tackling how to optimise children's nutritive intake and reduce plate waste while working under differing policy, resource and external and internal (school and municipality) environmental constraints.

Much like a jigsaw puzzle, school food systems, and their associated model of PSFP, are made up of a number of key interconnected sub-systems designed and managed with specific food, educational and service delivery goals, and specific stakeholder interests, in mind. Each sub-system, though distinct, is heavily reliant on and must work in harmony with other sub-systems in order to optimise nutritional intake and reduce plate waste. At its heart, the core aim of a school food systems, and its associated PSFP model, is to deliver tasty, nutritionally balanced meals on a daily basis that are consumed (and enjoyed) by children and which provide optimal energy and nutrients to help children thrive educationally, and develop both physically and socially.

Across our 5 countries, the 179 observed lunchtimes and the 22,529 plates scraped, we have developed an in-depth understanding of different types of school food systems, and their associated PSFP models, and learnt how all the moving parts interact with, are influenced by, and come together, on a daily basis in the school canteen. We found no single solution that will improve, and optimise nutritive intake, and reduce plate waste. Furthermore, apart from a possible link between location of meal preparation (i.e. on-site vs. off-site) and the freshness and flavour of the food, we did not find any systematic evidence that the nutritive values of menus, or levels of plate waste, are determined by the type of PSFP model adopted by school meals services. Instead, we identified other factors that are more important to explaining these outcomes, and we found these generally held true across the cases and countries, despite the very different histories, cultures, experiences in, resourcing of, and facilities for, delivering school lunches across the cases.

The following set of recommendations highlight the clear need for a systems approach to improving school food that explicitly acknowledges the role and influence of multiple factors and stakeholders, in daily school meal services. Grounded firmly in the observational, nutritive, and plate waste results reported above, the recommendations are split into 4 interconnected and interdependent categories: 1. National and Municipal Policies and Practices; 2. Staff Resourcing, Roles, Training and Skills; 3. School based Policies and Initiatives; and 4. Canteen Environment and Layout. All are strongly recommended across the countries and cases investigated though it is acknowledged that some are more relevant to, or urgently required by, certain countries and cases than others.

1. ***National and Municipal Policies and Practices***
    a. Development (Greece), implementation (Serbia) and regular reviewing of National Nutritional and Food Based Standards for Primary School aged Children (Croatia, Italy, UK), and where possible specific to school meals. This will, in particular, require consideration, at a national, municipality and school level, to be given to adjusting portion sizes for age and (where appropriate) gender.
    b. Polices and mechanisms should be developd to minimise (or elimiate) child refusal of whole meal components, and in particular vegetables, during school meal services. Such approach initiatives should: introduce children to a wider range of vegetables; present, and serve, vegetables in different, more appealling and easy to eat formats and portion sizes, and provide support and encouragement to children to increase their daily vegetable consumption.
    c. Creation, and resourcing of centrally managed (national and/or municipality level), pools of professionally trained nutritionists and/or dieticians who work closely with school based catering teams on menu innovation and development and nutritional analysis for primary school meals.
        i. Such developments may include reducing the served weight of food while optimising the nutritional profile of lighter meals, adjusting portions sizes by child age, changing the format in which meals are provided (i.e. more unique dishes; easier to eat dishes) and thinking creatively about how vegetable content (in particular) can be increased through innovative cooking practice (i.e. grated carrots and courgettes in pizza sauce and 50:50 fruit based dessert in UK LOC schools) for in particular main course dishes, sauces and desserts.
    d. Development of varied, yet nutritionally optimal and seasonally grounded, menu cycles that offer variation and respond to locally available supply (where appropriate and feasible).
        i. For the UK specifically, as all other countries offered one set menu, it is recommended that the amount and type of daily menu choice offered is reviewed, and possibly rationalised, in order to better focus attention and

staff resource on producing a managed range of high quality, nutritionally optimal and attractive menu options.

e. Development of national and municipality led mechanisms for greater, and better, stakeholder engagement and best practice sharing (i.e. stakeholder forums.

    i. These forums should regularly bring together suppliers; wholesalers; teachers; nutritionists and municipality employees to work collaboratively on menu development; share insights, and best practice ideas, from their professional coalface within the school meal system and help in the development and delivery of on- and off-site best food based initiatives.

f. Integration of the voices and experiences of children and parents into the processes of managing, and reviewing, school meal systems to ensure that the “consumer” voice is listened to, and valued in, the service design and delivery process.

g. Development, delivery and evaluation of national and/or municipality led food, nutritional and sustainability initiatives, including child and parental/wider family educational and cooking skills programmes.

2. *Staff Resourcing, Roles, Training and Skills*

a. Evaluation of, and investment in, the roles and skills of canteen staff (from Unit Managers to part time assistants) to maximise their positive impact in terms of school meal production (i.e. menu innovation; preparation and cooking techniques; presentation of food) and service delivery where optimal intake and waste minimisation are considered key indicators of good performance

b. Investment in greater canteen supervision capacity (catering and teaching staff) to support and encourage all children, no matter what their age, to eat as much of their lunch and in particular their vegetables as possible.

    i. Canteen supervisors should be out amongst the children, listening and talking to, and learning from, the children about their experiences of lunch, encouraging them to eat as much of their meal as possible and where necessary enforcing school meal policy.

c. Provision of generic, and onsite, training in how to interact with, and encourage children with optimal eating (given the environmental constraints each will be working on in their school) to get the best results from increased investment in dedicated, and trained, canteen supervisors.

d. Integration of catering staff into other available school based roles (pre or post lunchtime activities) to create better, more attractive mixed full time and part time roles within schools, helping to improve the connectedness and integration of such staff into wider school life.

    i. Such roles could include managing and delivering breakfast clubs and during and after, school clubs (especially those with a food focus), cleaning and school maintenance (including school gardens) roles, and teaching assistant roles

e. Establishment of food and non-food segregated recycling initiatives and waste stations and monitoring and tracking systems that require regular (daily/weekly) recording, and reporting, of daily plate, other food, and non-food waste (especially single use plastic and packaging) in school canteens to support schools, caterers and municipalities to learn from, reduce rates of, and dispose of optimally the daily plate, other food and non-food waste generated.

3. ***School based Policies and Initiatives***
   a. Schools are strongly encouraged to integrate food, nutritional and sustainability related topics into the broader culture and life of their schools both in terms of on, and extra curricula, activities.
      i. Encouraging, facilitating and resourcing teaching staff and students to learn through food (i.e. numeracy; geography, science) both in the classroom and beyond (i.e after school clubs; school gardens; intergenerational projects (children, parents and grandparents cooking together)) is important for helping to establish, and reinforce, good food habits in the canteen and beyond.
   b. Systemic review (municipality and school based) of the length and positioning of school lunchtimes within the broader school day to ensure children have optimal time for eating (and digesting) their lunch, engaging in very valuable peer to peer and peer to staff (supervisors) interaction, developing good food and eating practices and do not feel under pressure to eat fast for fear of missing out on playtime.
4. ***Canteen Environment, Layout and Food Service***
   a. Municipality and school based reviews are recommended regarding how food is ordered by (where pre-ordering is required in the UK), served to, children in the canteen.
      i. This should consider how, and where school food is produced (on-site or central), the impact of central kitchen production on the appearance, taste and temperature of served food, what items are served, and in what order, whether all main meal components (including dessert as happens in the UK) are served together, where children are served their food (service counter, from serving carts, at their tables), on what food is served (i.e. multi-compartment trays; plates; bowls) and how canteen supervision interacts with this process to optimise food intake and reduce plate waste.
   b. Review and investment in optimising, given school specific constraints, canteen layout and lunch service management.
      i. This should include reviewing how to optimise: the type and use of available canteen space (dedicated or multiuse), the height, and visual accessibility of the food service counter (where used), the canteen layout including the number, and type of seats and tables available, the type and number of segregated waste stations (to maximise waste recycling), noise levels during service and the available light and decoration of school canteens

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The Strength2Food project in a nutshell

Strength2Food is a five-year, €6.9 million project to improve the effectiveness of EU food quality schemes (FQS), public sector food procurement (PSFP) and to stimulate Short Food Supply Chains (SFSC) through research, innovation and demonstration activities. The 30-partner consortium representing 11 EU and four non-EU countries combines academic, communication, SMEs and stakeholder organisations to ensure a multi-actor approach. It will undertake case study-based quantitative research to measure economic, environmental and social impacts of FQS, PSFP and SFSC. The impact of PSFP policies on nutrition in school meals will also be assessed. Primary research will be complemented by econometric analysis of existing datasets to determine impacts of FQS and SFSC participation on farm performance, as well as understand price transmission and trade patterns. Consumer knowledge, confidence in, valuation and use of FQS labels and products will be assessed via survey, ethnographic and virtual supermarket-based research. Lessons from the research will be applied and verified in 6 pilot initiatives which bring together academic and non-academic partners. Impact will be maximised through a knowledge exchange platform, hybrid forums, educational resources and a Massive Open Online Course.

Strengthening European Food Chain Sustainability by Quality and Procurement Policy

Deliverable No: D6.3

EVALUATION OF ENVIRONMENTAL, ECONOMIC AND SOCIAL IMPACT OF DIFFERENT MODELS OF PSFP IN A SCHOOL CONTEXT:

PART 2:
COUNTRY REPORTS

Strengthening European Food Chain Sustainability by Quality and Procurement Policy

Deliverable No: D6.2

Report evaluating the nutritional impact of the different models of PSFP in a school context:

CROATIA COUNTRY REPORT

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Academic Partners

1. **UNEW**, Newcastle University (United Kingdom)
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3. **UNED**, University of Edinburgh (United Kingdom)
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28. **CPR**, Consortium of Parmigiano-Reggiano (Italy)
29. **ECOZEPT**, ECOZEPT (Germany)
30. **IMPMENT**, Impact Measurement Ltd (United Kingdom)

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EXTENDED ABSTRACT

Maintaining a healthy diet that satisfies nutritional needs is extremely important for people of all ages. Childhood, specifically, is a particularly complex and vulnerable period of life, with an increased demand for a balanced intake of energy and nutrients to ensure optimal growth and development. The provision of adequate nourishment for children in institutional contexts (i.e. schools) is considered a matter of special public health concern, and European and national governments have established specific school food based standards and nutritional guidelines for organized meal planning in kindergartens and schools. To ensure appropriate intake of all essentials macro and micro nutrients, school children must incorporate the recommended amounts of all food groups into their daily diet. Elimination, or sub optimal intake, of certain foods or food groups deprives children of essential macronutrients and micronutrients, which can result in nutrient deficiencies and health risks during childhood and in later life. However, the nutritional value of institutionally organized diets is not only determined by food based standards and nutritional guidelines, but also by food procurement policy. Therefore, this research explores how, if at all, different public sector food procurement (PSFP) models may be linked to, and influence the healthfulness and nutritive value of school meals.

This study was conducted in Zagreb City, the Capital of Croatia, with primary schools adopting one of two contrasting PSFP models: (i) LOW model, consisting of two 'regular' primary schools who each organised their own meal service according to normal contract arrangements; and (ii) LOC model, consisting of two primary schools belonging to a cluster, in which meals were provided by a hub school. Due to running a large budget, the hub school has sufficient resources to innovate and enrich standard meals with other ingredients, including some from local, organic and family-owned suppliers and their healthier products. The research analysed the nutritional composition of a sample of daily menus at two LOC and two LOW model schools (20 menus per model), collected all plate waste generated during the data collection period (20 days collection per case) and analysed the volumes, composition, and nutritional, carbon and economic values of the collected plate waste.

The key findings of the research were as follows.

In terms of <u>nutritional composition of daily menus</u>, nutritional deficiencies in the daily menus were found for both LOC and LOW schools. Although menus across both cases generally met national recommendations for carbohydrate and protein content, both provided insufficient energy and fibre, and a high proportion of menus in LOC schools were found to be too high in fat and saturated fat. In addition, a large proportion of daily menus were found to be deficient in key observed micronutrients, except for vitamin B6. Worryingly, across both cases, the salt content of school lunches was found to exceed total daily sodium recommendations for children for this one daily meal.

In terms of <u>plate waste</u>, LOW schools were found to have considerably lower plate waste per served meal (12%) compared to the LOC schools (28%). However, the differences between the cases did not appear to be driven by the case procurement model. Instead, the main reasons for lower plate waste levels in LOW schools are posited to be: (i) differences in the weight of the average meal served with 293g per meal served in LOW schools compared to 472g per meal served in LOC schools; and (ii) differences observed in the LOW schools lunchtime service environment, including a very good relationship between catering staff and students, more encouragement by staff to students to finish their meals; longer lunchtime periods and a better seating arrangement in one LOW school. In addition, it is observed that all meals in LOW schools were cooked on-site in the schools, which could have positive implications for their

freshness and flavour. For both cases, most collected plate waste came from vegetables (56% of the LOC schools and 45% of the LOW schools), followed by starchy food (27% of the LOC Schools and 45% of the LOW schools), then meat (13% of the LOC schools and 8% of the LOW schools). Other food and desserts comprised only 1-2% of total plate waste in both cases. Fruit was not served within the lunches, therefore did not feature in the waste collection.

In terms of the <u>nutritional impact of plate waste,</u> the nutritional composition of the LOC schools' collected plate waste caused, on average, a 25% loss of energy (kcal), 29% loss of protein, 21% loss of carbohydrate, 28% loss of fat, and a 38% loss of dietary fibre. Vitamin and mineral losses were 32-41%. In LOW case schools, average nutritional losses from collected plate waste were smaller: 12% loss of energy, 14% loss of protein, 9% loss of carbohydrate, 14% loss of fat, and 15% loss of dietary fibre. There was a 14-17% loss of vitamins and minerals due to LOW school plate waste. Overall, losses in the LOW schools were found to be 2-3 times smaller for energy, macronutrients (proteins, carbohydrate, fat, and fibre), and some vitamins and minerals, compared with the LOC schools. The main reason was the much smaller quantities of plate waste in LOW schools.

In terms of <u>the economic impact of plate waste</u>, the food costs associated with the collected plate waste were €0.27 per average meal in LOC schools (22% of the total meals budget), and €0.04 per average meal in LOW schools (3% of the meals budget). The much smaller cost of plate waste in LOW schools was due to the much lower quantities of waste in LOW case.

For <u>environmental impact,</u> the carbon emissions embodied in the collected plate waste amounted to 0.33 $kgC0_2eq$ in LOC schools (39% of total $C0_2$ emissions of the entire LOC meals service), and 0.05 $kgC0_2eq$ in LOW schools (5.4% of total $C0_2$ emissions of the entire meals service). Again, these impact results reflect the lower levels of plate waste found in LOW schools compared with LOC schools.

In a parallel project, University of Zagreb obtained permission from schools to speak to the children in the canteens during plate waste data collection and survey their food preferences, and reasons for not finishing the vegetable components of their school meals. Results found that the most frequent reasons given for not finishing their vegetables were: "I don't like the taste of the food" (the proportion of students' answers in LOC school case is 47% for stews and soups, 53% for side dishes, 30% for fresh salad, 34% for canned salad and in LOW case schools 53% for stews and soups, 61% for fresh salad, 54% for canned salad), "I cannot eat that much food" (the proportion of students' answers in LOC school case is 37% for stews and soups, 34% for side dishes, 31% for fresh salad, 23% for canned salad and in LOW case schools 25% for stews and soups, 24% for fresh salad, 33% for canned salad), and "I do not eat that at home" (the proportion of students' answers in LOC school case is 31% for stews and soups, 23% for side dishes, 10% for fresh salad, 20% for canned salad and in LOW case schools 23% for stews and soups, 34% for fresh salad, 25% for canned salad). The second reason is particularly interesting for this study given the lower average weight of food per meal served and lower levels of collected plate waste in LOW schools. Of the other two reasons, taste highlights the need for menus to be designed to not only to provide various food items but to also appeal to, and be adjusted to meet, children's taste preferences. The third reason confirms that what children get at home has a significant impact on children's perceptions and eating habits, therefore children and parents need to be educated as to why it is important to eat all food categories, especially fruit and vegetables, and schools need to find more ways to introduce various fruits and vegetables to them as part of the lunch experience. This research showed that vegetables were more popular in LOW than in LOC schools both in terms of child preference and levels of collected waste.

To improve the nutritional composition of school menus, we also strongly recommend that nutritionists are involved more directly in menu design. More training and support is needed for kitchen staff to encourage them to prepare more tasteful and healthier meals. Moreover, optimal school menus could be defined on the level of Zagreb City. Finally, interdisciplinary approaches should be taken to improve the quality, nutritive value and taste of school meals while also considering and improving the quality and design of the school canteen environment.

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List of Abbreviations and Acronyms

AV- adequate value

FCA - food composition analysis

HR – higher than recommended

LOC MODEL – School with an Alternative model of public food procurement

LOW MODEL – School with a model of LOW cost public food procurement

LR – lower than recommended

MFP-meat and fish products

PSFP- public sector food procurement

1. INTRODUCTION & METHODS

This report presents the methods and results of the WP6.2 Croatian study into the nutritional impacts of models of public sector food procurement (PSFP), focusing on primary school meals. Nutritional intake, and associated outcomes, for primary-school children is one of the most significant global public health issues. School nutrition should provide an adequate range, and nutritional value, of food for children, supporting their growth and development, and – at the same time – influence and shape the establishment of proper eating habits. Although many countries, including Croatia, have developed national nutritional guidelines for primary school meals, the nutritional values of institutionally organized diets depend not only on food standards and guidelines but also the criteria set by food procurement policies. Therefore, the aim of this study was to undertake a food composition analysis (FCA) and evaluate the nutritive value of daily menus at selected school canteens belonging to contrasting models of food procurement. In addition, we recognise that no matter the national guidelines or PSFP model in schools, children sometimes do not like to eat some food. Food refusal rates can directly affect the actual nutritional intake of children from school meals, compared with what is intended by the menu design. Therefore, as well as calculating the nutritive values of menus via FCA, we also collected and evaluated plate waste from the same selected school canteens, to establish the impacts (nutritional loss, economic loss and embodied carbon) attributed to the waste.

The study was conducted in Zagreb City, the Capital of Croatia, on primary schools adopting one of two contrasting PSFP models. All primary schools in Zagreb City are required to provide daily meals to children, with individual schools normally responsible for contracting, and managing, their own food supplies, and cooking meals for their children onsite. Therefore, the first PSFP model we studied, which we defined as LOW model, consisted of 'regular' primary schools who manage their own school meal service according to this typical context. Two schools from the five LOW schools featured in D6.3 Croatia Country Report were selected to participate in this study: LOWSchool A and LOWSchool C.

The other PSFP model comprised a cluster of schools linked to a key hub school. This hub school has a big central kitchen where meals for the hub, and 12 other, schools in Zagreb City are prepared representing a true exception to the regular PSFP model in Croatia. The hub school is large (both in terms of premises and the number of pupils) and due to running a large budget, it has had the opportunity, and resources, to enrich standard meals with healthier ingredients and products, including some sourced from local, organic and family-owned suppliers. This model is therefore described as a LOC model, and two of the five featured LOC schools described in D6.3 Croatia Country Report were selected to participate in this study: LOCSchool A - which is the hub school itself - and LOCSchool E.

The methodology for the FCA of daily menus was as follows. For the 4 selected schools (LOCSchools A and E, and LOWSchools A and C), daily menus were collected for a period of five consecutive school days (Monday to Friday) during two seasons (autumn/winter and spring/summer) in the school year 2017/2018. Therefore, a total of 40 daily menus were analysed, 20 each for LOC and LOW. Menus were obtained from the school staff while normative provisions (standard quantities of ingredients) were confirmed through direct conversation with head cooks. The nutritive value of school lunch recipes was calculated using Croatian National Food Composition Tables. Thus, for each recipe offered on the schools' daily menus, the total energy (calories), macronutrients (proteins, fats, carbohydrates, dietary fibres and saturated fatty acids) and selected micronutrients (Vitamin A, Vitamin B1, Vitamin B2, Vitamin B6, Vitamin B12, Niacin, Folate, Vitamin C, Vitamin D, Minerals: sodium, potassium, calcium, magnesium, phosphor, iron, zinc and copper) from a full consumed portion were calculated. For those foods not included in the national food composition database, energy and nutritive values were obtained from their food labels. The energy and nutrient values of the offered meals were then evaluated with regard to referent Croatian National guidelines for school meals for children in primary schools. These standards were adjusted for age but not gender of child. Therefore, for each recipe on the selected daily menus, the extent to which a full consumed portion could contribute to a child's recommended daily intake of energy and nutrients was evaluated. In undertaking the FCA, we also explored the possibility of making adjustments to reflect how food procured through alternative models, e.g. organic food, may possess different nutritional values. In practice however, the nutritional databases available to us did not support such adjustments.

The methodology for the plate waste study was designed to complement the FCA and nutritive analysis with plate waste collected daily in the same schools during the same weeks/seasons as that of the menu data. Therefore, plate waste was collected on and recorded for 40 days, 20 each for LOC and LOW cases. The first step was to select at random three portions of the offered daily meal, and weigh all components, and the meal as a whole. Using these values as a benchmark, an average weight of food per meal served was calculated and used a reference value against which the collected weight of plate waste could be benchmarked. For plate waste collection, plates/trays from all children eating lunch were collected on completion of their meal and the collected plate waste was separated into 6 different bins representing the main food categories: vegetables, fruit, starchy food, meat, fish and protein, dessert and other food. At the end of the lunch service, the total weight of each bin was recorded and the ratio per portion served between the total weight of plate waste collected per food category (for example vegetables) and the total weight of food served per food category was calculated.

Alongside the plate waste study, as part of a parallel research project conducted by University of Zagreb, additional ethical approval was granted from the schools participating in the plate waste study to engage directly with pupils to obtain daily feedback regarding the observed meals. On each day of plate waste collection, all children were issued with a survey sheet alongside their tray and meal. After the children finished their meals, their food preferences were assessed using a five-point 'faces' scale (scores 1 to 5; 5 being the most preferable). The actual question(s) asked were: if you didn't eat a whole vegetable from your lunch – please tell us why (children were able to mark multiple choice). The precise response format(s) were: I was not hungry", "I didn't like the taste of the food", "I cannot eat that much food" "I don't eat this at home", "I didn't have time to finish" ,"I didn't like the smell/appearance of the food" (Copy is in appendix).

In addition to plate waste data collection, and to complement this part of the study, a series of observations of the kitchens, canteens and lunchtime services was undertaken, as well as interviews with key kitchen staff, in the participating LOC and LOW schools. The purpose of collecting this complementary data was to help us understand fully the context of the lunchtime services in the four studied schools and thus helping to interpret and explain the similarities and differences found between the schools in terms of weight, and composition, of plate waste. The key observations made focused on:

- *the time spent preparing and consuming meals* (division and consumption together)
- *the behaviour of teachers* including: do they get lunch from the canteen; where do they sit with regard to the children; do they encourage the children to finish the lunch
- *the behaviour of kitchen staff* including:- do they adjust the portion sizes of meal components and total quantity of food served per meal; are the canteen staff courteous and/or accessible to the children; do they encourage children to eat; do children take the food by themselves or are they served; is some, or all, of the food served at a serving counter or brought to the table; how is bread served at lunch

- *the space where children receive and/or eat their lunch* including: the number of places; whether the children remain in their seats after finishing their meal; atmosphere (e.g. surrounding noise because lunch is in the hallway where other students pass); whether they have enough desserts; do children have to wait for dishes to be washed and served
- *food serving and consumption practices:* is there a possibility that some food is not served (e.g. if a lunch serves potato, spinach and eggs is a child able to refuse the spinach if he/she does not want to eat this component, and so there is a possibility that element is not served)

In the interviews with school based kitchen staff, including the cooks and administrative staff, all aspects of the school meal process were explored including food related initiatives and how they try to respond to, and/or change, children's eating habits. For example, while the National Recommendations say that brown bread with cereals should be served for breakfast, children usually don't eat this especially the youngest 1st grade children, who struggle due to teeth related problems and much prefer a slice of white bread.

Also, a rising problem is that many children are consuming less food at home than previous generations and as a result they often refuse to accept the vegetables offered. Hence in interviews, we discussed how schools respond to complaints from parents regarding menus, and how some have asked those responsible for school menus to prepare meals with less vegetables and/or which are generally less healthy.

2. SCHOOL FOOD POLICIES IN CROATIA

In Croatia, all primary schools must provide school meals to their children. Where school nutrition is organized at the municipality level, funds are provided from the state budget and the budgets of local and regional self-government units, while part of the costs are covered by parents. The City of Zagreb subsidies meal for 44300 pupils[8], which means that around 74% of children in Zagreb receive at least one meal (usually breakfast) in school. For students in day care (from 8 am to 4 pm), approximately 24% of all Zagreb primary school children, the school must plan to serve them three meals per day (a milk meal, a lunch and a snack). There is only lunch dish prepared per day and all children are served with this (i.e. there are no multiple options between dishes on the same day).

Two documents that are the legal basis for the organization and functioning of school meals in Croatia are the *Law on Education in Primary and Secondary Schools* (Official Gazette 87/08, 86/09, 92/10, 105/10, 90/11, 16/12, and 86/12) and *National Pedagogical Standard for Elementary Education* (Official Gazette 63/08 and 90/10).

In addition, the document titled *"National guidelines for school meals for children in primary schools"* (2013), prepared by the Working Group of the Ministry of Health, is intended to help and guide all employees involved in the preparation and service of school meals by proving necessary guidance to support schools to adhere to national nutrient guidelines and help them improve the quality of nutrition in schools. The document provides guidance for the organization and administration of the school meal service, the definition of public procurement contracts, and conditions of work, preparation, and delivery of meals to meet the needs of the relevant age groups of children and advice on how to teach and encourage children to adopt proper eating habits. The national dietary guidelines are an integral part of the standards for nutrition for primary schools, outlining the recommended types of foods and dishes, the optimal intake of energy and nutrients, as well as the number of meals and the allocation of the recommended energy intake per meal offered. In order for a school nutrition system to comply with these national recommendations, each school should have systems in place to enable the procurement and preparation of healthy meals.

The guidelines contain practical nutritional planning and menu design guidance for primary schools taking into account the reference values of daily energy, protein, carbohydrates, fibre, fat, minerals, vitamins and water for children aged between 7-18 years (Table 1 and 2). Moreover, dietary recommendations for food intake (number, type and schedule of meals and food types, food types that need to be avoided or less frequently consumed) are also provided. Each school, depending on their own preferences and resources, decides how many meals (max 4; min 1) they serve per day. In accordance with this decision, each school is expected to follow the instructions on the recommended energy intake as outlined in the National Guidelines. Where a school only prepares 1 meal, namely lunch, according to national guidelines, this lunch should provide 35% of daily energy (Real value from 584 to 714 kcal per day for children 7-9 years) whereas a school who prepares multiple meals must spread the total daily energy value across the multiple meals and in total these multiple meals should not exceed 35% of daily energy.

[8] http://www1.zagreb.hr/slglasnik/index.html#/akt?godina=2017&broj=250&akt=875FFD7FC6605D30C1258205003D1F23

Table 1. Recommended daily intake of energy and nutrients according to age and gender for planning school nutrition

Component	7-9 years		10-13 years		14-18 years	
	Female	Male	Female	Male	Female	Male
Energy (kcal/day)	1740	1970	1845	2220	2110	2755
Proteins (% of energy/day)	10-15		10-15		10-15	
Proteins (g/day)	43.5-65.3	49.3-73.9	46.1-69.2	55.5-83.3	52.8-79.1	68.9-103.3
Fats (% of energy/day)	30-35		30-35		25-30	
Fats (g/day)	58.0-67.7	65.7-76.6	61.5-71.8	74.0-86.3	≤ 70.3	≤ 91.8
Saturated fatty acid (% of energy/day)	≤ 10		≤ 10		≤ 10	
Saturated fatty acid (g/day)	≤ 19.3	≤ 21.9	≤ 20.5	≤ 24.7	≤ 23.4	≤ 30.6
Carbohydrates (% of energy/day)	>50		>50		>50	
Carbohydrates (g/day)	>217.5	>246.3	>230.6	>277.5	>263.8	>344.4
Simple sugars (% of energy/day)	<10		<10		<10	
Simple sugars (g/day)	<43.5	<49.3	<46.1	<55.5	<52.8	<68.9
Fibre (2.4 g/MJ or 10 g/1000 kcal)	>10		>10		>10	
Fibre (g/day)	>17.4	>19.7	>18.5	>22.2	>21.1	>27.6

f-female, m-male

Guidelines also contain Recommended daily intake of vitamins and minerals according to age (Table 2).

Table 2. Daily recommended intake of vitamins and minerals

Component	7-9 years	10-13 years	14-18 years
Vitamin A (equivalent mg RE)	0.8	0.9	1.03
Vitamin D (calciferol) (µg)	5	5	5
Vitamin E (mg equivalent)	9.5	12	13.25
Vitamin K (µg)	30	40	57.5
Vitamin B_1 (thiamine) (mg)	1.0	1.1	1.2
Vitamin B_2 (riboflavin) (mg)	1.1	1.3	1.4
Niacin (mg equivalent)	12	14	15.75
Vitamin B_6 (pyridoxine) (mg)	0.7	1.0	1.4
Folate (µg equivalent)	300	400	400
Pantothenic acid (mg)	5	5	6
Biotin (µg)	15-20	20-30	27.5-47.5
Vitamin B_{12} (µg)	1.8	2.0	3.0
Vitamin C (mg)	80	90	100
Sodium (mg)	1380	1380	1600
Chloride (mg)	690	770	830
Potassium (mg)	3800	4500	4700
Calcium (mg)	900	1100	1200
Phosphor (mg)	800	1250	1250
Magnesium (mg)	170	240	342.5
Iron (mg)	10	13.5	13.5
Iodine (µg)	130	150	175
Fluor (mg)	1.1	2.0	3.05
Zinc (mg)	7.0	8.0	8.38
Selenium (µg)	20-50	25-60	27.5-65
Copper (mg)	1.0-1.5	1.0-1.5	1.0-1.5
Manganese (mg)	2.0-3.0	2.0-5.0	2.0-5.0
Chromium (µg)	20-100	20-100	30-100
Molybdenum (µg)	40-80	50-100	50-100

According to national guidelines, lunch should consist of: soups, cooked vegetables or stews, potatoes, legumes and cereals, compound meat with vegetables, potatoes and grain products, poultry meat, fish, eggs and fresh fruit salads and vegetables. The recommended frequency that individual food categories should be served in schools is outlined in Table 3.

Table 3. Recommended frequency of food group intake at lunch during the school-week.

Food Group	Frequency of intake
Milk and dairy products	Every day
Meat, poultry, eggs, legumes, nuts and seeds	Every day with meat served 5 times per week
Fish	At least 1-2 times a week
Cereals, cereal products and potatoes	Every day
Fruit	Every day
Vegetables	Every day
Cereals (e.g. pasta, rice, barley, corn)	One serving every day
Food with high fat, sugar and salt content	A maximum of 1-2 times per month
Water	Every day

At the same time, meals served should be diverse, well balanced, and acceptable to children tastewise and lookwise. Therefore, it is recommended that at least one member of the school kitchen and menu planning staff should also hold a M.Sc. in Nutrition Science, who – besides participation in creating the menus –utilizes his/her know-how to contribute to the variety of food offered at schools. Currently, no staff employed in Croatian primary schools hold an M.Sc. in Nutrition Science. The Zagreb City Department of Education, Culture and Sport currently employs 1 qualified nutritionist (awarded an M.Sc. in Nutrition Science two years ago) who is a member of city's public procurement team and provides nutritional guidance to all kindergartens in the Zagreb.

3. PROFILE OF CASE SCHOOLS

3.1 LOC Case: LOCSchools A and E

3.1.1 School Profiles LOC

LOCSchool E, located in the heart of western Zagreb., is one of the largest schools in this City area with 719 pupils, all of whom have a right to school meals. Interestingly though school meals are more usually taken by younger pupils (1^{st}-4^{th} grades), who stay in a day care and the average school meal uptake for LOCSchoolE is 49%. A relatively low percentage of children (ca. 5%) are eligible for free school meals (children of disabled parents, unemployed parents, children from families that receive social welfare). The current administrator responsible for food procurement, who has been in service for 3 years, has initiated a range of projects and activities on food, health and child development and growth, which reflect a personal interest and commitment to these issues and this school is a true exception in the school meal supply scheme. Due to its infrastructure, resources and location, it produces meals for 12 other schools, therefore running a true and efficient small business. They function completely within the public procurement framework, and use the same suppliers as everyone else (who won the tenders). However, due to their budget surplus, they have had the resources to supplement and enrich the standard meals with healthier products from other, usually local, organic, and family-owned suppliers. They have a large bargaining power and run their kitchen in a very efficient way – not only in terms of food processing, but also in terms of logistics (optimisation of routes and operations).

LOCSchool E is the largest primary school in Croatia located in a city area with a pupil roll of 803 and 0.5% of pupils eligible for free school meals. Based on a decision made by the Head Teacher and due to their judged socially threatened circumstances, 4 pupils receive free food (a milk meal and a lunch). The head teacher actively pursues a healthy packed lunch policy, and encourages peers to make healthier choices. In the school year 2017/2018, LOCSchool E introduced their healthy diet project under the name Child Diet Optimization in the primary school E and the average uptake of school meals is 37% (Table 4), which is lower than the city average. Lunches are prepared in, and delivered from, LOCSchool A and as such it is very interesting to include LOCSchool E in this study, as it is the only school in WP6 Croatia research which serves lunches not made on-site in the school kitchen. That said, LOCSchool E does prepare a milk meal and a snack in house and in accordance to their agreed menu.

Table 4. Pupil roll and meal uptake in (LOC) featured schools

School code	Pupil roll (n)	% free meals	Daily average meals (n)	Average (n)	Daily average uptake across all meals served(%)	Daily average uptake Lunch only(%)
LOCSchool A	719	5%	530 (breakfast) 360 (lunch) 165 (snack)	352	49%	50%
LOCSchool E	803	0.5%	478 (breakfast) 233 (lunch) 180 (snack)	297	37%	37%

3.1.2 Approach to Food and Sustainability Issues

At LOCSchool A, the food procurement manager explained that they do a lot of work on health and nutrition awareness-raising with their children. For example, in 2018 they delivered school based sessions to children to explaining the dietary reasons for a new government policy promoting the serving of fish. The campaign "Today we're having fish, initiated by the Ministry of Agriculture in cooperation with educational institutions at national level, was designed to raise awareness of the importance of domestic fishery and aquaculture products in order to promote the offering of such products more widely to school children and, thus, help them to become part of their healthy meals. The campaign was focused on the youngest children, 1st grade, who were approached and offered packages containing: a can of Adriatic sardine in olive oil, sardines' pâté, and a picture book entitled "Today, we're having fish". LOCSchool A participated in the initiative which in total distributed 40,000 packages across 2,000 Croatian schools.

Also, since 2017, LOCSchool A has participated in the programme entitled *School Honey Day* which promotes Croatian apiaries. The programme is aimed at the promotion of domestic honey, and each ever 1st grade child received a 370 ml jar of honey and an educational picture book. The programme aims to promote local producers - those who hold the certification Med hrvatskih pčelinjaka (Honey from Croatian apiaries) – to increase children's honey intake, raise awareness of the importance of healthy nutrition and nutritional values of honey, and educate students about the importance of beekeeping for the agricultural production and biodiversity as a whole. Initiated by the Ministry of Agriculture, Croatian Agricultural Agency, and Paying Agency for Agriculture, Fisheries, and Rural Development, this programme is focused on the 1st grade primary school children throughout the whole of the Republic of Croatia.

The LOCSchool A's food procurement manager spoke very positively about the relationships they have developed with local suppliers, and which were conveyed as extremely helpful to the smooth running of their school food service. Strong relationships were argued to provide greater flexibility and the development of trust. For example, Fresh Meat (Vajda in 2016/2017 or Igomat (2017/2018), Agrodalm, and ambient food suppliers Naše klasje, Klara, Pik Rijeka, Velpro, Žitnjak and Ledo were all described as willing to adjust their delivery schedules in the event of bad weather, to ensure schools did not run short of items. A specific example was the sharing of information by Agrodalm about forthcoming shortages in the harvest, which would likely cause problems in sourcing pears or tangerines in spring/summer 2017. As a result of this information, LOCSchool A adjusted its forthcoming daily menu to reduce reliance on pears or tangerines, substituting with other fruits.

LOCSchool E has an eco-garden, and students are involved in the sowing, planting and growing of annual plants. with, 84 new plants planted during the 17/18 school year. LOCSchool E also regularly celebrates the Days of Bread and Thanksgiving for fruits of the soil, which involves children's education, workshops, Erasmus visits and the welcoming of Erasmus students. Since 2017, the head teacher, who radiates enthusiasm for spreading healthy eating habits amongst parents and children, has introduced various nutritional related educational initiatives including banning cakes from school menus.

3.1.3 Organisation of School Meals

All primary schools are required to ensure their children receive meals that are compliant with nutritional recommendations. In Zagreb primary schools, approximately 44,300 pupils (74%) are eligible to receive subsidized food paid for by the City of Zagreb through school budgets. To be edible for subsidised school food, children must meet one or more of the following criteria:

- Pupils who are entitled to have **free meals**: milk meal, lunch and snacks are:
- Whose family is recipient of social support;
- Whose parents (applies to both parents or a single parent) are unemployed and regularly registered at the Employment Bureau or haven't received a salary in the last two months
- Children of the Homeland War Veterans with disabilities.

The price of a dairy meal is €0.67 (5.00 HRK), lunch €1.20 (9.00 HRK), and snack €0.34 (2.50 HRK) totalling €2.21/day (16.50HRK) for all 3 offerings. The pupils are entitled to subsidized meal prices, in accordance with the established criteria outlined above and benchmarks of this program. The difference in funds between the subsidized price and the established full price of free and subsidized meals is made payable to the school from the budgetary funds. Parents pay the monthly food price calculated from school records of the number of consumed meals/child with monthly invoices issued by the school to parents. This system also applies to the LOWschools.

In LOCSchool A, menus are planned one month in advance by the cook and the food procurement administrator who are responsible for meal planning. They try to create menus in accordance with the National guidelines. No nutritionist is employed by either LOCschool A or E, and therefore, school staff try to do their best in planning nutritionally compliant school meals. All payments from parents are handled by the school accountant (including sending monthly invoices).

In LOCSchool E, the school accountant, supported by the school accounting clerk, is responsible for: managing applications for free school meals;, the dissemination of payment slips and reminders to parents; preparing monthly invoices; managing daily entry of payments into the accounts; issuing invoices and payment reminders, forced collections, cards, cooperation with parents; supporting the procurement of foodstuffs; managing relationships and cooperation with suppliers; helping with menu creation; and managing the lunch ordering system. .

Lunches are delivered to LOCSchool E from LOCSchool A where they are prepared. LOC School E has limited input into, and impact on, lunch menu planning, though they do communicate with LOCSchool A proving feedback from LOCSchool E children about the lunches, which LOCSchool A takes into consideration and responds to if possible. At LOCSchool E, the milk meal and snack are prepared on-site by LOCSchool E staff, in accordance with the general rules and guidance for primary-school pupils diet of the Croatian Ministry for Health. The seasonal menu is planned by LOCSchool E's dietary team who keep track of wishes/critiques from children, and class teachers.

Table 5 presents examples of four one-week menus for both schools (LOCSchool A sets the menu for all the schools it delivers to, therefore there is ONE menu only in LOC case). As can be seen, the daily menus comprise a single meal option (hot main dish plus a salad or dessert). The main dish is typically a meat and vegetable stew accompanied by bread or potatoes, although the menu also features pasta, gnocchi and polenta-based dishes. Salads most often comprise beetroot, cabbage, lettuce or tomato. Desserts can be milk-based puddings or juice.

Table 5. Sample of school menus in LOCSchools A and E

Season	Monday	Tuesday	Wednesday	Thursday	Friday
AUTUMN/WINTER	Polenta, pork goulash, pickled beetroot, bread	Bean stew with pasta and sausages, rye bread	Soup with noodles, vegetable risotto, corn bread, biscuit chocolate cake	Potato stew with beef, bread, biscuit cake with dried cranberries	Boiled brussels sprouts with potato, breaded hake, bread with sunflower seeds, juice made from syrup
	Green beans stew with beef, bread, dairy dessert "Euforia"	Cooked potato, meatballs in tomato sauce, bread	Vegetable stew with turkey, corn bread, biscuit cake with chocolate and coconut	Bean stew with pasta and sausages, bread with sunflower seeds, juice made from syrup	Mashed potato, spinach with milk, cooked eggs, bread with pumpkin seeds
SPRING/SUMMER	Peas stew with gnocchi and beef, bread, chocolate pudding	Pasta, chicken fricassee, lettuce salad, rye bread	Vegetable stew with turkey, corn bread, vanilla shake	Rice with peas, breaded chicken, cabbage salad, graham bread	Pasta with tuna sauce, cucumber or pickled beetroot salad, bread with sunflower seeds
	Tomato soup, risotto with vegetable and turkey, bread with pumpkin seeds, juice made with syrup	Cabbage stew with beef, graham bread, biscuit cake	Mashed potato, breaded turkey, tomato salad, corn bread	Bean stew with barley and smoked meat, bread, chocolate pudding	Boiled chard with potato, breaded hake, bread with sunflower seeds

3.1.4 Kitchens and Canteens

In the LOCSchool A kitchen, breakfast, lunch and a snack are prepared daily. Apart from their own school needs, the LOCSchool A kitchen also prepares lunch for 12 additional schools. In the kitchen, 3 chefs and 4 assistant cooks, all female, are employed to distribute and stack food, serve food, prepare beverages, wash up the dishes, prepare for lunch service (cooking side dishes, preparing salads, serving snacks (cooking grits and cornflakes), and to undertake general cleaning of the kitchen on Fridays. Twice a year, extractor fans are professionally cleaned. At the end of each month, the chef performs a full stock take of all inventory. LOCSchool A canteen is arranged as an open space (Figure 1) predominantly used for eating lunch. Tables and chairs are generally left in place from day to day. For certain occasions, they are moved away so that space can be used for other purposes as a space for social gatherings for children and their parents.

Figure 29. School canteen and serving counter in LOCSchool A

In LOCSchool E, the kitchen makes all breakfasts and snacks on-site. In addition, they receive, unpack and serve the lunches delivered daily to them by LOCSchool A. In the LOCSchool E kitchen, 2 qualified female cooks are employed who are responsible for distributing and stacking of food, serving food, preparing beverages, washing the dishes, preparing for lunch (cooking side dishes, finishing salads, serving snacks (cooking grits and cornflakes), general kitchen cleaning on Fridays, and stacking food on Mondays, as well as all other tasks referred to in the annual plan and programme of the school and other regulations. The 2 qualified chefs work full-time, 8 hours a day and in addition to kitchen based tasks are also responsible for cleaning the dining hall tables. As in LOCSchool A, the LOCSchool E canteen is arranged as an open space (Figure 2) predominantly used for eating lunch. Tables and chairs are generally left in place from day to day. For certain occasions, they are moved away so that space can be used for other purposes as a space for social gatherings for children and their parents.

Figure 30. School canteen and serving counter in LOCSchool E

3.1.5 Lunchtime Service

In LOCSchool A**,** lunchtime begins at 11:15, lasting 2hrs 45mins, until 14.00. The children are split up into groups and each group has approximately 15-20mins for their lunch. Children from 1st and 2nd grades come to lunch in groups, according to their classes accompanied by their teachers, and they all sit together at a large table. Kitchen staff put cutlery and glasses on the tables before the children come to lunch, as well as baskets with bread and plates with daily salad (salad is served in one bowl/5 students which is placed on the tables). Water is served in a water jugs placed on the tabled, and children usually have they own cups. Also, kitchen staff serve meals from serving carts bringing them to the table where the children are sitting and as such children in LOCSchool A do not queue up to receive their lunch. Every student is served with the same portion with all the elements of meal are already on the plates when placed on the serving carts ready for serving. The children do not have a choice with respect to the quantity of food they are served. Three children from the class bring plates with meals to other students. There is a daily rota with different children in charge each day. The students can take as much bread from baskets and salads from the bowls as they want and, if they want, they can ask for more food. Teachers sit and eat at the same tables as their children, and some of the teachers encourage the children to try out new foods. After lunch, all children need to show them their plates to one of the teachers and they, where needed, try to encourage the children to eat a little more if they notice that they are not eating enough. After lunch, students throw their plate waste in a single (aggregate) bin, and put their cutlery and plates into separate plastic containers. The students from the 3rd and 4th grades then come alone to the lunch, depending on when their classes being and/or end. The kitchen staff serve them the whole lunch (the main dish, salad, bread, and dessert) from the serving tray, and the children sit in available empty seats at the tables provided. No one encourages the 3rd and 4th grade children try out new food, or to finish their meals. After lunch, the 3rd and 4th grade children throw their plate waste in a single (aggregate) bin, and put their cutlery and plates into separate plastic containers.

In LOCSchool E**,** lunchtime begins at 11:45. lasting for 1.5hours until 13.15. Every group has 20 minutes for lunch with children from the 1st and 2nd grade coming first to lunch in groups, according to their classes. The children queue up and the kitchen staff serve them their main dish on a serving tray and, the children then take their lunch and cutlery sitting together as a group at a large table. Before lunch, kitchen staff put baskets with bread and plates with daily salad (1 plate for 5 students) on the table. Glasses and water jugs are also placed on the serving table and children can take the water whenever they want during lunch. The children can take as much bread from baskets and salad from the plates as they want and, if they want, they can take more main meal food. All teachers sit at separate table and they check the 1st and 2nd grade children's plates after they have finished their meal, but they do not encourage them to try out new food or finish their meal. Desserts and juices are served on the teachers' table, and they give desserts out to students after they finish their main meal. 3rd and 4th grade children come alone to the lunch, depending on when their classes begging and/or end. The kitchen staff serve them their whole lunch (the main dish, salad, bread, and dessert) on a serving tray, and they sit in available empty places at the tables. No one encourages them to try out new food, or to finish their meals. After lunch, all students from 1st to 4th grade are responsible for taking their trays to a separate counter for dirty dishes. The kitchen staff throw away the plate waste in a single (aggregate) bin, and put the cutlery and plates into a dishwasher.

3.1.6 Waste Management and Plastics Use

In LOCSchool A, only a small quantity of plastics is used (plastic cups for juice, vanilla shake, chocolate pudding and dairy dessert Euforia). All other food is served on a ceramic/metal plate and/or in non-plastic reusable cups which are washed daily. After the food waste is collected and bagged, 70% is sent to a local family farm usually known to the school and who use the food waste for animal feed and the other 30% is sent to Agroproteinka, an established company with a 60-year long tradition and expertise in collecting and managing animal by-products and who, for the past 10 years, have been using the waste in the production of renewable energy sources. One year ago, bio-gas equipment was installed to support the processing biodegradable waste into biogas, managed via an anaerobic digestor. In this project, Agroproteinka agreed to act as voluntary partners giving all possible support with measurement of plate waste in the 4 plate waste schools.

In LOCSchool E, food waste is first collected in an onsite 50L special food waste container, which is transported from the school on a daily basis. 70% of the collected food waste is sent to a local, and known farm where the waste is used for animal feed. The remaining 30% is sent to Agroproteinka. In terms of non-food waste in LOCSchool E, single use plastic pots are sometimes used for serving pudding and water.

3.1.7 School Fruit and Vegetables Scheme

The "School scheme" began in the school year 2017/2018, and combines two existing school schemes "Fruit and vegetable school scheme" (started in school year 2013/2014) and "Milk program in schools" (started in school year 2015/2016).
The main goals of the new "School scheme" are to:

- increase intake of fresh fruit, vegetables, and dairy products and consequently reduce the intake of foods with high salt, added sugar and fat content;
- raise awareness of the importance of healthy eating and the nutritional value of fresh fruit and vegetables, as well as milk and dairy products;
- provide education programmes to children in order to help reduce food waste.

For implementation of "School schemes" in school year 2017/2018, the European Commission offered financial support for the purchase of fruit, vegetable, and dairy products supplies. Each "School scheme" participating school receives a free meal of fresh fruit, vegetables, and dairy products for each child with fruits and vegetables delivered direct to the schools at least once a week throughout the entire school year with on average weekly provision of 100-150g per children. Milk and dairy products are delivered to schools once a week for at least 12 weeks per school year with on average 150-250ml per child per week. Schools can choose preferred local suppliers, who have signed up for delivering groceries, from the following list:

- fruit - apples, pears, citrus fruits, peaches, nectarines, plumbs, apricots, cherries and berry fruits;
- vegetables - carrot, beetroot, beet, celery, tomato, radishes, and other rooted vegetables;
- dairy products – milk, lactose-free milk, yoghurt, fermented dairy products without added sugar, fruits, flavours, walnuts and cocoa.

In order to help connect the children to agriculture and support their learning about healthy eating habits, provisions for accompanying educational measures via the Annual Action plan are provided about local food supply chains, organic production, sustainable production, including:

- In school Fruit and vegetable courses;
- Support with maintaining the school gardens;
- Visits to local farms.

In February 2017, the Croatian Institute of Public Health published a document titled *"Evaluation of the Implementation of the Scheme of School Fruit and Vegetables for the School Years 2013/2014, 2014/2015, and 2015/2016*". According to this evaluation document, 81.4% of Croatian schools participated in Scheme of School Fruit and Vegetables during the school year 2013/2014, and in the following two years the number of Croatian primary schools participating increased to 86.5%. As such, it can be concluding that schools are aware of the need for improvement of schools' menus and students' diet. The results of the evaluation performed in school year 2014/2015 show that - on average - 40% of students eat vegetables daily in school, and 65% at home during the weekend. Also, one year after the implementation of the Scheme, it was noticed that consumption of fresh vegetables had significantly increased during the school week, and 28% of parents stated that there was an increased consumption of vegetables in their family in comparison to the previous year. After the implementation of Scheme in school year 2015/2016, the results of the evaluation showed that the consumption of fruits and vegetables did not change significantly in comparison to the previous year. However, 44% of parents noticed a significant and positive impact of the Scheme on their children's dietary habits. Also, 30% of parents noticed an increase in fruit and vegetables consumption in their household compared to the previous year while - on average - 70% of parents did not notice the difference in fruit and vegetable consumption (Croatian Institute of Public Health, 2017).

3.2 LOW Case Schools: LOWSchools A and C

3.2.1 School Profile LOW

LOWSchool A, a primary school located in the western Zagreb, has pupil roll of 390 pupils (195 girls, and 195 boys), making it a medium-sized Zagreb city school. In in-class teaching (younger 1st and 2nd grade children), a total of 200 pupils are schooled, 105 of which are girls and 95 boys. In subject teaching (older 3rd and 4th grade children), there is a total of 170 pupils (80 girls and 90 boys). The pupils come from a diverse range of family types with different socio-economic status. Their catchment area covers facilities in which war veterans, disabled veterans, and socially threatened families are accommodated, with some coming from such families. Also, their settlement is close to a mosque, so the school has children who adhere strictly to Islamic customs and as such the Islamic children are offered an alternative meal when pork is served. Therefore, the sociologic structure of LOWSchool A pupils is diverse. Day care is organized children in the 1st and 2nd grade, with 73 pupils in the day care programme for the 17/18 school year. The average uptake of school meals is 37% (Table 6), which is slightly lower than the regional average and 3% of children are eligible for free school meals.

LOWSchool C, a primary school serving an eastern part of Zagreb City, was first opened on the 1st October 1964 in the district of Borongaj-North, on vegetable farmers land. It has a current pupil roll of 368, making it a medium-sized Zagreb city school. In the past 2 years, pupils numbers have increased due to an influx of families who have move into their admission area and an earlier admission of older siblings being encouraged. Most parents have secondary education qualifications with only a small number of pupils eligible for free meals. The average uptake of school meals is 58% (Table 6), well above the regional average.

Table 6. Pupil roll and meal uptake in (LOW) featured schools

School ID	Pupil roll (n)	% free meals	Daily average meals (n)	Average (n)	Daily average uptake (%)	Daily average uptake Lunch only(%)
LOWSchool A	390	3%	278 (breakfast) 85 (lunch) 69 (snack)	144	37%	22%
LOWSchool C	368	5%	296 (breakfast) 222 (lunch) 127 (snack)	215	58%	60%

3.2.2 Approach to Food and Sustainability Issues

LOWSchool A took part in "the healthier, the happier, Erasmus + 2014 – 2016" initiative - an EU-funded project which promoted healthy lifestyles which included campaigns related to the development of healthy dietary habits, public discussions, tastings of healthy, locally grown foodstuffs, setting up a billboard promoting seasonal and healthy foodstuffs, and drafting of a healthy cookbook. At the beginning, and end, of the project, evaluations were conducted. LOWSchool A was involved as a partner in that project which involved mobility of school staff and student, as well as visits from organizations and other partners to LOWSchool A. Another important imitative in which LOWSchoolA participates is the School scheme (a school fruits and school milk scheme) – a national/European funded project which funds the provision of one fruit and one milk meal per week per school child in almost 85% Croatian primary schools. In 2017/2018 LOWSchool A was also involved with the project entitled “Hidden Calories”. This involved running workshops for 3rd grade pupils on a healthy diet and hidden calories in industrially processed food. The workshops were designed and delivered by medical students from the Medical Faculty at University of Zagreb in cooperation with the Public Health Institute representative “Dr. Andrija Štampar”.

Also, in LOWSchoolA every October, **Days of Bread** are celebrated. During Thanksgiving for the fruits of the soil, the in-class teaching pupils carry out a number of activities during and after their classes – reading relevant texts, writing, drawing, and singing. The central celebration is held the school hall and involves decorating the holiday table with fruits of the soil. The pupils from 4th grade also visited a mill from Lovrak’s novel “Družba Pere Kvržice”.

LOWSchool C has pursued a number of health and food-related initiatives in recent years, reflecting a personal enthusiasm and commitment of the Head Teacher. This school has an urban garden, and through practical hands on work in the garden the children are getting acquainted with soil cultivation tools and are learning how to operate certain tools. Through fun and physical contact with the soil, issues including environmental protection and nature are being brought closer to children applying methods and language they understand. Through their work in the garden, children have an opportunity to see how: their grandparents sowed; how to develop and grow an organic garden, and that vegetables don’t come from the refrigerator, but from the garden, which needs our care and affection. These workshops are carried out with the support of the association O.A.Z.A. A Zagreb based organisation, O.A.Z.A. (sustainable alternative to community) was founded in January 2013 with the aim to organise various youth programmes, in a pleasant and motivating atmosphere, helping children to develop their own potential and become responsible and exemplary leaders of sustainable social change.

3.2.3 Organisation of School Meals

The price and the school meal ordering system for LOWSchools A and C are the same as described for the LOC model (pages 13-14). In LOWSchool A, menus are planned on monthly basis in accordance nutritional recommendations from the responsible ministry or the City office related to children's diet in primary schools and three chief cooks (2 women and 1 man) are responsible for food ordering and managing food supplies. An interesting initiative, first suggested by the IT professor (see appendix X), and driven by the enthusiasm of the chief cooks, an illustrated school cookbook has been published featuring all the dishes prepared in the school kitchen. The pictures are also uploaded onto the school website so parents can also see them.

In LOWSchool C, a group of school staff are collectively responsible for food ordering including the: school accountant, administrator, chief cooks, a specialist teacher and the headteacher. The cooks, supported by the LOWSchoolA Chemistry and Biology teacher (the school team) plan their school menus on a monthly basis. This is not unusual in Croatian schools – especially for those LOWSchools as the chief cook usually needs some advice or support or help from other school staff be it the headteacher, or some proactive teacher from specialist areas and/or who is interested in being involved in the planning and management of the school food provision and meal service.

Four examples of one-week menus for both LOWSchools are presented in Table 7. Salad is not listed very often on these menus, as cooked vegetables are usually served in form of stews and in such cases salad is not provided as a matching component to meal. As can be seen, the menus are quite similar to the LOC case, comprising a single option hot main dish, plus salad or dessert, and the main dish is typically a meat and vegetable-based stew, with bread or potatoes. However, in LOWSchools pasta appears more frequently as a main dish compared to LOCSchools. The LOWSchools generally do not serve desserts as they have limited budgets and instead choose to spend available resources on the main meal and cooks are too busy to preparing the main meal every day from scratch to regularly serve dessert. On some occasions, they cook homemade pudding, or pie with fruits, or marble cake. In spring time, they served ice-cream (a few times per whole term)

Table 7. Sample of school meals in LOWSchool A and LOWSchool C

Season	Monday	Tuesday	Wednesday	Thursday	Friday
AUTUMN/WINTER	Polenta, sauerkraut goulash, bread	Bean stew with sausages, bread	Soup with noodles, mashed potato, turkey burger, pickled peppers, bread	Peas stew with chicken, bread	Risotto with tomato and hake, lettuce salad, bread
	Risotto with turkey, pickled beetroot, corn bread	Green beans stew with chicken, corn bread	Polenta, beef goulash “pašticada”, corn bread	Peas stew with turkey, corn bread	Spaghetti with shrimps and tomato sauce, lettuce salad, corn bread
SPRING/SUMMER	Polenta, beef goulash, pickled mixed vegetable, bread	Green beans stew with chicken, bread	Domestic pasta “Mlinci”, roasted chicken, lettuce and chicory salad, bread	Bean stew with barley and smoked meat, cabbage salad, bread	Potato stew with haddock, bread
	Mashed potato, roasted turkey, cabbage salad, bread with sunflower seeds	Peas stew with turkey, corn bread	Spaghetti with chicken sauce, corn bread	Polenta, beef in mushroom sauce, corn bread	Pasta with cottage cheese, corn bread

3.2.4 Kitchens and Canteens

In LOWSchool A, breakfast, lunch and a snack are prepared on-site daily. There are 3 kitchen based employees (1 female and 2 males – 1 chief cook and 2 assistants), working 8 hours per day who are in charge of preparing and serving all meals and beverages and washing up the dishes. They are not responsible for cleaning the dining hall. The school canteen, which is occasionally used for other purposes than lunch service, is a relatively small space, and not all students have a place to sit down at once (some of them stand during the meal at high tables) (Figure 3).

Figure 31. School canteen and serving counter in LOWSchool A

In LOWSchool C, a breakfast, lunch and snack are also prepared onsite daily. The cooks and the chemistry and biology teacher (the school team) plan the school menus. Three kitchen based employees, a chief cook and two catering assistant (one full-time, one part–time) are responsible for hygiene, cleaning of the kitchen, and monthly examinations by the public health institute. The school canteen is shown in Figure 4.

Figure 32. School canteen and serving counter in LOWSchool C

3.2.5 Lunchtime Service

In LOWSchool A, lunchtime begins at 12:00 and lasts until 13:30, with each group of children having 15 minutes for lunch. Only 1st grade children, who stay in day care, come to lunch as a group. All other children come alone to the lunch, depending on when their classes begin/end.

The kitchen staff serve standard sized portions of the main meal to all children from the service counter and, after children take their lunch, they find an empty seat to sit at. Children get all lunch components on their tray at once and the pick up their salad, cutlery and/or bread at the end of the serving counter. The basket with bread is located at the end of the serving line, and children can take as much bread as they want. Also, if they want, they can get more main meal food if they want. Children are used to bringing their own bottles with water into the canteen as they do not have access to water in the canteen during lunchtime. Teachers can decide where they want to sit – next to children or with their own colleagues. The kitchen staff encourage the children to try new food, or to finish more of their meals. After lunch, all children from 1st to 4th grade are responsible for taking their trays back to the service for waste processing and washing. The kitchen staff throw away the plate waste into a single (aggregate) bin, and put the cutlery and plates into a dishwasher.

In school LOWSchool C**,** lunchtime begins at 11:30 lasting for 2.5 hours till 14:00. Every group of children spend 45 minutes for lunch from queuing for food, finding a place to sit, eating their lunch and returning their dishes. This is much longer than in all other LOW and LOC schools. On average, the children were observed to take about 30 minutes to finish their meal, but they can stay longer if needed. The big canteen space, food service organisation and the number of students having lunch in LOWSchoolC all combine to facilitate this longer lunchtime period.

LowSchoolC kitchen staff serve the main dish and salad on a serving tray (the same size portion whatever the child's age) and, after children take their lunch, they sit at tables of 4. On every table, the kitchen staff put a basket with bread and cutlery. The students can take as much bread from basket as they want and, if they want, they can take more main meal food by asking at the counter. All teachers sit at another table, though they were observed checking children's plates after the meal, and putting in a lot of effort to encourage their children to eat almost all their lunch. Also, the teachers encourage the students to try out new food. The 4th grade students come alone to the lunch, depending on when their classes begging/end. The kitchen staff serve them their whole lunch (the main dish, salad, bread, and dessert) on a serving tray, and they then find an empty sit to sit at. As with the younger children, the teachers and kitchen staff encourage the 4th graders to try out new food, or to finish their meals. Water glasses and water jugs are available at the tables and children can serve themselves throughout their lunch. After lunch, all children, from 1st to 4th grade, are responsible for putting their trays on the window for ready for washing. The kitchen staff throw away the plate waste into a single (aggregate) bin, and put the cutlery and plates into a dishwasher.

3.2.6 Waste Management and Plastics Use

In LOWSchool A, waste management consists of a partial waste separation (3 non – food items are separated from each other – 1. glass, 2. cardboard and paper, 3. plastics). Single use plastics are used in the form of dishes used for storage and preparation of foodstuffs (e.g. plastic cups are used for serving cooked puddings prepared in school). Food waste is separated into two categories - bread and other food. The collected food waste is sent usually to a locally known family farm who use it for animal feed, especially the waste bread. The rest of the waste is taken by Agroproteinka, as per LOCSchool.

In LOWSchool C, non-food waste is separated from the food waste - there are no waste stations (no bins for separation of paper, plastic and glass), and only small amounts of non-food waste were observed. Sometimes this school uses single use, disposable plastics (disposable cutlery, disposable cups/plates, beverages, etc.). The collected food waste is sent to a locally owned family farm known to school staff as well as an official company, Agroproteinka, who specialise in waste disposal.

3.2.7 School Fruit and Vegetables Scheme

LOWSchools participate in the Fruit and Vegetables Scheme in the same as described for LOC schools (see Section 3.1.7).

4. Nutritional Composition of Menus in Case Schools

Section 4 presents the results of the nutritional composition analysis of the selected menus from two LOCSchools A&E and LOWSchools A&C. The results present the intended nutritive value of case school lunches, based on student intake of the full standard portions. As described in Section 1, food composition analysis was carried out on 40 daily menus (over two weeks/seasons), 20 in LOC case schools and 20 in LOW case schools. The nutritive value of school meals was calculated using Croatian National Food Composition Tables.

Lunch is considered to be one of the most important meals during the day, contributing significantly to the total quality of nutrition provided to school children. The Croatian National guidelines for the nutrition of primary-school students gives recommended energy and nutritive values for school lunches. Table 8 provide recommended energy and nutritive values of school lunches which is calculated from the national guideline which propose that lunch should provide 35% energy of total daily intake.

Table 8. Recommended energy and nutritive values of school lunches (National guidelines for Croatia, 2013)

	Recommended energy and nutritive value for primary school children	% of total daily intake
Energy and Macronutrients:		
Energy	584-714kcal	35%
Carbohydrate	>81 g	>50% of meal energy
Fat	21.6 – 25.2 g	30-35% of meal energy
Saturated fatty acids	≤7.2 g	≤10% of meal energy
Fibre	>6.5 g	>10 %
Protein:	16.2 – 24.3 g	10-15 % of meal energy
Vitamins:		
Vitamin A	0.3 mg RE	35%
Vitamin B_1	0.3 mg	35%
Vitamin B_2	0.4 mg	35%
Niacin	4.2 mg	35%
Vitamin B_6	0.2 mg	35%
Folate	105 µg	35%
Vitamin B_{12}	0.6 µg	35%
Vitamin C	28 mg	35%
Vitamin D	1.7 µg	35%
Minerals:		
Sodium	482 mg	35 %
Potassium	1329 mg	35 %

Calcium	315 mg	35 %
Magnesium	59 mg	35 %
Phosphor	280 mg	35 %
Iron	3.5 mg	35 %
Zinc	2.4 mg	35 %
Copper	0.3 mg	35 %

The analytical procedure was as follows. First, we confirmed the food composition of the 40 daily menus with school catering staff, according to the normative for a standard portion (i.e. the specific ingredients comprising the main dish, salad and dessert, along with the ingredients' weights and whether cooked/uncooked). This data was then entered into a bespoke database and analytical tool (foodpbf.com) created by University of Zagreb for the Strength2Food project. Using this tool, the meal normative for the LOC and LOW case menus were analysed and a full energy, macronutrients and micronutrient profile of a standard portion of lunch for each of the daily menus in the LOC and LOW cases was produced. The tool also compared the produced profiles with the Croatian national nutritive guidelines.

In the results that follow (Figures 5-8), the proportions are presented of the daily menus from both cases which achieved the recommended energy, macronutrients and micronutrient shown in Table 8. To begin with however, we present a consolidated summary of the energy, macronutrients and micronutrient profiles of an average daily menu at LOC and LOW schools, respectively (Table 9). These data were produced by averaging the energy, macronutrients and micronutrient profiles across all 20 daily menus in LOC and LOW schools, respectively. The results are expressed per standard portion as average ± standard deviation.

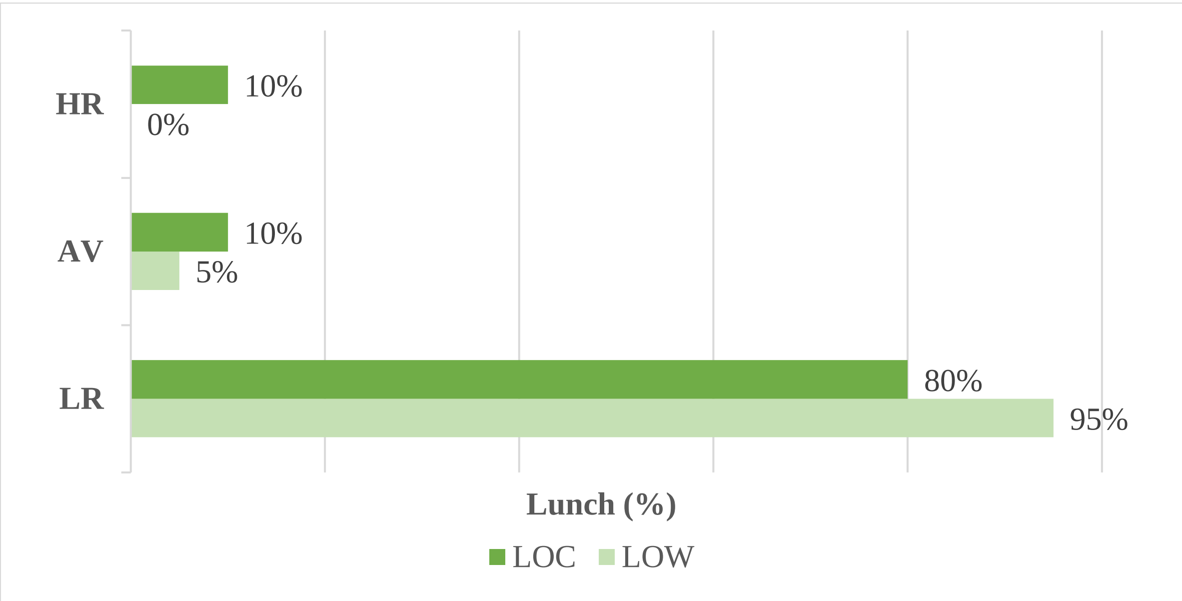
Table 9. Energy and nutritive values in the average lunch at LOC and LOW case schools

Parameter	LOC	LOW	ω^2-ANOVA
Average weight of standard portion	472g	293g	
ENERGY and MACRONUTRIENTS (average ± SD)			
Energy (kcal)	525 ± 115	352 ± 124	0.0279 (no effect)
Total proteins (g)	18.0 ± 5.4	19.8 ± 742	0
Total carbohydrates (g)	66.4 ± 14.8	48.8 ± 19.5	0.0127 (no effect)
Dietary fibre (g)	4.6 ± 2.7	3.3 ± 3.0	0.0077 (no effect)
Total fat (g)	21.7 ± 9.4	9.2 ± 5.1	0.0259 (no effect)
Saturated fatty acids (g)	4.6 ± 2.7	2.7 ± 2.0	0.0079 (no effect
VITAMINS			
Vitamin A (mg RE)	0.16 ± 0.19	0.09 ± 0.07	0.0314 (no effect)
Vitamin B_1 (mg)	0.25 ± 0.15	0.19 ± 0.10	0
Vitamin B_2 (mg)	0.22 ± 0.14	0.17 ± 0.07	0.0077 (no effect)
Niacin (mg)	3.71 ± 2.69	5.14 ± 3.62	0
Vitamin B_6 (mg)	0.32 ± 0.25	0.27 ± 0.19	0
Folate (µg)	*na*	*na*	/
Vitamin B_{12} (µg)	*na*	*na*	/
Vitamin C (mg)	25.36 ± 23.64	15.98 ± 16.13	0.0255 (no effect)
Vitamin D (µg)	*na*	*na*	/
MINERALS			
Sodium (mg)	1086.57 ± 331.50	878.15 ± 521.87	0.0010 (no effect)
Potassium (mg)	645.11 ± 482.09	564.08 ± 427.32	0.0036 (no effect)
Calcium (mg)	49.46 ± 36.76	45.99 ± 28.45	0.0063 (no effect)
Magnesium (mg)	34.38 ± 28.33	31.19 ± 22.35	0
Phosphor (mg)	171.32 ± 89.93	227.57 ± 100.74	0
Iron (mg)	2.27 ± 1.10	2.25 ± 1.12	0
Zinc (mg)	0.68 ± 0.50	0.65 ± 0.51	0
Copper (mg)	0.32 ± 0.35	0.21 ± 0.19	0.0038 (no effect)

na-data not available from the national food composition database

As shown in Table 9, the average energy provided in a standard portion of lunch in LOC schools amounted to 525kcal (± 115), compared with only 352kcal (± 124) in LOW schools. This result is consistent with the fact that the standard average lunch portion in LOC schools, at 472g/portion, is much higher than the 293g/portion in LOW schools. Table 9 also shows that for all macronutrients, planned intake was higher in on average LOC compared to LOWSchool, with the exception of total proteins (g). In terms of vitamins and minerals, the results were more mixed with the average provision in LOC school lunches higher for three of the six vitamins, and six of the eight minerals analysed. The average sodium content of lunch for the LOC and the LOW models was 1086 mg and 878 mg respectively, both exceeding lunch recommendation of 482 mg but also almost exceeding the daily sodium recommendation of 1380 mg. In order to allow for the correction of sodium content in the school lunch, reasons for that have to be determined, i.e. the sources of sodium in the school lunch (e.g. natural sources, salt added to dishes during food preparation, processed food).

The next set of results focus on the daily menus, and show the proportions of the 20 menus per case which met the national nutritional guidelines (Table 8). First, we present the energy provision of the daily menus. According to the National Croatian school food guidelines, a school lunch should provide 35% of a child's daily energy requirements i.e. between 584 to 714 kcal. Our results show that only 10% of school lunches from the LOC case, and 5% from the LOW case, are of the adequate calorific value (Figure 5). Instead, the majority of analysed school lunches, 80% in the LOC schools and 95% in the LOW schools, had energy values below recommended in the National guidelines and 10% from the LOC model only having higher that recommended energy values. Over a long period of time, this could become a significant problem, which, ultimately, could result in a lower daily intake of energy. An inadequate intake of energy in school meals can at the same time indicate an inadequate intake of micronutrients, as it will be shown below.



Note: HR – higher than recommended, AV- adequate value, LR – lower than recommended; National guidelines for school meals for children in primary schools

Figure 33. Proportion of daily menus in LOC and LOW cases that met National recommendations for energy

Next we report the macronutrient content of the daily menus and compare to national guidelines. The macronutrient content was evaluated by calculating the energy percentage of each macronutrient and comparing the two models, as shown in Figure 6. The energy contribution of carbohydrate in both models reached 50% of energy, which is the minimum recommended level. Therefore, menus in both models were found to be achieving the national guidelines for carbohydrate. The nationally recommendations say that no more than 30-35% of meal energy should come from total fat. Figure 6 shows that school lunches from the LOW model are below recommend total fat levels, while lunches from the LOC model exceed this recommendation. Finally, in terms of protein, figure 6 shows that lunches from the LOC model are within national recommendation for proteins (10-15 %) while the levels in the LOW model exceeds this recommendation. Excessive protein is not a concern for children in this age group, as proteins are a significant building component in children who are growing and developing. Therefore, it can be concluded that the average proportions of protein in daily menus for both LOC and LOW models are in line with national recommendations.

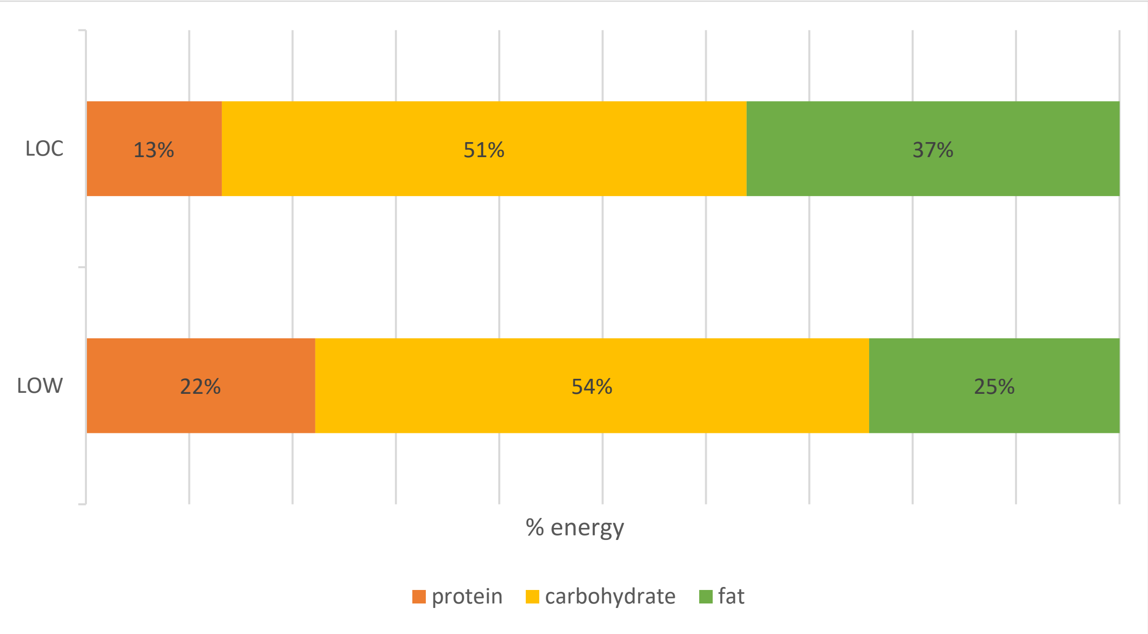
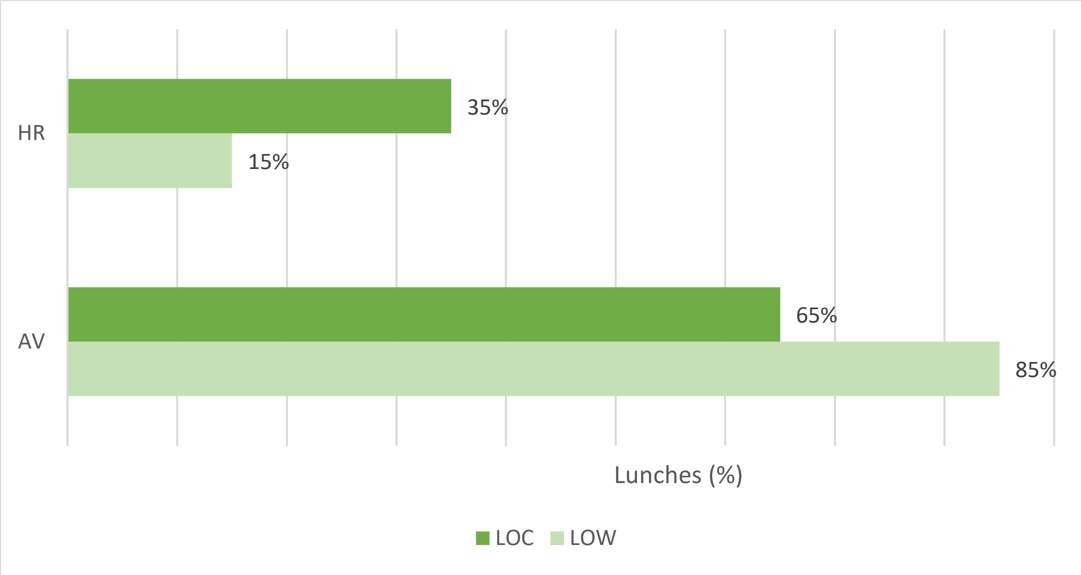


Figure 34. Average proportions of macronutrients in terms of % meal energy in daily menus of LOC and LOW cases

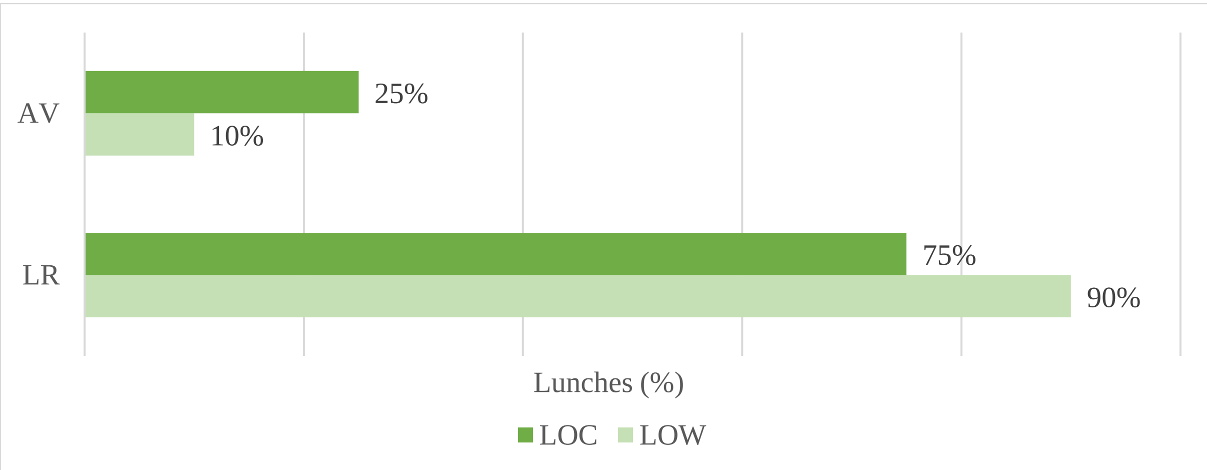
According to the national recommendation, no more than 10% of meal energy for a school lunch should come from saturated fatty acids. Our results show that although the majority of lunches in both LOC (65%) and LOW (85%) achieved this recommendation, the proportions differed with 85% of LOW menus compliant, while only 65% of LOC menus were compliant (Figure 7). Therefore, over 35% of daily LOC menus were found to have excessive levels of saturated fatty acids. As a part of a healthy diet, it is important not only to reduce the amount of total fat, but also to reduce saturated fat levels replacing with unsaturated fats. Based on this menu analysis, it can be assumed which food is the major source of saturated fats (> 10% of meal energy): old animals e.g. meal with beef instead meal of calf; some dairy products including cheeses and whole milk, butter, creams and some cooking oils. Healthier alternatives are available though they depend on how meals are prepared and changes may be required to reduce saturated fat intake e.g. bake rather than fry meat; Steam rather than fry fish etc. Therefore, an important first stage, before creating new menus, is to conduct a comprehensive analysis of the sources of saturated fats in LOC school lunches.



Note: HR – higher than recommended, AV- adequate value; National guidelines for school meals for children in primary schools

Figure 35. Proportions of daily menus in LOC and LOW cases that met National recommendations for saturated fatty acids

Next we report the fibre content of the daily menus. Our results show the fibre content of analysed LOC and LOW menus is concerningly low. Only 25% of LOC menus and 10% of LOW menus offer the recommended amount of dietary fibre (Figure 8). School menus urgently need to be redesigned to increase the content of fibre by for example increasing the amount and type of naturally-occurring plant-based foods high in dietary fibre, including whole-grain foods, cooked dry beans and peas, vegetables, fruits, and nuts.

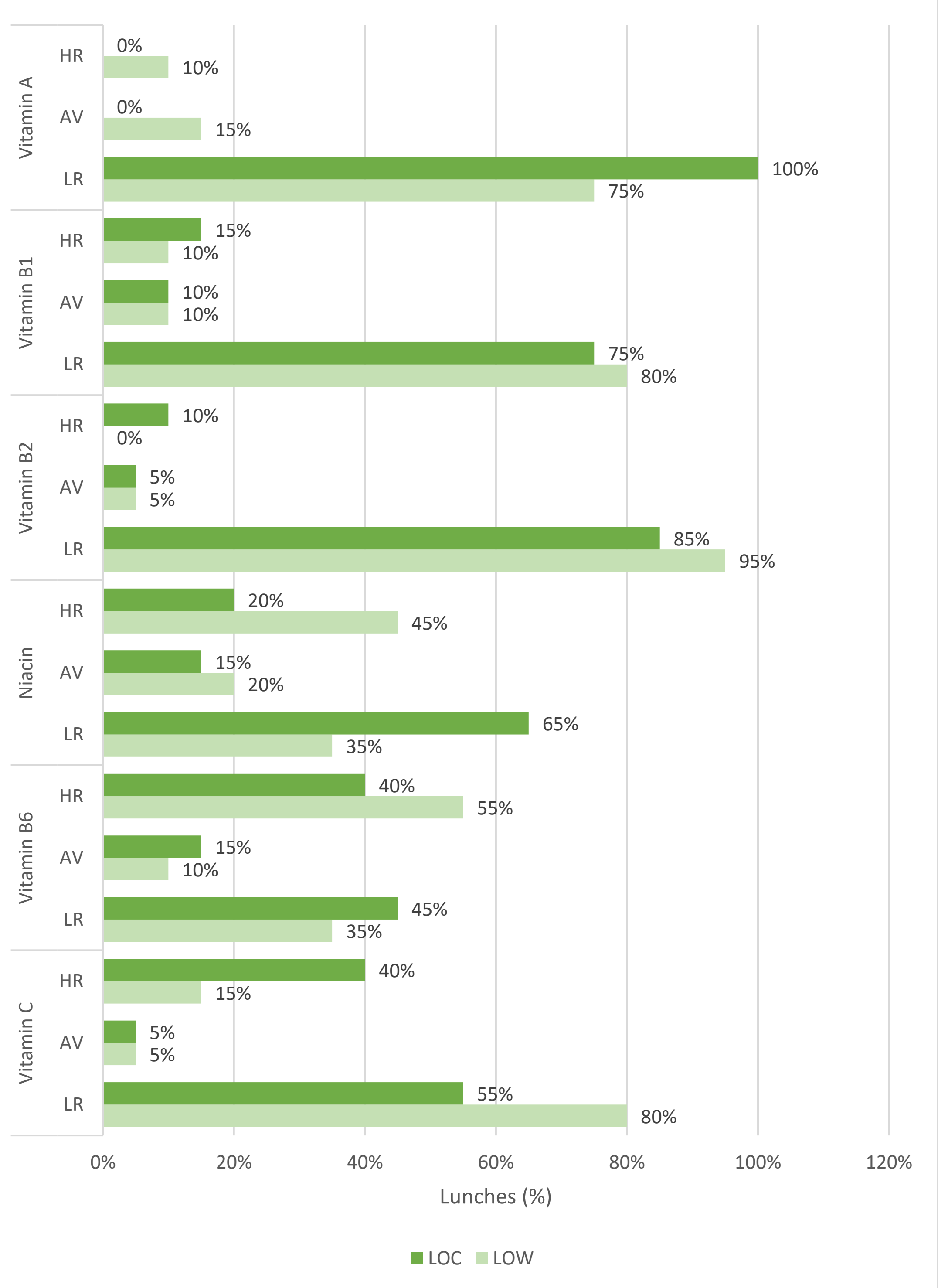


Note: AV- adequate value, LR – lower than recommended; National guidelines for school meals for children in primary schools

Figure 36. Proportions of daily menus in LOC and LOW cases that met National recommendations for dietary fibre

Next, we report vitamin content of the daily menus. As illustrated in Figure 9, the majority (50% or more) of both LOC and LOW menus below the for Vitamin A, Vitamin B1, Vitamin

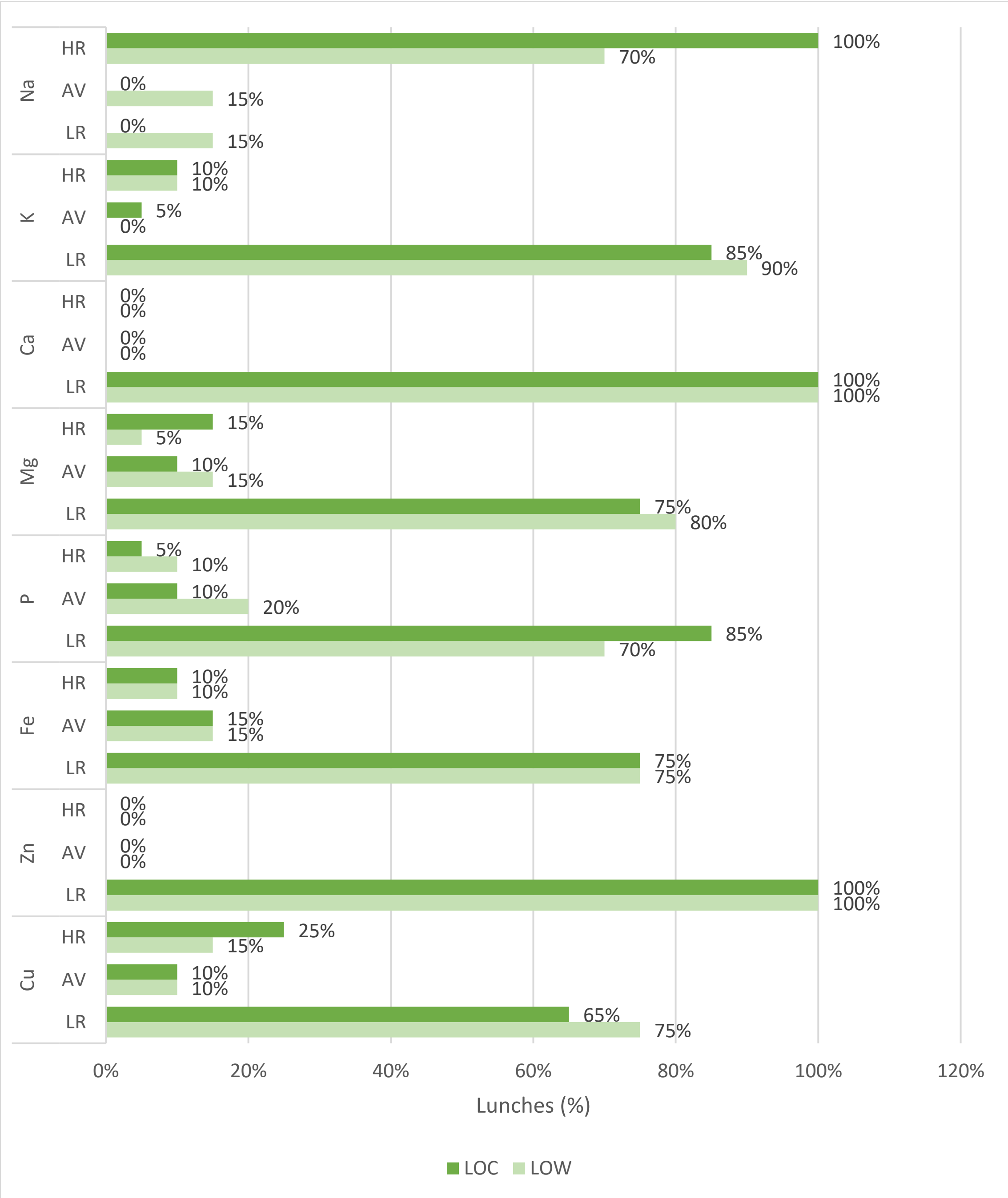
B2 and Vitamin C. In addition, the majority of LOC menus provide insufficient Niacin. The only vitamin where the majority of menus across the cases achieve or exceed national recommendations is Vitamin B6.



Note: AV- adequate value, LR – lower than recommended; National guidelines for school meals for children in primary schools

Figure 37. Proportions of daily menus in LOC and LOW cases that met National recommendations for vitamins

Finally, we report the mineral content of the case menus (Figure 10). As can be seen, the majority (50% or more) of LOC and LOW menus provide lower than recommended levels for 7 of the 8 minerals analysed, and in six of these (Potassium, Calcium, Magnesium, Phosphorus, Iron and Zinc), the proportion of menus deficient was 70% or more. Interestingly, only for sodium (Na) were the majority of LOC and LOW menus found to exceed national guidelines.



Note: AV- adequate value, LR – lower than recommended; National guidelines for school meals for children in primary schools

Figure 38. Proportions of daily menus in LOC and LOW cases that met National recommendations for minerals

In summary, the nutritional composition analysis shows that there are nutritional deficiencies across the analysed LOC and LOW menus. Although the menus analysed were found to meet National Recommendations for carbohydrate and protein content, they were found to be insufficient in terms of energy and fibre, and a high proportion contained excessive levels of fat and saturated fat. In addition, the majority (50% or more) were found to be deficient in a range of vitamins (A, B1, B2 and C), with only Vitamin B6 being found at recommended levels. For minerals, the majority (50% or more) of analysed menus, across the cases, provided lower than recommended levels for 7 out of 8 minerals analysed, and in six of these (Potassium, Calcium, Magnesium, Phosphorus, Iron and Zinc), the proportion of deficient menus was 70% or more. Interestingly, only for sodium (Na) were the majority of LOC and LOW menus found to exceed national guidelines.

5. PLATE WASTE IN CASE SCHOOLS

This section reports the results of the plate waste study. As explained in Section 1, the plate waste was collected during the 2017/18 school year in the 4 schools on which the FCA of selected menus was undertaken: LOCSchools A and E (LOC case) and LOWSchools A and C (LOW case). In each school, plate waste was collected for five consecutive days (one school week) per two seasons (autumn/winter season and spring/summer) with a total of 20 days of collection activities completed per case. On the selected data collection days, plate waste was collected from the plates/trays of all children who took a school meal totalling 3793 LOC plates (52% from boys and 48% from girls), and 2183 LOW plates (44% from boys and 56% from girls) respectively. In both cases, the children were aged between 7 to 10 years.

Modified aggregate selective plate waste was the method used for the collection of plate waste data (Comstock et al., 1979). On each data collection day, three random samples of the served meals were weighed, and an average was calculated as a reference point for the average weight per meal served. Then, on completing their lunch, the children brought their finished plates/trays were to the waste station, where a researcher was waiting to take it and separate the different components of the plate waste into 6 food category specific bins namely: (1) fruit (fresh fruit); (2) vegetables (including mixed vegetable stews, legume stews, vegetable soup, fresh and canned salads, side dishes that encourage the intake of vegetables and contain more than 30% of vegetables in the composition, and meal components that couldn't be divided, e.g. rice and peas, mixed vegetable with rice, pasta with cabbage); (3) meat, fish and other protein (all meat and meat products, fish and fish products, and poultry and poultry products, eggs); (4) starchy foods (e.g. bread, pasta, rice, potatoes, cereals, bakery products, main dishes mainly containing starchy foods with other items that couldn't been separated, e.g. pasta with Bolognese sauce, risotto with beef); (5) desserts (foods that are part of the school menu and listed as "dessert", e.g. puddings, cakes, shakes, dairy desserts, fruit yoghurt); and (6) other food (food served during lunch time in school, which is not included in the first five groups, e.g. soup with noodles, juice made with syrup).

As explained in Section 1, and as part of a parallel research project conducted by University of Zagreb, permissions were granted by the participating schools to obtain feedback from children about the observed meals. On each plate waste collection day, all students were issued with a survey sheet along with their tray and meal. After children had finished their meal, they were asked to indicate their food preferences using a five-point 'faces' scale (scores 1 to 5; 5 being the most preferable). Also, if the students did not finish their meal, they were asked to choose the reasons why: „I didn't like the taste of the food ", „I didn't like the smell/looks of the food ", „I don't eat this at home ", „I am not hungry ", „I cannot eat that much food ", „I didn't have enough time ", „I didn't try the food ". Finally, the children noted their gender and grade on the food preference questionnaire.

The plate waste results are organised as follows. First, we present the total weight of plate waste collected across all food category bins for the 20 days per case (Section 5.1). Next, we report the food category composition of the waste across both cases (Section 5.2). Third, we present the results of the student survey, which reveals students' views of the food and the reasons why they did not finish their meals (Section 5.3). We then present our analysis of the nutritional losses associated with the plate waste across both cases (Section 5.4), and finish with our analysis of the estimated financial cost, and levels of embodied carbon, associated the collected plate waste (Sections 5.5 and 5.6).

5.1 Total Plate Waste in LOC and LOW Cases

Food waste occurs at all stages of the food service system, but specifically plate waste refers to the weight or percentage of edible served food which remains uneaten by subjects to whom it has been served. While there are no standards for acceptable levels of plate waste, some studies have suggested that 12% of plate waste is not excessive (Buzby and Guthrie, 2002). In a school context, recent literature indicates that plate waste in school canteens can vary from 9-45% of served food, with the main reasons given for such great discrepancies being age of students, duration of the lunchtime, timing of the lunchtime, encouragement of the students by the school staff to finish their meals, education activities in school, and methodology used for plate waste estimation (Bergman et al., 2004; Byker et al., 2014; Engstrom and Carlsson-Kanyama, 2004; Liu et al., 2016; Liz Martins et al., 2015; Thorsen et al., 2015). For our study, table 10 presented aggregate plate waste results allowing us explore areas of similarities and differences between the LOC and LOW case models.

Table 10. Weight of served meals and plate waste across all food categories (n=20 lunches per PSFP case)

PFSP model	LOC	LOW
Total no. of served meals in four weeks (n)	3793	2183
Total weight of food served in four weeks (kg)	1791 kg	641 kg
Average planned weight of food/meal served (g)	472 g	293 g
Total weight of collected plate waste (kg)	494 kg	78 kg
Average collected plate waste/meal served (g)	130 g	36 g
Collected plate waste as a proportion of planned food served (%)	28%	12.2%

The total served food represents the total weight of served food, according to the average size of a served meal across both seasons in the case schools. As Table 10 shows, across 2 weeks, a total of 1791 kg of food was served in LOC Schools, 1150 kg more than in both LOW Schools, where 641 kg of food was served. Comparing total weight of meal served, the average weight of food served per meal was found to be greater in LOC Schools (472 g/meal served) compared to LOW Schools (293 g/meal served). The total weight of collected food waste, excluding the food waste generated by the kitchen, was calculated across both cases. On average, more food was wasted in LOC Schools compared to LOW Schools with an average of 130g plate waste/LOC meal served compared to 36g of plate waste/LOW meal served. Also, as a proportion of the total weight of food served, the collected plate waste was calculated to higher in LOC (28%) compared to LOW school (12%), a difference of 16% between the LOC and LOW schools.

To conclude, while the total proportion of collected plate waste in LOC schools (28%) falls within the mid-range suggested by previous studies (9-45%), the proportion in LOW schools

(12%) is at the lower end of the range. A number of plausible, and potentially interconnected reasons are put forward to explain these differences. First, there were important differences in the total weights of food served per meal in LOW and LOC schools, with LOW children receiving on average 179g less food per meal served. As LOW school children ate a greater proportion, and wasted less, of the food they were served, this raises pertinent questions about the optimal weight of food/meal served and the relationship to plate waste. Second, LOWSchool kitchen and teaching staff were observed to be very engaged with, and more likely to check, their children's plates and encourage them to finish their meals. This on-site, real time, daily encouragement and supervision appeared to have an impact on the type and quantity of food eaten (and associated plate waste) during school lunch. Third, in LOWSchool C specifically, it was observed that the canteen layout and longer lunchtimes periods (up to 45mins/child compared to 15 mins/child in other schools) may also have contributed to an environment where children were more likely to finish their meals. Fourth, it is observed that all of the meals in LOW case were cooked on-site in the schools, whereas LOCSchool E had meals transported from LOCSchool A. This may have implications for the freshness and flavour of the food served.

5.2 Total Plate Waste Composition by Food Categories in LOC and LOW Cases

In previous studies, Liu et al. (2016) have shown that in primary schools in Beijing, 43% of the plate waste comes from staple food categories: 42% from vegetables, 10% from meat, and 5% from the other food category (soups). According to the results of Engström and Carlsson-Kanyama (2004), in a primary school in Sweden, half of the plate waste comes from starchy food (potato, pasta, rice) and fish, which is a higher proportion than in our results, but only 29% of the plate waste comes from vegetables.

Across our LOC and LOW schools, collected plate waste was separated into six distinct food categories. Table 11 presents a summary of total collected plate waste per food category (kg), the average plate waste/meal served/food category, the proportion of total collected plate waste by food category and the differences, where observed, in this distribution. We also explore the effect, if any, of the frequency of menu options on the volume and composition of the collected plate waste.

Table 11. Proportion of categories plate waste from total plate waste across two seasons in both schools per case (n=20 lunches per PSFP case)

Food categories	LOC (n=3793 lunches)		LOW (n=2183 lunches)	
	kgs	%	kgs	%
Starchy food	133.4	27	35.1	45
Vegetables	276.6	56	35.1	45
Fruit	Not served	0	Not served	0
Meat	64.2	13	6.2	8
Desserts	9.9	2	Not served	0

Other food	9.9	2	0.8	1
Total waste	494	100	78	100

As Table 11 shows, in both LOC and LOW cases, vegetables and starchy food were the largest contributory components to total collected plate waste. While in LOC and LOW schools, 83% and 90% of collected waste respectively was attributed to vegetables (56%, LOC; 45% LOW) and starchy food (27%, LOC; 45% LOW), some between category differences were observed with considerably smaller quantities of starchy food plate waste, and marginally greater quantities of vegetable plate waste collected in LOC compared with LOW schools. Meat, Fish and Protein waste was ranked 3rd in both LOC (13%) and LOW (8%). Finally, for both cases, dessert and other food plate waste were found in very small quantities. Overall, the results are consistent with findings of previous studies which show starchy foods and vegetables are the dominant components of plate waste in school meals, followed by meat.

Table 12. Amount of served food and plate waste by food categories and the differences between food categories and case study (n=20 lunches per PSFP case)

Plate waste food categories	Starchy food	Fruit	Vegetable	Meat	Desserts	Other food
LOC case						
No. of served meals in two weeks (n)	5083	not served	3835	2813	1526	967
Served meals in two weeks (kg)	469	not served	783	179	144	216
Plate waste in two weeks (kg)	131	not served	276	62	8	12
Average plate waste/meal served (g)	26	not served	72	22	5	12
Proportion of waste coming from plate waste in two weeks (%)	28	not served	35	35	5	5
LOW case						
No. of served meals in two weeks (n)	3606	not served	1666	1154	not served	123
Served meals in two weeks (kg)	334	not served	232	64	not served	12
Plate waste in two weeks (kg)	35	not served	34	8	not served	1
Average plate waste/meal served (g)	10	not served	20	7	not served	9
Proportion of waste coming from plate waste in two weeks (%)	11	not served	15	12	not served	9

Plate waste of food categories (%) per number of served meals in both seasons and both schools per case differs between cases (table 12), but it can be notice that the most wasted food category in both case school was vegetable followed by meat category, starch and starchy food category. In LOW case schools, students threw away 17% more food from starchy food category, 20% form vegetable category and 23% from meat category than students in LOC case schools. According to our results in LOW case school student wasted 4% more food from other food then in LOC case schools, but in 20 lunches in LOW case school only once was served meal item from this food category while in LOC case schools in 20 lunches were 5 meal items served. In LOC case schools 5% of desserts were wasted, while desserts were not served in lunchtime in LOW case schools. Fruits were not served neither in LOC case schools nor in LOW case schools.

In availably literature plate waste (%) of individual food categories differs due to the same reasons as the amount of waste each food category contributes, as a % of total food waste. Proportion of served food and plate waste of vegetable food category ranges from 34% to 73%, of fruit food category from 24% to 47%, starchy food category from 27% to 45%, meat category from 1% to 32% (Cohen et al., 2013; Cullen et al., 2015; Dinis et al., 2013; Niaki et al., 2017).

Additionally, it was observed that the difference in the amount of the total waste, and waste/food category may be influenced by:

- the difference in the frequency of serving certain dishes from certain food categories,
- the difference in the weight of food served – not only of meal components, but also of the whole lunch
- child preferences towards certain foods, and
- eating habits of children.

As Section 2 outlined, a typical meal across LOC and LOW cases consists of a starchy food component (potato, pasta, domestic Croatian pasta “mlinci”, gnocchi, and polenta), the meat, fish and protein component (roasted chicken or turkey, breaded chicken, beef, pork or chicken goulash), the vegetable component served as a salad or a side dish, and bread. Table 13 presents a synthesis of the frequency of food components served. While bread was served every day and children are free to take as much as they want in both cases, the variety of bread served per day varied by case with LOW schools serving multiple varieties of bread daily (white bread, corn bread, rye bread, graham bread, whole wheat bread, bread with sunflower seeds, or bread with pumpkin seeds) and LOW schools serving only one type of bread daily (white bread or corn bread).

Table 13. Total frequency of served food categories across both seasons (n=20 lunchtimes) according to PSFP cases

Procurement Model	Starchy food (n)	Fruit (n)	Vegetable (n)	Meat (n)	Desserts (n)	Other food (n)
LOC	27	0	20	15	8	5
LOW	33	0	16	9	0	1
Difference (n) between LOC and LOW case	-6	0	4	6	8	4

The LOC schools offered marginally more food from the vegetable category during the data collection period than the LOW schools with vegetable stews served 8 and 7 times respectively in LOC and LOW schools. Meat is included in all of the vegetable stews served. For example, green beans stew and potato stew are cooked with beef or pork meat, peas stew and mixed vegetable (broccoli, cauliflower, and carrot) with chicken or turkey meat, and the bean stew with sausages or smoked ham. The starchy food component of stews is usually potatoes, except in the bean stew, where potatoes are replaced with a small amount of added pasta or barley. As a side dish (e.g. boiled chard or brussels sprouts with potatoes, spinach with milk, sauerkraut), vegetables were served 3 times in LOC schools and once in LOW schools during the data collection period. Across all schools and both cases, the commonly served salads during the autumn/winter season were: (1) fresh salad, such as lettuce or cabbage; and (2) pickled vegetables, such as beetroot, peppers, cucumbers, or cabbage. In LOW schools during the spring/summer season, the same salads are served as in autumn/winter season while in LOC schools, fresh salads are served more during the spring/summer season, including fresh tomatoes, cucumbers, pepper, and a combination of lettuce with chicory or lamb’s lettuce. During spring/summer, salads were served 6 times in LOC schools, once from a canned salad product and 5 times using fresh lettuce while during the same period salads were served 8 times in two weeks in LOW schools, 3 times using canned salads and 5 times using fresh lettuce.

In both cases, meat is served almost every day as a part of stews, risottos, sauces, or as a piece of roasted meat. In addition, fish, included in the MFP category, is served on Fridays. From Table 13, LOC schools offered more MFP components than LOW schools. The other food category includes soups and juices made from syrup. Food components from the other food category are rarely served in the LOW case schools, once in two weeks, and occasionally in the LOC case schools, 5 times in two weeks. Desserts are only served, after lunch, in LOC schools twice per week, and 8 times in total across the schools and data collection period with variation per week in the type of desserts served between cake based and dairy based, (pudding, fruit yoghurt, shakes, ice cream). No schools, across both cases, offered fruit at lunchtime as it is served as a morning or afternoon snack.

In conclusion, the LOC schools served 4 more servings of vegetables, 6 more servings of meat, 8 more servings of desserts, and 4 more servings of other food compared with LOW case schools, meaning that LOC schools offer a greater variety of served food with 14 different serving food categories than LOW case schools representing a 10.4% difference in the number and variety of food categories served.

Table 14. Average amount of served lunch and food categories per student in school lunches (n=20 per model) according to PSFP model (x ± SD)

Food category	LOC		LOW	
Total weight of food per meal served	100 %	464 ± 140 g	100 %	301 ± 38 g
Starchy food	59 ± 10 %	249 ± 77 g	64 ± 20 %	190 ± 54 g
Bread	9 ± 4 %	39 ± 11 g	11 ± 3 %	32 ± 11 g
Vegetable	40 ± 24 %	199 ± 122 g	43 ± 33 %	127 ± 98 g
Fruit	not served	not served	not served	not served
Meat	14 ± 9 %	64 ± 43 g	19 ± 10 %	57 ± 30 g
Desserts	21 ± 8 %	94 ± 51 g	not served	not served
Other food	39 ± 5 %	223 ± 73 g	26 %	95 g

From the Table 14, LOC schools, on average, serve larger (by weight) servings of total meals, and by starchy food, vegetables, and the other food categories than LOW schools. Looking specifically across both cases at the average weight of food served per food category, starchy food was found to be served in the greatest quantity (g/meal served), followed by vegetables, other food, meat, desserts, and bread.

5.3. Students' Food Preferences and Reasons for not Finishing their Meals

As explained in Section 1, University of Zagreb conducted a parallel research project in which schools participating in the WP6.2 gave permissions for their children to be surveyed about their food preferences and reasons for not finishing their meals. The methods for this study are also described in Section 1. Given that it is strongly argued that children's preferences and eating habits directly affect how much a child will eat and how much food he/she will refuse (and thus waste), the liking and reasons for not finishing selected meals were captured. The focus was specifically on meals containing vegetables, due to the importance of vegetables to children’s nutrition and health. Therefore, on data collection days when a vegetable meal was served, first it was observed the proportion of meals not finished and the children who hadn’t finished their meal were asked to give the reasons for why. The results are shown for LOC and LOW case students in Figures 10 and 11, respectively. For both cases, the most common reasons given by children who did not finish their vegetable meals was: “I didn’t like the taste of the food”, followed by: “I cannot eat that much food” and “I don’t eat this at home” with some variation observed between he different types of vegetables served. It was also observed that some children didn’t try any of the served vegetable dish, especially if it was served as a salad.

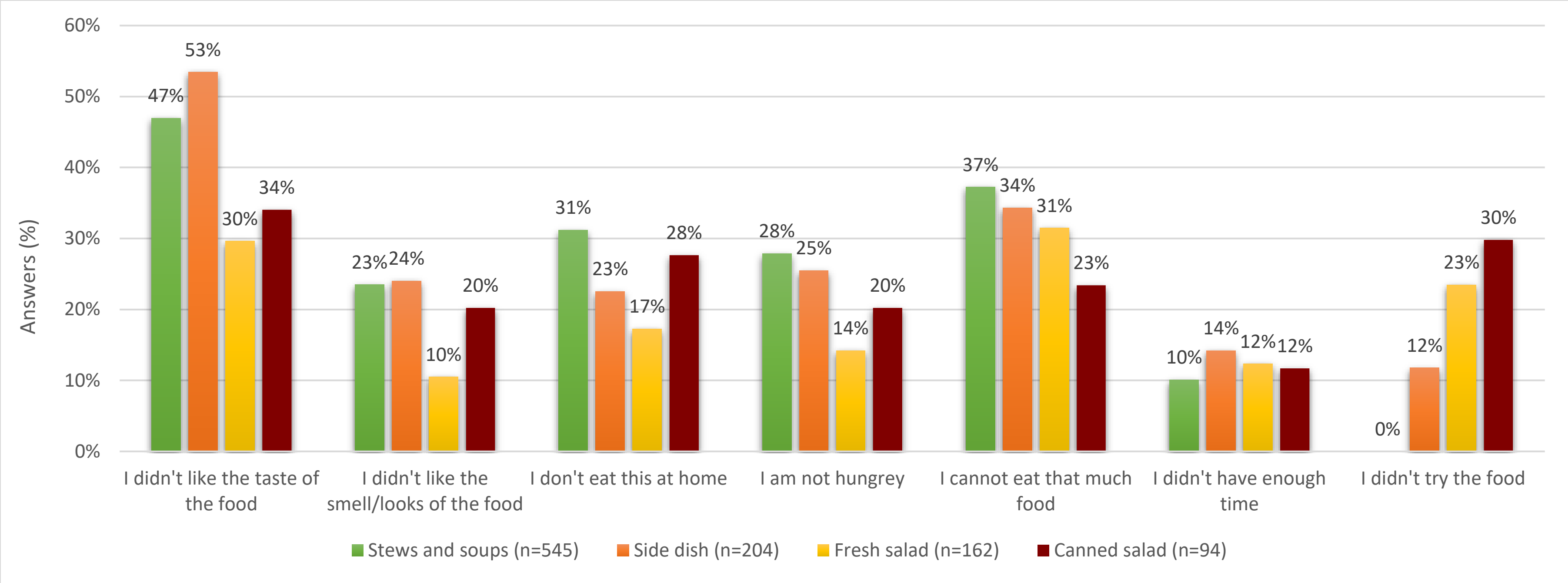


Figure 39. Reasons for not finishing the meal among students (n=1105) who did not eat whole served food from vegetable category in LOC case schools

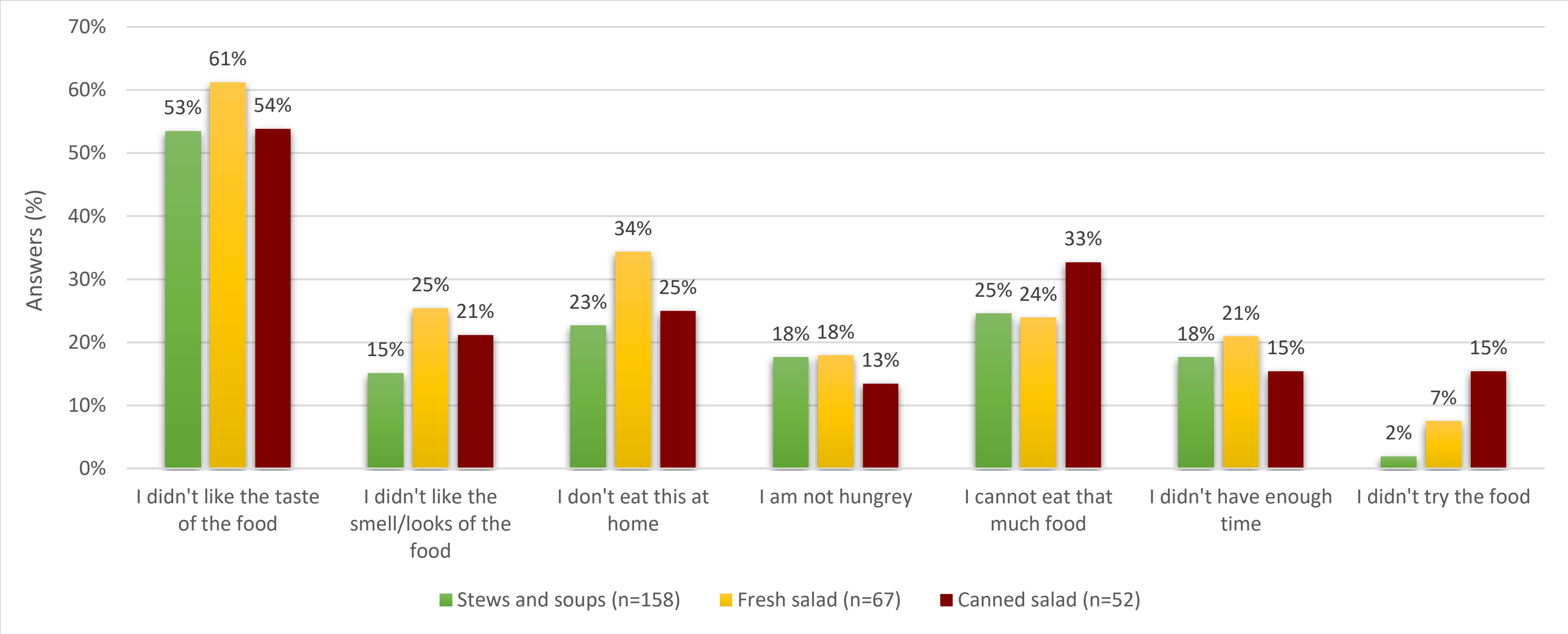


Figure 40. Reasons for not finishing the meal among students (n=277) who did not eat whole served food from vegetable category in LOW case schools

According to the observed parameters and collected plate waste results presented, it is concluded that in LOC schools, which had a greater number of served meals and a larger average amount of served lunch (g) per student, a greater amount of plate waste was collected (130g/meal served) compared with LOW schools (36g/meal served). In both cases, the majority of collected plate waste came from the most served food categories with the greatest quantities (by weight)/meal served namely: vegetables (56% LOC; 45% LOW) and starchy food (27% LOC and 45% LOW schools). LOWschools were found to offer more meal types including more food from the starchy food category and less food from other food categories, which could help explain the greater % of collected plate waste from starchy food in LOW schools. This observation is really interesting to compare with the child preference results, as the second most frequent reason given by children who did not finish their vegetable meals was “I cannot eat that much food”, with this reason more frequently given in LOC compared to LOW schools.

The distribution of collected plate waste data across the 6 food categories showed that, in both cases, the single most wasted food category was vegetables (Table 11). The most frequent reasons given by students who didn’t finish their vegetable meals were: “I don’t like the taste of the food”, “I cannot eat that much food”, and “I do not eat that at home” (Figure 11 and Figure 12). From this, it can be argued that children who waste vegetable meals do so because they are not familiar or accustomed to the taste of served vegetables during the school lunchtime. The second most wasted food category was starchy food (27% LOC and 45% LOW schools). The third most wasted food category was the MFP category (13% LOC; 8% LOW) with most MFP waste coming from beef, chicken with bones, and fish. The least wasted categories are other food (2% LOC; 1% LOW) and desserts (2% LOC, LOW no desserts served).

Therefore, in terms of reducing plate waste, we posit that it is necessary to first reflect on, and adjust, if appropriate, the total and per food component serving size (by weight and by proportion across food categories) in line with what children are able to eat (which is influenced by preferences, eating habits, canteen layout, time available to eat lunch and adult supervision and encouragement) while still ensuring that school meals satisfy their nutritional needs. Also, menus need to be designed to provide more variety of food items adjusted for children’s consumption, so that they can try out new foods and avoid saturation by the same dishes. Even though we didn’t observe such repetitive menus (i.e. kale always served as kale stew), improvements to existing, and development of new recipes (e.g. kale stew could be improved or replaced with kale fritters) are encouraged.

Much lower quantities of plate waste were collected in LOW schools (36g/meal served in LOW compared to 130g/meal served in LOC) and based on our observations it is argued that this was driven by the children having significantly longer (100-150% more time) for lunch, greater levels of staff encouragement and supervision, tastier meals (as per child responses) and in LOWSchool C specifically a more optimal canteen design and layout. The results of this research showed that vegetable meals were better evaluated in LOW model than in LOC model schools (respectively, 3.87±1.52 compared to 3.44±1.67; n (LOW) = 1702; n (LOC) = 2303; $p<0.001$).

In addition to considering menu, canteen and procurement interventions in, it is also argued, based on the insights gained form the child preference survey, that more education of primary-school students, and their parents, is needed in order to explain why it is important to eat all food categories, especially fruit and vegetables, and offer opportunities to introduce children and parents alike to different fruits and vegetables (shape, texture, taste) is needed.

5.4. Nutritional Impact of Plate Waste at LOC and LOW Case Schools

This section reports the analysis of the nutritional composition of the collected plate waste, and the associated implications for nutritional intake. In Section 4, the nutritional composition of the daily menus at LOC and LOW case schools was reported, and large proportions of the analysed meals across both cases were found to have nutritional deficiencies, for example in terms of energy and fibre. In addition, the quantities and composition of plate waste reported in the preceding Sections can be expected to further impact the actual nutritional intake of children from school meals, compared with what is planned in menu design. Loss of energy and nutrients depends on the proportion of energy and nutrients in the meals as a whole and per individual meal component, as well the amount of plate waste collected per food category. Therefore, in order to estimate the loss of energy and nutrients from collected plate waste, we estimated the nutritional composition of the plate waste. To do this, the nutritional composition of each component served per day was estimated by calculating for each food item the % of collected plate waste per child and then using these values to estimate the nutritional composition of plate waste per food category. The differences between the nutritional composition of served items and the estimated composition of plate waste represents the estimated actual intake of energy and nutrients per child. The nutritional composition, estimated waste composition and real intake of dishes were summed up per meal per day to calculate a whole lunch profile. The average values of nutritional composition, estimated waste composition and real intake of energy and nutrients were then calculated using values that represented whole lunch. In our case 20 lunches (days) per model were analysed and the results are shown in Table 15 and 16 and Figure 13, 14, and 15.

Table 15. Nutritional composition of served lunches and plate waste in LOC and LOW cases (n= 20 lunch served per case)

Parameter (average ± SD)	Nutritional composition of served lunches		Nutritional composition of plate waste		Estimated Actual Nutritional Intake Δ (% of planned intake)	
	LOC	LOW	LOC	LOW	LOC	LOW
Energy (kcal)	525 ± 115	352 ± 124	132 ± 69	42 ± 26	392 ± 84 (75)	312 ± 111 (88)
Total proteins (g)	18.0 ± 5.4	19.8 ± 742	5.2 ± 2.6	2.8 ± 2.2	12.9 ± 4.4 (71)	17.1 ± 6.9 (86)
Total carbohydrates (g)	66.4 ± 14.8	48.8 ± 19.5	14.0 ± 6.8	4.8 ± 3.4	52.4 ± 11.3 (79)	44.0 ± 17.3 (91)
Dietary fibre (g)	4.6 ± 2.7	3.3 ± 3.0	1.6 ± 1.1	0.6 ± 0.7	3.0 ± 2.1 (63)	2.7 ± 2.5 (85)
Total fat (g)	21.7 ± 9.4	9.2 ± 5.1	6.4 ± 4.9	1.3 ± 1.2	15.3 ± 6.5 (72)	7.9 ± 4.5 (86)
Saturated fatty acids (g)	4.6 ± 2.7	2.7 ± 2.0	1.4 ± 0.9	0.4 ± 0.5	3.2 ± 2.2 (67)	2.2 ± 1.7 (86)

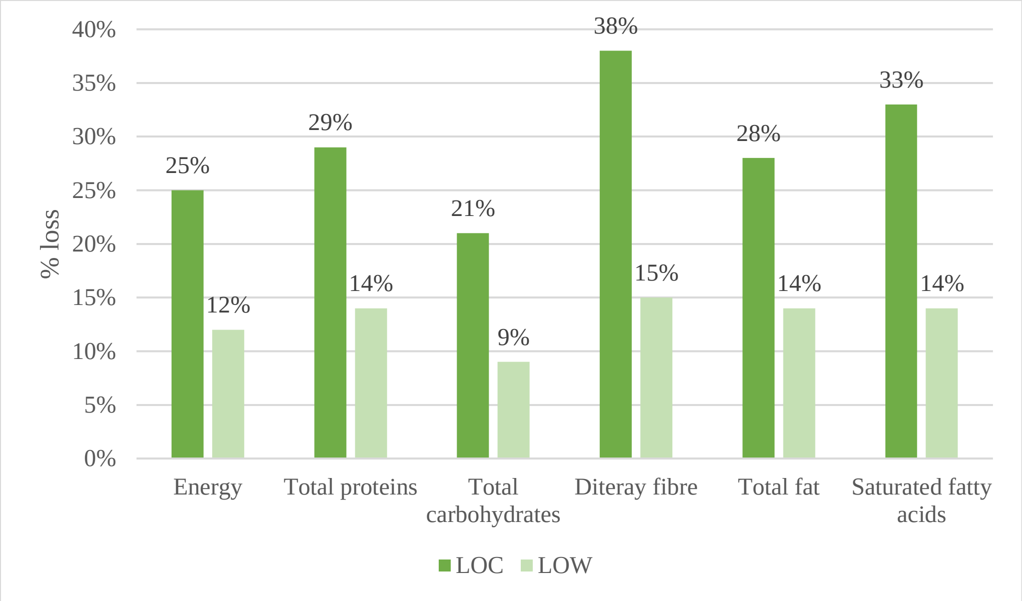


Figure 41. Losses of energy and macronutrient of school lunches (n= 20 lunch served per case

Overall, Table 15 and Figure 13 show that the collected plate waste generated greater energy and macronutrient losses in LOC compared to LOW schools, with the increased quantity and different proportional waste distribution across the 6 food categories providing the primary explanation for this. As a greater quantity of plate waste was collected in LOC schools, it is understandable that LOC School had a larger estimated loss of energy and macronutrients compared with LOW schools. In the LOC schools, the greatest nutrient loss recorded was of dietary fibre linked directly to the high quantities of vegetable waste collected which are excellent sources of dietary fibre and relied upon in menu design as the primary source of dietary fibre provision. Following the loss of fibre, the second greatest recorded loss across both cases was of saturated fatty acids, followed by total fat, and then protein. The main reason for this was greater quantities of waste from the starchy food category which included complex meals containing fats and proteins, such as spaghetti Bolognese, where meat couldn't be separated into a separate category. However, plate waste from the MFP category accounted for 13%, and 8%, respectively of total collected plate waste in LOW and LOC schools although it was observed that red meat was more often thrown away than other MFP components especially where the red meat contained visible fat (i.e. sausages and deep-fried fish sticks and hake).

Table 16. Micronutrient composition of served lunches and plate waste in LOC and LOW cases (n=20 lunch served per case)

Parameter (average ± SD)	Nutritional composition of served lunches		Nutritional composition of plate waste		Difference between FCA of served lunch and plate waste Δ (%)	
	LOC	LOW	LOC	LOC	LOC	LOW
Vitamin A (mg RE)	0.16 ± 0.19	0.09 ± 0.07	0.04 ± 0.05	0.01 ± 0.02	0.12 ± 0.17 (68)	0.07 ± 0.06 (84)
Vitamin B_1 (mg)	0.25 ± 0.15	0.19 ± 0.10	0.08 ± 0.04	0.04 ± 0.05	0.17 ± 0.13 (63)	0.15 ± 0.07 (84)
Vitamin B_2 (mg)	0.22 ± 0.14	0.17 ± 0.07	0.07 ± 0.04	0.03 ± 0.02	0.15 ± 0.14 (64)	0.14 ± 0.06 (84)
Niacin (mg)	3.71 ± 2.69	5.14 ± 3.62	1.26 ± 0.79	0.72 ± 0.59	2.45 ± 2.25 (61)	4.41 ± 3.28 (85)
Vitamin B_6 (mg)	0.32 ± 0.25	0.27 ± 0.19	0.11 ± 0.08	0.04 ± 0.06	0.21 ± 0.21 (62)	0.22 ± 0.17 (84)
Folate (µg)	*na*	*na*	*na*	*na*	*na*	*na*
Vitamin B_{12} (µg)	*na*	*na*	*na*	*na*	*na*	*na*
Vitamin C (mg)	25.36 ± 23.64	15.98 ± 16.13	10.05 ± 14.57	2.07 ± 2.73	15.31 ± 14.75 (63)	13.91 ± 14.91 (85)
Vitamin D (µg)	*na*	*na*	*na*	*na*	*na*	*na*
Sodium (mg)	1086.57 ± 331.50	878.15 ± 521.87	353.40 ± 213.52	124.04 ± 171.38	733.18 ± 243.79 (68)	754.11 ± 404.62 (88)
Potassium (mg)	645.11 ± 482.09	564.08 ± 427.32	232.58 ± 161.23	90.46 ± 85.10	412.53 ± 395.81 (59)	47362 ± 382.12 (84)
Calcium (mg)	49.46 ± 36.76	45.99 ± 28.45	14.84 ± 7.20	7.40 ± 8.25	34.63 ± 33.25 (65)	38.59 ± 25.33 (85)
Magnesium (mg)	34.38 ± 28.33	31.19 ± 22.35	11.45 ± 8.82	4.62 ± 4.32	22.93 ± 22.81 (63)	26.57 ± 18.70 (86)
Phosphor (mg)	171.32 ± 89.93	227.57 ± 100.74	60.97 ± 30.20	35.25 ± 26.30	110.35 ± 75.71 (61)	192.32 ± 89.99 (85)
Iron (mg)	2.27 ± 1.10	2.25 ± 1.12	0.79 ± 0.40	0.38 ± 0.41	1.47 ± 0.95 (62)	1.87 ± 0.91 (85)
Zinc (mg)	0.68 ± 0.50	0.65 ± 0.51	0.25 ± 0.22	0.09 ± 0.09	0.43 ± 0.34 (63)	0.56 ± 0.44 (83)
Copper (mg)	0.32 ± 0.35	0.21 ± 0.19	0.07 ± 0.06	0.03 ± 0.04	0.25 ± 0.31 (68)	0.18 ± 0.16 (84)

na- data not available from the national food composition database

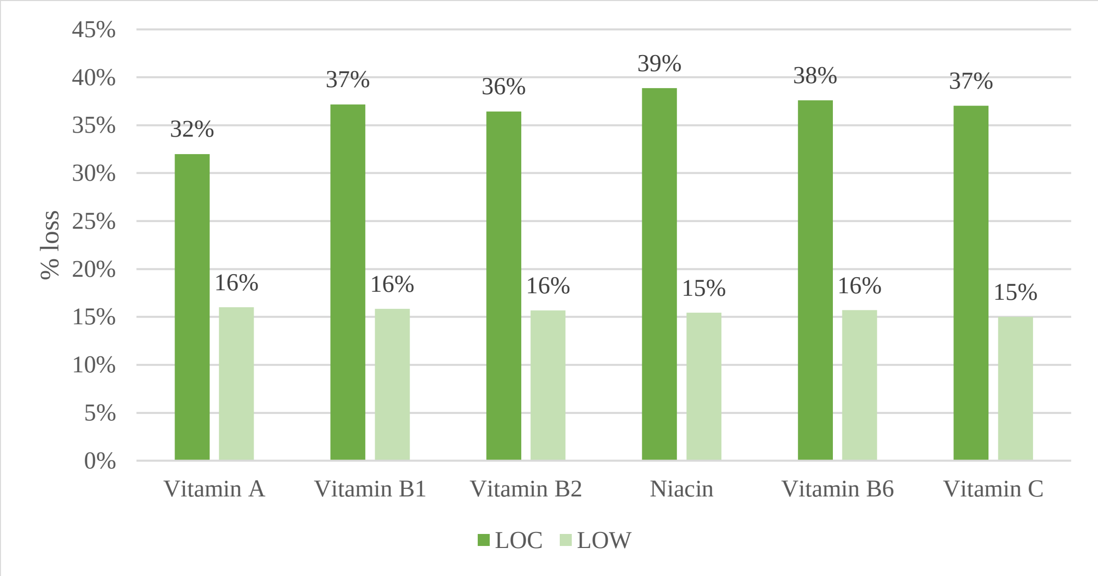


Figure 42. Losses of vitamins in average school lunch due to plate waste, in LOC and LOW cases (n=20 lunch served per case)

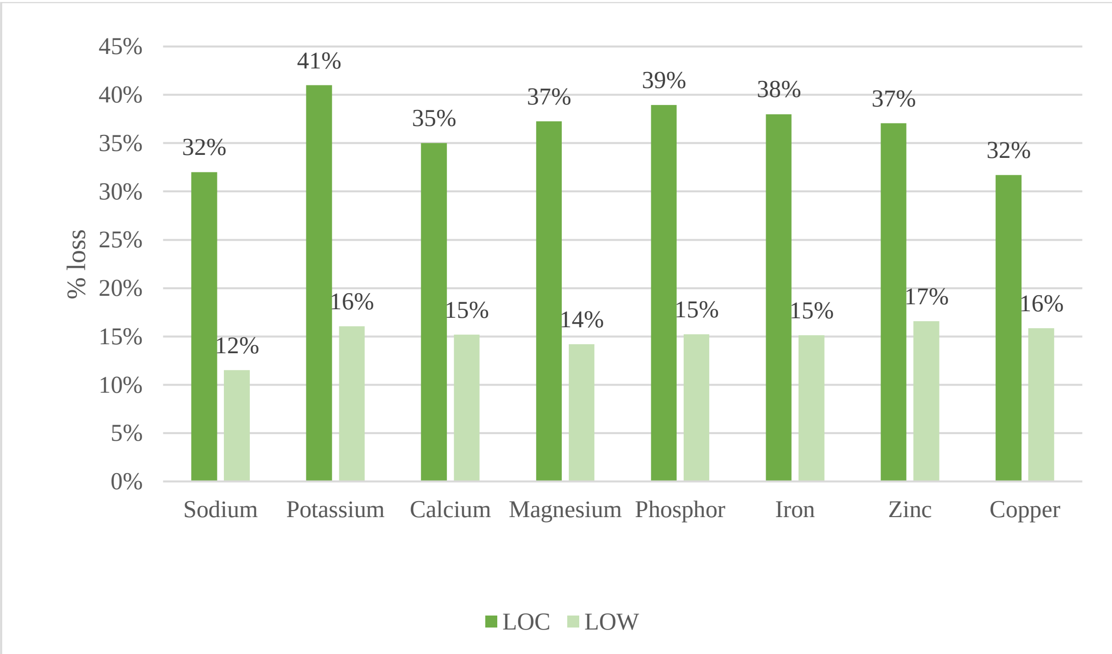


Figure 43. Losses of minerals in average school lunch due to plate waste, in LOC and LOW cases (n=20 lunch served per case)

Overall, Table 16 and Figures 14 and 15 show that collected plate waste generated a greater loss of vitamins and minerals in LOC compared to LOW schools. This can be primarily explained by the greater amount of collected plate waste in LOC case compared with LOW case.

Depending on the waste of individual food categories and the composition of the meals themselves, there was a greater or a lesser loss of some vitamins and minerals. Namely, since carrots, green leafy vegetables (spinach, kale, chard), and eggs are an excellent source of vitamin A and/or β-carotene, the greatest loss of vitamin A was noticed on the days when the meals offered contained sautéed rice with meat and vegetables, boiled Brussels sprouts, boiled chard, mixed vegetable stews (broccoli, cauliflower, and carrots). Foodstuffs, such as carrots, tomatoes, and tomato sauce – although often found in menus, especially stews – are used in small amounts, thus they did not have a big influence on the total amounts of vitamin A in the menus, so that the waste from such meals did not drastically reduce the intake of vitamin A via school meals. Across both cases, Table 16 and Figure 14 show a somewhat greater loss of vitamin B as compared to the loss of vitamin A, since the dietary source of vitamin B is food of plant and animal origin, such as spinach, chard, peas, beans, tomatoes, Brussels sprouts, kale, broccoli, cauliflower, potatoes, cereals, pork meat, eggs, and turkey meat, and it is exactly these foodstuffs that were found among the collected plate waste across the vegetable, starchy food, and meat categories, which make up a very large proportion of the total waste in both cases. Meals with a content of vitamin C larger than 20 mg per serving size in LOC School menus were boiled Brussels sprouts with potatoes, boiled chard with potatoes, mixed vegetable stew (broccoli, cauliflower, and carrots), fresh cabbage stew, spinach with milk, and boiled potatoes and mashed potatoes. The collected plate waste from such meals varied from 25% to 73% per pupil depending on the amount served. In LOW schools, meals containing more than 20 mg of vitamin C per serving size were mashed potatoes, lettuce and red cabbage salad, and the collected plate waste from such meals varied from 5% to 14% per child depending on the size of meal served.

In terms of sodium, all meals have salt or Vegata, an herbal mixture containing salt, added during the preparation process. As such, sodium is estimated to be proportionally lost through the collect quantities of plate waste. Also, ready-made products that contribute to a larger intake of sodium include canned salads, and their waste amounted to ca. 45% of each LOW meal served and between 73% to 89% per LOC meal served. In addition, sodium is lost via waste bakery products, through this is estimated to be less than 10% per pupil. For potassium, greater losses were observed when meals served contained potatoes, cabbage plants, and legumes were served. The loss of potassium was greater than 50% on days when cabbage salad (84% of waste per pupil), potato goulash with baby beef (68% and 86% of waste per pupil, respectively), and Brussels sprouts with boiled potatoes (73% of waste per pupil), chicken stew (59% of waste per pupil), lettuce (39% of waste per pupil), and fresh cabbage casserole (78% of waste per pupil) were served. In both LOC and LOW schools, the intake of calcium during lunchtime was delivered by foodstuffs, such as green leafy vegetables and legumes since milk as dairy products were not present in menus, except for Fridays in the form of cottage cheese added to the pasta (this meal was served once every two months) and more often as a part of the meal (e.g. mashed potatoes, spinach), or dairy desserts were served (e.g. pudding, fruit yoghurt, milkshake in LOC school only). Milk based desserts were offered only in LOC schools, and their waste amounted to between 3-8% dessert served. Since very little milk based plate waste was collected, calcium loss was primarily attributed to waste from rice and peas, spinach with milk, and chard with boiled potatoes. In terms of magnesium, the dietary source in the school menus came from cereals and grain products, legumes, and potatoes. Therefore, since only a small amount of collected plate waste was made up of bread, the greatest loss of magnesium (> 50%) was attributed to meals which served: polenta (59% of waste per pupil), potato goulash (68% of waste per pupil), Brussels sprouts with boiled potatoes (73% of waste per pupil), rice with peas (31% of waste per pupil), and meals which served a combination of boiled potatoes (28% of waste per pupil) and meat balls (18% of waste per pupil). Although red and other meat products are one of the main dietary sources of phosphorus, their serving size per meal, and their waste per meal, were lower than with other sources of phosphorus, therefore, MFP waste did not contribute significantly to loss of phosphorus. Instead, the loss of phosphorus (>50%) was attributed to dishes including: sauerkraut with pork meat (69% of waste per pupil), potato goulash with baby beef (68% and 86% of waste per pupil, respectively), boiled Brussels sprouts (73% of waste per pupil), pasta with a chicken stew (39% and 59% of waste per pupil, respectively), vegetable stew (44% of waste per pupil), and beans casserole with barley and smoke-dried pork meat (27% of waste per pupil). Just like with phosphorus, there greater loss of iron was limited from the MFP category and was estimated to be primarily attribute to the following meals: sauerkraut with pork meat (69% of waste per pupil), beans casserole (from 21% to 41% of waste per pupil), pickled red beet (68% and 87% of waste per pupil) were served. The greatest loss of zinc (>50%) was estimated for days when meals such as beans casserole (from 21% to 41% of waste per pupil), Brussels sprouts with boiled potatoes (73% of waste per pupil), and pasta with a chicken stew (39% and 59% of waste per pupil, respectively) were served. More than 50% of copper was lost on days when mashed potatoes (29% of waste per pupil) and beans casserole with pasta (41% of waste per pupil) were served.

5.5. Economic Impact of Plate Waste in LOC and LOW case schools

In this section, we report our analysis of the financial cost of the plate waste in LOC and LOW schools. The estimation was made at the full case level, i.e. for the five featured schools in each case (as described in D6.3), for one whole school year. This was done in order to make the results more relatable to D6.3 results. To estimate the cost of the plate waste, first, the quantities of plate waste recorded in the two D6.2 schools were aggregated, pro rata, to all five schools in each case for the whole school year. By this calculation, the total quantities of plate waste in LOC and LOW cases were 17,158 kg and 4,681 kg, respectively. Next, an average price per kg for each waste food category was calculated by dividing the total supply budget related to this category by the volumes of specific items procured within the category, in proportion to each other (the sources for the values were the procurement data collected for D6.3). In this way, the average prices per kg reflected the varying volumes of different food items procured within the category, and their specific prices. Finally, the total cost of each waste food category was summed to derive the estimate of the total cost of all the food waste in each case. Tables 17 and 18 presents results for LOC and LOW cases, respectively.

Table 17. **Estimated Cost of Plate Waste at LOC case schools, per year (n=5 schools)**

Waste Categories	Volume (kg)	Average Cost per kg (€)	Total Cost (€)	Cost per Average Meal (€)
Starchy Food (fresh potatoes, bread, rice, pasta, flour)	3790	1.06	4,409	
Starchy Food with Veg	562	1.39	781	
Starchy Food with Meat, Fish or Cheese	2773	3.50	9,706	
Vegetables	6620	1.24	7,944	
Meat and Fish	2104	6.12	12,544	
Soups	791	1.25	989	

Desserts (cakes, dairy puddings)	217	4.91	851	
Juices	227	3.63	824	
TOTAL	17158	2.89	38,374	0.27

As Table 17 shows, the total cost of the wasted food in LOC case was €38,374, equivalent to €0.27 per meal. This represented 22% of the total school meals budget, and 23% of the full price of a meal to parents (€1.20).

Table 18. Estimated Cost of Plate Waste at LOW case schools per year (n=5 schools)

Waste Categories	Volume (kg)	Average Cost per kg (€)	Total Cost (€)	Cost per Average Meal (€)
Starchy Food (fresh potatoes, bread, rice, pasta, flour)	906	0.74	899	
Starchy Food with Veg	50	1.37	69	
Starchy Food with Meat, Fish or Cheese	732	3.54	2,591	
Vegetables	1,985	1.36	2,271	
Meat and Fish	535	5.14	2,429	
Soups	414	1.13	468	
Desserts (cakes, dairy puddings)	19	4.91	98	
Juices	40	3.63	145	
TOTAL	4,681	2.73	8,968	0.04

As Table 18 shows, the total cost of the wasted food in LOW case was €8,968, equivalent to €0.04 per meal. This represented 3% of the total school meals budget, and 3% of the full price of a meal to parents (€1.20). Comparing the cases, it is clear that the estimated economic impact of plate waste was considerably smaller in LOW case compared to LOC case. The key reason for this is the much smaller quantities of wasted food per meal in LOW case compared with LOC case.

5.6 Environmental Impact of Plate Waste in LOC and LOW case schools

Food waste has direct and indirect effects on the environment, leading to consequences for natural resources at a global level. Here, we defined the environmental impact of food waste as being the carbon emissions (kgs$C0_2$eq) embodied in the waste, as derived from its production, transportation and disposal. To be consistent with the emissions estimates for the entire LOC and LOW school meal services, reported in D6.3, we used the same sets of emissions factors and calculation approach here, described below.

First, in order to make the analysis relatable to the carbon footprint results generated in D6.3, we made the estimation for all five featured schools in LOC and LOW cases (as described in D6.3), for one school year, rather than only for the specific schools/weeks of plate waste from the WP6.2 data collection. We did this by taking the volumes of plate waste recorded in the data collection and aggregating these pro rata to the other schools in each case, based on their meal uptake figures. We then multiplied these amounts by the correct number of weeks to arrive at a total waste volume for the whole school year in each case.

To estimate the carbon emissions embodied in these total waste volumes, we first inspected their compositions, and made estimates of the quantities of individual food items within each category of waste (e.g. beef within the 'meat and fish' category), based either on the direct observations of the plate waste data collectors in WP6.2 (where possible) or by inspecting the relevant ratios of the food procurement data collected as part of D6.3 (guided by the menus/recipes). Then, having determined which food items comprised all the categories of waste in each case, and in which proportions, an average emissions factor per kg (EF) for each food category was calculated by dividing the total production emissions generated by all the items in the waste food category (in kgs CO_2eq) by the total volumes of those items procured for the five schools in each case. In this way, the average EF for each food category took account of the varying proportions of specific food items within the waste category, and their specific EFs. If the waste food category only included one item (e.g., milk), the actual EF for this item was used as the category EF. The average EF for each food category was then multiplied by the total volumes of waste recorded for those food categories in each case, to give the total production-related carbon emissions embodied in each food waste category. The same methodology was followed to calculate the transport-related emissions embodied in each food waste category. Finally, the disposal-related emissions (i.e. transportation and handling of the waste itself) were added. All three components of the embodied carbon emissions (production, transportation and disposal of the wasted food) were then summed to get the total embodied carbon emissions of the waste in each case.

Tables 19 and 20 report the results for LOC and LOW cases, respectively.

Table 19. Estimated embodied carbon in plate waste in LOC case schools, per year (n=5 schools)

Waste Categories	Volume (kg)	Embodied Emissions (kg $C0_2eq$)	Embodied Emissions per Average Meal (kg $C0_2eq$)
Starchy Food (fresh potatoes, bread, rice, pasta, flour)	3790	7448	0.33
Starchy Food with Veg	562	939	
Starchy Food with Meat, Fish or Cheese	2773	13272	
Vegetables	6620	9422	
Meat and Fish	2104	12296	
Soups	791	1336	
Desserts (cakes, dairy puddings)	217	782	
Juices	227	285	
Transport from central kitchen to schools		686	
Waste handling		504	
TOTAL	17158	46968	

As Table 19 shows, the total estimated volume of waste in LOC case (for five schools, over one year) was 17,158 kgs. We estimated that the total embodied emissions generated from this waste were 46,968 kgs $C0_2eq$, equivalent to 0.33 kgs $C0_2eq$ per average meal. This represented 39% of the total $C0_2$ emissions of the entire LOC meals service (as reported in D6.3 Croatia Country Report). It is notable that although meat and fish (both combined with and without starchy food) were relatively small components in terms of the plate waste volumes (28%), they represented a much greater proportion of the embodied carbon emissions (54%).

Table 20. Estimated embodied carbon in plate waste in LOW case schools, per year (n=5 schools)

Waste Categories	Volume (kg)	Embodied Emissions (kgC0$_2$eq)	Embodied Emissions per Average Meal (kgC0$_2$eq)
Starchy Food (fresh potatoes, bread, rice, pasta, flour)	906	1382	
Starchy Food with Veg	50	68	
Starchy Food with Meat, Fish or Cheese	732	3148	
Vegetables	1985	2973	
Meat and Fish	535	3446	0.05
Soups	414	646	
Desserts (cakes, dairy puddings)	19	46	
Juices	40	50	
Waste handling		87	
TOTAL	4681	11845	

As Table 20 shows, the total estimated volume of waste in LOW case (for five schools, over one year) was 4,681 kgs. We estimated that the total emissions embodied in this waste were 11,845 kgsC0$_2$eq, equivalent to 0.05 kgCO$_2$eq per average meal served. This represented 5.4% of the total C0$_2$ emissions of the entire LOC meals service (as reported in D6.3 Croatia Country Report). As with LOC case, while meat and fish (both combined with and without starchy food) were relatively small components in terms of the weight of plate waste collected (27%), they contributed a much greater proportion of the embodied carbon emissions (56%). However, the total embodied carbon emissions of LOW case plate waste were much smaller than LOC case due, as previously discussed, to the significantly lower quantities of total plate waste in LOW case.

6. CONCLUSIONS/RECOMMENDATIONS

This report has presented the WP6.2 results for Croatia. We explored how different PSFP models may be linked to healthy eating and the nutritive value of school meals through detailed nutritional composition of daily menus from 2 LOC and 2 LOW schools in the City of Zagreb. We also analysed the volumes and compositions of plate waste collected over a 2-week period in each of these schools. The results showed that a large proportion of daily menus, across both cases, did not meet National Nutritional Recommendations for energy (kcals) and fibre (g), and are deficient in terms of providing certain micronutrients. Furthermore, these deficiencies were worsened by the quantities and compositions of plate waste generated by pupils, leading to the conclusion that, on average, actual intakes of energy and certain macronutrients and micronutrients for children in the Case schools were considerably lower than National Recommendations.

The research found some key differences between the LOC and LOW cases. In terms of the nutritional composition of daily menus, a greater proportion of LOC menus exceeded national recommendations for total fat and for saturated fatty acids. Also, LOC schools generated considerably higher levels of plate waste (28%) than LOW schools (12%). These differences in plate waste levels translated into notable differences in nutritional, economic and environmental impacts from the waste. Whereas in LOW case, children's actual nutritional intake, on average, was 85-91% of planned energy and macronutrients and 83-88% of planned micronutrients as a result of plate waste, in LOC case, the higher waste levels meant that actual intake was 70-75% of planned energy and macronutrients and 59-68% of planned micronutrients (on average). Moreover, the cost of the waste in LOW case was €0.04 per meal (3% of meals budget) with embodied emissions of 0.05 kg$C0_2$eq, whereas in LOC case, the waste cost was €0.27 per meal (22% of meals budget), with embodied emissions of 0.33 kg $C0_2$eq.

Importantly however, these differences in nutritional composition of menus and plate waste did not appear to depend on, nor be explained by, the case specific procurement model. Instead, the reasons for low plate waste levels in LOW schools were due to (i) the much smaller weight (g) of food per average LOW meal served than for LOC meals (293g vs 472g) and (ii) the lunchtime service environment and canteen layout in LOW schools, specifically, the levels of supervision and encouragement provided by staff to support children in finishing their meals, and the length of the lunchtime period and seating arrangement in one LOW School. Although we did observe a possible connection between the site of meal preparation (on-site vs. off-site) and consequences for the freshness and flavour of the food (which could therefore represent one feature of a school meals supply chain that is associated with rates of plate waste), our study was not able to explore this aspect in depth. This remains an issue for future research.

Hence, although procurement model types may help to illuminate and prioritize potential interventions that would support healthy, nutritious and tasty meals, in practice, other factors are more important than food procurement model in terms of impact on nutritional outcomes. Indeed, results showed that menus across LOC and LOW models failed in accordance with National Recommendations. This highlights an urgent need for menu, canteen design and school meal management interventions to improve nutritional outcomes and reduce losses associated with plate waste in the school meal setting, whatever the procurement model.

Our recommendations are as follows. Currently, menu design in Croatian schools is a devolved task with each school designing their own menus and managing their own school food procurement process. In particular, it is school cooks, teaching staff (in some cases) and/or administrative staff, who are generally expected to develop menus that align with existing national normative provisions and nutritive recommendations. More training, support and potentially greater collaboration between schools, and the city council, are needed if improvements to nutritional outcome are to be made. Therefore, one of the recommendations emerging from this research would be to the provision of greater support and involvement from nutritionists, across all City of Zagreb primary schools and beyond, in order to improve nutritional outcomes of Croatian school menus.

In terms of child food preferences, differences between the LOC and LOW model were found and therefore a strong recommendation is to encourage, and provide, education and skills courses and menu innovation workshops for cooks and catering assistants to help improve their cooking and preparation skills and broaden out their repertoire of dishes offered on school meals, whilst also tapping into and drawing on their invaluable insights to drive and support menu innovation.

Since the City of Zagreb showed understanding and support for exploring school menus, the recommendation is to organize a city forum. This forum will be set up to consult with, inform and educate key school based stakeholders about the importance of optimal school nutrition. The aim of the forum is to draw up an action plan for improving school meals in elementary schools. Part of that forum will consider procurement of the food (Support of local producers) and setting up an optimal common menu for all 144 City of Zagreb schools.

The results are recognized by Zagreb Council as an excellent basis from which to drive improvement of school meals in a sustainable way. Zagreb Council is willing to be part of that process despite public procurement barriers (being the major challenge for food procurement). Related to that, an interdisciplinary approach is advocated to improve the quality, nutritive value and taste of school meals without increasing the total price.

Although LOW schools wasted less served food than the LOC case schools, all schools should seek to minimise the proportion of plate waste per average meal served as all waste represents a loss of planned energy, macronutrients, vitamins, and minerals, as well as an associated loss of money spent and embodied carbon emissions. Therefore, for plate waste reduction, we recommend schools pay attention to: adjusting the serving size of lunches and their components; creating menus that will satisfy students' nutritional needs; and providing more variety of food items and adjusted recipes that will increase children's consumption to meet their preferences. We also recommend more educational programmes targeting of primary-school children and their parents about the importance of eating all food categories, especially fruit and vegetables, and about finding more ways to introduce new fruits and vegetables into school meal service and in their own households. For example, fruit salad should be part of school lunch as it is recommended by National Guidelines.

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APPENDICES

Appendix 1 - Example of the questionnaire for children food preference (paper put on the tray under the dish during the lunchtime)


STRENGTH 2FOOD
prehrambeno biotehnološki fakultet
Sveučilište u Zagrebu

OŠ:
ID UČENIKA:
DATUM:

JA SAM:
IDEM U ☐ RAZRED

KOLIKO TI SE SVIĐA JELO OD POVRĆA?

1 2 3 4 5

AKO NISI POJEO/POJELA SVE,
MOLIM TE OZNAČI ZAŠTO:

- ☐ NIJE MI BILO UKUSNO
- ☐ NIJE MI SE SVIĐAO MIRIS/IZGLED HRANE
- ☐ OVO JELO NE JEDEM KOD KUĆE
- ☐ NISAM GLADNA/GLADAN
- ☐ NE MOGU POJESTI TAKO PUNO HRANE
- ☐ NISAM IMAO DOVOLJNO VREMENA


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- ☐ NISAM GLADNA/GLADAN
- ☐ NE MOGU POJESTI TAKO PUNO HRANE
- ☐ NISAM IMAO DOVOLJNO VREMENA

Appendix 2 – picture of typical meal in LOWSchool

Mashed potatoes, spinach with milk, hard boiled eggs

Risotto with vegetable and beef meat

Bean stew

Polenta, beef goulash with peas

Potato stew with hake

Lasagne with mince meat

Vegetable stew with turkey meat

Spaghetti with tuna sauce

Mashed potatoes, sauerkraut and meet rolls

Dumplings with plums and cherry sauce

The Strength2Food project in a nutshell

Strength2Food is a five-year, €6.9 million project to improve the effectiveness of EU food quality schemes (FQS), public sector food procurement (PSFP) and to stimulate Short Food Supply Chains (SFSC) through research, innovation and demonstration activities. The 30-partner consortium representing 11 EU and four non-EU countries combines academic, communication, SMEs and stakeholder organisations to ensure a multi-actor approach. It will undertake case study-based quantitative research to measure economic, environmental and social impacts of FQS, PSFP and SFSC. The impact of PSFP policies on nutrition in school meals will also be assessed. Primary research will be complemented by econometric analysis of existing datasets to determine impacts of FQS and SFSC participation on farm performance, as well as understand price transmission and trade patterns. Consumer knowledge, confidence in, valuation and use of FQS labels and products will be assessed via survey, ethnographic and virtual supermarket-based research. Lessons from the research will be applied and verified in 6 pilot initiatives which bring together academic and non-academic partners. Impact will be maximised through a knowledge exchange platform, hybrid forums, educational resources and a Massive Open Online Course.

HORIZON 2020

Strengthening European Food Chain Sustainability by Quality and Procurement Policy

Deliverable No: D6.2

EVALUATION OF THE NUTRITIONAL IMPACT OF DIFFERENT PSFP MODELS IN A SCHOOL CONTEXT:

GREECE COUNTRY REPORT

October 2018

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Academic Partners

1. **UNEW**, Newcastle University (United Kingdom)
2. **UNIPR**, University of Parma (Italy)
3. **UEDIN**, University of Edinburgh (United Kingdom)
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27. **Arilje**, Municipality of Arilje (Serbia)
28. **CPR**, Consortium of Parmigiano-Reggiano (Italy)
29. **ECOZEPT**, ECOZEPT (Germany)
30. **IMPMENT**, Impact Measurement Ltd (United Kingdom)

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EXTENDED ABSTRACT

The evaluation of the nutrional impact of different Public School Food Procurement (PSFP) models took place in the primary schools in the Greek co-capital city of Thessaloniki (Case 1) and in the rural town of Kastoria (Case 2). The case 1 PSFP model was the “LOW” cost model where the contracted catering company sourced the food ingredients with the lowest cost while the case 2 An alternative PSFP model was a “LOC” model where the school meal ingredients were mainly sourced from local suppliers allocated within a 50km radius from Kastoria.

In this study, nutritional analysis of a sample of school lunch menus was conducted and plate waste was collected during school lunch service in in 4 participated schools (2/case study) by the research team of the Aristotle University of Thessaloniki (AUTh). The provision of schools meals is very new in Greece, with the first appearing during the 16/17 school year when 36 schools participated in a 3 month pilot schools meals program. In 17/18, the pilot program was expanded to 798 schools in Greece for a total of 24 weeks. The pilot program is coordinated by the Ministry of Labour, Social insurance & Social Solidarity in collaboration with the Ministry of Education. Private catering companies were contracted to prepare and deliver the school meals at the participating primary school.

Through the plate waste study, it was found that 43.3% and 37.5% of LOW and LOC school meals, respectively, were wasted (left on the plate and not eaten). The most wasted food category in LOW Schools was starchy food (rice, pasta or potatoes) with 53% followed by vegetables with 47,3% and meat/fish with 40,4%. In LOC Schools, the most wasted food category was vegetables (including salad) with 54,8% followed by the mixed food with 43,3% and dairy products (FETA cheese and boiled egg) with 39,9%. Furthermore, in LOW schools, the least wasted school lunch was boiled peas with carrot and potatoes (meat free day) while the least wasted school meal in LOC schools was the roasted chicken with rice (69,8%) followed by the lentil soup (67,8%).

The results from the nutritional impact analysis indicated that the pupils in the LOC case received and consumed higher nutritional values than the pupils in the LOW case. In particular, the pupils in LOC case consumed 553kcal while the pupils in LOW case 445kcal, 108kcal lower than the LOC case. Moreover, the pupils in LOC case consumed 4.7g more proteins, 16.5g carbohydrates, 2.6g dietary fibre and 2.6g total fat than in LOW case. Overall, all the school meals in both cases provided higher energy values, fatty acids and Vitamin C than the recommendations of World Health Organisation (WHO). However, 20% of the served meals in LOC case and 40% in LOW case resulted to lower dietary fibre values than WHO recommendation.

In terms of <u>financial impact</u>, we found the cost of the plate waste per average meal served was €0.58 for LOWSchool, and €0.46 for LOCSchool representing a proportional financial losses from the food supply budget of 36% and 54% for LOWSchool and LOCSchool, respectively.

In terms of <u>carbon impact</u>, we found the carbon emissions embodied in the waste amounted to 1.53kgC02eq per average LOWSchool meal served, and 1.15kgC02eq per average LOCSchool meal. Overall, the percentage of waste from the total carbon emissions was 63% in the LOW model, slightly higher than the LOC model (62%).

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List of Abbreviations and Acronyms

PSFP- Public Sector Food Procurement

LOC MODEL – School with an Alternative model of public food procurement

LOW MODEL – School with a model of LOW cost public food procurement

FCA - Food Composition Analysis

HR – Higher Than Recommended

AV- Adequate Value

LR – Lower than Recommended

WHO - World Health Organisation

QA – Quality Assurance

1. INTRODUCTION

This report presents the methods and results of the WP6.2 Greece study into the nutritional impacts, and plate waste analysis, of different models of public sector food procurement (PSFP), for primary school meals. School nutrition should ensure an adequate range of food for children, supporting their growth, development and educational attainment. Although many countries have developed national nutritional guidelines for primary school meals, the nutritional values of institutionally organized diets depend not only on food standards and guidelines but also the criteria set by food procurement policies. Therefore, the aim of this research was to undertake a food composition analysis (FCA) of daily menus at selected school canteens belonging to contrasting models of public sector food procurement, in order to evaluate the nutritive values of those menus. In addition, it is recognised that no matter the national guidelines or PSFP model in schools, some foods are not popular with children. This can lead to children refusing and/or wasting (not eating some or all of the portion given) certain foods which in turn affects the actual nutritional intake of children from school meals, compared with what is intended by menu planning and development. Therefore, as well as calculating the nutritive values of menus via FCA, plate waste were also collected and evaluated from the same selected school canteens, to reveal the nutritional and financial losses and embodied carbon burden of the collected plate waste.

As explained in D6.1 Greece Country Report, until very recently no meals were offered in schools in Greece. However, in the 2016-17 school year, due to concerns for socio-economic inequality, the Greek Ministry of Labour, Social insurance and Social solidarity (LSS), in collaboration with the Ministry of Education, launched the "School Meals" program in 38 primary schools, selected from specific Municipalities based on deprivation criteria. In the school year 2017-18, the program was expanded to 798 public primary schools. None of the public schools in Greece comes with kitchen facilities and thus private catering enterprises are contracted to prepare and deliver meals to the pupils in schools. As explained in D6.3, all school meals tenders are evaluated using the common Most Economically Advantageous Tender (MEAT) framework, however some differences in procurement arrangements can be found in different areas. The two models that were selected for the research were a low-cost model (LOW) and a local procurement model (LOC).

The LOW case comprised the "School Meals" provision program as it has been implemented in Thessaloniki, specifically the Municipality of Evosmos – Kordelio. As explained above, the private caterer was awarded the contract according to the MEAT framework, and thus there was no limitation or specification on the origin of the products to comprise the meals. Hence, this case was defined as LOW. The WP6.2 dataset consists of two schools from the five LOW case schools described in D6.3 Greece Country Report (LOW School A and LOW School B

The LOC case comprised the "School Meals" provision program as it has been implemented in Kastoria, a municipality in north-western Greece. In this case, although the contract was awarded also according to the MEAT framework, the caterer had chosen to procure goods from a number of local suppliers. Therefore, this case represented the LOC procurement model for this research. The WP6.2 dataset consists of two schools from the five LOC case schools described in D6.3 Greece Country Report (LOC School A and LOC School E).

The methodology for the FCA and nutritive evaluation of menus was briefly as follows. For each of the four selected schools in the study (LOC Schools A and E and LOW Schools A and B), daily menus were collected for a period of five consecutive school days (Monday to Friday) during January, February and March in the school year 2017-18. In total therefore, 40 daily menus were analysed, 20 each for LOC and LOW cases. Menus were obtained from the school staff while normative provisions (standard quantities of ingredients) were obtained from direct conversation with the cooks. The nutritive values of school lunch recipes were calculated using an updated national food composition database (Composition tables of Foods and Greek dishes HFF). Thus, for each recipe offered on the schools' daily menus, calculations were made of the total energy (calories), macronutrients (proteins, fats, carbohydrates, dietary fibres and saturated fatty acids) and selected micronutrients (Vitamins A, B1, B2, B6, B12, Niacin, Folate, Vitamin C, D, and Minerals sodium, potassium, calcium, magnesium, phosphorus, iron, zink and copper) from a full consumed portion. For those foods that were not a part of the national food composition database, energy and nutritive values were obtained from the food labels. The energy and nutrient values of the offered meals were evaluated with regard to referent World Health Organisation (WHO) guidelines for school meals for children in primary schools. Therefore, for each recipe on the daily menus, we evaluated the extent to which a full consumed portion could contribute to a child's recommended daily intake of energy and nutrients. In undertaking the FCA, we also explored the possibility to make adjustments to reflect how food procured through alternative models may possess different nutritional outcomes. In practice however, the data did not support a justification for this adjustment.

The methodology for the plate waste study was designed to complement the FCA and nutritive analysis. A full explanation of the method is given in Section 5, but briefly, plate waste was collected daily in the same schools during the same weeks as the collection of menu data. Therefore, a total of 40 days of plate waste data was recorded, 20 each for LOC and LOW cases. Each day, the representative sample of five meals were weighted and an average weight of food/meal served calculated in order to establish a daily benchmark weight/meal served. Next, plate waste (if any was left) was collected from the plates/trays of all children who had taken a school lunch. The leftovers were separated into 6 different bins representing the main food categories: a) meat or fish; (b) (i) starchy food (pasta, rice, potatoes) and (ii)bread; (c) vegetables (salad); (d) dairy products (FETA cheese) and/or egg while fruit or desert wasn't served to the pupils. At the end of the lunch service, the total weight of each bin was recorded. Analysis then involved calculating the total weight of collected plate waste, the distribution of waste by food category, the proportion of served food wasted and the average weight of plate waste per meal served. In addition, using the composition of each bin, the nutritional and financial losses associated and the amount of embodied carbon was estimated for the collected plate waste.

Alongside the plate waste study, a series of observations were made of the lunchtime services in both LOC and LOW schools. These observations consisted of interviews, photographs, and discussions To supplement the observations, interviews were conducted with the headteachers and the teachers responsible for receiving the school meals, the catering companies Quality Assurance manager and the kitchen staff. As the study did not have ethical approval to interview the children, no formally interviewing of the children took place though some voluntarily provided their preferences and liking for different meals served. Furthermore, the school teachers explained the procedures followed for serving school meals, the preferences of the pupils, daily school meal uptake and daily comments on the provided school meal. As regards to the catering staff, they explained how they plan, prepare and deliver the daily school meal service in their schools providing the research team with a comprehensive insight into lunchtime service in the four case schools. These data helped interpretation and explanation of the results, and any similarities and differences found between the schools in terms of plate waste volumes and composition.

2. SCHOOL FOOD POLICIES IN GREECE

There is limited history of, and experience in delivering school meals in Greece. In 16/17, a small pilot programme entitled "School Meals" and fully funded by the Greek government was launched and in 17/18 the programme was expanded to 798 primary schools. The total cost of school meals provided under the "School Meal" programme was covered by the government and all pupils from the 798 participating primary schools were eligible to receive free school meals. The daily menu consists of only lunch (i.e. breakfast or snack was not offered) with one lunch option offered per day which consisted of a main meal, salad, bread and once or twice per week a dairy product. Fruit, dessert or any drink are not provided. As regards to the main meal, it was comprised of meat/fish, rice/pasta/potatoes, while one or two days per week, a meat free meal is offered such as lentil soup or boiled spinach with rice.

Generally speaking, Greek primary schools do not have in house kitchens, and none of the case schools in either Thessaloniki (LOW) and in Kastoria (LOC), had in-house kitchen or dining facilities. As a result, private catering companies were contracted by the Ministry of Labour, Social Insurance & Social Solidarity to prepare, and deliver on a daily basis the school meals at the school facilities. The school meals are served to, and eaten by the, children in their classroom after cleaning their desk with their own place mats. Sustainability requirements, in relation to food sourcing, were not included in the contract. Instead, specific food safety and quality provisions were included to protect children where all appointed catering organisations were obliged to use only fresh and unprocessed meat, fresh or frozen fish (no longer than 3 months) and no food additives.

Greece does not have National Guidelines for Nutritional or School meals and thus the appointed caterers were instructed to prepare the school meals in accordance with the Mediterranean recipes designed by the Agricultural University of Athens. Two samples of the school meals menu were included in the call for tenders of the "School meals" program, and subsequently, the appointed caterers offered menus in accordance to the contract provisions. As a result, the participating schools and/or the local Primary Education Offices were no consulted during, nor participated in, the selection of school meal menus.

The procurement provisions of the Directive 2014/24/EU and the National Greek Procurement Law 4412/2016 adopted the MEAT requirements and thus no sustainability or nutritional provisions were incorporated as part of the awarding criteria. Furthermore, Greece has not participated in the EU School Fruit and Vegetables Scheme and fruits are not served along with the school lunch. Lastly, the schools did not participate in health or nutritional related projects and activities were limited to recycling initiatives ran by the school teacher in collaboration with the pupils.

3. PROFILE OF CASE SCHOOLS

3.1. Case 1 LOW Thessaloniki

3.1.1 School Profiles: LOWSchools A and B

The first case study, LOW case, took place in the city of Thessaloniki and specifically in the municipality of Evosmos-Kordelio which is located in the west side of Thessaloniki (figure 1). The municipality of Evosmos-Kordelio covers an area of 12,768 km^2 with a population of 101,010 citizens (ELSTAT, 2011) with the majority employed in low-income job positions. The unemployment rate is marginally higher (21,8%) than the Greek national average (21,2%), (ELSTAT,2018). The area populated in 1922 repatriated with immigrants from Izmir, while the population increased the last twenty years because of the low cost for new apartments by repatriated Greeks from the former USSR and other economic immigrants (Municipality of Evosmos-Kordelio, 2018[9]). The employment is almost at average 21.8%, slightly higher than the national average of 21.2% (EUROSTAT, 2018). As it is an urban area, agriculture has a minor role in the economy and accounts only for 0.96% of workforce (ELSTAT, 2018)[10] while SMEs (24.6%) and Public sector (9.3%) are the biggest single industries in the area.

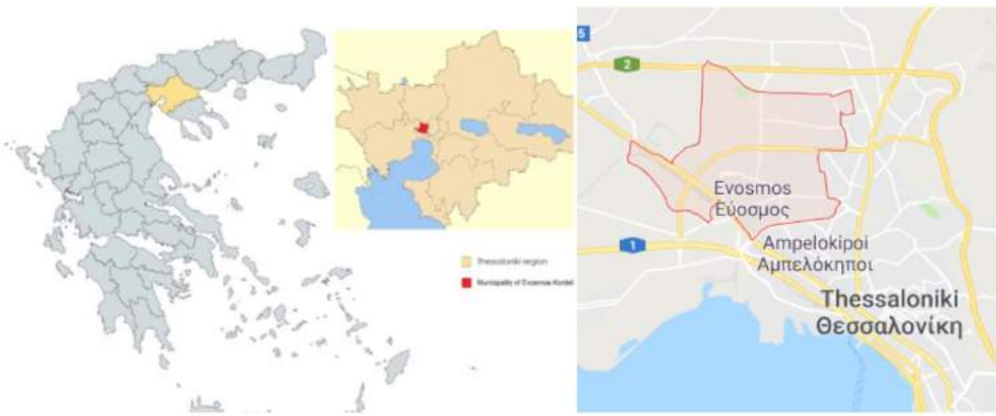

Figure 44. Map of the region of Thessaloniki and the municipality of Evosmos - Kordelio

The Municipality runs 33 primary schools and all participated in the national pilot program "School meals". The average number of pupils per school is 235 pupils/school with the school meals program starting in the 2^{nd} week of January (2018) and running for 24 school weeks until the 2^{nd} week of June (2018). While all children were eligible to participate in the school meals program, the average meal uptake was confirmed as 71%. The school meals program started in the 2^{nd} week of January (2018) and ended the 2^{nd} week of June (2018), covering a total of 24 school weeks. The two participating LOW schools have an average pupil roll of 271, slightly more that the Municipality's average, and an lower than average school meal uptake of 62.65% (table 1). It is noteworthy that the school meals were offered in plastic PET containers and pupils were eligible to consume them either at the school or at home. The pupils who consumed the school meals at home, were given a bag with the school meal and were leaving the school at 13:15, before the lunchtime of the pupils who consumed the meals at school.

[9] http://www.kordelio-evosmos.gr/index.php?option=com_content&task=view&id=331&Itemid=494
[10] http://www.statistics.gr/el/statistics/-/publication/SAM04/-

Name of the school	School meals participation		Consume at school		Consume at home
	Registered pupils	Average participation	Registered pupils	Average participation	Registered pupils
LOW School A	266	58.3%	80	70.5%	186
LOW School B	276	67.0%	60	71.0%	216
TOTAL	542	-	140	-	402

Table 21. The two participated primary schools of the Thessaloniki (LOW) case

3.1.2 Approach to Food and Sustainability Issues

The teachers in LOW schools initiated a voluntary program for recycling. In particular, they launched sessions to educate pupils about recycling and monitored children's daily participation in recycling. Each day, a pupil was responsible for the proper implementation of the recycling initiative. It was found that pupils engaged very much to the recycling initiatives in comparison with the common recycling practices of the general population in Greece. When it comes to food and health related projects, there wasn't any activity such as classroom activities, visits workshops or special projects/prizes. As a result, it is recommended to establish a new framework to activate such initiatives on food and health related projects, workshops, visits and even special prizes.

3.1.3 Organisation of the School Meals

LOW school meals were prepared and delivered by the LOW caterer (D6.3 Greece Country Report) at a cost of €2.23/school meal which was fully subsidized by the Central Greek government. The caterer employed 39 employers of which 5 are occupied for the delivering of the school meals to the schools. Each school meal consisted of a main meal, a salad, a piece of bread, and one day per week, a dairy product (FETA cheese). The menu was planned by the caterer and while the school had no input in menu design, headteacher are responsible to providing regularly feedback to the caterer in order to improve the school meal service. For instance, on one of the data collection days the salad came with a very small portion of olive oil and the headteacher alerted the caterer asking them to increase the amount of olive oil provided and by the next day the problem had been resolved. Table 2 presents a summary of a weekly menu in the LOW schools.

Day & Participation (%)	Meat & Fish	Starchy food		Vegetables	Mixed	Other (egg, FETA cheese)
Monday (80%)	Beef chicken	Rice	Bread	Salad (boiled beetroot)	-	-
Tuesday (65%)	-	-	Bread	Salad (boiled carrot)	Pasta with minced meat	-
Wednesday (72,5%)	Fish	Potatoes (oven)	Bread	Salad (fresh carrot & cabbage)	-	-
Thursday (70%)	Beef	Barley	Bread	Salad (Fresh Cucumber-Carrot)	-	-
Friday (65%)	-		Bread	Salad (boiled beetroot)	Boiled Peas with Carrot and potatoes (main meal)	FETA cheese

Table 22. School menu of the Primary Schools in LOW case, Thessaloniki

3.1.4 Lunchtime Service

The school meals were delivered to the school facilities between 12:15-12:30 in thermal incubators using LOW Caterers owned vans. Lunch started at 13:15 with meals were served to children in their classrooms or the school halls since the schools did not have dedicated in house dining facilities. In LOW school A, teachers used the computer classroom as dining room (figure 2) while in LOW School B all students consumed the school meals in their classrooms. While some pupils consumed their school meal in school during lunch, others chose (and were allowed) to take the meal home and consume it there. The children who did not accept the offered school lunch (approximately 30%) brought their own lunch into school and consumed it in the classroom alongside the other pupils. Drinks were not provided and thus the pupils brought in their own water. Lunchtime ended at 14:00 when the school bell rang. The teachers cleared away the pupils' dining tablecloths and cleaned the desks while LOW catering staff returned to pick up the empty incubators. Normally, the plate waste is put into the available bins by the pupils for disposal in landfill while the plastic containers recycled and put in special bins for recyclable material.

Figure 45. (a) Lunch preparation in LOW case, (b) a typical school meal in LOW case

3.1.5 Waste Management and Plastics Use

The avoidable food waste leftovers from the school meals is treated as garbage and directed to the non-recycling bins. However, all of the participated schools ran internal recycling initiatives and every day one pupil was responsible for the proper implementation of the recycling process of the recyclable materials such as the school meals plastic packages. In total, the plastic used for the school meals for 120 days in both schools is calculated to 582 kg (table 3).

Plastic package (PET)	Weight of 1 package (g)	Total plastic used in 120 days per pupil (g)	Total plastic used for both LOW schools in 120 days (kg)
Main meal plastic package	24	2.880	285,12
Salad package	13	1.560	154,44
Cheese package	12	288	142,56
Total	**49**	**4.728**	**582,12**

Table 23. Plastic use in LOW Schools A and B

3.1.6 School Fruit and Vegetable Scheme

While Greek schools participated in the EU School Fruit and Vegetables scheme in 12/13 and 13/14, the LOW Schools, in line with all other schools in Greece, do not currently participate in the EU School Fruit and Vegetables Scheme[11].

[11] https://ec.europa.eu/agriculture/sites/agriculture/files/sfs/documents/el_evaluation_report_-_2016-2017_en.pdf

3.2. Case 2 (LOC): Kastoria

3.2.1 School Profiles: LOCSchool A and LOCSchool E

The second case study, LOC case, is situated in a rural region of Kastoria specifically the Municipality of Kastoria which shares the same name with the prefecture. It is located in north-west Greece and is part of the prefecture neighbouring with Albania (figure 3). The municipality of Kastoria has a population of 35,874 citizens and covers an area of 763,3km^2 (ELSTAT, 2011). It is comprises of the towns of Kastoria and the villages Aposkepos, Kefalari and Chloi. The town of Kastoria, covers an area of 57,3 km^2 and has a population of 13,387 citizens. The average unemployment is at 28,2%, higher than the national average 21.8%, (EUROSTAT, 2018). The economy of the Munipality is oriented to fur production, tourism and agriculture (Municipality of Kastoria, 2018). Agriculture is the single main employer in the region with 17,77% of the workforce followed by the Public Sector with 10.96% of labour (ELSTAT,2018)[12].

Figure 46. Map of Municipality of Kastoria

Kastoria Municipality has 30 primary schools (Primary education office, 2018) with 50% (15 schools) registered for, and participating in, the “School Meals” program. On average, 77 pupils per school are registered to participate in the school meals program with an average meal uptake of 81%. The average number of pupils Kastoria is 67,23% lower than in Thessaloniki (LOW case), although the average participation is 9,92% higher than the primary schools in Evosmos-Kordelio, Thessaloniki. The duration of the school meals program was 24 weeks, starting from the second week of January (8th of January) until the end of the school year (13th of June). The two LOC schools had, on average, 81 pupils/school with an average participation of 83.3%, higher than the Municipality’s average (table 4).

[12] http://www.statistics.gr/el/statistics/-/publication/SAM04/-

Name of the school	School meals participation		Consume at school		Consume at home
	Registered pupils	Average participation	Registered pupils	Average participation	Registered pupils
LOC School A	83	84,3%	70	73,7%	13
LOC School E	79	82,3%	55	70,5%	24
TOTAL	162	-	125	-	37

Table 24. The five primary schools of the "LOC" model case study in Kastoria

3.2.2 Approach to Food and Sustainability Issues

The LOC schools in Kastoria followed the same approach as the LOW schools described above in section 3.1.2. No food and sustainability initiatives have been developed and/or delivered in these schools.

3.2.3 Organisation of the School Meals

The school meal in LOC case was prepared and delivered by the LOC caterer (D6.3 Greece Country Report) at a cost of €2.22/school meal which was fully subsidised by the Greek government. The caterer employed 17 employees, 2 of which are occupied delivering the school meals to the schools. Each school meal consisted of a main meal, a salad, a piece of bread, and two day per week, a dairy product (FETA cheese) or a boiled egg. As per the LOW schools, The menu was planned by the caterer and headteachers were responsible to providing feedback to the caterer to help improve the school meal service. Table 5 demonstrates the school menu of the LOC case in Kastoria.

Day & Participation (%)	Meat & Fish	Starchy food		Vegetables	Mixed	Other (egg, FETA cheese)
Monday (80%)	Roasted chicken	Rice	Bread	Salad (boiled carrot)	-	-
Tuesday (65%)	-	-	Bread	Salad (fresh cabbage)	Pasta with minced meat	-
Wednesday (72,5%)	-	Lentil soup	Bread	Salad (broccoli)	-	Cheese feta
Thursday (70%)	Roasted chicken	Groats	Bread	Salad (fresh carrot & cabbage)	-	-
Friday (65%)	-		Bread	Salad (fresh cucumber)	Spinach with rice	Boiled Egg

Table 25. School menu of the Primary Schools in LOC case, Kastoria

3.2.4 Lunchtime Service

The school meals were consumed by the pupils in the classrooms or the school halls, were teachers installed dining tables with tablecloths for the pupils. The lunchtime service applied in Kastoria (LOC case) was similar to that in the LOW case. The LOC school meals were delivered to the school facilities at approximately 12:15-12:30 in thermal incubators (figure 4a,b) using a LOC Caterer owned van. Lunch service started at 13:15 and the meals were served in the classrooms and the school halls. As per LOW case, while some pupils consumed their school meal in school during lunch, others chose (and were allowed) to take the meal home and consume it there. The children who did not accept the offered school lunch (approximately 28%) brought their own lunch into school and consumed it in the classroom alongside the other pupils. Drinks were not provided and thus the pupils brought their own water.

The lunchtime lasted for 45 minutes, ending with the school bell at 14:00. The teachers cleared away the pupils' dining tables and tablecloths and cleaned the desks while LOW caterer staff returned to pick up the empty incubators. While normally the plate waste were put directly into bins by the pupils for disposal via landfill, it was observed that sometimes plate waste was taken by the teachers and given to stray animals in Kastoria. The plastic containers were recycled by the pupils to special bins for recyclable material.

Figure 47. (a) Thermal incubators that are used for the transportation of the school meals and the salads, (b) the school meals in the thermal incubators, (c) a typical school mail in Kastoria, and (d) Lunch preparation in LOC case school

3.2.5 Waste Management and Plastics Use

The school meals were served in PET packages (main meal and salad) and the bread in plastic films. Generally the plate food waste was disposed of via non-recycle bins, treated as garbage and sent for disposal via landfill. However, it was observed that some teachers were collecting the meat based food wastes in order to offer them to the stray animals in Kastoria town. Lastly, as regards to the plastic waste, pupils and teachers collaborated to recycle the single used plastics from the school meals. In total, 412.2kg of plastic was recycled by LOC School pupils and staff during the 120 days (24 weeks) of the school meals program (table 6).

Plastic package (PET)	Weight of 1 package (g)	Total plastic used per pupil in 120 days (g)	Total plastic used for both LOC schools in 120 days (kg)
Main meal plastic package	26	3120	282.05
Salad package	12	1440	130.18
Total	**38**	**4560**	**412.2**

Table 26. Plastic use in LOC Schools A and E

The total volumes of plastic were used in LOC case were lower than in LOW case. The total volumes of plastic packages per pupil weighted 4,73kg for 120days in LOW case and in LOC case 4,56kg. The difference is mainly attributed to the plastic package of the cheese where the LOC caterer offered FETA cheese with the salad in the same package container while the LOW caterer offered FETA cheese separately.

3.2.6 School Fruit and Vegetable Scheme

While Greek schools participated in the EU School Fruit and Vegetables scheme in 12/13 and 13/14, the LOW Schools, in line with all other schools in Greece, do not currently participate in the EU School Fruit and Vegetables Scheme[13].

13 https://ec.europa.eu/agriculture/sites/agriculture/files/sfs/documents/el_evaluation_report_-_2016-2017_en.pdf

4. NUTRITIONAL COMPOSITION OF MENUS IN CASE SCHOOLS

This section presents the results of the nutritional composition analysis of the selected menus for both LOC and LOW schools. What the results show is the intended nutritive value of lunches for each case region, assuming full intake of the full standard portion. As described in Section 1, food composition analysis was carried out on 40 daily menus (over two weeks/seasons), 20 per case region. The nutritive value of school meals was calculated using national food composition database, Composition Tables of Food and Greek Dishes HHF.

The WHO guidelines for the nutrition of primary-school students give recommendations for the energy and nutritive values of school lunches. Table 7 provides a summary of these guidelines.

	Unit (g/mg/kcal)	% of total daily intake
	Energy and Macronutrients	
Energy	501-612 kcal	30 % of EAR
Carbohydrate	69-84 g	not less than 55% of food energy
Fat	17-20 g	not more than 30% of food energy
Saturated fatty acids	6-7 g	not more than 10% of food energy
Fibre	>4,47 g	not less than 30% of the reference value
Protein:	>8.49 g	not less than 30% of the RNI
	Vitamins:	
Vitamin A	>150 µg	not less than 30% of the RNI
Folate	>120 µg	not less than 40% of the RNI
Vitamin C	>10.5 mg	not less than 35% of the RNI
	Minerals	
Sodium		
Calcium	>245 mg	not less than 35% of the RNI
Iron	>3.48 mg	not less than 40% of the RNI

Table 27. Recommended energy and nutritive values of school lunches (WHO, Food and nutrition policy for schools)

The analytical procedure was as follows. First, the food composition for 20 daily menus was confirmed with the contracted private catering companies via interviews with the catering representatives (quality manager and R&D manager) according to the normatives for a standard portion (i.e. the specific ingredients comprising the main dish, salad and dessert, along with the ingredients' weights and whether cooked/uncooked). These data were then entered into a bespoke database and analytical tool (foodpbf.com) created by University of Zagreb for the Strength2Food project. Using this tool, the meal normatives for the LOC and LOW case menus were analysed to produce a full energy, macro- and micronutrient profile of a standard portion of lunch for each of the daily menus across both LOC and LOW cases. The tool also then compared these calculated profiles with the WHO nutritive guidelines.

To begin with however, a consolidated summary is presented of the energy, macro- and micronutrient profiles of an average daily menu at LOC and LOW schools, respectively (Table 8). These data were produced by averaging the energy, macro- and micronutrient profiles of all 20 daily menus in LOC schools, and all 20 daily menus in LOW schools, respectively and the results are expressed per standard portion as average ± standard error. This is followed by figure 5 which presents the proportions of daily menus, across both cases, achieving the recommended energy, macro- and micronutrient thresholds.

Parameter(average ± SD)	**LOC**	**LOW**	**ω^2-ANOVA**
MACRONUTRIENTS			
Energy (kcal)	815.25 ± 109.32	759.46 ± 118.62	0.0091 (no effect)
Total proteins (g)	34.80 ± 6.10	29.90 ± 6.53	0.0008 (no effect)
Total carbohydrates (g)	87.65 ± 14.74	79.85 ± 15.64	0.0105 (no effect)
Dietary fibre (g)	7.50 ± 5.26	4.36 ± 0.96	0.0594 (no effect)
Total fat (g)	36.15 ± 7.35	35.31 ± 7.86	0
Saturated fatty acids (g)	8.55 ± 2.18	9.66 ± 4.37	0
VITAMINS			
Vitamin A (mg RE)	na	na	/
Vitamin B1 (mg)	0.49 ± 0.14	0.48 ± 0.12	0.0014 (no effect)
Vitamin B2 (mg)	0.56 ± 0.25	0.41 ± 0.28	0.0043 (no effect)
Niacin (mg)	na	na	/
Vitamin B6 (mg)	0.42 ± 0.25	0.73 ± 0.26	0
Folate (μg)	na	na	/
Vitamin B12 (μg)	na	na	/
Vitamin C (mg)	58.10 ± 50.76	65.32 ± 44.54	0.0031 (no effect)
Vitamin D (μg)	na	na	/
MINERALS			
Sodium (mg)	1492.97 ± 627.74	1695.35 ± 585.10	0
Potassium (mg)	1125.30 ± 363.80	1144.04 ± 353.58	0
Calcium (mg)	300.42 ± 117.31	366.62 ± 139.93	0
Magnesium (mg)	129.38 ± 37.86	130.06 ± 50.77	0.0003 (no effect)
Phosphor (mg)	510.20 ± 280.09	439.07 ± 326.32	0
Iron (mg)	7.45 ± 3.23	5.76 ± 2.06	0.0072 (no effect)

Zinc (mg)	6.11 ± 1.75	6.15 ± 2.75	0
Copper (mg)	0.66 ± 0.40	0.53 ± 0.15	0.0020 (no effect)

na: data not available from the national food composition database

Table 28. Average energy and nutritive value of school lunches (n=10) per PSFP model

As table 8 illustrates, the calculated energy of the LOC school meals is 55.8 kcal higher than that offered in LOW schoolS. Furthermore, the total proteins of the LOC case school meals are 4.9g higher than in LOW School meals. Similarly, the total proteins, total carbohydrates, dietary fibre and total fat are higher in LOC case by 4.9g, 7.8g, 3.14g and 0.84g respectively. Saturated fatty acids totals are higher by 1.1g in the LOW compared to LOC Schools. Vitamins B_1 and B_2 are higher in the LOC school meals, although Vitamins B_6 and C are higher in the LOW schools. The minerals Phosphor, Iron and Copper are lower in the LOW compared to school meals as are the concentration of Sodium, Potassium, Calcium, Magnesium and Zinc. According to the Anova analysis[14], there is no effect between the mean values of the two PSFP model parameters.

The next set of results focus on the daily menus, and show the proportions of the 20 menus in LOC and LOW cases that met the WHO nutritional guidelines (Table 7). First, the energy provision of the daily menus is presented. According to the WHO guidelines, a school lunch should provide 30% of a child's daily energy requirements (1740 to 2220 kcal) and as such the daily recommended energy intake from school lunch is estimated between 501-612kcal.

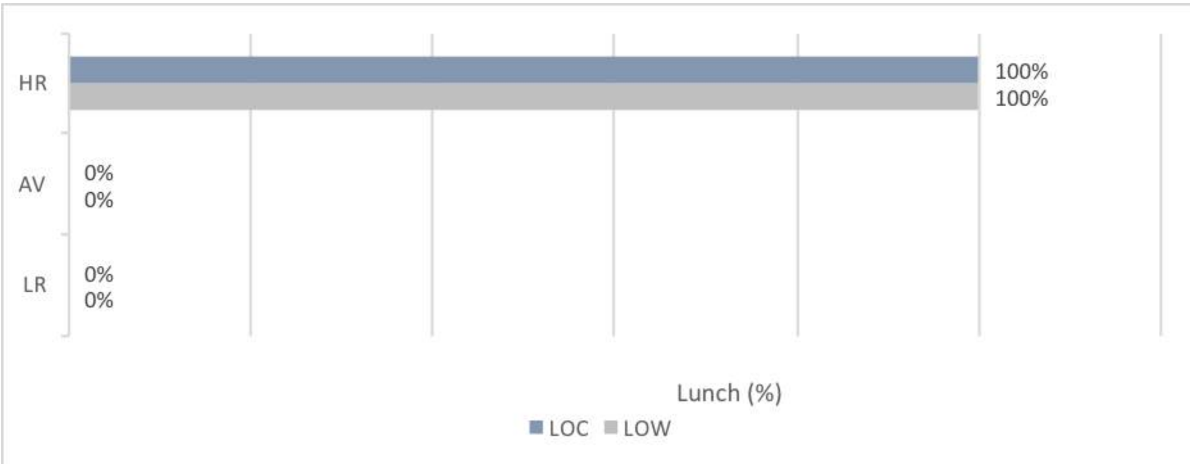

Figure 48. Distribution of energy values in school meals (n=10) per PSFP model according to WHO recommendation

[14] Statistics: **ANOVA ω²** statistics was selected because of low bias and non-parametric correlation showing true relationship between data sets.

ANOVA ω² significance values are in the following ranges: i) 0 - 0.063 not significant differences (no effect); ii) 0.063 – 0.14 significant differences (medium effect); iii) >0.14 significant differences (high effect)

As Figure 5 shows, according to the World Health Organization (WHO), and across both cases, the energy intake of all the analysed and served school meals (100%) were found to be higher than WHO recommendations.

Next we present results relating to fat content (Figure 6). According to WHO recommendations (Food and nutrition policy for schools, 2006), not more than 30% of food energy should be originated from total fat distrand no less than 55% from total carbohydrates. For both cases, and across all analysed and served meals, the average total fat was found to be much higher than recommended at 42% (LOW) and 40% (LOC) respectively. The average total carbohydrates per meal served was found to be much less than recommended at 42% (LOW) and 43% (LOC) respectively.

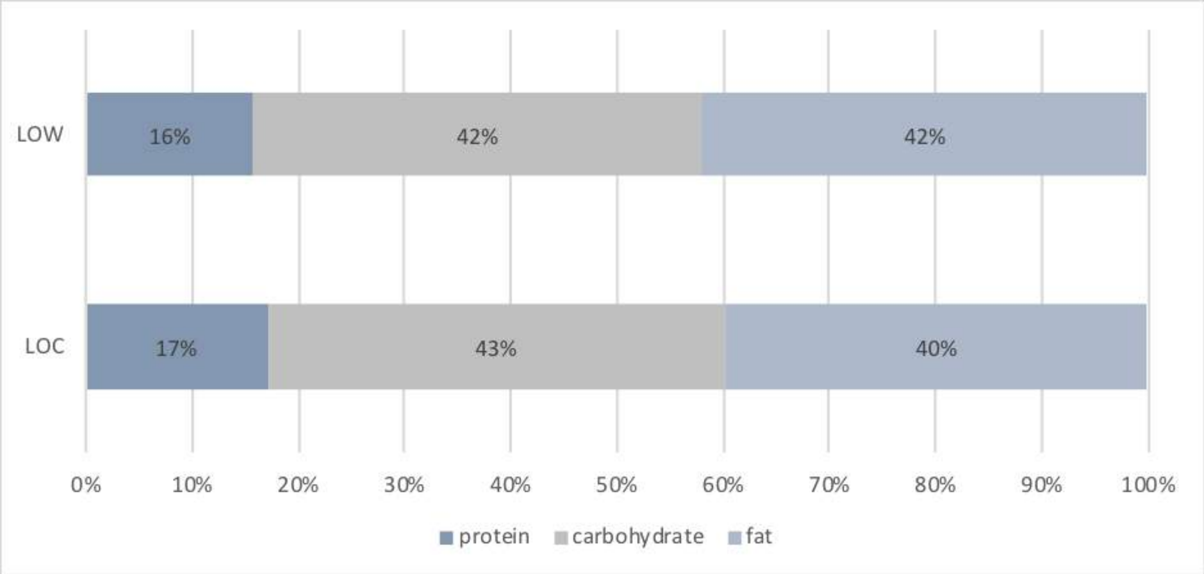

Figure 49. Average distribution of macronutrients of school meals (n=10) per PSFP model

Next the results relating to saturated fatty acids are presented (Figure 7). According to WHO recommendation not more than 10% of food energy should be originated from saturated fatty acids. For LOC menus, 30% were found to have higher than recommended levels of saturated fatty acids values. Similarly, 60% of the LOW menus were found to have higher than Recommendation saturated fatty acids levels. No meals, across both cases, were found to have saturated fat levels below the recommended levels.

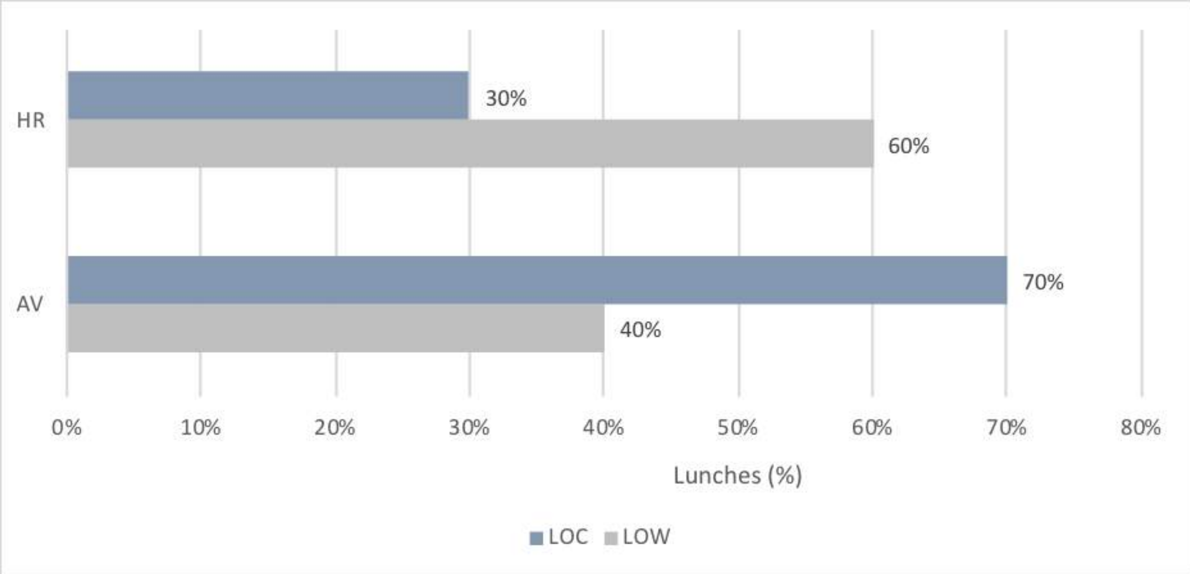

Figure 50. Distribution of saturated fatty acids values in school lunches (n=10) per PSFP model according to WHO recommendation

Next, figure 8 presents the distribution of the dietary fibre values in LOW and LOC case. According to WHO recommendations, school lunches should contain a minimum of 4.47g of dietary fibre. While 80% of the LOC menus were found to provide proadequate levels of dietary fibre, only 60% of LOW menus were adequate in fibre. The remaining menus in LOC (20%) and LOW (40%) were found to have lower than recommended levels of dietary fibre.

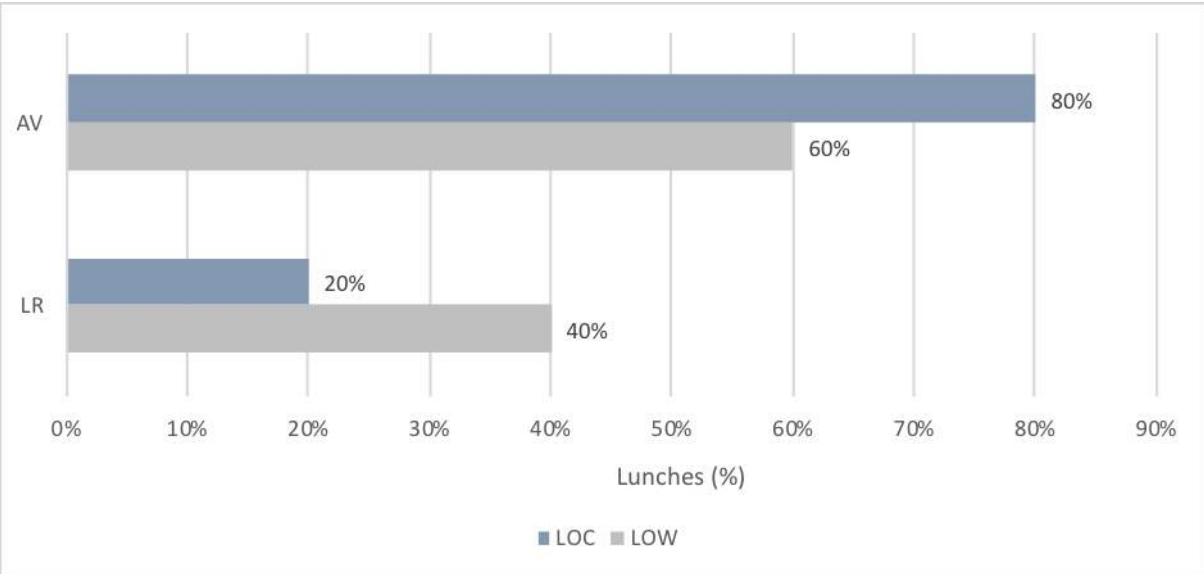

Figure 51. Distribution of dietary fibre values in school lunches (n=10) per PSFP model according to WHO recommendation

Lastly, figure 9 presents the results relating to vitamins and minerals. For vitamins, only Vitamin C was found to have a standard recommendation, and as figure 9 shows, all LOC and LOW menus were found to meet this standard. For minerals, only iron and calcium have standard recommendations. As figure 10 shows, almost all LOC AND LOW menus were found to have recommended amounts of iron, though in both cases, 40% of the menus had lower than the recommended levels of calcium.

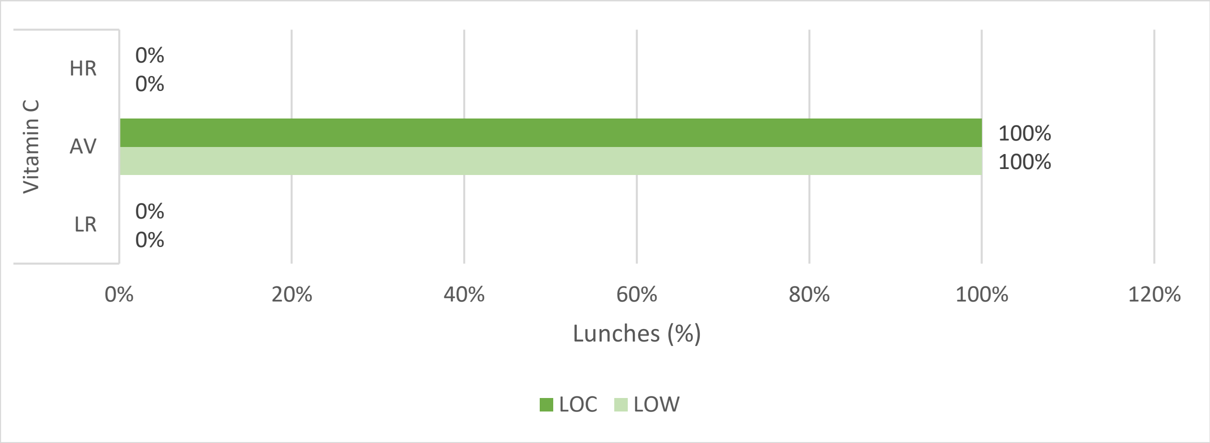

Figure 52. Distribution of vitamin C values in school lunches per PSFP model according to WHO recommendation

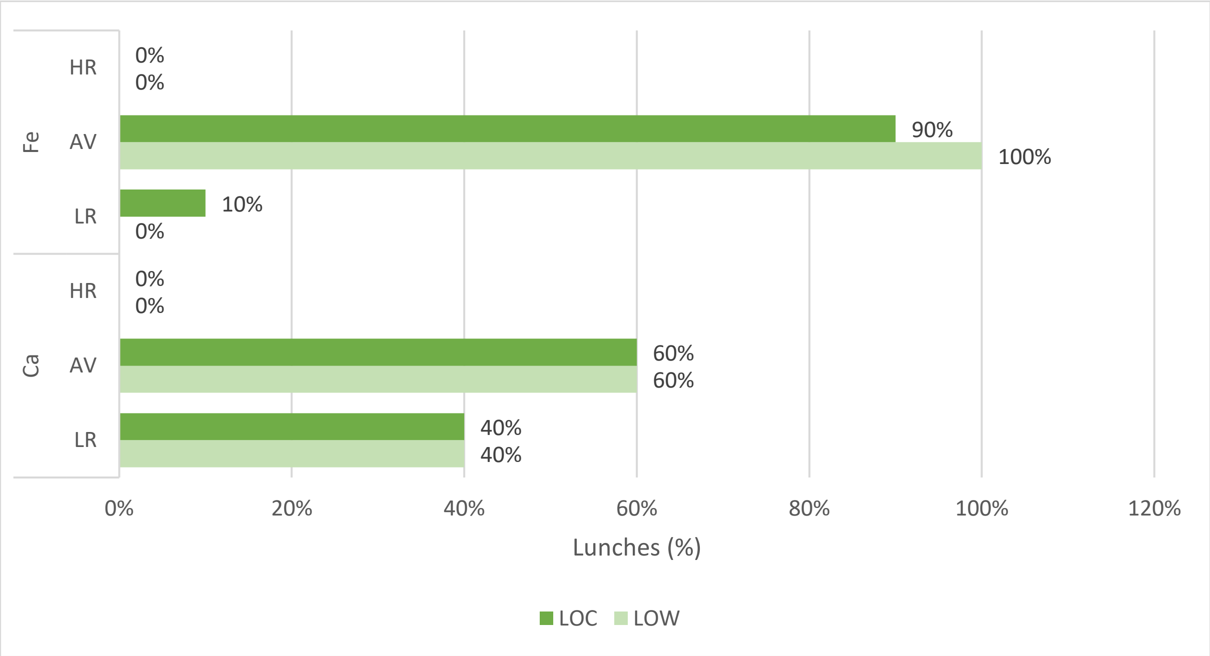

Figure 53. Distribution of mineral values in school lunches per PSFP model according to WHO recommendation

5. PLATE WASTE IN CASE SCHOOLS

5.1. Plate waste methodology

The plate waste study employed the aggregate selective plate waste method (Methodological Handbook, D6.2, Strenght2Food, 2018). This methodology requires the collection of plate waste (if any is remaining) from the trays of every pupil taking school lunch on the data collection According to Baric, Bituh and Brecic (2017), this methodology is fast and accurate and it is estimated that plate waste can be collected from 50 pupils per researcher/hr with a minimum of two researchers per day. For the Greek plate waste data collection, two researchers per school were employed. They were equipped with digital precision scles (1g), 1g precision, scrapers, gloves and multiple bins for the segregative food categories/items. Applying the measurement procedure, across case studies, the research team segregated the plate waste into six food categories: a) meat or fish; (b) (i) starchy food (pasta, rice, potatoes) and (ii) bread; (c) vegetables (salad); (d) dairy products (FETA cheese) and/or egg; and (e) mixed food (pasta with minced meat or boiled spinach with rice). On each day, and in each school, a representative sample of five school meals were weighed in order to calculate the reference portion sizes of the meals and associated six food categories (figure 11). Due to the school meal system, the school meals were served in two PET packages rather than trays, one for the school meal and one for the salad. In addition the bread wrapped in a plastic protective film.

Figure 54. Measurement of the school meal reference portions

Across both cases, school meals were served at the end of the typical school program between 13:15 and 14:00. The school meals were delivered to the primary schools by the catering companies an hour before lunch time and the research team started the reference portion measurement 20-30 minutes prior lunch time. After lunch service ended, the research team discussed the lunch service with the headteacher of each school reflecting on daily pupils' participation, any daily issues encountered (none were recorded during the measurement of both case studies) and pupils preferences as observed by the teachers regarding the daily meal. In line with the ethical approval in place for this study, the research team was not authorized to speak to the pupils or make use of any questionnaire in the first round of plate waste data was collected for the LOW schools from 22-26/01/2018 and for the LOC schools from the 14-16/02/2018 (Wednesday to Friday) & 05-06/03/2018 (Monday to Tuesday). The LOW menu did not change, except for some minor changes in the served salads. Hence, the measurement took place one week per school. Lastly, all the plate waste records were analysed in order to calculate the total food waste and the produced food waste per food category both in total values and as proportions from the reference portions.

The plate waste results are organised as follows. First is presented the total volume of waste collected from all bins during the 20 days of data collection in LOC and LOW case schools, respectively (Section 5.2). Next, the food category composition of the waste is reported in both cases (Section 5.3), followed by overview of waste from illustrative menus (Section 5.4). Next, is the analysis of the nutritional losses associated with the plate waste in both cases (Section 5.5). Finally, the analysis is given of the estimated financial cost and levels of embodied carbon in the plate waste (Sections 5.6 and 5.7).

5.2. Total Plate Waste in LOC and LOW Cases

As presented in Table 9, in LOW schools, across 495 served meals and 251.1kg of total weight of food served (507.3g/meal served), 108.8kg of plate food waste was collected across all 6 food categories. In LOC schools, across 452 served meals and 197.9kg of total weight of food served (437.8g/meal served), 74.2kg of plate food waste was collected across all 6 food categories. This equates to an average of 164.2g (LOC) and 219.8g (LOW) respectively of plate waste per meal served.

PFSP model	LOC	LOW
Total number of served meals (n)	452	495
Total volume of food in served meals (kg)	197.9	251.1
Average volume of food per served meal (g)	437.8	507.3
Total volume of plate waste (kg)	74.2	108.8
Average volume of plate waste per served meal (g)	164.2	219.8
Proportion of served meal volume that is plate waste (%)	37.5	43.3

Table 29. Amount of served meals and plate waste across all food categories and both seasons in two schools per case (n=10 lunches per PSFP case)

While school meal uptake differs slightly between the cases, the collected plate food waste as a proportion of the total weight of food served was very similar with 37.5% for LOC Schools and 43.3% for LOW Schools (Table 9).

5.3. Total Plate Waste Composition by Food Categories in LOC and LOW Cases

In section 5.2, the composition of the collected plate food waste, across the 6 food categories, is presented where the six food categories are: a) meat or fish (MF); (b) starchy food (pasta, rice, potatoes), (SF); (c) vegetables (V); (d) bread (B); (e) mixed food (M); and (f) dairy products (D). Total weight of plate food waste from the food categories; MF, SF, V and B; is higher in the LOW cases while the food categories M and D produce higher plate food waste in the LOC case (figure 12).

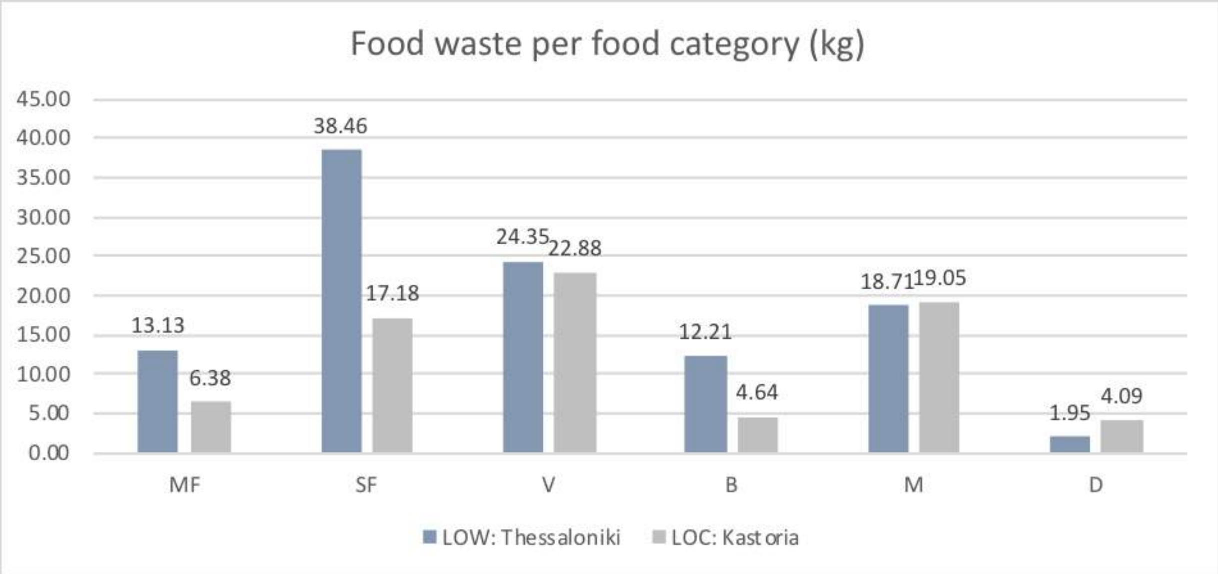

Figure 55. Food waste per food category among the two PSFP models

Food categories	LOC (n=5 lunches)		LOW (n=5 lunches)	
	kgs	%	kgs	%
Meat or fish	6,4	8,6%	13,13	12,1%
Starchy food	17,2	23,1%	38,46	35,3%
Vegetables	22,9	30,8%	24,35	22,4%
Bread	4,6	6,3%	12,21	11,2%
Mixed food	19,1	25,7%	18,71	17,2%
dairy products	4,1	5,5%	1,95	1,8%
Total waste	74.2	100	108.8	100

Table 30. Food waste per food category among the two PSFP models

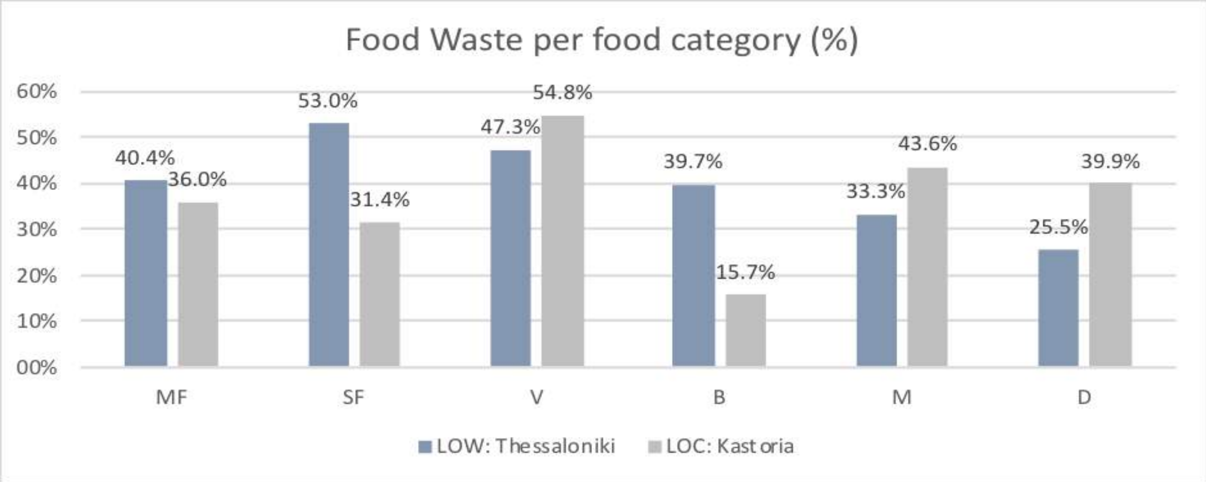

Figure 56. Food waste per food category as a proportion from the total served food among the two PSFP model.

Plate waste food categories	Meat & fish	Starchy food	Vegetable	Bread	Mixed food	Dairy products
LOC case						
No. of served meals in one week (n)	185	277	452	452	175	167
Served meals in one week (kg)	17,74	54,76	42,79	28,60	43,73	10,25
Plate waste in one week (kg)	6,38	17,18	22,88	4,64	19,05	4,09
Average plate waste/meal served (g)	34,49	62,02	50,62	10,27	108,86	24,49
Proportion of waste coming from plate waste in two weeks (%)	36.0	31.4	54.8	15.7	43.6	37.9
LOW case						
No. of served meals in one week (n)	310	310	495	495	185	92
Served meals in one week (kg)	32,48	72,57	51,52	30,74	57,85	7,64
Plate waste in one week (kg)	13,13	38,46	27,50	12,20	18,71	1,95
Average plate waste/meal served (g)	42,35	124,06	55,56	24,65	101,14	21,20
Proportion of waste coming from plate waste in two weeks (%)	40.4	53.0	47.3	19.7	33.3	25.5

Table 31. Food waste per food category as a proportion from the total served food among the two PSFP models

The food waste by food category and per academic year in the LOW case, is presented in table 10-12. On average, in the LOW case, 26.5g of meat and fish, and 77.7g of starchy carbohydrates per meal served is wasted representing 47% of total collected LOW plate waste. In addition, 49.2g of vegetables are wasted per meal served representing a further 22.3% of total collected LOW plate waste. The food category with the least weight of collected waste is D, the FETA cheese, with 3.9g per meal.

Food categories:	Meat & Fish	Starchy food	Vegetables	Bread	Mixed	Other (FETA Cheese)
a) Waste per Meal (g)	26,5	77,7	49,2	24,7	37,8	3,9
b) Estimated Total Waste (kg) per Academic year (average school meal waste * total number of meals per year (873*5*24))	2778,8	8138,9	5.153,1	2583,9	3.959,5	411,8

Table 32. LOW case: (a) Food waste per meal and food category, (b) Total waste per academic year (120 days) and food category

Additionally, as regards to the LOC case, the meat and fish, and vegetable, waste per meal is calculated at 14,1g and 50,6g per meal served respectively. The bread waste per meal were 10,3g and the mixed meals 42,1g. The food waste calculations, among the six food categories, for one academic year (120 days) in the LOC case are presented on table 11.

The distribution of LOC plate food waste by food category and per academic year is presented in table 10, 11 and 13. On average, 14.1g of meat and fish, and 38g of starchy carbohydrates are wasted per LOC meal served representing 31.7% of total collected LOW plate waste. In addition, a further 50.6g, on average, of vegetables are wasted per LOC meal served representing 30.8% of total collected plate waste. The food category with the least weight of collected plate waste is D, FETA cheese, with 3.9g per meal.

Food categories:	Meat & Fish	Starchy food	Vegetables	Bread	Mixed	Other
a) Waste per Meal (g)	14,1	38,0	50,6	10,3	42,1	9,0
b) Total Waste (kg) per Academic year (average school meal waste * total number of meals per year (305*5*24))	516,5	1.391,1	1.852,8	376,0	1.542,6	330,8

Table 33. LOC case: (a) Food waste per meal and food category, (b) Total waste per academic year (120 days) and food category

The breakdown of plate waste by food category as a proportion of served food is presented in figure 15. The proportion of served food/food category wasted is higher in the LOW case for meat and fish (4%) starchy food (22%) and bread (24%). On the other hand, the collected food waste from vegetables, and mixed food, was found to be 8%, and 11%, higher respectively in the LOC compared to LOW case. Similarly, the collected waste in the dairy products category, was 14,4% higher in the LOC compared to LOW case.

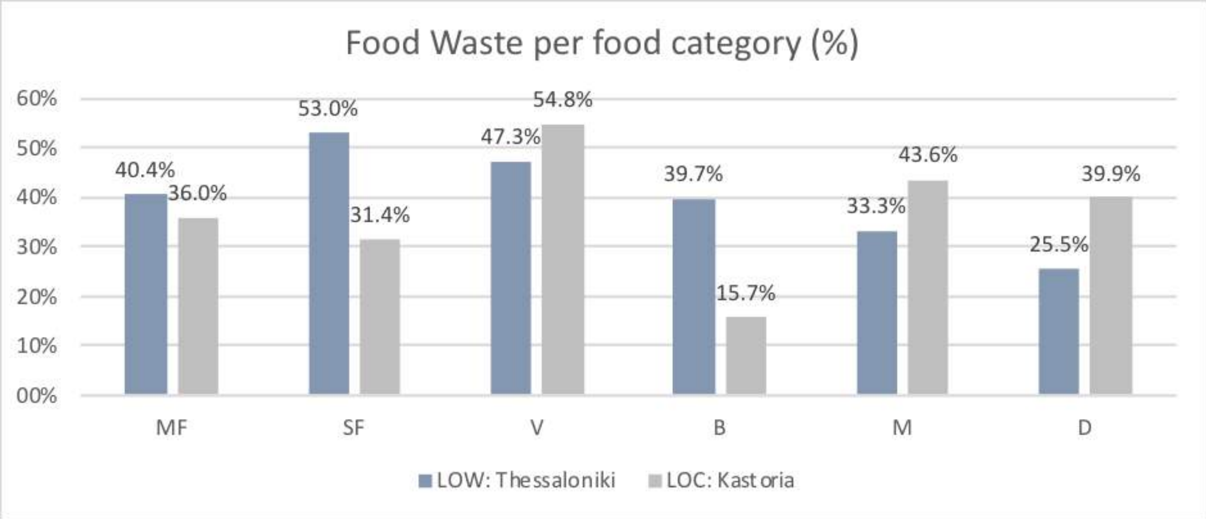

Figure 57. Food waste per food category as a proportion from the total served food/food category for the two PSFP models

As illustrated in Figure 14, differences were found within, and between, the proportions of food wasted/food category across LOC and LOW with starchy foods being the most wasted category (53%) in LOC while in LOW vegetables were the most wasted (54.8%). Conversely, there are also differences in terms of the least wasted food categories with dairy products in LOC schools (25.5%) and bread in LOW (15.7%).

5.4. Plate Waste from Illustrative Daily Menus and/or Dishes

Looking in more detail into LOW food waste differences between components of each food categories, we see some differences in food waste levels (figure 15). Taking “Meat and fish” (MF) as an example, while on average 36-40% (LOW-LOC) of served meat and fish were collected as waste, when beef was served this level increased to 45% compared to compared to 39.4% for served chicken and 36.5% for served fish. Similarly, for starchy food rice, served on Monday, was the most wasted (62,4%), followed by 55.5% of potatoes served on Wednesday. The least wasted starchy food was barley, served on Friday, at 41.9%. In terms of vegetables, 69,3% of the boiled beetroot served was wasted in addition to the consumption of the same food item on Monday (81,8%). The measured vegetable waste on Tuesday to Thursday ranges from 46,9% (cucumber & carrot) and 58,3% (cabbage with carrot). Bread waste ranges from 27,9% (Monday) and 55,4% (Friday). As regards to the mixed food category, which represents the main meals of Tuesday and Friday are being consumed the most among the main meals of the other days. In particular, the consumption of the pasta with minced meat and the boiled spinach with rice, on Tuesday and Friday, is calculated to 65,4% and 67,7% respectively. Lastly, the consumption of the FETA cheese was the highest (74,5%) among all the served food items.

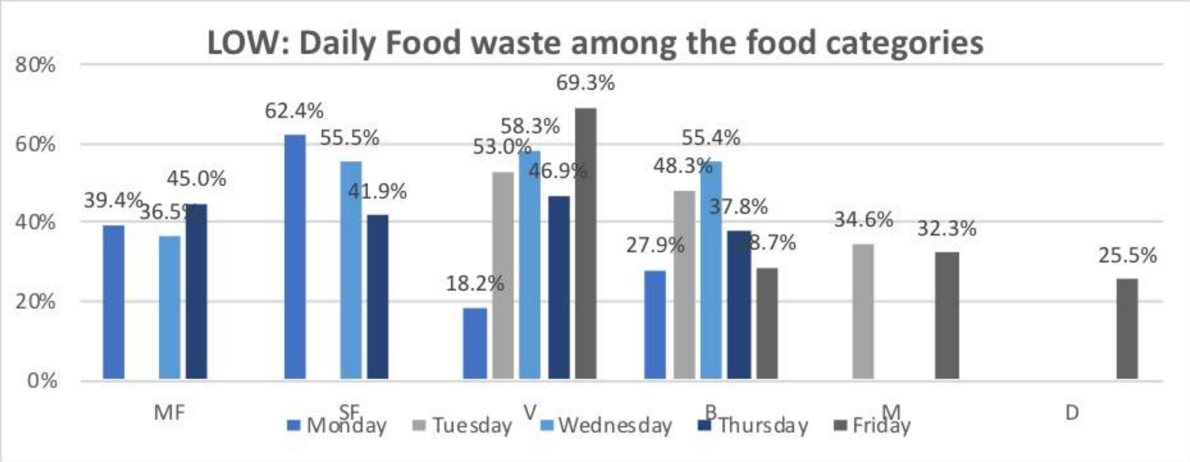

Figure 58. Daily food waste (%) among the six food categories of the LOW case

Subsequently, in the LOC case, the chicken wastes on Monday were 33,2% and on Thursday 40,3% (figure 16). Moreover, on Monday the chicken was served with rice which 27,9% of it was wasted as well as the 33,4% of groats, which was served on Thursday. It is noteworthy that the lentil soup wastes, meal served on Wednesday, are calculated to 32,2%. The same day, the vegetable consumption was the highest wasted category with broccoli consumption to be calculated to 20,6%. However, on Friday the cucumber wastes were low (27,4%) in comparison to the rest vegetable items. The same day, bread was the food item which was wasted the most (34,1%) while the other days ranged from 10,4% to 16,7%. The mixed food category, pasta with minced meat, which was served on Tuesday, wasted by 36,1% while spinach with rice on Friday wasted by 55,6%. Lastly, FETA cheese (Wednesday) wasted by 45,3% while the avoidable wastes of boiled eggs on Friday are calculated to 33,5%.

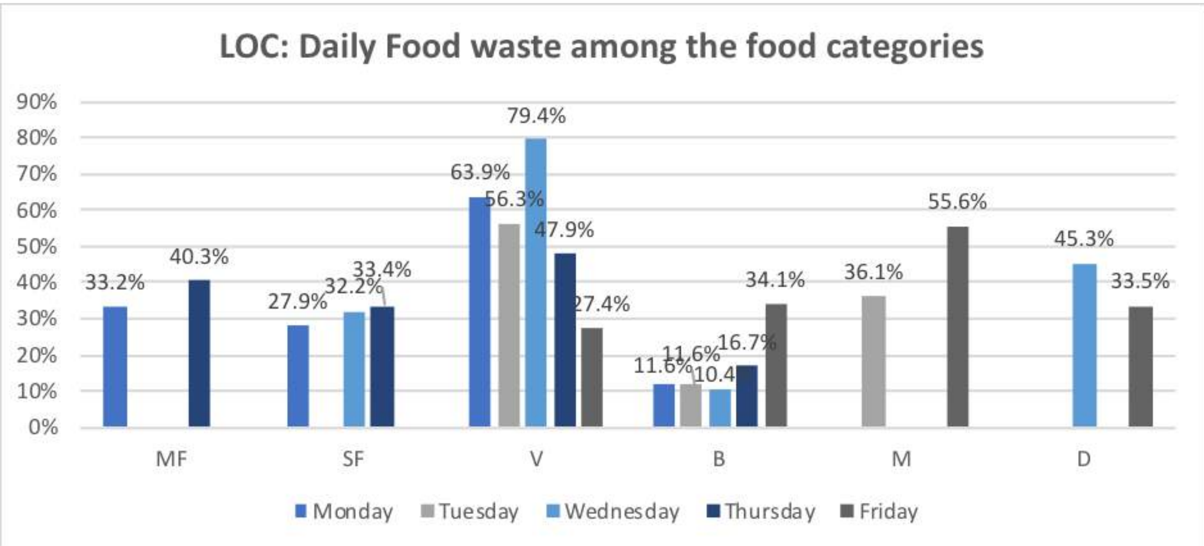

Figure 59. Daily food waste (%) among the six food categories of the LOC case

Comparatively, the wasted meat and fish items were higher in the LOW compared to LOC case. However, the latter served two “meat free” main meals compare to the LOW case which had one “free meat” main meal. Moreover, in LOC case, the wastes of the bread and the starchy food items, including the legume based main meal, lentil soup, are lower compare to the LOW case. However, the vegetable consumption during the meat free days are very high in both cases except the cucumber consumption of the pupils in Kastoria on Friday. Lastly, the plate wastes from the mixed main meal, boiled spinach with rice, which was served in both case studies, was higher in the LOC case than in the LOW case, although in Kastoria the catering offered also a boiled egg.

5.5. Nutritional impact Nutritional Impact of Plate Waste at LOC and LOW Case Schools

This section reports the nutritional composition of the collected plate waste, and the associated implications for nutritional intake from school meals. In Section 4, the nutritional composition of 20 daily menus across LOC and LOW schools were analysed, with some meals across both cases found to be nutritionally deficient. However, plate waste affect the final actual nutritional intake of children from school meals, compared with what is intended by the menu design.

Table 14 presents the nutritional composition of the served meals, after adjustments for collected plate waste, with the results highlighting that LOC children consume 108 more calories (kcal) per meal served than LOW children. Similarly, LOC children consume more total proteins (4.7 g), carbohydrates (16.6 g), dietary fibre (2.6 g) and total fat (2.6 g) per meal served than LOW children, while LOW children consumer higher amounts of saturated fatty acids (0.6g) than LOC children.

Parameter (average ± SD)	**Nutritional composition of served lunches per child**		**Nutritional composition of plate waste per child**		**Difference between FCA of served lunch and plate waste Δ (%)**	
	LOC	**LOW**	**LOC**	**LOW**	**LOC**	**LOW**
Energy (kcal)	836 ± 118	777 ± 116	283 ± 66	331 ± 68	553 ± 140 (65)	445 ± 83 (57)
Total proteins (g)	34.9 ± 7.3	30.5 ± 6.7	11.8 ± 2.4	12.1 ± 3.8	23.1 ± 7.0 (65)	18.4 ± 3.5 (61)
Total carbohydrates (g)	90.6 ± 11.2	81.8 ± 16.1	28.1 ± 12.5	36.0 ± 9.0	62.5 ± 18.1 (68)	45.9 ± 11.5 (56)
Dietary fibre (g)	7.6 ± 4.8	4.6 ± 1.1	2.5 ± 1.4	2.0 ± 0.7	5.2 ± 3.8 (66)	2.6 ± 0.6 (56)
Total fat (g)	36.8 ± 8.0	35.7 ± 6.8	13.6 ± 3.3	15.2 ± 4.3	23.2 ± 6.3 (62)	20.6 ± 4.5 (58)
Saturated fatty acids (g)	8.5 ± 2.4	9.7 ± 4.2	3.2 ± 1.1	3.8 ± 1.7	5.3 ± 1.5 (63)	5.9 ± 3.0 (59)

Table 34. Average nutritional composition of served lunches and plate waste

Figure 17 presents the macronutrient losses from the plate waste. In particular, it is evident that LOW nutritional losses higher LOC for all macronutrients with the highest losses recorded for total carbohydrates followed by the dietary fibre.

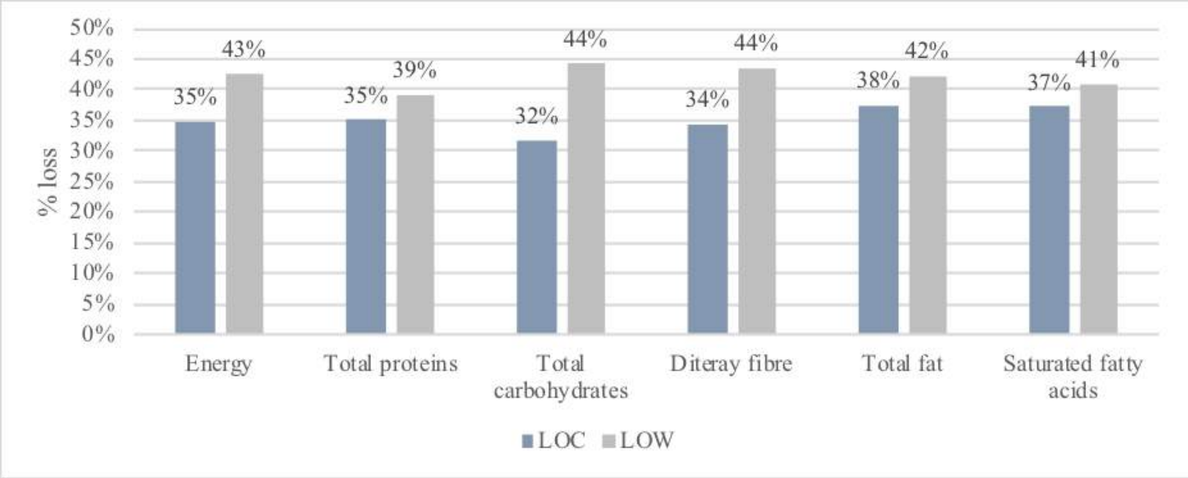

Figure 60. Losses of energy and macronutrient of school lunches in LOW & LOC case

Table 15 summarizes the micronutrient losses from plate waste for both cases. While micronutrient losses, especially for nutrients, are higher in LOC than LOW schools (figure 18), final estimated micronutrient intake, after adjustments for plate waste, in LOC schools was higher, notwithstanding the losses, in Vitamin B_1, Vitamin B_2, Vitamin C, Pottasium, Magnesium, Phosphor Iron, Zinc and Copper and lower in Niacin, Vitamin B_6, Sodium and Calcium compared to LOW schools. The highest nutrient losses, across the cases, were recorded for Vitamins B_6 and C.

Parameter (average ± SD)	**Nutritional composition of served lunches**		**Nutritional composition of plate waste**		**Difference between FCA of served lunch and plate waste Δ (%)**	
	LOC	**LOW**	**LOC**	**LOW**	**LOC**	**LOW**
Vitamin A (mg RE)	*na*	*na*	*na*	*na*	*na*	*na*
Vitamin B_1 (mg)	0.52 ± 0.13	0.48 ± 0.12	0.17 ± 0.08	0.20 ± 0.04	0.34 ± 0.11 (43)	0.28 ± 0.10 (84)
Vitamin B_2 (mg)	0.66 ± 0.22	0.41 ± 0.28	0.25 ± 0.12	0.15 ± 0.07	0.40 ± 0.13 (42)	0.26 ± 0.22 (84)
Niacin (mg)	*na*	*na*	*na*	*na*	*na*	*na*
Vitamin B_6 (mg)	0.38 ± 0.24	0.74 ± 0.26	0.14 ± 0.08	0.31 ± 0.09	0.24 ± 0.17 (63)	0.43 ± 0.21 (84)
Folat (μg)	*na*	*na*	*na*	*na*	*na*	*na*
Vitamin B_{12} (μg)	*na*	*na*	*na*	*na*	*na*	*na*
Vitamin C (mg)	83.61 ± 60.23	67.33 ± 43.01	36.86 ± 36.84	29.14 ± 21.56	46.75 ± 27.07 (64)	38.19 ± 25.04 (86)
Vitamin D (μg)	*na*	*na*	*na*	*na*	*na*	*na*

Sodium (mg)	1462.09 ± 488.21	1719.20 ± 580.53	533.55 ± 286.05	690.93 ± 159.19	928.54 ± 357.29 (64)	1028.27 ± 480.81 (58)
Potassium (mg)	1195.30 ± 425.99	1166.37 ± 356.79	462.41 ± 244.37	517.28 ± 183.34	732.89 ± 257.21 (62)	649.09 ± 213.71 (56)
Calcium (mg)	313.25 ± 127.68	365.87 ± 139.62	114.81 ± 75.25	152.28 ± 49.24	198.44 ± 74.87 (66)	213.59 ± 109.00 (57)
Magnesium (mg)	136.30 ± 44.27	133.36 ± 52.65	51.79 ± 33.72	57.69 ± 23.23	84.51 ± 23.05 (64)	75.67 ± 33.04 (56)
Phosphor (mg)	533.16 ± 267.85	445.47 ± 333.45	187.96 ± 98.99	166.27 ± 94.35	345.20 ± 178.35 (65)	279.19 ± 250.29 (58)
Iron (mg)	7.94 ± 2.96	5.96 ± 2.17	2.63 ± 1.31	2.57 ± 0.85	5.32 ± 2.41 (67)	3.38 ± 1.41 (56)
Zinc (mg)	5.87 ± 1.36	6.22 ± 2.77	2.14 ± 1.04	2.77 ± 1.28	3.73 ± 0.84 (65)	3.45 ± 1.61 (56)
Copper (mg)	0.68 ± 0.40	0.55 ± 0.16	0.21 ± 0.13	0.24 ± 0.07	0.47 ± 0.31 (67)	0.31 ± 0.12 (56)

Table 35. Average micronutritional composition of served lunches and plate waste

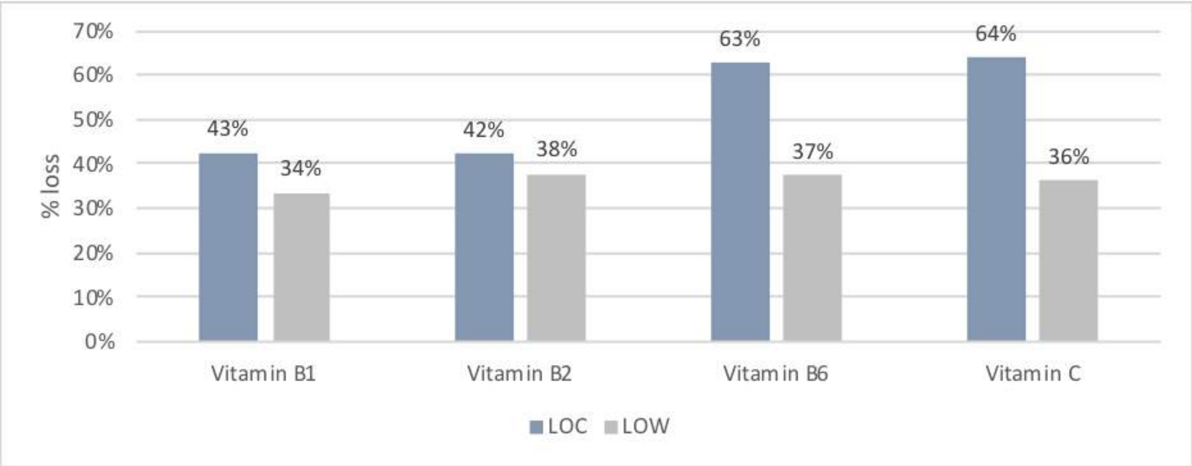

Figure 61. Losses of vitamins of school lunches in LOW and LOC case

Lastly, mineral micronutrient losses are higher in the LOW compared to LOC schools with the highest losses recorded for iron and copper micronutrients (Figure 19).

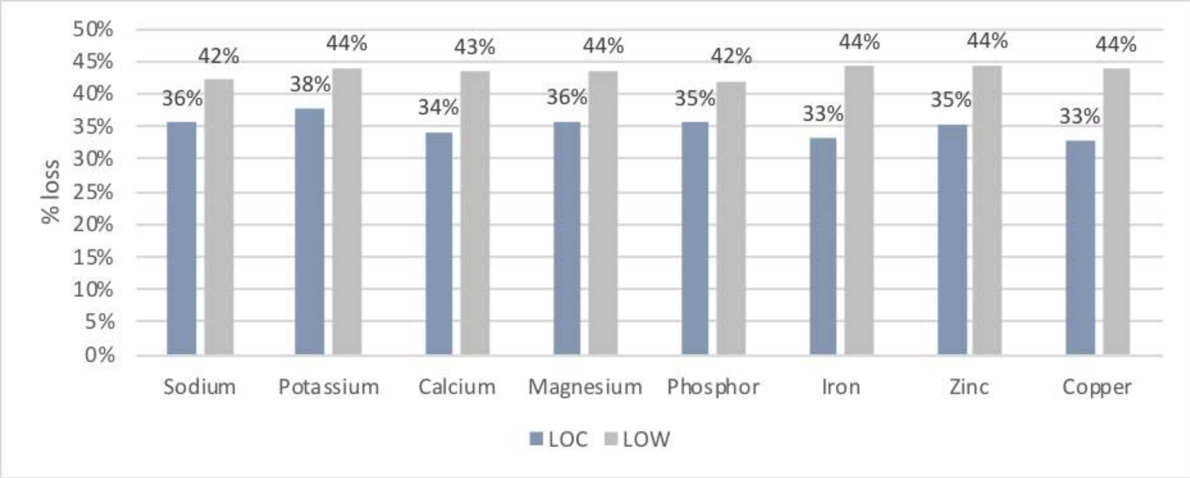

Figure 62. Losses of mineral of school lunches in LOC and LOW case

Overall, the nutritional loss from plate waste was found to be is higher in the LOW Schools than LOC school. After accounting for nutritional losses from plate waste, it was determined that LOW children consume less planned energy and macronutrients, and less mineral micronutrients than LOC children. Interestingly, as less vitamins were lost in LOW schools due to plate waste LOW children consumed more vitamins than LOC children.

5.6. Financial Impact of Plate Waste at LOW and LOC Case Schools

To estimate the financial cost of the plate waste, an average price per kg for each waste food category was calculated by dividing the total supply budget related to this category by the volumes of specific items procured within the category, in proportion to each other (the sources for the values were the procurement data collected for D6.3). In this way, the average prices per kg reflected the varying volumes of different food items procured within the category, and their specific prices. Finally, the total cost of each waste food category was summed to derive the estimate of the total cost of all the food waste in each case.

Analysis of the financial value of the collected plate waste for the LOW case was estimated to be €60,340 (table 16). For LOW schools, the bigger financial losses recorded were for beef products, rice and the food ingredients of the mixes meal "pasta with minced meat". It is noteworthy that the meat free school meal "briam" produced less financial losses than the meat based meals.

Waste Categories	Main components	% Share	Volume per Item (kg)	Total cost of waste (€)
Vegetables	Beetroot (boiled)	40%	2069	2814
	Carrot (boiled)	25%	1304	1773
	Cabbage & Carrot (fresh)	15%	788	1072
	Cucumber & Carrot	19%	991	1348
Meat And Fish	Chicken	37%	1036	2476
	Beef	37%	1026	9759
	Fish	26%	717	5224
Starchy Carbs	Rice	34%	2800	9463
	Barley	26%	2119	2840
	Potatoes (oven)	40%	3220	4379
Mixed Food	Pasta with minced meat (beef)	45%	1787	9683
	Briam	55%	2173	2955
Bread	Bread	100%	2584	2274
Other	FETA cheese	100%	412	4279
Total			**23026**	**60340**

Table 36. Financial analysis of the plate waste impact in LOW model

Of the total LOW food suppliers budget, 36% is estimated to be lost via plate waste (table 17), equating to €0.58 per meal and 26% of the price charged per school meal (€2.23).

Total number of meals	Total suppliers budget (Euro)	Total cost of waste (€)	% Total Waste financial loss from total supply budget	Waste cost per meal (€)
873	169590	60340	36%	0,58

Table 37. The economic impact of the LOW case plate waste

Analysis of the financial value of the collected plate waste for the LOC case was estimated to be €16,891 (table 18). Similarly to the LOW case, the bigger LOC losses were recorded for school meal "pasta with minced meat" although the meat free school meals had high financial losses (spinach with rice and lentil soup). However, the food category with the highest financial losses from the plate waste was "fresh meat" with an €3.507 financial loss.

Waste Categories	Main components	% Share	Volume per Item (kg)	Total cost of waste (€)
Vegetables	Carrot (boiled)	25%	471	457
	Cabbage (fresh)	25%	455	442
	Broccoli	22%	405	393
	Carrot & cabbage, fresh	20%	371	360
	Cucumber	8%	150	145
Meat And Fish	Items under 'Fresh Meat'	100%	517	3507
Starchy Carbs	Rice	23%	319	875
	Groats	25%	353	473
	Lentils (soup)	52%	719	1969
Mixed Food	Pasta with minced meat (beef)	51%	790	3238
	Spinach with rice (boiled)	49%	753	2952
Bread	Bread	100%	376	278
Other	FETA cheese	61%	214	1463
	Egg	39%	136	339
Total			**6029**	**16891**

Table 38. Financial analysis of the plate waste impact in LOC model

Of the total LOC food suppliers budget, 54% is estimated to be lost to plate waste (table 19), equating to €0.46 per meal and 21% of the price charged per school meal (€2,22).

Total number of meals	Total suppliers budget (Euro)	Total cost of waste (€)	% Total Waste financial loss from total supply budget	Waste cost per meal (€)
305	31363	16891	54%	0,46

Table 39. The economic impact of the LOC case plate waste

5.7. Carbon Impact of Plate Waste in LOC and LOW Case Schools

Drawing from the comprehensive carbon footprint analysis reported in Deliverable 6.3., and using the total collected plate waste/food category as reference estimates, table 20 reports the levels of embodied carbon attributed to the collected plate waste across all schools (5/region) in and both cases. Briefly, the method to estimate the embodied carbon of the food waste was as follows. First, in order to make results linkable to the carbon footprint results generated in D6.3, we based the estimation on not just two, but all five schools comprising the samples in the LOCSchool and LOWSchool cases. We also made the estimates for the whole academic year, rather than the specific weeks of plate waste data collection. For both, we made the calculations by aggregating pro rata the volumes of plate waste recorded over two weeks for the two schools in each case study. Therefore, the total waste volumes reported in this section are higher than the volumes in the other sections of 6.2. The waste rates of individual food items within each food category were estimated either by the direct observation of the food waste collector (where this was possible) or by calculating the relevant ratios of the food procurement data collected as part of D6.3 (guided by the menus/recipes). Having determined which food items comprised all the categories of the waste in each case, and in which proportions, an average emissions factor per kg (EF) for each food category was calculated by dividing the total production emissions generated by all the items in the waste food category (in kgs CO2eq) by the total volumes of those items procured for the five schools in each case. In this way, the average EF for each food category took account of the varying proportions of specific food items within the waste category, and their specific EFs. If the waste food category only included one item (e.g., milk), the actual EF for this item was used as the category EF. Next, by multiplying the average EF for each food category by the total volumes of waste recorded for those food categories in each case, the total production-related embodied carbon emissions for each food waste category were calculated. The same methodology was followed to calculate the transport-related embodied carbon emissions for each food waste category. Finally, the embodied emissions relating to the food waste itself (i.e. transportation and handling of the waste) were added. All three components of the embodied carbon emissions (food production, transportation and waste disposal) were then summed to get the total embodied carbon emissions of the food waste in each case.

The total carbon footprint, attributed to the procurement of the food ingredients and the transportation of the goods from the suppliers to the kitchen facilities, of LOW schools was calculated as 90,318kgCO2eq. Adding the emissions from the school meals transportation (kitchen facilities) to the primary schools and the carbon emissions from the plate waste handling, the total carbon footprint increased to 160,275kgCO2eq. This carbon footprint is attributed to the 873 pupils of the LOW case for the 120 days running school meals program.

Waste Categories	Main components	% Share	Total Volume (kg)	Total CO2eq (kg)
Vegetables	Beetroot (boiled)	40%	5153	1658
	Carrot (boiled)	25%		601
	Cabbage & Carrot (fresh)	15%		380
	Cucumber & Carrot	19%		874
Meat & Fish	Chicken	37%	2779	3703
	Beef	37%		13222
	Fish	26%		4546
Starchy Carbs	Rice	34%	8139	23701
	Barley	26%		15144
	Potatoes (oven)	40%		1646
Mixed Food	Pasta with minced meat (beef)	45%	3960	14703
	Boiled peas with carrot & potatoes	55%		1068
Bread	BREAD	100%	2584	4189
Other	FETA cheese	100%	412	4883
Total			23.026	90,318
Plus transportation co2eq from central kitchen to five schools				1151
Plus waste handling co2eq				68,805
Total co2eq				**160,275**

Table 40. Plate waste carbon footprint analysis of the LOW case school meals

As such, the collected LOW plate waste contains 63% of the total embodied carbon from production, transportation and plate waste handling and the plate waste carbon burden in LOW schools is estimated at 1.53kgCO2 per meal served.

Total volume (kg) of procurement	% of total waste from total volume	Total Original kgCO2eq (including waste before mitigation)	Total Waste CO2 Burden	% of waste burden from total CO2eq	Waste kgCO2eq burden per meal
51570	45%	253074	160275	63%	1,53

Table 41. Plate waste carbon impact of the LOW model

Taking the same analysis for the LOC case, the total carbon footprint, attributed to the food supplies and the transportation of the goods from the suppliers to the kitchen facilities, is estimated to be 24,387kgCO2eq. Adding the carbon emissions from the school meals transportation from the kitchen facilities to the primary schools (301kgCO2eq) and the carbon emissions from the plate waste handling (17.385kgCO2eq), the total carbon footprint increased to 42,074kgCO2eq. This carbon footprint is produced from the 305 pupils for the of school meals program duration (120 days).

Waste Categories	Main components	% Share	Total Volume (kg)	Total CO2eq (kg)
Vegetables	Carrot (boiled)	25%	1853	471
	Cabbage (fresh)	25%		455
	Broccoli	22%		405
	Carrot & cabbage, fresh	20%		371
	Cucumber	8%		150
Meat And Fish	Items under 'Fresh Meat'	100%	517	517
Starchy Carbs	Rice	23%	1391	319
	Groats	25%		353
	Lentils (soup)	52%		719
Mixed Food	Pasta with minced meat (beef)	51%	1543	790
	Spinach with rice (boiled)	49%		753
Bread	BREAD	100%	376	376
Other	FETA cheese	61%	350	214
	Egg	39%		136
Total			23.026	24,387
Plus transportation co2eq from central kitchen to five schools				301
Plus waste handling co2eq				17,385
Total co2eq				**42,074**

Table 42. Plate waste carbon footprint analysis of the LOC case school meals

As such, the collected LOC plate waste contains 62% of the total embodied carbon from production, transportation and plate waste handling and the plate waste carbon burden in LOC schools is estimated at 1.15kgCO2 per meal served.

Total volume (kg) of procurement	% of total waste from total volume	Total Original kgCO2eq (including waste before mitigation)	Total Waste CO2 Burden	% of waste burden from total CO2eq	Waste kgCO2eq burden per meal
15736	38%	68319	42074	62%	1,15

Table 43. Plate waste carbon impact of the LOC model

Overall, the total embodied carbon in collected plate waste is higher in LOW compare to LOC schools among the limitations of this research is the exclusion of food waste produced during school meal preparation by the private appointed caterers.

6. CONCLUSION

The study was conducted across two PFSP cases applied; LOW and LOC. In both cases, the school meals were prepared by private catering companies with LOC schools procuring the school meals food ingredient mainly from the local area (radius <50km).

As regards to the nutritional impact, the pupils in the LOC case received and consumed higher energy and macronutrient values. The plate waste nutritional composition of the average LOW case school meals indicated that pupils in Thessaloniki recorded higher nutritional losses than the pupils in Kastoria. As a result, the nutritional impact is higher in the LOW case compare to the LOC case nutritional impact results.

The carbon impact analysis of the LOW case revealed higher carbon emissions burden per school meal compare to the LOC case. Moreover, the percentage of waste burden from the total carbon emissions were slightly higher in the LOW case. Therefore, the carbon impact is in favour of the LOC case since the average waste kgCO2eq burden is lower than in the LOW case. It is evident that the LOW case 'meat and fish', rice and barley categories produce the highest carbon emissions from the plate waste analysis. On the contrary, the 'vegetables' and the 'mixed' food categories produce higher carbon emissions in the LOC case.

Lastly, the economic impact of the plate waste is higher in the LOW case since the average waste cost per meal is 5% higher than the LOC model. However, the total waste financial losses from the supply budget are higher in the LOC case (54%) compare to the LOW model (36%). This is mainly attributed to the higher prices of the LOC model food ingredients and the total budget for the food ingredients supply. In both cases, the higher financial losses are recorded at the meat and starchy food categories.

Variable	Parameter	LOW model	LOC model
Nutritional impact	Energy (kcal)	553 ± 140 (65)	445 ± 83 (57)
	Total proteins (g)	23.1 ± 7.0 (65)	18.4 ± 3.5 (61)
	Total carbohydrates (g)	62.5 ± 18.1 (68)	45.9 ± 11.5 (56)
	Dietary fibre (g)	5.2 ± 3.8 (66)	2.6 ± 0.6 (56)
	Total fat (g)	23.2 ± 6.3 (62)	20.6 ± 4.5 (58)
	Saturated fatty acids (g)	5.3 ± 1.5 (63)	5.9 ± 3.0 (59)
Carbon impact	Total Waste CO2 Burden	160275	42074
	% of waste burden from total CO2eq	63%	62%
	Waste kgCO2eq burden per meal	1,53	1,15
Economic impact	Total cost of waste (€)	60340	16891
	% Total Waste financial loss from total supply budget	36%	54%
	Waste cost per meal (€)	0,58	0,46

Table 44. Comparison of the nutritional, carbon and economic impact of the LOW and LOC model plate waste

In conclusion, the measured plate waste in the LOW model is higher than in LOC model. The LOW model affected the most from the plate waste incidents. Plastic use was also higher in the LOW case than in LOC case. Moreover, the pupils of the LOC case received in average higher nutritional values and higher energy (kcal) than the pupils in Thessaloniki (table 24.

Recommendations for the school meals applied in Greece firstly include the establishment of a National nutritional requirements for the school meals. In addition, a monitoring mechanism for the plate waste measurement and nutritional intakes assessment is recommended to be run either by the caterers or by schools. Furthermore, advancements in infrastructures, such as dining rooms, are necessary in order to provide a safe and conducive space for the pupils which has the potential to decrease plate waste and optimise nutritional intake. As regards the schools, it is important that training programs are provided to pupils in the form of workshops, visits to farms or visits to the caterers. It is also recommended that an award scheme is created that recognizes children and schools who are active in, and knowledge about food and nutrition. Lastly, it is recommended that instruction needs ot be provided to parents about the nutritional guidelines that their children should be meeting – either national or the one provided by the WHO. A strong collaboration between the schools and the caterers is mandatory for taking actions that are in favor of the pupils, help reduce waste and support optimal nutritive intake.

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Ministry of Education: https://www.minedu.gov.gr

Ministry of Labour, Social insurance & Social Solidarity: http://www.ypakp.gr

Municipality of Evosmos - Kordelio: http://www.kordelio-evosmos.gr

Municipality of Kastoria http://www.kastoria.gov.gr

Primary Educaton Office of Kastoria: http://dipe.kas.sch.gr

Primary Educaton Office of West Thessaloniki: http://dipe-v-thess.thess.sch.gr

The Strength2Food project in a nutshell

Strength2Food is a five-year, €6.9 million project to improve the effectiveness of EU food quality schemes (FQS), public sector food procurement (PSFP) and to stimulate Short Food Supply Chains (SFSC) through research, innovation and demonstration activities. The 30-partner consortium representing 11 EU and four non-EU countries combines academic, communication, SMEs and stakeholder organisations to ensure a multi-actor approach. It will undertake case study-based quantitative research to measure economic, environmental and social impacts of FQS, PSFP and SFSC. The impact of PSFP policies on nutrition in school meals will also be assessed. Primary research will be complemented by econometric analysis of existing datasets to determine impacts of FQS and SFSC participation on farm performance, as well as understand price transmission and trade patterns. Consumer knowledge, confidence in, valuation and use of FQS labels and products will be assessed via survey, ethnographic and virtual supermarket-based research. Lessons from the research will be applied and verified in 6 pilot initiatives which bring together academic and non-academic partners. Impact will be maximised through a knowledge exchange platform, hybrid forums, educational resources and a Massive Open Online Course.

Strengthening European Food Chain Sustainability by Quality and Procurement Policy

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ITALY COUNTRY REPORT

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Beatrice Biasini, Alice Rosi, Michele Donati Francesca Giopp, Gianluca Lanza, Daniele Del Rio, Filippo Arfini, Francesca Scazzina	University of Parma, Italy
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Academic Partners

1. **UNEW**, Newcastle University (United Kingdom)
2. **UNIPR**, University of Parma (Italy)
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List of abbreviations and acronyms

FCA: food composition analysis

LOC-ORG: local-organic

ORG: organic

SFA: short fatty acids

CRA-NUT: Research Centre for Food and Nutrition

ISEE: Equivalent Economic Situation Indicator

PDO: Protected Designation of Origin

PFSP: public sector food procurement

PGI: Protected Geographical Indication

TSG: Traditional Speciality Guarantee

WHO: World Health Organisation

EXTENDED ABSTRACT

This report presents the results of WP6.2 research on school meals in Italy. Food composition and waste analysis in the school canteen context is particularly relevant from an educational, nutritional, environmental and economic point of view, due to the large number of users and the consequent amount of food handled every day. The Italian public administration targets the improvement of school catering service sustainability by designing healthy diets, according to the recommendations of the Research Centre for Food and Nutrition (CRA-NUT), and promoting organic and locally sourced products. Recommendations about food waste are also included.

The research activities described in the present report were aimed at (i) analysing the nutritional composition of selected daily menus in primary schools and (ii) collecting, elaborating, evaluating and comparing children's food waste in primary school lunches addressing the issue from a nutritional, environmental and economic perspective. The research was conducted in two municipalities, each representing a different school meals procurement model: Case 1 (Parma) represented a local and organic model (LOC-ORG), while Case 2 (Lucca) represented an organic (ORG) model.

For the food composition analysis, using national food composition data, the energy and nutritive values of the school meals planned by the catering firms in each case were calculated and compared to National dietary standards. Almost all of the planned lunch menus fell within the ranges recommended by the Health Ministry in both Case 1 and 2, reaching 90% and 95% of the compliance to the standards, respectively. Moreover, concerning proteins and carbohydrates, LOC-ORG menus were more frequently above the standards (25% of planned menus for proteins and 5% for carbohydrates) compared to ORG model menus. On the contrary, the fat content of the ORG school menus was more frequently lower than the recommendations (5% of planned menus) compared to LOC-ORG. With regard to the fibre content, LOC-ORG menus resulted totally in accordance with the fibre standard, while 15% of the ORG menus were below the recommendations. In terms of the nutritional composition of an average meal in both cases, the average percentage of proteins was slightly higher than the range indicated by the National recommendation: 17% and 16% respectively for Case 1 and 2 *vs.* a recommended range of 10-15%. On the other hand, the proportions of carbohydrates and fats were in line with the standards, representing less than 60% and 30% of the lunch energy content. With regard to saturated fatty acids, 25% and 15% of ORG menus were adequate and above the recommended values, respectively. On the other hand, just 10% of LOC-ORG menus were adherent, while 20% of them overcame the recommendations. Between the models, compared to the standards, discrepancies were observed also in terms of micronutrients (i.e. calcium and iron), but differences were still within 10%. In summary, overall LOC-ORG model showed a better performance than ORG model for fibre, however the ORG model was preferable for proteins and SFA (short fatty acids) contents.

Food waste, defined as the uneaten edible proportion of food served to the children (plate waste), was evaluated both as a total proportion of meals served, as well as broken down according to seven food categories (namely starchy foods served as first course; bread; protein-based dishes (meat, fish, dairy, legumes); vegetables served as side dish; fruits; desserts; and "other" which included semi-unique and unique dishes). The so-defined food waste was collected during five consecutive observation days, in winter 2017 and in spring 2018, in four primary school canteens, the selection of which was based on three main criteria: number of children, model of food preparation and delivery, and position/distance from the cooking centre. Hence, in Case 1 (Parma, LOC-ORG model), ParmaSchoolOne had 215 pupils, it was located in the town centre and it had an internal kitchen where the food was cooked and prepared starting from the raw products. ParmaSchoolTwo counted

239 pupils, was relatively far from the cooking centre and the meals were supplied by a central kitchen and just seasoned in the internal kitchen before being served. On the other hand, in Case 2 (Lucca, ORG model) a unique cooking centre is used to prepare and cook all the food that is delivered at lunch time to all the local schools. Thus, the two schools differed for the number of pupils, i.e. 184 and 249 respectively in LuccaSchoolOne and LuccaSchoolTwo, and the distance from the cooking centre. Only standard meals were considered, with the exclusion of special diets. The serving size of the provided foods was calculated as mean of the weight of 3 servings for each food item per turn. Both the serving size and the food waste were assessed using electronic weighing scales.

Based on the obtained results, the total amount of food waste collected across the two schools and seasons showed a difference of approximately 11 kg. However, despite this relatively small difference, the percentage of food waste obtained was equal to 25.7% for LOC-ORG case and to 38.4% for ORG case, mainly attributable to the different number of pupils attending the schools, which was greater in LOC-ORG than ORG. The waste per meal (g) calculated for LOC-ORG case was lower than ORG case, not only for values obtained across the two schools and seasons, but also considering the individual schools and weeks. In both models, the starchy food served as first course and fruits were associated to the largest amount of food waste. However, the ORG model was characterised by higher amounts even if the number of served meals was smaller compared to LOC-ORG. Different results were instead obtained for the proportions of food wasted within each food category. According to this, the categories with the highest proportions of waste were starchy food – bread, at 37.2% for LOC-ORG, and fruits, reaching 53.4% for ORG. In both cases, these percentages were followed by those reported for vegetable – side dish (36.9%, LOC-ORG and 52.0%, ORG). By contrast, with a waste percentage of 17.7% and at a quantity of waste per meal of 11.4 g, protein based dishes represented the least wasted category for LOC-ORG, while for ORG the lowest waste was reported for the category “other”, which reached a percentage of 11.6% and 19.9 g of waste per meal. As reported for ORG case, considering the percentage of waste, the pupils’ intake of plant–based food (i.e. fruit and vegetables) was less than the 50% of the mean size served, while in LOC-ORG this value was approximately 70%.

Concerning individual food items, bread showed a similar percentage of waste for the two models (≥ 40%). Although it is possible to highlight some similarities between the waste percentages reported for similar food items served as protein-base dish in the two case studies, higher proportions were mostly reported for ORG case. In addition, results suggest that pupils’ intake of vegetables served in LOC-ORG reached higher percentages than ORG case. With regard to the fruit category, the waste percentages for LOC-ORG case were up to 50% higher than those calculated for ORG.

In parallel to the food waste assessment, a nutritional analysis of the plate waste was carried out. In this framework, the nutritional consequences of plate waste showed a higher detrimental impact for the ORG model compared to the LOC-ORG one. More specifically, the loss of energy and macronutrients was almost 10% greater on average in the ORG than the LOC-ORG model (36% vs 26%). Similar percentages were found also in relation to total proteins and carbohydrates. In both LOC-ORG and ORG, the loss of proteins was the lowest among macronutrients (23% and 34%, respectively), while dietary fibre (30% and 43%, respectively) and most of the micronutrients showed higher values, with ORG case reaching greater percentages than LOC-ORG. Moreover, subtracting food waste amount, the actual energy and nutrient intake of the consumed meals was evaluated and compared with the reference standards. Results showed that in LOC-ORG case, pupils’ actual intake was around three quarters of the planned energy and macronutrients, and around two thirds of the planned micronutrient values. In ORG case, actual pupil intake was two thirds or less of planned energy and macronutrient values, and between 52% and 70% of micronutrients.

Finally, evaluations of the carbon and economic impacts of the plate waste were performed. For environmental impact, we estimated the embodied carbon emissions (kgs $C0_2$eq) in the plate wastes in both cases, by summing the estimates made for the five featured schools in LOC-ORG and ORG cases (D6.3), over one whole school year. With regard to the economic impact, the total cost due to food waste for each food category was estimated according to the average unit cost for each food item included in the school meal menus. Again, the cost was estimated for five featured schools in each case, for one school year.

In terms of the embodied carbon emissions of the food waste in both cases, results showed that in LOC-ORG case, emissions were 90,247 kgs $C0_2$eq, equivalent to 0.34 kgs $C0_2$eq per meal, or 36% of the total $C0_2$ emissions of the entire LOC-ORG meals service. In ORG case, emissions were 46,256 kgs $C0_2$eq, equivalent to 0.37 kgs $C0_2$eq per meal. This represented 35% of the total $C0_2$ emissions of the entire ORG meals service. The food waste composition of LOC-ORG case and ORG case presented a different pattern. In LOC-ORG, the most carbon emissive food categories were the starchy food, while in ORG case meat and fish based plates contributed significantly with the starchy food to the total food waste emissions. It is noteworthy that meat and fish included in starchy food plates explain the high emissions for this category. For LOC-ORG, the emissions associated with unique plates, such as cous-cous with meat, was probably overestimated due to the limited time-span along which the food waste analysis in the schools has been carried out. In any case, in LOC-ORG, meat and fish-based plates showed a low level of emissions, while in ORG the percentage was much higher. LOC-ORG differed from the ORG model also for the food waste carbon emission intensity. The food waste CO_2 burden per kg of waste in ORG was 17% lower than in LOC-ORG (1.46 kgCO2eq/kg vs. 1.76 kgCO2eq/kg). This reflects the different composition of the food waste. In LOC-ORG, the average carbon emission factors for fruit and vegetables based plates was significantly higher than in ORG. The present analysis pointed out that the level of food waste for both the school meals services is relevant and requires a new and effective strategy for minimizing the volume of foods otherwise addressed to waste disposal, that needs to be set up by the City Council and Cater.

In terms of the economic impact of the plate waste, in LOC-ORG case the total cost of the wasted food was €84,806, equivalent to €1.65 per meal. This represented 18% of the total school meals budget, or 27% of the full price of a meal to parents (€6.18) in this case. In ORG case, the total cost of the waste food was €88,381, equivalent to €2.79 per meal. This represented 34% of the total school meals budget, or 56% of the full price of a meal to parents (€5.00). The cost per kg of food waste was 69% higher in the ORG model than in LOC-ORG. This was due to the different internal compositions of the food waste within the two cases, which affected, through the unit cost of each item, the total food waste cost. More specifically, in ORG case, all the food categories showed a higher average cost per kg of food waste than in LOC-ORG case except for vegetables. This depended on the type of meals and the ingredients used for their preparation. However overall, ORG case showed much higher cost compared with LOC-ORG case, greatly affecting the socio-economic sustainability of the entire school meal supply chain. In both cases, the weight of costs due to food waste on the contract budget was significant, but for ORG case it reached a very high level.

In conclusion, the obtained results show that the planned menus at LOC-ORG and ORG cases comply well with nutritional standards. However, due to high levels of plate waste, there are important nutritional and economic losses, and also negative environmental impacts. The obtained results highlight the need for a re-thinking of the school meals service organisations, with the aim to reduce the food waste and thus address these problems. These actions could include greater inclusion of more simple recipes, and also greater inclusion of quality products (e.g. Geographical Indications) originating from the local territory. Such actions could contribute to a greater acceptability of the school menus and consequently to a lower food waste.

1. INTRODUCTION

This report presents the methods and results of the WP6.2 Italy study into the nutritional impacts of models of public sector food procurement (PSFP), focusing on primary school meals. The nutrition of primary-school children is one of the most significant public health issues facing almost every country in the world and although many countries, including Italy, have developed national nutritional guidelines for primary school meals, the nutritional values of institutionally organized diets depends not only on food standards and guidelines but also the criteria set by food procurement policies. Therefore, this research had two main aims. First, the research aimed to undertake a food composition analysis (FCA) of daily menus at selected school canteens belonging to contrasting models of PFSP, in order to evaluate nutritive profiles. However, it is a fact that no matter the national guidelines or PSFP model in schools, children sometimes do not eat some or all of the food served. Undertaken an analysis of plate food waste in the school canteen context is relevant from an educational, environmental and economic perspective due to the huge number of users, budgetary pressures, and the amount of food handled daily. Moreover, from a nutritional intake perspective, plate waste threatens the primary goal of school food procurement, which is to provide students with an appropriate and balanced meal daily[15]. Through analysing plate waste, estimates of actual nutritional intake from school meals can be calculated, and comparison made between what is intended by the menu design and what is lost through plate waste. Therefore, as well as calculating the nutritive values of menus via FCA, the second aim of this research was to collect and evaluate samples of plate waste from the same selected schools, to reveal the estimated nutritional and associated financial losses, as well as the embodied carbon burden, of school plate waste.

The study was conducted in two municipalities, which are also administrative centres of their provinces: Parma (Case 1) located in Emilia-Romagna Region, in the North of Italy, and Lucca (Case 2) in Tuscany Region, in the Centre of Italy. Each municipality operates a different procurement model. In Parma, a local and organic (LOC-ORG) model exists, in which the procurement contract encourages sourcing of foods from within a local/regional area and a minimum amount of organic food is employed for meal preparation (70% of total). Two schools from the five LOC-ORG case schools described in D6.3 Italy Country Report were selected to participate in this study: ParmaSchoolOne and ParmaSchoolTwo. In Lucca, an organic (ORG) model exists, in which the procurement contract specifies that the majority of foods used in meal preparation must be certified organic, but there are no specifications relating to the origin of the food. Two schools from the five ORG case schools described in D6.3 Italy Country Report were selected to participate in this study: LuccaSchoolOne and LuccaSchoolTwo. The school selection was driven by specific criteria, such as a minimum number of 100 pupils attending the schools to allow a meaningful comparison with the other European case studies selected within this task, the presence of a distinct meal preparation and delivering model (e.g. food prepared and distributed from central or school based in house kitchen), or different distances between the schools and the cooking centre if a unique meal-delivering model was applied.

While in some Parma primary schools have an internal kitchen where the meals are prepared daily starting from the raw products, in others (including the selected school) the daily lunch menus are seasonally adjusted, with most meal components prepared and cooked in, and delivered from, a central cooking kitchen and then served in the school canteen. The exception is the starchy-based meal components, which are generally prepared on site in the school kitchen. In Lucca the meal preparation takes place in the central kitchen that provides lunch meals to the schools, where only cereals-based dishes (e.g. pasta and stock soups) can be assembled with sauce or other dressing. Thus,

[15] Byker et al, J. Nutr. Educ. Behav., 46 (5) (2014): 406-411

in this case, school selection was based on the number of pupils and the distance from the cooking centre. In the selected schools, pupils attend school from 8.30 am to 4.30 pm every day and are aged from 6 to 11. Only standard meals were considered, with the exclusion of special diets. Serving size of edible food was calculated daily as mean weight of 3 reference servings for each food component. Both the serving size and the collected food waste were weighted using electronic weighting scales.

The methodology for the FCA and nutritive evaluation of menus was as follows. For the two Parma schools (ParmaSchool One and Two), planned daily menus covering the full 17/18 school year were obtained in September 2017, while for the two Lucca schools (LuccaSchool One and Two), planned daily menus for the autumn, winter and spring periods were obtained in September 2017, November 2017 and March 2018 respectively. Planned menus were obtained from the City Council web sites, and/or directly from school Officers of the Council Operative Unit for School catering services, while normative provisions (standard quantities of ingredients and recipes if available) were obtained from the local managers of the central school catering services. A period of five consecutive school days (Monday to Friday) across two seasons (autumn/winter and spring/summer) were then selected for each school (10 days/school; 20 days per case; 40 days in total). The nutritive values of school lunch recipes for the four selected weeks were calculated using an updated national food composition database. Thus, for each recipe offered on the schools' daily menus, for the data collection period, we calculated the nutritive profile including total energy (calories), macronutrients (proteins, fats, carbohydrates, dietary fibres and saturated fatty acids) and selected micronutrients (Vitamin A, B1, B2, B6, B12, Niacin, Folate, Vitamin C, D, Minerals: sodium, potassium, calcium, magnesium, phosphor, iron, zinc and copper) from a full planned portion. For those foods that were not a part of the national food composition database, energy and nutritive values were obtained from the food labels. The energy and nutrient intake was evaluated with regard to referent National dietary standards, using a database and online tool designed bespoke by University of Zagreb for Strength2Food WP6.2. Therefore, for each recipe on the daily menus, we evaluated the extent to which a full planned portion contributes to a child's recommended daily intake of energy and nutrients. In undertaking the FCA, the possibility was explored to adjust the compositions to reflect how food procured through alternative models may possess different nutritional outcomes. In practice however, the data did not support such adjustments.

The methodology for the plate waste study was designed to complement the FCA and nutritive analysis. A full explanation of the methodology is given in Section 5.1. Briefly, food waste, the uneaten edible fraction of food served to the children (plate waste), was collected in 4 selected school canteens, two in Parma and in two in Lucca, during five consecutive observation days in winter 2017 and in spring 2018 (10 days/school; 20 days/case; 40 days in total). Due to unexpected adverse weather and subsequent school closure during the 2017 winter data collection period, plate waste data could only be collected in the two Lucca primary school for 4 of the 5 selected consecutive days. Therefore, a final total of 39 daily menus were analysed, and 39 days of plate waste date collected, 20 for LOC-ORG and 19 for ORG cases. Each day, plates/trays from all students who had taken school lunch were collected after they had finished eating their meal. The plate waste leftover were separated into 7 different bins representing the main food categories: starchy foods served as first course; bread; protein-based dishes (meat, fish, diary, legumes); vegetables served as side dish; fruits; desserts; and "other" which included semi-unique and unique dishes. At the end of the lunch service, the total weight of each bin was recorded. The waste was then evaluated as a total composite amount, as well as by the seven food categories. Analysis then involved calculating the nutritional composition of each bin to evaluate the nutritional losses associated with the waste. In addition, analysis was conducted, drawing on data from D8.3, to estimate the financial cost of, and embodied carbon in, the collected plate waste.

Alongside the plate waste study, detailed observations of the central and school kitchens, canteens and lunchtime services in the two LOC-ORG and two ORG case schools were made. These observations mainly consisted of details regarding the the features of the lunch room(s), the kitchen appliance, the table arrangement including the material characterizing the plates and cutlery used by the children, the time children have to eat their lunch, the organization of, and splitting up of, the children into groups for lunchtime service, and the food and non-food waste disposal. In addition, interviews with the staff and the local manager of the catering service, as well as with the teachers were undertaken. The purpose and value of the detailed observational and interview data was to understand fully the context of the lunchtime services in the four studied schools. These data help with interpreting and explaining similarities and differences found within, and between, the schools in terms of the weight and composition of collected plate waste.

2. SCHOOL FOOD POLICIES IN ITALY

The Italian public administration addresses to the improvement of school catering service sustainability designing healthy diets, according to the recommendations of Italian National Research Institute for Food and Nutrition, and promoting organic and locally sourced products. Recommendations about food waste are also included[16].

In Italy, there are a total of 21,605 state primary schools and comprehensive institutes[17] (source: Ministry of Education at 1st September 2017), located across 20 different regions, with each region having a different number of primary schools according to its population. The school distribution varies according to the geographical area, with the higher institute proportion (44.3%) in Northern Italy, followed by 25.2% in the South, 17.9% in the Centre and 12.5% in the Islands. Not all children eat at school, as almost 40% of Italian schools do not have a canteen with big differences across the regions, especially comparing North and South Italy. For example, Meals are provided by more than the 70% of schools in Piemonte, Lombardia, and Liguria, by 60-70% of schools in Basilicata, Veneto, Sardegna, Toscana, Marche, Friuli Venezia Giulia, Abruzzo, Calabria, Molise, Umbria, Emilia Romagna, and Lazio, and by around the 50% of schools in Sicilia, Campania, and Puglia. Moreover, where meals are provided 70% are prepared by catering companies in either on-site or central cooking kitchens. Unfortunately, to the best of our knowledge, no current national data are available.

The Ministry of Health defines national dietary standards for school meals for children aged between 3 -14. The national guidelines for school catering set out mandatory standards that all local authorities and schools must meet for the school meals they provide. Italian dietary standards specify the recommendation for school lunch considering both energy and nutrient intakes and food groups. The comprehensive guideline is available online (only in Italian) at http://www.salute.gov.it/imgs/C_17_pubblicazioni_1248_allegato.pdf (Figure 1).

Figure 63. Italian Guidelines for school catering service.

Italian municipalities can interpret these guidelines and have relative freedom to set up their own regulations and standards, mainly because non-compliance with national and regional guidelines is not sanctioned, leaving them directly responsible for public school meals. They control and manage the meal systems in house, or may outsource to the service to a private catering companies, in which case the municipality still maintains control of the meal system, but consults the private catering company in connection with the practical work and day to day delivery of the school meal service.

[16] Falasconi et al, Sustainability 7.11 (2015): 14745-14760

[17] The comprehensive institutes are represented by buildings in which are present both primary schools and junior high schools.

Italy also has a few municipalities who have created public or public-private companies to manage the school meal system. In all cases, municipalities have to cover all the costs for school catering services, and decide how to distribute these costs. Thus, they manage financial terms (price charged per daily meal and additional municipality top up) and lay out rules concerning subsidies. Normally, families pay according to their income and, in some cases, low income families pay less than 50% of the daily meal price, whereas families with a medium or higher income pay between 50-100% of the meal price. In addition, municipalities top up the income received from parents by between 10-30% to ensure viability and affordability of their school meal service.

Briefly, energy content must fall into different ranges (440-640; 520-810; 700-830 kcal) on the basis of child age groups, with corresponding minimum and maximum levels for specific nutrients and minerals (i.e. iron, calcium). One serving of fruits (at least three different types must be offered per week) and one serving of vegetables must be offered daily. In addition, a serving of cereal-based food must be offered every day. Fish and meat must be offered once or twice a week. Potatoes, eggs and cheese (apart from parmesan) should not be offered more than once a week. Extra virgin olive oil should be used as condiment, while butter can only be used in a limited number of recipes, while salt, always in the form of iodised salt, must be used moderately.

Taken from the Italian national guidelines, the main recommendations for energy and nutrient requirements and for frequency of food group intakes for school lunch of primary school-age children are reported in Table 1 and Table 2, respectively. Unlike other national guidelines, the standard servings are defined by each municipality based on regional guidelines, and refer only to the amount of edible ingredients (Table 3 Parma municipality and Table 4 Lucca municipality). Daily energy and nutrients values are based on gender, age, and physical activity level according to the Italian Society of Human Nutrition's reference levels of nutrients and energy for the Italian population. The composition of the menu is elaborated by the catering firm, in accordance with National and Regional Guidelines[18], and it is approved every year by each single municipality and by the Local Health Authority.

Component	6-11 years
Energy (kcal) (35% of daily energy)	520-810
Proteins (g) (10-15% of the meal energy)	13-30
Animal-Plant Proteins Ratio	0.66
Fats (g) (30% of the meal energy)	18-27
of which saturated fat (g)	6-9
Total Carbohydrates (g) (55-60% of the meal energy)	75-120
of which sugars (g)	13-30
Iron (mg)	6
Calcium (mg)	350
Fibre (g)	6

Table 45. Reference ranges or values for energy and nutrients of lunch provided by schools to children aged 6-11 years.

[18] Guidelines for the supply of healthy food and beverage in schools and instruments for its assessment and control, 2012

Food Group	Frequency of intake
Fruit	One serving every day
Vegetables	One serving every day
Cereals (e.g. pasta, rice, barley, corn)	One serving every day
Bread	One serving every day
Legumes	Once or twice a week
Potatoes	No more than once a week
Meat	Once or twice a week
Fish	Once or twice a week
Eggs	Once a week
Cheese	Once a week
Ham and cured meat	Twice a month
Single dish (e.g. pizza, lasagne)	Once a week

Table 46. Recommended frequency of food group intake at lunch during the school-week.

	Foods	Standard serving		Foods	Standard serving
First dish	Pasta for vegetable/ meat soup	35-40	**Second dish**	Meat	60-70
	Pasta for vegetable sauce and legumes	25-30		Meatball	120
	Rice, barley and spelt for soup	25-30		Ham	30-35
	Couscous and millet for soup	20-25		Fish	80-100
	Eggs fresh pasta	90-100		Egg (unit)	1
	Vegetables for soup	200		Fresh cheese	60-70
	Filled fresh pasta	140		Mozzarella	70-80
	Dry pasta	70-80		Semi-cured cheese	50
	Potatoes dumplings	180		Cured cheese	40
	Semolina dumplings	45		Fresh/frozen legumes	100
	Vegetables/meat lasagne	220-250		Raw legumes	30
	Meat/fish for sauce	25-30	**Vegetables**	Leaf-vegetables	50
	Vegetables sauce	80-110		Frozen vegetables (NS)	150-200
	Grated cheese (seasoning)	7-8		Potatoes	140-160
	Extra-virgin olive oil (seasoning)	5-6	**Breakfast and snacks**	Ice cream	70-75
	Butter (seasoning)	7-8		Milk (breakfast)	250
	Raw legumes	30		Yogurt (125 g.)	1
Various	Pizza	240-260	**Various**	Cereals flakes	25
	Extra-virgin olive oil (per meal)	15-18		Dry cookies/crackers	35
	Bread	50		Yogurt (125 g.)	1

	Fresh fruits	150-200		Honey/jam	20
	Dried fruits	20-25			

Table 47. Standard servings provided by Parma municipality to children aged 6-11 years.

	Foods	Standard serving		Foods	Standard serving
First dish	Pasta/rice	70-80	**Second dish**	Meat	60
	Pasta /rice for soup	30		Fish	100
	Rice, barley and spelt for soup	30-40		Egg (unit)	1
	Potatoes dumplings	160		Ham	40
	Grated cheese (seasoning)	5		Mozzarella cheese	50
	Tomato sauce	30		Semi-cured/cured cheese	30
	Extra-virgin olive oil (seasoning)	5		Fresh/frozen legumes	60
Breakfast and snacks	Milk (breakfast)	250		Raw legumes	30
	Yoghurt (125 g)	1	**Vegetables**	Leaf-vegetables	40/60
	Honey/jam	20		Fresh raw vegetables	100/150
	Cereals flakes	40/50		Cooked vegetables	150/200
	Dry cookies/crackers	40/50		Potatoes	140-160
Various	Pizza	240-260	**Various**	Whole wheat bread	60
	Bread	50		Fresh fruits	100/200

Table 48. Standard servings provided by Lucca municipality to children aged 6-11 years.

3. PROFILE OF CASE SCHOOLS

3.1. LOC-ORG case

3.1.1. Schools profile

Parma's municipality has 33 primary schools, 1 of which is private and 6 which are charter, with an average pupil roll of over 200/school. Amongst the children attending primary and junior high schools, 5,594 (47%) eat school meals. Usually, the price paid per daily meal is shared between parents and the municipality and is based on the Equivalent Economic Situation Indicator (ISEE). Some price reductions are in place for families with two or more children and who have an ISEE lower than € 20,000, and partial or total exemption for families in cases of social and/or economic difficulty. On average, across the 25 state primary schools in Parma, 249 daily lunch meals are served daily per school ranging from a min of 46 to max of 500[19]. The average uptake of school meals across Parma's primary and junior high schools is approximately 47% (5,594 of 11,906 children) though this uptake % is lowered by junior high children aged from 11 to 14 years who rarely take lunch at school since they usually do not have class in the afternoon. Adjusting for 11-14 years old, the estimated average school meal uptake in primary schools in Parma is 90%.

Within Parma municipality, two schools were selected for the plate waste data collection: ParmaSchoolOne, located approximately 700m from the municipality's office (in Parma City centre); and ParmaSchoolTwo, located 10.6 km from Parma city centre. The pupil roll and the % daily average school meal uptake[20] were, respectively, 215 and 90.2% (194) for ParmaSchoolOne and 239 and 95% (227) for ParmaSchoolTwo. On average, across the 25 state primary schools in Parma, 249 daily lunch meals are served per school with a range from 46 to 500[21]. The average meal uptake o across Parma's primary and junior high schools is approximately 47% (5,594 of 11,906 children). However, this percentage refers to children aged from 6 to 14 years old and only a very low proportion of children aged from 11 to 14 years take lunch at school since they usually do not have class in the afternoon. Adjusting for 11-14 years old, the estimated primary school average school meal uptake in Parma is 90%.

3.1.2. Approach to Food and Sustainability Issues

According to the National (Ministry of Health, 2010) and Regional[22] Guidelines (Guidelines for the supply of healthy food and beverage in schools and instruments for its assessment and control, 2012), as well as to the indications provided by Parma municipality, school meal provision in Parma is mainly constituted by local products (produced within the province), "zero Km" products (supplied at a maximum distance of 100 km from the city centre), products regulated by EU legislation (e.g. PDO, PGI, TSG), including organic raw materials (at least 70% of the food products employed for meal preparation) and short chain products (produced within an area including provinces adjacent to one of Parma). On the basis of the analysis of the contract tender stipulated between the municipality and the private catering firm, the school food procurement model of primary schools in Parma is defined as "local-organic".

[19] The reported numbers refer to the sum of children and teachers who daily receive the school lunch.

[20] The daily average uptake indicates the average number, also expressed as percentage, of pupils who were present at the school canteen during the period February – March 2018.

[21] The reported numbers refer to the sum of children and teachers who daily receive the school lunch.

[22] The regional Guidelines are those in force in Emilia – Romagna

According to the Parma public tender specifications, the contracted private catering firm responsible for preparing and delivering school meals to the children are also required to provide financial support for educational projects targeting food education and the promotion of healthy lifestyles. These activities consist of educational initiatives as well as laboratories. In detail, the economic support provided has to correspond to 0.6% of the annual value established for primary school procurement.

The educational activities on healthy habits and lifestyles promoted by the education sector, complement the school lunch service, and can consist in educational activities and laboratories addressed to children and their families, as well as to personnel working in the primary schools managed by the Parma's City Council. Every year, Parma municipality draw up and proposes food educational projects to the schools.

Some initiatives during recent years have been organised in collaboration with suppliers. For example, recently, Parma City Council, ParmaCater and QualMeat organised interesting farm visits for schoolchildren to meet animals and to discover more about animal breeding. Another interesting, and more recent, initiative offered by the City Council in collaboration with ParmaCater and some suppliers is the project "Crescere in Armonia – Growing in Harmony", a national project, developed by the Italian Health Ministry, to address children, their parents and school teachers by supporting healthy life styles and promoting a new culture on food and nutrition with a particular focus on sustainability concepts and biodiversity protection. In 2018, within this project, some initiatives were organised: "Food Factor", a series of laboratories where children meet the food science and food supply chain; "SOS-Teniamo l'Ambiente", for promoting sustainable behaviours towards energy consumption, food waste, circular economy; "Lo spreco da non alimentare", a prize contest that invites schoolchildren to propose projects to reduce food waste. An indirect involvement of the suppliers is the project "Menu Interculturali a Scuola – Intercultural Menus at School", thanks to which children learn to know the food characterizing different cultures in our society. During the school year, some days are dedicated to ethnic lunches, such as Balkcan menu (with rice and "byrek"), Indian menu (with chicken with curry) and Maghrebi menu (with fish cous-cous).

In addition, since 2009, the City Council, the University of Parma and some private firms promoted the Giocampus school program, an educational program aimed at promoting the wellbeing of future generations through a program of physical activity and healthy eating education in all Parma municipality primary schools. A specific figure called "Maestro del Gusto" (literally "Master of Taste") through an integrated ''learning through playing'' approach delivers knowledge about healthy foods and food sustainability. Children follow three thematic lessons across the year based on the importance of good food habits and about the Mediterranean Diet. In particular, the last year of the program was focused on food environmental impact, from production to distribution, and on the double pyramid (nutritional + environmental). All the described projects and activities are/were active in both ParmaSchool One and Two.

3.1.3. Organisation of School Meals

The price paid for a meal is shared between parents and the municipality, based on the Equivalent Economic Situation Indicator (ISEE). Specifically, the prices charged to parents are: € 2.30/meal (ISEE € 0-6,360.17); € 4.12/meal (ISEE € 6,360.18-11,764.89); or € 6.18/meal (ISEE above € 11,764.90). The full price fee is paid by the families residing outside Parma but whose children attend one of Parma's 25 state primary schools. In addition, there are some reductions for families with two or more children, with an ISEE lower than € 20,000 and partial or total exemption in case of social and/or economic hardship.

Considering the National Guidelines for school catering (Ministry of Health, 2010), menus are developed by dietitians employed by the contracted catering companies with menu approval required annually from the municipality, and final approval awarded by the health authorities. Moreover, a technical-scientific-medical committee with representatives from public institutions and professionals with a background in nutrition specifically relating to childhood and adolescence are asked to verify and evaluate the quality of the school catering service. Specifically, the committee is composed of representatives from Parma's City Council (educational service sector); Parma's local heath authority (community paediatric service, Food safety and nutrition service, public and animal service); University of Parma; the regional school Office for Emilia-Romagna; a professional qualified specialist in food allergies and food intolerance; and a professional in nutrition related to sport sciences. Moreover, each school has a canteen commission composed of volunteer parents of children attending the schools. This canteen commission can periodically perform verification visits, taste the meals of the day, make proposals and lodge complaints in relation to the food served. The municipality of Parma requires the intervention of the two committees during the year to deal with professionals and users.
The school menu in Parma works on a four week-cycle differentiated across the four seasons to respect the seasonality of plant-based products. An exemplary primary and junior high school meal is organized as follows:

- First course: cereals (pasta, rice, barley, maize, etc.), prepared with different recipes, respecting local traditions and often associated with vegetables and legumes. Legumes, if associated with cereals, and traditional plates, such as pizza or lasagne, can be served as semi-unique or unique course.
- Second course: white and red meat, salami, fish, eggs, or cheese.
- Side dish: Vegetables (potatoes no more than once a week and associated with a meal poor in other carbohydrates).
- Bread with no fats and a low salt content.
- Seasonal fruits of at least three different types throughout the week.
- Both raw and cooked extra virgin olive oil must be used as ordinary condiment, while butter can be used only for a few recipes. Salt must be used moderately and, in any case, always iodised.

Moreover, dessert is usually only served as part of the school lunch for special occasions (e.g. in proximity to Christmas). Preference is given to healthy cooking methods such as baking, steaming and stewing. Parma municipality include in their guidelines additional recommendations related to daily sodium and salt intakes for different age ranges. With regard to the beverages, no drinks with the exception of tap water are served. In case of allergy, celiac disease, religious reasons or specific requests, special diets are provided in lieu of the standard menu. An example of standard menu is provided in Table 5.

Monday	Thursday	Wednesday	Thuesday	Friday
09/18/17	09/19/17	09/20/17	09/21/17	09/22/17

Pasta with EVO and Parmigiano cheese Baked omelette with vegetables Green beans with EVO oil–tomatoes / fennels Bread Seasonal fruit	Pasta in meat-soup Boiled meat with sauce Salad with mixed vegetables Bread Seasonal fruit	Egg-pasta with ricotta cheese and herbs Vegetable pie Tomatoes/ julienne fennel Bread Seasonal fruit	Pasta with clam sauce Cannellini beans with flavourings Julienne carrots Bread Seasonal fruit	Rice with tomato sauce and basil Plaice fillet cooked au gratin Salad with corn Bread Seasonal fruit

Table 49. A weekly standard menus planned by the catering service for Parma's primary schools.

3.1.4. Kitchens and Canteens

The private contracted catering firm employs all school based kitchen staff and manages all contracts for the supply of fresh/processed foods from wholesalers and distributors. The catering service applies two modalities of food preparation and distribution, in compliance with the characteristics of the school kitchens:

1) In 8 primary schools the entire menu can be cooked and prepared directly in school based fully equipped internal kitchens. ParmaSchoolOne belongs to this group.
2) For 25 primary schools, the meal preparation takes place in a central kitchen produces lunch meals for the group of 25 primary schools, with only cereal-based dishes (e.g. pasta and stock soups) cooked and assembled with sauce(s) or other dressing(s) in the in school facilities. ParmaSchoolTwo belongs to this group.

In the central food storage/collection centre, goods and products are stored in preservation cells, at set temperatures, or in climate-controlled ripening rooms, in compliance with the characteristics of the products. The supply process is designed according to the principle of forward workflow, in order to avoid contaminations, while the storage process is based on the "first-in, first-out" principle to guarantee the maintenance of the product shelf life.

In Parma, 32 staff work in the central kitchen and 181 in the school based canteens (across 33 schools) with 87% female and 83% working part time. Specifically, 6 people work in the in house ParmaSchoolOne kitchen, while 5 people work in the ParmaSchoolTwo canteen and during the data collection period all school based employees were female . ParmaSchoolsOne is located at raised ground floor level and is made up of 3 rooms: the canteen, an equipped kitchen and a storage room. In ParmaSchoolTwo, the canteen is located at ground floor with one big unique room arranged for the lunch service and a small kitchen. There is no dedicated storage room as fresh meals are delivered every day by the central kitchen.

3.1.5. Lunchtime Services

In both ParmaSchools, the school lunch service is 1hr in total which is split into 2*30min periods. The two periods are distinguished only in ParmaSchoolTwo where 1st and 2nd graders are always served first. Kitchen staff set the tables before the start of service, according to the number of students who are taking school meals, and serve food, only modifying the standard portion, if requested to by the children. Teachers and kitchen staff supervise and encourage the children to eat all they have been served and avoid food waste, encouraging especially vegetable consumption. When they have finished their lunch, the children are responsible for disposing of their plate waste in a single (aggregate) bin, and putting their cutlery and plates into separate plastic containers located in the canteen. Furthermore, once a month, the children are asked to separate their plate waste into specific boxes allocated near their tables, as kitchen staff are required to record, once a month, the amount of organic waste for each food item - corresponding to the served but not consumed food fraction - in order to optimize food production and minimize surplus. Figure 2 presents the total food waste % as a proportion respect to the total amount of food prepared using the catering staff records for the amount of food waste (plate waste + prepared but not served food) collected and then estimates the waste percentage considering the amount of raw food that is used for meal preparation. Specific conversion factors, that differ according to the food item, are used to estimate the weight of cooked food starting from the weight of uncooked raw food. Specifically, for ParmaSchoolOne, the total waste value (estimated as a proportion of the amount of wasted food respect to the amount of prepared food), correspond to 15.9%, split between organic waste which goes for composting (12.4%) and leftover food which goes to third sector (3.5%). In ParmaSchoolTwo, the total waste value corresponds to 6.4%, with 4.4% organic waste for composting and 2.0% leftover food going to the 3rd sector (Figure2).

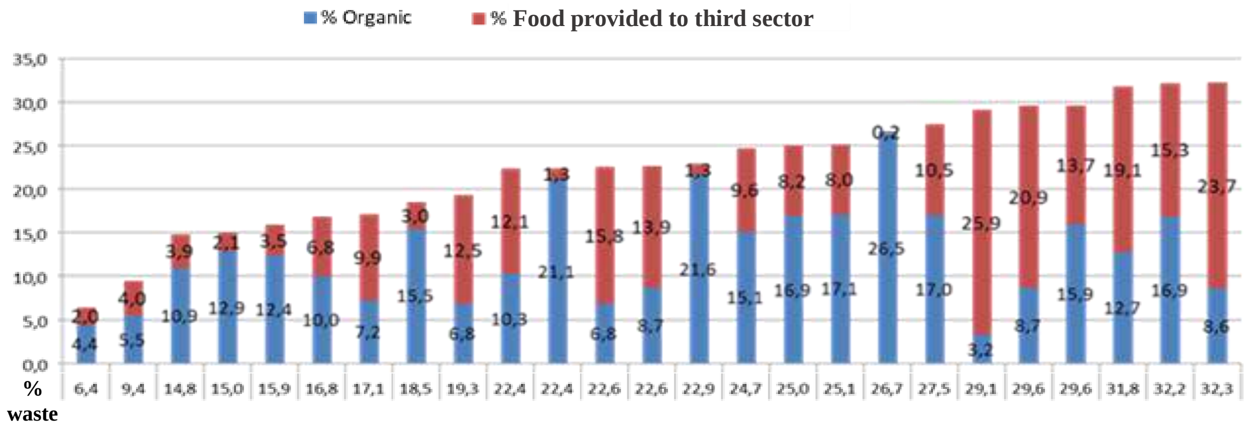

Figure 64. Percentages of waste generated by the organic fraction and by the food donated to the third sector associations in 25 primary schools in Parma.

Each bar represents one primary school. The first and fifth histogram refer to ParmaSchoolTwo and ParmaSchoolOne, respectively. Source: Parma municipality.

The plastic used during the lunch service in both ParmaSchool One and Two was limited to 1) reusable: plastic water jugs (not disposable); 2) bowls containing Parmigiano (one for each table) in ParmaSchoolTwo, and 3) bins used to collect the food waste and the cutlery. No other plastic (reusable nor disposable) was observed during data collection. However, to facilitate a separated waste recycling collection system in each canteen room, two recycling bins, one for plastic stuff and one for paper stuff, were provided to the side of the food waste bins.

3.1.6. Schools Fruit and Vegetables Scheme

Fruit and vegetables are supplied daily to the School Caterer central kitchen or directly to the school kitchens who cook and prepare meals in house. Moreover, the fruit and vegetables are supplied by different suppliers, most of which located within Emilia-Romagna region and certificated organic. As a result, only seasonal fruit and vegetables (excluding frozen products) were included on school menus and selection depends on their availability. Vegetables are served as a side dish daily with the portion size differing dependent on the cooking procedure where 50 g is the reference portion for raw vegetables, while 150 g refers to cooked vegetables (baked, steamed or stewed). Only salt, extra-virgin olive oil and vinegar were used as seasoning. According to the planned menus and regional guidelines, each child should receive at least one portion of fruit (150 g) per day at school. However, due to the “Frutta nelle Scuole” campaign, which promotes fruit consumption amongst children, two portions were distributed twice weekly during the 17/18 school year. The project is supported by European Union and managed in Italy by the Ministry of Agricultural, Food and Forestry Policy in collaboration with the Ministry of Education, the Ministry of Health, Agricultural Delivery Agency (AGEA) and Regions. All municipality schools subscribing the project were provided with additional fruit supplied by a cooperative located about 70 km from Parma city. The initiative aims to encourage the adoption of healthy dietary behaviours in children aged from 6 to 11 in the primary school context which represents an ideal setting for building healthy food lifestyle habits. When combined, Parma primary school children can eat between 200-450 g of fruit and vegetables daily, between 50-100% of the recommended WHO Guidelines for adults. In both selected schools, fresh fruit was distributed daily during the mid-morning break and could be eaten straight away, after lunch or before going home.

3.2. ORG case

3.2.1. Schools profile

Lucca's municipality has 54 schools including 29 primary schools, 2 of which are private, with an average pupil roll of under 100, considerably smaller than the Italian national average of 171. Usually, the price paid for a meal is shared between parents and the municipality, based on the Equivalent Economic Situation Indicator (ISEE). Similarly to Parma, with some reductions for families with two or more children or total exemption in case of social and/or economic difficulty. The two primary schools selected in Lucca were: LuccaSchoolOne located close to the historical city centre and LuccaSchoolTwo, located 3.5 km far from the city centre. The pupil roll and daily average uptake of school meals were 168 and 90% (151) for LuccaSchoolOne and 212 and 88% (186) for LuccaSchoolTwo. This is slightly above the regional average of approximately 80% and on average across the 27 state primary schools, 115 lunches are served per school per day with a min of 40 and maximum of 316.[23].

3.2.2. Approach to Food and Sustainability Issues

According to the National Guidelines (Ministry of Health, 2010) and the Lucca municipality, school meal provision in Lucca is mainly constituted by organic products, followed by quality products (PDO, PGI, TSG) and short chain products. Specifically, Lucca municipality requires:

- quality assurance systems and traceability certifications for all suppliers;
- organic certification for the majority of the raw materials (pasta, fruits, vegetables, potatoes, legumes, olive oil and dairy products).

On the basis of these characteristics, the Lucca school food procurement model has been defined as "organic". The Regional guidelines also specify the importance of developing educational programs targeting teachers, parents and students, aimed at educating these groups towards conscious consumption and the value of food, taking into consideration the environmental compatibility of food production. As specified in the contract tender, the services provided by the catering firm engaged in preparing and delivering school meals to the children have to refer to a quality Project. This Project has to involve all the services included in the tender and has to comprise a program of food education. Specifically, 13 primary schools in Lucca, including LuccaSchoolTwo, are involved in a project named "Orti in condotta" (literally, "ongoing gardens") started in 2015 in the framework of "Centomila Orti in Toscana" (literally "one hundred thousand vegetable gardens in Tuscany"). It is based on the development of educational vegetable gardens using areas outside the school. It is a national project promoted by Slow Food in which some training initiatives are planned for, and delivered to, teachers. Moreover, food, taste and environmental education is addressed with the children, while some seminars are planned for, and delivered to, parents and grandparents. Different actors are involved in the vegetable gardens realisation, including local producers, as well as high school students from a village in Lucca province. The constituted community promotes knowledge transfer to younger generations in relation to food culture and environmental protection.

3.2.3. Organisation of School Meals

The price per meal is shared between parents and the municipality, based on the Equivalent Economic Situation Indicator (ISEE). Accordingly, parents pay as follows: free (ISEE € 0-5,500.00); € 2.00 - € 4.99/meal (ISEE € 5,500.01-29,999.99) and € 5.00/meal (ISEE above € 30,000.00). In addition, there

[23] The reported numbers refer to the sum of children and teachers who daily receive the school lunch.

are some reductions for families with two or more children, i.e. a 25% discount for the 2nd child, 50% for the 3rd child, and 100% for the 4th and additional children.

Taking into account the National Guidelines for school catering (Ministry of Health, 2010), the composition of the menus and the desired nutritional profile, dieticians employed by the private contracted catering companies develop menus which must be approved annually by the municipality, with the supervision and the final approval of the health authorities. The Lucca School lunch menu runs on a 7-8 weeks cycle and is differentiated in two periods (autumn-winter; spring-summer) to guarantee the supply of seasonal fruit and vegetables. At the beginning of each school year, and for each school, a canteen commission is set up composed of nominated parents (of children attending the school) and school teachers. The purpose of the canteen commission is to verify the food and school canteen service quality. The commission meets twice annually to discuss and evaluate the school meals and make recommendations on how to improve the menus and the school's canteen service. Kitchen staff are never notified in advance that the canteen commission intended school canteen visits.

Very similar to the PARMA exemplary except that dessert is served more often, an exemplary Lucca primary and junior high school meal menu is detailed below:

- First course: cereals (pasta, rice, barley, maize, etc.), prepared with different recipes, respecting local traditions and often associated with vegetables and legumes. Legumes, if associated with cereals, and traditional plates, such as pizza or lasagne, can be served as unique or semi-unique course.
- Second course: white and red meat, salami, fish, eggs, or cheese.
- Side dish: Vegetables (potatoes no more than once a week and associated with a meal poor in other carbohydrates).
- Bread with no fats and low salt content.
- Seasonal fruits of at least three different types throughout the week, possibly ready for consumption.
- Dessert: chocolate pudding or yoghurt can be occasionally served instead of fruits.
- Both raw and cooked extra virgin olive oil must be used as ordinary condiment, while butter can be used only for few recipes. Salt must be used moderately and always iodised.

Preference is given to healthy cooking methods such as baking, steaming and stewing. In case of allergy, celiac disease, religious reasons or specific requests, special diets are provided in lieu of standard menus. See Table 6 for the weekly LuccaSchool menu from September 2017.

Monday	Tuesday	Wednesday	Thursday	Friday
18/09/17	19/09/17	20/09/17	21/09/17	22/09/17
Strained cream soup Chicken cutlet Salad Bread Fruits	Rice with EVO Squid with green peas Bread Dessert[5]	Pulses soup with spelt Pecorino cheese Courgettes cooked in oil with parsley and garlic Bread Fruits	Pasta with tomato sauce and basil Roast veal Mashed potatoes Bread Fruits	Lasagne with pesto Cooked ham Salad with tomatoes Bread Fruits

Table 50. A weekly standard menus planned by the catering service for Lucca's primary schools.

3.2.4. Kitchens and Canteens

The private contracted catering firm employs the all school based kitchen staff and manages the contracts for the supply of fresh/processed foods from wholesalers and distributors. All Lucca school meal preparation takes place in the central kitchen which produces lunches for a total of 54 schools, including the 27 state Lucca primary schools. Only cereals-based dishes (e.g. pasta and stock soups) are cooked and assembled with sauce or other dressing onsite in the school kitchens. All products are delivered to the central kitchen where these are stored until use. The central kitchen has both a warehouse for the storage of ingredients/raw foods and a commercial kitchen where all meals are prepared and then delivered to the onsite school kitchens for final preparation and service. Raw materials and products is received daily, according to an agreed weekly plan with each supplier, in accordance with the programme of the central kitchen. Products are stored in preservation cells at a set temperature, or in climate-controlled ripening rooms, in compliance with the characteristics of the products. The supply process is designed according to the principle of forward workflow, in order to avoid contaminations, while the storage process is based on the "first-in, first-out" principle to guarantee the maintenance of the product shelf life. In both Lucca case schools, the canteen is located at ground floor in a big unique room arranged for lunch service and a small kitchen. There is no dedicated storage room and fresh meals are delivered daily from the central kitchen. In Lucca, 10 to 25 people are employed at the cooking centre with a further 3-4 employees per school canteen. In total, 93% of LuccaCater employees are female with 945 working part time. In LuccaSchool One and Two, 3 and 4 people are employed as kitchen staff, respectively and during the data collection period, all school based employees were female.

3.2.5. Lunchtime Service

In Lucca, the school lunch service between 60-90mins in length split across 2 time periods with younger children always served first. Every day the standard (and alternative menus where required due to special dietary requirements) are delivered pre-cooked and prepared by the central kitchen to LuccaSchool One and Two, with the exception of the starchy food based-plates (as pasta, rice and other cereals) which are assembled on site with sauces. Kitchen staff set the tables before the start of lunch service, in line with the number of expected children, and serve food portions in compliance with the standard portion size references. Teachers supervise and encourage the children not to waste foods and when the children are finished all leftover food waste is collected in single aggregated food waste bin.

In LuccaSchoolOne, lunchtime begins at 12:30pm lasting for 90minutes and ending at 2.00p.m. with every group of children having between 25-30minutes for lunch. Pupils eat in a quite big canteen room. After the first turn, the kitchen staff clear the canteen and set the tables again for the 2nd service. The school kitchen only has facilities only to wash plates, cutlery and glasses, and to distribute them to the children. Kitchen staff lay out glasses, steel cutlery, and reusable plastic containers containing grated cheese (i.e. Grana PDO), according to the number of children taking lunch. All the children are accompanied into the canteen by their teacher with the first group belonging to the 1st, 2nd and 3rd grades, while older students have lunch after, during 2nd service. Ceramic dishes are used to distribute meals. Bread is freely available on a distinct table. Kitchen staff serves meals from serving carts bringing them to the table where the children are sitting. Teachers sit and eat on a separated table and try to keep students quiet. However, despite this, the level of noise is generally quite high during the lunch service. The teachers were not observed to be encouraging the children to try out new food, or to finish their meals. At the end of the service, food plate waste is generally collected in into a unique bin with the catering service staff clearing the tables and dealing with both the food and non-food waste.

Differently, in LuccaSchoolTwo lunchtime lasts one hour, from 12.30 to 13.30 as there is no need, due to pupil numbers to have separate services. At the beginning of the service, the 1st and 2nd graders come to the canteen accompanied by their teacher and sit together at tables of 6. A few teachers supervise and encourage the children to eat their lunch and not to waste foods. Before the beginning of the service, in accordance with the number of children taking lunch, kitchen staff put on the table baskets with bread (one slice per child), reusable plastic water jugs, glasses and plastic bowls containing grated cheese (i.e. Grana PDO). A serving cart is used to bring meals to the tables where children are sitting. As they school does not have sufficient ceramic plates for all children who take lunch, those children coming later to service receive their meals on reusable plastic dishes. Moreover, teachers eat at a distinct table and try to keep students quiet. However, despite this, similarly to LuccaSchoolOne, the noise levels are generally quite high. Plate food waste is collected by kitchen staff at the end of the lunch and put into a unique bin. Following a request form the kitchen staff request, the older students help to clear up the tables at the end of the service. Thus, a different cleaning management is applied in the two schools.

3.2.6. Waste management and Plastic Use

The use of water from the local public water supply system (tap water) allows not only the reduction of waste and road transport, but also the valorisation of local water resources. Lucca municipality requires the adequate differentiated waste collection throughout the supply chain. Organic and dry waste generated in the schools must follow the same separate waste collection already applied more generally in the municipality. Out of a total of 54 schools, 7 primary schools, including LuccaSchool One and Two, and 3 kindergartens have activated a pilot project onto donate uneaten food (e.g. bread and fruit) to a third sector association. The project called “Non tirare la pasta” (literally “don’t throw pasta”), and which has 4 employees, has been active from several years using a vehicle to pick up food, and making use of some insulated containers and a blast cabinet. During the 2017/2018 school year, a total of 1267, 1265 and 1147 trays in relation to the first course, the second course and the side dish, respectively were collected across the participating schools. In addition, 429kgs of fruit and 11295kgs of bread were also collected. Table 7 outlines the specific number of trays and kgs of fruit and bread collected from LuccaSchool’s One and Two during the 17/18 school year. For schools not involved in the project, the leftover bread and fruit distributed but not consumed at lunch time can be brought to the class, at the discretion of the pupils. The rest of the prepared and not consumed food is not recycled for human consumption but disposed of following the Lucca's separate waste collection plan.

School	First course*	Second course*	Side dish*	Fruit (n)	Bread (kg)
1	122	126	110	72	80
2	130	131	114	28	24
3	129	128	116	74	295
4	121	124	115	26	67
5	131	126	116	67	171
6	120	117	107	30	41
7	130	132	117	3	76
8	131	131	121	82	170
9	131	131	116	6	201
10	122	119	115	41	170
Total	1267	1265	1147	429	1295

Table 51. Amount of food donated by the 10 schools involved in the project "Non tirare la pasta" to third sector association across the 17/18 school year.

* the value refers to the number of trays collected. Schools 1, 2, 3, 5 correspond to LuccaSchool One, Two, Three, Five enrolled in the data collection performed in WP 6.2 and/or 6.3, while schools from 8 to 10 are nursery schools located in Lucca.

The plastic use for LuccaSchoolOne was limited to reusable water jugs and bins used to collect the food waste and cutlery. Interestingly, disposable plastic glasses were used in LuccaSchoolTwo but not in LuccaSchoolOne. In both schools, reusable plastic baskets containing bread and plastic bowls with grated cheese and a reusable plastic tea spoon are used. Similar to Parma schools, and to facilitate a separate recycling collection system, two big recycling bins, one for plastic stuff and one for paper stuff, were available in each canteen beside the food waste bin.

3.2.7. Schools Fruit and Vegetables Scheme

Fruit and vegetables are supplied daily to the SchoolCater central kitchen. Although the fruit is supplied by different wholesalers, they are all delivered by one local distributor. Thus, only seasonal fruit and vegetables (excluding frozen products) were included in the school menu, and their selection depends on their availability. Vegetables are served daily as a side dish, raw or cooked according to the season and the type of vegetables. Only salt, extra-virgin olive oil and vinegar are used as seasoning. As established by the catering service, each child receives one portion of fruit daily with different varieties provided throughout the week. The children receive their fruit at different times depending on the school with LuccaSchoolOne distributing their daily fresh fruit at lunch-time and it is consumed after lunch or the mid-afternoon, while LuccaSchoolTwo distribute their daily fruit mid-morning and it is consumed by the children before going home. Depending on the teachers' decision, if children do not consume their portion, they can permit them to bring it home.

4. NUTRITIONAL COMPOSITION OF MENUS IN CASE SCHOOLS

This section presents the results of the nutritional composition analysis of the selected menus at the two Parma (LOC-ORG) and two Lucca (ORG) case schools. What the results show is the intended nutritive value of lunches at the case schools, based on student intake of full standard portions. As described in Section 1, food composition analysis was carried out on 40 daily menus (over two weeks/seasons), 20 in LOC-ORG case schools and 20 in ORG case schools. The nutritive value of school meals was calculated using Italian national food composition database.

Lunch is considered one of the most important meals during the day, which significantly contributes to the total daily nutritional intake of school children. The Italian national guidelines for the nutrition of primary-school students give recommendations for the energy and nutritive values of school lunches (Table 1, page 15). The analytical procedure was as follows. First, the food composition of the 40 selected daily menus was confirmed with school catering staff, according to the regulations for a standard portion (i.e. the specific ingredients comprising the main dishes, vegetables and dessert (where applicable), along with the ingredients' weights and whether cooked/uncooked). These data were then entered into a bespoke database and analytical tool (foodpbf.com) created by University of Zagreb for the Strength2Food project. Using this tool, the meal normative for the LOC-ORG (Parma) and ORG (Lucca) menus were analyzed to produce a full energy, macro- and micronutrient profile of a standard portion of lunch for each daily menu in both the LOC-ORG and ORG cases. The tool also compared these profiles with the Italian national nutritive guidelines. In the results that follow (Figures 3-6), the proportions of daily menus across both cases which met the recommended energy, macro- and micronutrient thresholds as shown in Table 1. To begin with however, a consolidated summary is presented of the energy, macro- and micronutrient profiles of an average daily menu at LOC-ORG and ORG schools, respectively (Table 8). These data were produced by averaging the energy, macro- and micronutrient profiles of all 20 daily menus in LOC-ORG schools, and all 20 daily menus in ORG schools, respectively. The results are expressed per standard portion as average ± standard error.

4.1. Nutritional comparison between LOC-ORG and ORG case menus

The nutritional composition of the menus in terms of macro-and micro-nutrients was compared between the two cases. Furthermore, the selected menus were analysed considering the National recommendations (Italian Guidelines for school catering service).

Parameter (average ± SD)	**ORG**	**LOC-ORG**	**ω^2-ANOVA**
MACRONUTRIENTS			
Energy (kcal)	698.15 ± 68.37	706.10 ± 92.73	0.0119 (no effect)
Total proteins (g)	27.37 ± 5.01	30.55 ± 5.93	0.0037 (no effect)
Total carbohydrates (g)	104.48 ± 12.02	104.20 ± 12.13	0.0131 (no effect)
Dietary fibre (g)	10.24 ± 4.67	12.90 ± 3.50	0.0056 (no effect)
Total fat (g)	20.96 ± 4.49	20.40 ± 7.15	0.0076 (no effect)
Saturated fatty acids (g)	5.77 ± 3.11	7.03 ± 6.35	0
VITAMINS			
Vitamin A (µg RE)	522.32 ± 339.31	909.13 ± 672.66	0

Vitamin B_1 (mg)	0.48 ± 0.15	0.52 ± 0.19	0.0039 (no effect)
Vitamin B_2 (mg)	0.39 ± 0.10	0.44 ± 0.14	0.0061 (no effect)
Niacin (mg)	1.28 ± 0.61	1.22 ± 0.82	0
Vitamin B_6 (mg)	0.80 ± 0.23	0.79 ± 0.34	0.0136 (no effect)
Folate (µg)	96.97 ± 42.83	118.81 ± 38.73	0
Vitamin B_{12} (µg)	1.43 ± 0.76	2.53 ± 4.27	0.0068 (no effect)
Vitamin C (mg)	55.70 ± 46.16	82.20 ± 37.12	0
Vitamin D (µg)	0.86 ± 1.81	0.32 ± 0.36	0.0002 (no effect)
MINERALS			
Sodium (mg)	647.19 ± 324.31	630.10 ± 142.47	0.0020 (no effect)
Potassium (mg)	1064.85 ± 295.89	1335.53 ± 389.99	0
Calcium (mg)	302.66 ± 131.34	368.03 ± 212.70	0
Magnesium (mg)	43.40 ± 18.87	45.91 ± 22.89	0
Phosphor (mg)	424.39 ± 67.57	510.75 ± 103.20	0
Iron (mg)	4.10 ± 1.30	5.41 ± 1.83	0
Zinc (mg)	3.39 ± 1.13	3.30 ± 0.80	0.0054 (no effect)
Copper (mg)	0.35 ± 0.31	0.31 ± 0.24	0

Table 52. Average energy and nutritive value of school lunches (n=20) per PSFP model, as planned by the catering firm.

Results are expressed as average ± DS. The ANOVA ω2 statistics test was used to analyse non-parametric correlation. ANOVA ω^2 significance values are in the following ranges: 0 - 0.063 not significant differences (no effect); 0.063 – 0.14 significant differences (medium effect); >0.14 significant differences (high effect).

As Table 8 shows, the average total energy (kcal) per standard portion of lunch in Lucca ORG schools is 698kcal (± 68), compared with 706kcal (± 93) in Parma LOC-ORG schools. This result is consistent with the fact that the standard portion weight of an average school lunch in Parma is 615g, 22% (113g) heavier than the average Lucca lunch (502g). However, Table 8 shows more mixed results in terms of macro, and micro, nutrient content of the average school lunch meal across both cases. For macronutrients, the average Parma lunch provided more protein, fibre and saturated fatty acids, while meals across both cases provide almost the same amount of carbohydrate and total fat. In terms of micronutrients, the average Parma lunch contains a higher content of 6 of the 9 vitamins tested (A, B1, B2, folate, B12 and C), whereas the average Lucca lunch contains more Niacin, Vitamin B6 and Vitamin D. In terms of minerals, the average Parma lunch contains higher contents of 5 out of 8 of the minerals analysed (Potassium, Calcium, Magnesium, Phosphorus and Iron), while the average Lucca average lunch is higher in Sodium, Zinc and Copper. However, despite these observed nutritional differences no significant differences in terms of nutritional profile were observed between the Parma and Lucca school lunch menus.

4.2. Compliance of the school menus with the national nutritional guidelines

The next set of results focus on the daily menus, and show the menus proportions across the two cases that met the national nutritional guidelines (as shown in Table 8). First, we present the total energy provision (Figure 3) followed by total protein, carbohydrates and fat (Figure 4) of the daily menus. In terms of total energy, according to the Health Ministry guidelines, a school lunch should provide 35% of a child's daily energy requirements i.e. from 440 to 830 kcal. As reported in Figure 3, almost all the planned menus fell within the recommended ranges for both the LOC-ORG and ORG models. However, the ORG model showed a higher compliance with the standards (95%) than the LOC-ORG model (90%). For protein, the average percentage of proteins provided by the proposed menus in both cases was slightly higher than the 10-15% range indicated by the National recommendation: 17% and 16% respectively for LOC-ORG and ORG model. On the other hand, the % of total carbohydrates were less than 60% of the lunch energy content, in line with the National recommendation, while the fat content was below 30%, slightly lower than the recommendation (Figure 4).

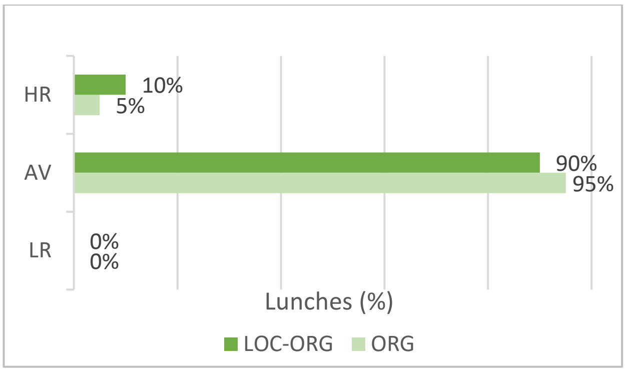

Figure 66. Distribution of energy values in school lunches (n=20) per PSFP model according to National recommendation.
HR: higher than recommendation; AV: adequate value; LR: lower than recommendation.

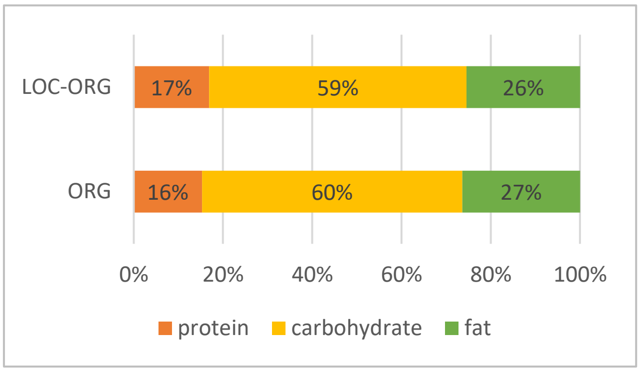

Figure 65. Average distribution of macronutrients of school lunches (n=20) per PSFP model.

In terms of saturated fat, and according to the National recommendation, no more than 10% of a child's lunch energy meal intake should be provided by saturated fat. As Figure 5 shows, only 10% and 25% of analysed menus for the LOC-ORG and ORG models respectively were found to meet the National recommendation for saturated fat, and while 70%, and 60%, respectively below the National recommendations they were in line with accordance with the National Recommended Energy and Nutrient Intake Levels[24], as well as with the dietary reference values for fats provided by European Food Safety Authority (EFSA)[25]. Of the remaining menus, 20% and 15% respectively were found to have higher than recommended levels of saturated fat. In terms of dietary fibre, the National recommendation is that a school lunch should provide between 5-7.5g. As can be seen from Figure 6, all the LOC-ORG menus were found to be in line with this fibre standard, while 85% of ORG menus also met this recommendation.

[24] http://www.sinu.it/html/pag/06-LIPIDI.asp
[25] https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2010.1461

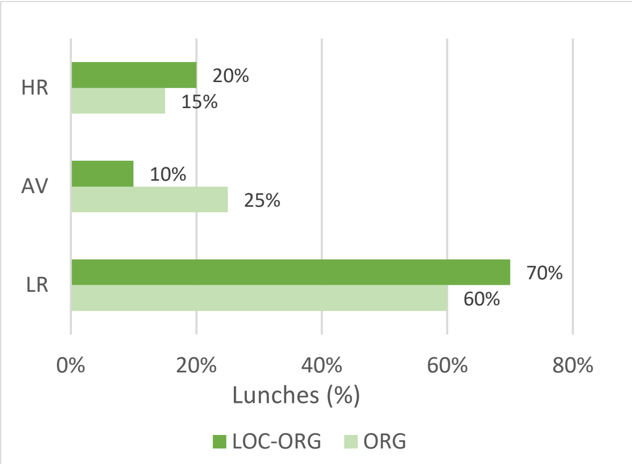

Figure 68. Distribution of saturated fatty acids values in school lunches (n=20) per PSFP model according to National recommendation.

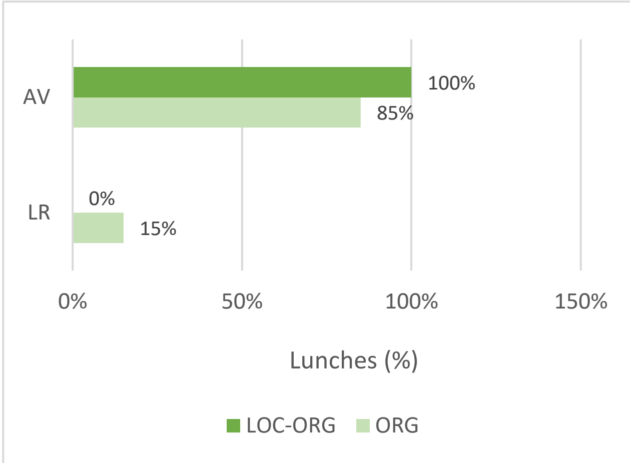

Figure 67. Distribution of dietary fibre values in school lunches (n=20) per PSFP model according to National recommendation.
HR: higher than recommendation; AV: adequate value; LR: lower than recommendation

Overall, Figures 3-6 illustrate that the vast majority of the daily analysed lunch menus in Parma LOC-ORG and Lucca ORG schools are compliant with all recommended national energy and macronutrient standards. The only exceptions are a very small proportion (5-10%) of meals in both cases providing greater than recommended energy, and a small proportion (15-20%) of meals in both cases providing higher than recommended levels of saturated fatty acids. The iron content of the planned lunch menus was overall below the recommendations: 80% and 90% of the LOC-ORG and ORG menus, respectively with no menu found to be recommendations. With regard to calcium content, similar results to those for iron content were found (Figure 7). Overall, a higher compliance with the national recommendations can be found for LOC-ORG model in relation to fibre, and for ORG model in relation to proteins and SFA.

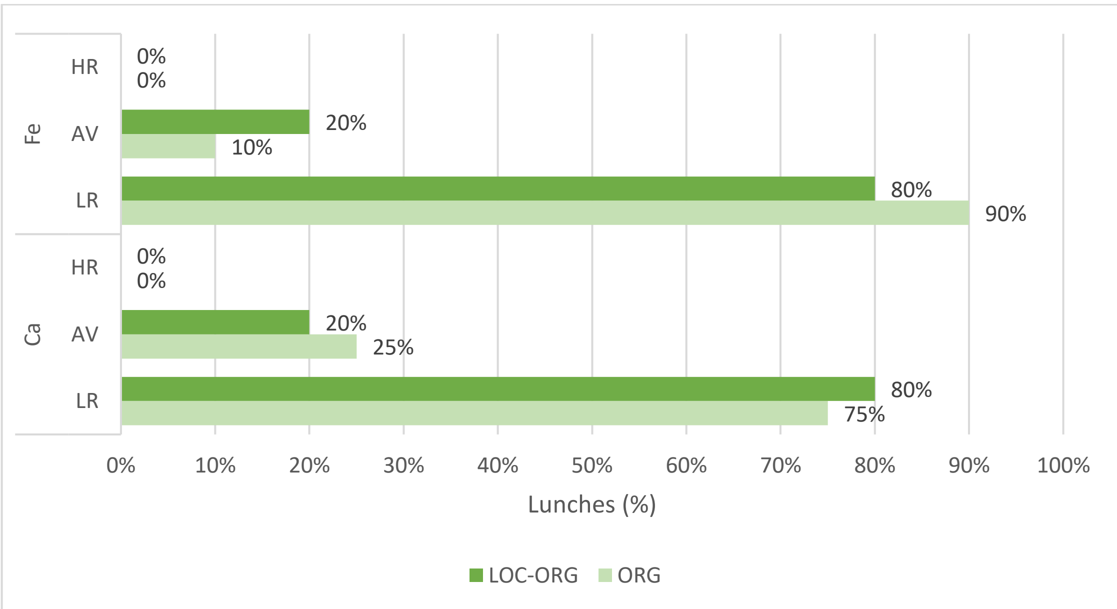

Figure 69. Distribution of calcium and iron values in school lunches (n=20) per PSFP model according to National recommendation.
HR: higher than recommendation; AV: adequate value; LR: lower than recommendation.

5. PLATE WASTE FOR CASE SCHOOLS

5.1. Methodology for Plate Waste Study

Section 5 reports the findings of the plate waste study conducted in ParmaSchool One and Two (LOC-ORG Case) and LuccaSchool One and Two (ORG) during the 17/18 school year in the same four schools on which the menu composition analysis was undertaken. The reported plate waste data were collected across 2*1 week periods (where a week equals 5 consecutive school days from Monday to Friday), a spring/summer week and an autumn/winter week, giving a total of 10 days/school and 20 days/case region. For ParmaSchool One and Two (LOC-ORG Case) and LuccaSchool One and Two (ORG), plate waste was collected from 3897 and 2897 plates respectively with waste collected from the trays of all children taking school lunches on each data collection day. Considering the presence of different meal preparation/delivering methods, four primary schools (2 per case), each with a minimum of 100 pupils and a different position/distance from central kitchen were selected for the plate waste data collection. For the LOC-ORG case, ParmaSchoolOne, in the city centre, equipped with the internal kitchen and ParmaSchoolTwo, 10.6km from the city centre, provided by the central kitchen were selected. For the ORG case, LuccaSchoolOne, in the historical city centre and LuccaSchoolTwo, 3.5km outside the city, were selected.

A modified aggregate selective plate waste method[26] was applied to measure school lunch plate waste during 5 consecutive observation days in winter and in spring (2017/2018 school year), for a total of 20 days of collection activities (10 for each school) with between 2-3 researchers involved in the daily data collection. The procedure used to measure food waste was a direct weighing method where food waste, collected from the plates of all children eating standard lunch meals on the data collection days, was separated and weighted across 7 food categories namely: starchy foods served as first course; bread; protein-based dishes (meat, fish, diary, legumes); vegetables served as side dish; fruits; desserts; and "other" which included semi-unique and unique dishes. The fruit category was included although it was not served at lunch, but mid-morning, to be eaten as a snack. An electronic kitchen scales and professional weighting scales, owned by the school kitchens, were used to weigh reference portion sizes and food waste, respectively. Before starting the investigation in the selected schools, discussions were held with representatives from the municipalities, head-teachers, grade teachers, the school catering company and school based kitchen staff to discuss the school meal service and advise on the project and the planned data collection activities. On each data collection day, based on the daily menu, one (or more) bin(s) for each of the 7 food categories were prepared. Next, a sample of three random servings for each daily served meal were weighed, to calculate a mean reference weight per daily served portion. Since the school meal service is split into two service groups, this weighing procedures was were performed twice, for each service. Thus, the final reference daily portion serving size for each food component was calculated as a mean of the weight across the six random weighted servings. Pupils attending ParmaSchoolOne eat in three different rooms (Figure 8) at the same time, therefore three bin stations were set up and used to collect plate waste. A similar process was used in ParmaSchoolTwo, but in this case as the canteen is made up of one big space, only one bin station was required. Once the Param children were finished eating they brought their dishes to the table where all leftovers were scraped into relevant food category bins. In both LuccaSchools, the large single room canteens (Figure 9) which host all the pupils across two services meant that only one bin station was required. Accordingly, the weighing procedures for establishing the reference portion size weight, were performed for both lunch services. In LuccaSchoolOne, the researchers collected the

[26] Comstock et al (1979). *Plate waste in school feeding programs: Individual and aggregate measures* (No. NATICK/TR-81/011).

plates from the children, with the help of the kitchen staff, and then scrapped all the plates accordingly. In LuccaSchoolTwo, as per usual school procedure, older children helped to clear the tables and brought the dishes to the workstation where all plate waste was scraped into the relevant food category bins. In LuccaSchoolOne, this operation was instead just done by the researchers with the help of the catering service. In both the schools, the presence of a big canteen (Figure 9) hosting all the pupils in two turns allowed the use of just one bin for each food. Accordingly, the weighing procedures were performed in two turns.

A

B

Figure 70. One on the three rooms where the pupils eat in ParmaSchoolOne (A) and the big school canteen hosting all the pupils at lunch time in ParmaSchooTwo (B), LOC-ORG case.

A

B

Figure 71. The school canteens present in LuccaSchoolOne (A) and LuccaSchoolTwo (B), ORG case.

Once collected plate waste was weighed, data were recorded on paper sheets and then, during the same day of data collection, copied into Excel worksheets to calculate the percentages of food waste. Using the collected data, the total collected plate waste (kg) was calculated by summing of the food waste (kg) collected across all 7 food categories, for all schools, and across all data collection weeks. In parallel, the total served food (kg) was calculated using the weighted reference daily portions for each daily meal, and corresponding food categories across both cases and all data collection weeks. The served food (kg) corresponds to the amount of food that was planned to go on plates multiplied by the number of the served meals. The percentage of plate waste per food category (or food item) was obtained from the ratio between the total weight of food waste (kg) per food category (or food item), and the total amount served per food category (or food item) (kg). Finally, the total aggregated plate waste (kg) and the total food waste per food category (kg) were divided by the number of served meals in order to obtain an estimated average weight of collected plate waste per meal served (g).

The plate waste results are organised as follows. First, is presented the total volume of waste collected from all bins during the 20 and 19 days of data collection for LOC-ORG and ORG model, respectively (Section 5.2). Next, is reported the food category composition of the waste in both cases (Section 5.3), calculated by the contribution of the waste in each food category to total waste and the proportion of waste to served portion within each food category. Third, are presented some illustrations of the levels of waste in specific daily menus (Section 5.4). Then the results are given of the nutritional losses associated with the plate waste in both cases (Section 5.5), and finally the analysis is given of the financial cost and levels of embodied carbon in the plate waste (Sections 5.6 and 5.7).

5.2. Total Plate Waste in LOC-ORG and ORG schools

This section reports the results of the total plate waste generated from the LOC-ORG and ORG schools. Table 9 summarises the total number of meals served in the schools, the total weight of food served, the total weight of plate waste collected, the average weight of food served, and plate waste collected, per meal served and the proportion of served food collected as plate waste across all 4 schools and the full data collection period.

PFSP model	Parma LOC-ORG	Lucca ORG
Total number of served meals (n)	3897	2897
Total volume of food in served meals (kg)*	2103.2	1436.2
Average volume of food per served meal (g)	527.1	498.1
Total volume of plate waste (kg)	540.6	551.8
Average volume of plate waste per served meal (g)	139.6	191.3
Proportion of served meal volume that is plate waste (%)	25.7	38.4

Table 53. Amount of served meals and plate waste across all food categories and both seasons in two schools per case (n=20 lunches in LOC-ORG model and 19 in ORG).

* the values have been calculated as the average of the meal (intended as the sum of first course, second course, side dish, bread and fruit) served during 20 and 19 days in LOC-ORG and ORG case.

As Table 9 shows, the average weight of served food per meal is 29g greater in in LOC-ORG than ORG though despite this the average weight of collected plate waste per served meal was 51.7 g greater in ORG than LOC-ORG with 38.4% of food served in ORG collected as plate waste compared to 25.7% in LOC-ORG schools. More details about the weight and percentage of collected plate waste are presented in the subsequent sections below.

5.2.1. *Total plate waste in LOC-ORG case*

As reported in Table 10, while the total plate waste collected in LOC-ORG schools in winter was similar in both schools (138.8 kg *vs.* 133.9 kg), a difference between ParmaSchoolOne and ParmaSchoolTwo of 12.8 kg was observed in spring (127.5 kg *vs.* 140.3 kg).

	PARMA Loc-Org	Total served meals		Average served meal	Total waste	Waste	Waste/ Meal
		(n)	(kg)	(g)	(kg)	(%)	(g)
Winter	School 1	918	440.14	479.35	138.84	31.54	151.41
	School 2	1024	544.23	531.37	133.93	24.61	131.11
	School 1+2	**1942**	**984.37**	**506.78**	**272.77**	**27.71**	**141.26**
Spring	School 1	889	484.69	545.21	127.51	26.31	145.80
	School 2	1066	634.17	595.13	140.27	22.12	130.24
	School 1+2	**1955**	**1118.86**	**572.42**	**267.78**	**23.93**	**138.02**
Winter + Spring	School 1	1807	924.83	511.75	266.35	28.80	148.60
	School 2	2090	1178.40	563.88	274.20	23.27	130.68
	School 1+2	**3897**	**2103.23**	**539.70**	**540.56**	**25.70**	**139.64**

Table 54. Total food waste referred to LOC-ORG case.
*each value in the column has been calculated as the ratio between the relative total amount of served meal converted in grams and the total number of served meals (n) indicated in the table. Data are reported as total (kg) and average served meal (g), total amount of food waste (kg), waste percentage (%) and waste per meal (g) referred to ParmaSchoolOne and ParmaSchoolTwo in winter and spring. Moreover, the sum of values obtained across both data collection weeks and/or across both schools is reported.

While the proportion of collected plate waste to food served exceeds 30% in ParmaSchoolOne for the winter week (31.5%), the total proportion of collected waste to food served across both ParmaSchools, for the full data collection periods, is 25.7%. The average weight of collected waste per meal served (g) ranges from 130.2 g and 151.4 g, with a small difference between the average winter total winter (141.3 g) and spring (138.0 g) weight compared to the aggregate across both seasons (139.6 g).

5.2.2. Total plate waste in ORG case

As reported in Table 11, a difference in the weight of collected plate waste between LuccaSchoolOne and LuccaSchoolTwo was found with higher levels in spring (121.7 kg vs 159.2 kg) compared to winter (139.3 kg vs 131.6 kg).

	LUCCA Org	Total served meals		Average served meal	Total waste	Waste	Waste/ Meal
		(n)	(kg)	(g)	(kg)	(%)	(g)
Winter	School 1	647	326.66	505.04	139.31	42.65	216.24
	School 2	699	352.89	505.14	131.55	37.28	187.10
	School 1+2	**1345**	**679.55**	**505.09**	**270.86**	**39.86**	**203.29**
Spring	School 1	691	328.37	474.88	121.70	37.06	176.17
	School 2	860	428.26	498.06	159.21	37.18	184.90
	School 1+2	**1551**	**756.63**	**487.73**	**280.91**	**37.13**	**180.54**
Winter + Spring	School 1	1338	655.03	489.45	261.00	39.85	196.20
	School 2	1558	781.15	501.23	290.76	37.22	185.88
	School 1+2	**2896.73**	**1436.18**	**495.79**	**551.77**	**38.42**	**191.31**

Table 55. Total Food Waste referred to ORG case.
*each value in the column has been calculated as the ratio between the relative total amount of served meal converted in grams and the total number of served meals (n) indicated in the table. Data are reported as total (kg) and average served meal (g), total amount of food waste (kg), waste percentage (%) and waste per meal (g) referred to LuccaSchoolOne and LuccaSchoolTwo in winter and spring. Moreover, the sum of values obtained across both data collection weeks and/or across both schools is reported.

While the proportion of collected plate waste to food served exceeds 42% in LuccaSchoolOne for the winter week (42.65%), the total proportion of collected waste to food served in Org Schools is 38.42%. The average weight of collected plate waste per meal served (g) ranges from 176.17g

(LuccaSchool1, Spring) to 216.24g (LuccaSchool1, Winter), with an average difference of 22.75g between the average collected plate waste per meal served in winter (203.29 g) and spring (180.54 g) and an aggregated average collected plate waste per meal served of 191.31g.

5.2.3. Commentary comparing LOC-ORG and ORG case

As illustrated above, the total weight of food waste (kgs) collected in winter across both cases was very similar (272.8 kg vs 270.9 kg), while small differences (13.1kg) were observed between the cases during the spring data collection. (267.8 vs 280.9 kg). Despite the relative small difference in the total weight of plate waste, the proportion of plate waste compared to the food served was very different between the cases with 25.7% of food served in LOC-ORG schools collected as plate waste compared to 38.4% in ORG schools. Giving an explanation for this discrepancy is not easy due to the multiplicity of factors affecting the children food consumption at school: meal composition and preparation, canteen environment, lunch duration, children behaviour, as well as the teacher behaviour that can play an important role in promoting food consumption and contrasting food neophobia. Overall, although in both the cases the plate waste percentage is relevant, the LOC-ORG schools obtained better outcomes that may be due to a greater effort in addressing the food waste issue. Indeed, children's awareness of the importance to reduce food waste and the education they receive on food and nutrition themes are relevant aspects to take into account in interpreting the obtained results, as in the case of the LOC-ORG schools, where children had nutrition class and food waste collection activities during the school year. Similarly to plate waste percentage, the waste per meal (g) calculated for Parma was lower when compared to Lucca, not only for values obtained across the two schools and seasons, but also considering the individual schools and weeks.

5.3. Total plate waste by food categories in LOC-ORG and ORG case

Food categories	**LOC-ORG (n= 3897 lunches)**		**ORG (n= 2897 lunches)**	
	Kgs	%	Kgs	%
Starchy food – Bread	53.57	10	34.12	6
Starchy food – First course	162.59	30	191.53	35
Vegetables – Side dish	98.71	18	68.14	12
Fruit	163.61	30	180.81	33
Protein-based dish	39.45	7	60.18	11
Desserts	Not served		13.71	3
Other food	22.62	4	3.28	0,6
Total WASTE	540.56	100	551.77	100

Table 56. Total Plate Waste by Food Categories in LOC-ORG and ORG cases.

In section 5.3, we present the composition analysis by food category of the collected plate waste in LOC-ORG and ORG schools. Category plate waste data can be represented in two ways, which we report separately. First, we report the category waste as a proportion of the total waste in the schools in each case (Table 12). Then we report it as the volumes or percentages of waste to served portion, within each food category (Table 13, 14).

5.3.1. Total Plate Waste by Food Categories in LOC-ORG case

For both LOC-ORG and ORG cases, bread, starchy food, vegetables and fruit were the largest proportional contributors of the collected plate waste, with more than 88% (LOC ORG) and 86% (ORG) of collected plate waste attributed to these 4 food categories. Next we present results by food category of how much plate waste was collected as a proportion of total food served by food category. Table 13, and 14, shows the results for LOC-ORG and ORG models respectively, followed by some more detail breakdown by seasons.

PARMA Loc-Org schools	1+2					
Season	Winter +Spring					
Food categories	Total served portions (n)	(kg)	Average served portion (g) *	Total waste (kg)	Waste (%)	Waste/ Portion (g)
Starchy food - Bread	3988	144.01	36.11	53.57	37.20	13.43
Starchy food - First course	3526	813.22	230.63	162.59	19.99	46.11
Protein-based dish	3471	223.40	64.36	39.45	17.66	11.37
Vegetable - side dish	3979	267.89	67.33	98.71	36.85	24.81
Fruit	4134	539.26	130.45	163.61	30.34	39.58
Other - Cous cous	387	115.45	298.33	22.62	19.59	58.44
Dessert	Not served					

Table 57. Volume and proportion of waste in each food category, compared with served portions, in Parma LOC-ORG case.

* each value in the column has been calculated as the ratio between the relative total amount of served food portion (g) and the total number of served portions (n) indicated in the table. Data are expressed as total and average served portion, total amount of food waste (kg), waste percentage (%) and waste per food portion (g) calculated across the schools and seasons.

Table 13 shows that the highest % waste, across the food categories, for LOC-ORG was "starchy food – bread", with 37.2% of food served in category wasted followed by vegetables (36.9%). The lowest is for protein based – dish, where 17.7% of the served portions were wasted. The strong heterogeneity reported in relation to the waste per food category, ranging from 11.4 g to 58.4 g, is partially explained by a different serving size (g) (e.g. the mean serving size of bread is lower than the mean serving size of fruit). Finally, no data are reported for the category "dessert" since, as already mentioned, it is not planned as part of the school menus in Parma. Table 14 provides some more details about the proportions of waste within food categories in LOC-ORG case.

Season	Winter																	
Loc-Org schools	1						2						1+2					
Food category	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)
SF - Bread	918	44.73	48.73	17.71	39.59	19.29	1031	27.41	26.58	9.54	34.81	9.25	1949	72.14	37.01	27.25	37.78	13.98
SF - First course	908	179.60	197.80	30.34	16.89	33.42	1002	243.32	242.84	59.56	24.48	59.44	1910	422.92	221.43	89.90	21.26	47.07
Protein-based dish	907	54.65	60.25	10.27	18.79	11.32	996	71.25	71.54	12.43	17.45	12.48	1903	125.90	66.16	22.70	18.03	11.93
Veg - side dish	929	51.98	55.95	20.86	40.13	22.46	1002	58.19	58.07	26.66	45.81	26.60	1931	110.17	57.05	47.52	43.13	24.61
Fruit	929	109.18	117.52	59.66	54.64	64.22	1090	144.06	132.16	25.75	17.87	23.62	2019	253.24	125.43	85.40	33.72	42.30
Other	Not served						Not served						Not served					
Dessert	Not served						Not served						Not served					

Season	Spring																	
Loc-Org schools	1						2						1+2					
Food categories	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)
SF - Bread	933	46.01	49.32	16.92	36.78	18.14	1106	25.86	23.38	9.40	36.35	8.50	2039	71.87	35.25	26.32	36.62	12.91
SF - First course	740	175.88	237.68	29.92	17.01	40.44	876	214.41	244.76	42.76	19.94	48.82	1616	390.30	241.52	72.69	18.62	44.98
Protein-based dish	707	48.12	68.06	8.92	18.53	12.62	861	49.38	57.35	7.83	15.86	9.10	1568	97.50	62.18	16.75	17.18	10.68
Veg - side dish	943	57.52	61.00	24.37	42.37	25.85	1105	100.20	90.68	26.82	26.77	24.27	2048	157.72	77.01	51.19	32.46	25.00
Fruit	943	116.41	123.44	34.46	29.60	36.54	1172	169.61	144.72	43.75	25.80	37.33	2115	286.02	135.23	78.21	27.34	36.98
Other	179	40.75	227.64	12.92	31.69	72.15	208	74.71	359.17	9.70	12.99	46.64	387	115.45	298.33	22.62	19.59	58.44
Dessert	Not served						Not served						Not served					

Table 58. Seasonal volumes and proportion of waste in each food category, compared with served portions, in Parma LOC-ORG case.

* each value in the column has been calculated as the ratio between the relative total amount of served food portion (g) and the total number of served portions (n) indicated in the table. Data are expressed as total and average served portions, total amount of food waste (kg), waste percentage (%) and waste per served food portion (g) collected in winter and in spring in ParmaSchoolOne and ParmaSchoolTwo. Moreover, the sum of the data obtained across both schools in each season is reported.

The lowest amount of food waste registered for ParmaSchoolTwo was for starchy food - bread (9.4 kg) during spring, which, however, corresponds to the most wasted category in terms of percentage in the same school and season (36.4%). Moreover, the percentage values registered in winter confirm fruit (54.6%) as the most wasted in ParmaSchoolOne, followed by vegetable – side dish (40.1%), which was the most wasted category in the same school in spring (42.4%) and in ParmaSchoolTwo in the winter week (45.8%). On the other hand, in ParmaSchoolOne the lowest percentages were found in relation to starchy food served as first course, both in winter (16.9%) and spring (17.0%). With regard to ParmaSchoolTwo, the protein-based dish was the least wasted in winter (17.5%), while second to the category "other" in spring (13%). Comparing the seasonal data obtained across the two schools, the protein-based dish registered the lowest waste percentages (18.0% and 17.2% respectively in winter and spring), while the vegetable-side dish in winter (43.1%) and the starchy food – bread in spring (36.6%) showed the highest waste percentages. Finally, concerning the results expressed as waste per meal (g), the highest amount obtained was found for the category "other" (58.4 g), while the lowest was registered for the protein – based dish (10.7 g). In conclusion, a general trend of higher plate waste percentages was observed during the winter assessment. This could be principally due to a higher waste of the vegetable side dish and of fruit, the two food categories that changed most in the seasonal menus. Moreover, the lower percentages of plate waste observed in the spring season compared to the winter season may be also due to an increased awareness by the children in relation to the issue represented by the food waste. In fact, during the data collection days, pupils had the possibility to observe the amount of food waste collected in the bins after the lunch and were interested in knowing the aim of the activities performed by the researchers in the school canteen.

5.3.2. Total Plate Waste by Food Categories in ORG case

For the proportions of waste across food categories in ORG schools (Table 15), where data collected in winter and in spring are separated according to the school, the fruit category is confirmed as the most wasted in terms of kg across both seasons for LuccaSchoolOne (59.7 kg and 34.5 kg), and in spring for LuccaSchoolTwo (43.8 kg). On the other hand, the least wasted categories in terms of weight of waste collected for LuccaSchoolOne were the protein-based dish both in winter (10.3 kg) and in spring (8.9 kg), similar to the relative amount collected for LuccaSchoolTwo (12.4 kg and 7.8 kg).

For the proportions of waste within food categories ORG schools, as shown in Table 15, the highest levels of collected plate waste were for starchy food served as first course (191.5 kg). Conversely, the least wasted category, by weight of waste collected, was "other" (3.3 kg), and was represented by pizza, a semi-unique dish. For the fruit and vegetable – side dish categories over 50% of food served was collected as plate waste, while only 11.6% of "other" food served was wasted. Not only for Parma case but also for Lucca, the strong heterogeneity reported in relation to the waste per meal ranging from 10.5 g to 78.5 g can be partially explained by a different serving size (g) delivered to the pupils.

Lucca Org schools	1+2					
Season	Winter +Spring					
Food categories	Total served portions (n)	(kg)	Average served portion (g)*	Total waste (kg)	Waste (%)	Waste/ Portion (g)
Starchy food - Bread	2677	81.68	30.51	34.12	41.77	12.74
Starchy food - First course	3331	603.40	181.15	191.53	31.74	57.50
Protein-based dish	2523	176.21	69.84	60.18	34.15	23.85
Vegetable - side dish	1453	131.13	90.25	68.14	51.96	46.90
Fruit	2304	338.83	147.06	180.81	53.36	78.48
Other - Cous cous	311	28.20	90.68	3.28	11.61	10.53
Dessert	690	76.73	111.20	13.71	17.87	19.87

Table 59. Volume and proportion of waste in each food category, compared with served portions, in Lucca ORG case.

* each value in the column has been calculated as the ratio between the relative total amount of served food portion (g) and the total number of served portions (n) indicated in the table. Data are expressed as total amount of food waste (kg), waste percentage (%) and waste per meal (g) calculated across the schools and seasons.

Distinguishing the results across schools and season (Table 16), the most wasted category in terms of weight of plate waste collected in LuccaSchoolOne was starchy food served as first course where 45kg and 47.3 kg of wasted was collected in winter and spring respectively. These findings were mirrored in LuccaSchoolTwo where 57.1 kg of fruit per season was collected as waste. Accordingly, these two food categories show the highest amount of waste if total season data are considered (100.1 kg, 87.2 kg, 80.2 kg and 104.4 kg registered, respectively, for fruit and starchy food served as first dish in winter and spring). On the other hand, the lowest amount of waste was recorded in relation to the dessert served in winter in LuccaSchoolOne (1.2 kg) and to pizza, alternatively served in the two schools during winter (1.5 kg) and spring week (1.8 kg). With regard to the percentage values, the highest food waste was found for vegetable – side dish (78.5%, LuccaSchoolOne, winter), followed by the fruit category, (60.6% during winter in LuccaSchoolTwo). Contrarily, the lowest percentages were found for the dessert category during spring in LuccaSchoolTwo (7.1%), and in “other” during spring in LuccaSchoolOne (10.8%). Considering the total season results, the vegetable – side dish and starchy food served as first dish reached more than 50% of waste only in winter, while fruit also in spring. By contrast, the category “other” and the dessert were confirmed as the least wasted. Furthermore, among data shown as waste per meal, the highest values were reached by the fruit category (87.1 g winter and 69.8 g in spring), while the categories “other” and bread were minimally wasted.

Season	Winter																	
Org schools	1						2						1+2					
Food category	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)
SF - Bread	692	18.60	26.88	10.92	58.70	15.78	534	12.22	22.89	5.16	42.20	9.66	1226	30.82	25.14	16.08	52.16	13.11
SF - First course	667	138.90	208.25	45.02	32.41	67.49	872	153.23	175.73	42.15	27.51	48.33	1539	292.14	189.82	87.16	29.84	56.64
Protein-based dish	785	47.02	59.90	17.78	37.82	22.65	522	31.01	59.40	8.81	28.40	16.87	1307	78.03	59.70	26.59	34.08	20.34
Veg - side dish	528	26.63	50.44	20.90	78.47	39.58	353	29.73	84.23	12.89	43.33	36.50	881	56.37	63.98	33.78	59.93	38.35
Fruit	619	87.70	141.69	43.53	49.63	70.32	536	94.23	175.80	57.11	60.60	106.54	1155	181.94	157.52	100.64	55.31	87.13
Other	Not served						170	11.59	68.16	1.48	12.77	8.71	170	11.59	68.16	1.48	12.77	8.71
Dessert	78	7.80	100.00	1.16	14.90	14.90	167	20.88	125.00	3.97	19.02	23.77	245	28.68	125.00	5.13	17.90	20.95

Season	Spring																	
Org schools	1						2						1+2					
Food category	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)	Tot served portions (n)	Tot served portions (kg)	Av. served portion (g)*	Tot waste (kg)	Waste (%)	Waste/ Portion (g)
SF - Bread	579	19.37	33.45	10.07	51.97	17.38	872	31.49	36.12	7.98	25.33	9.15	1451	50.86	35.05	18.04	35.47	12.43
SF - First course	951	139.25	146.42	47.31	33.97	49.74	841	172.01	204.53	57.06	33.17	67.85	1792	311.26	173.69	104.37	33.53	58.24
Protein-based dish	524	30.17	57.57	14.30	47.41	27.29	1015	68.02	67.01	19.29	28.36	19.00	1216	98.18	80.74	33.59	34.21	27.62
Veg - side dish	402	22.68	56.41	11.54	50.91	28.72	692	52.09	75.27	22.81	43.80	32.97	572	74.76	130.70	34.36	45.95	60.06
Fruit	439	69.25	157.74	29.32	42.34	66.78	710	87.65	123.45	50.86	58.02	71.63	1149	156.90	136.55	80.18	51.10	69.78
Other	141	16.61	117.83	1.80	10.80	12.73	Not served						141	16.61	117.83	1.80	10.80	12.73
Dessert	275	31.05	112.91	7.37	23.73	26.80	170	17.00	100.00	1.21	7.13	7.13	445	48.05	107.98	8.58	17.86	19.28

Table 60. Seasonal volumes and proportion of waste in each food category, compared with served portions, in Lucca ORG case.

*each value in the column has been calculated as the ratio between the relative total amount of served food portion (g) and the total number of served portions (n) indicated in the table. Data are expressed as total and average served portions, total amount of food waste (kg), waste percentage (%) and waste per served food portion (g) collected in winter and in spring in LuccaSchoolOne and LuccaSchoolTwo. Moreover, the sum of the data obtained across both schools in each season is reported.

5.3.3. Commentary comparing LOC-ORG and ORG case

In summary and across both LOC-ORG and ORG cases, starchy food served as first course and the fruit showed the largest amount of food waste in terms of kgs. However, ORG case was characterised by higher amounts even if the number of served meals was smaller compared to LOC-ORG. Different results were instead obtained with regard to the percent values, according to which the most wasted categories were starchy food – bread standing at 37.2% for Case LOC-RG, and fruit reaching the 53.4% for ORG case. In both cases, these percentages were followed by those reported for the vegetable – side dish, with a value of 36.9% and 52.0% as reported respectively by LOC-ORG and ORG case. By contrast, standing at a waste percentage of 17.7% and at a quantity of waste per meal of 11.4 g, the protein-based dish represented the least wasted category for LOC-ORG, while for ORG the lowest waste was reported for the category "other", which reached a percentage of 11.6% and 19.9 g of waste per meal. As reported for ORG case, considering the percentage of waste, the pupils' uptake of plant – based food (i.e. fruit and vegetables) was less than the 50% of the mean size served to the pupils, while in LOC-ORG this value is approximately 70%. As already mentioned in Section 5.3.1, the declining trend in the waste percentage observed in both schools for almost all the food categories, comparing winter and spring data can be partially explained by an increased awareness by the children regarding the issue represented by the food waste..

5.4. Illustrations of How Waste Differs Across Menus in LOC-ORG and ORG case

5.4.1. Parma LOC-ORG case

Some examples of the dishes served in LOC-ORG case provided in Figure 10.

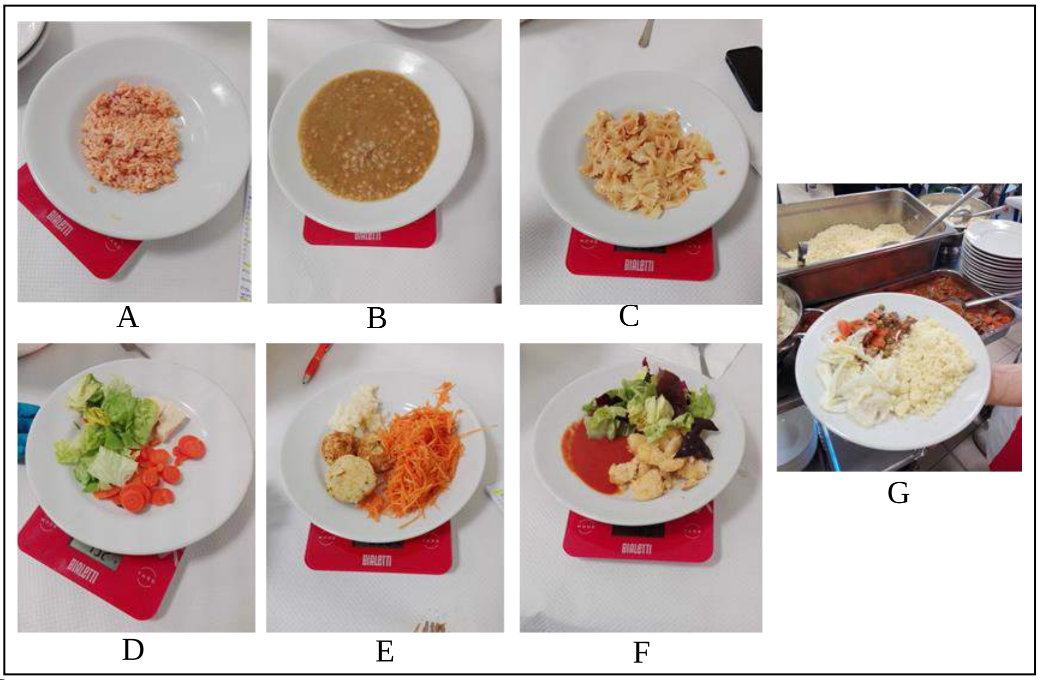

Figure 72. Some dishes from LOC-ORG case.

First courses: A, rice with tomato sauce and basil; B, pasta in vegetable and legume soup; C, pasta with fish sauce. Second courses with vegetables: D, Parmigiano Reggiano PDO, salad and sautéed carrots; E, mini cannellini bean burgers with julienne carrots and sautéed cauliflower; F, baked Halibut nuggets with tomato sauce and salad. Unique dish; G, cous cous with extra virgin olive oil and beef stewed with green beans/carrots.

As shown in Table 17, overall, no product served in Case 1 was wasted more than 50%. However, a certain heterogeneity characterizes the starchy food category, in which both the most and almost the least wasted items, namely bread (with a percentage of 47.5%) and egg pasta in vegetable soup (9.3%) are present. Simple recipes - such as rice with extra-virgin olive oil and Parmigiano, wholemeal pasta with butter and Parmigiano and pasta with fish sauce – were associated with relative higher pupils' uptakes, corresponding to more than 85% of the mean serving size provided to the students. As expected, most of the food items collected in the protein-based dish showed low waste proportions. In particular, baked turkey cutlet, Parmigiano Reggiano PDO, Prosciutto Crudo di Parma PDO, and baked halibut nuggets with tomato sauce stand at a waste percentage lower than 15%. On the other hand, second courses prepared with legumes and fish reached a waste of 26.7%. Moreover, plant-based products, such as vegetables and fruit reached more than 30% of waste, with the exception of banana (16.6%), orange (29.4%) and pear (23.1%).

Starchy food	Bread	Rice with EVO oil and Parmigiano Reggiano PDO	Pasta in vegetable and legume soup	Pasta with vegetable ragu	Vegetable lasagne	Egg pasta in vegetable soup	Wholemeal pasta, butter and Parmigiano Reggiano PDO	Rice with tomato sauce and basil	Pasta with fish sauce	Vegetable soup with spelt
Waste (kg)	70.03	11.94	27.69	23.76	17.98	8.53	10.05	24.30	13.01	25.33
Waste %	47.45	14.33	28.17	30.63	23.08	9.25	13.52	21.40	12.89	25.04
Protein-based dish	**Stewed lentils**	**Baked turkey cutlet**	**Baked Halibut nuggets**	**Parmigiano Reggiano PDO**	**Halibut fillet gratin**	**Prosciutto crudo di Parma PDO**	**Mini cannellini bean burgers**	**Baked Halibut nuggets with tomato sauce**		
Waste (kg)	9.67	2.44	4.52	3.74	4.21	0.68	8.29	5.90		
Waste %	20.68	13.03	15.55	14.18	23.08	9.23	26.72	12.80		
Vegetable - side dish	**Julienne fennels**	**Julienne cabbage and roast potatoes**	**Salad with mixed vegetables**	**Salad**	**Julienne carrots and sauteed cauliflower**	**Salad and sauteed carrots**				
Waste (kg)	17.66	8.81	22.39	8.87	28.52	12.47				
Waste %	45.19	31.67	42.93	33.17	35.01	33.06				
Fruit	**Kiwi**	**Tangerine**	**Banana**	**Orange**	**Pear**					
Waste (kg)	42.77	43.94	17.84	37.15	21.92					
Waste %	31.51	45.24	16.56	29.44	23.11					
Other	**Cous cous with EVO oil and beef stew with green beans/carrots**									
Waste (kg)	22.62									
Waste %	19.90									

Table 61. Food waste reported according to each food item served in both schools and seasons referred to Parma LOC-ORG case.

Data are expressed as amount of food waste (kg) and waste percentage (%) computed across schools and seasons. If the same food item has been served in both weeks and/or in both schools, waste quantity (kg) is reported as the sum of all data, while in the formula used to compute waste %, the serving size (g) of each food item has been calculated as mean of all serving size referred to the same food.

5.4.2. ORG case

Figure 11 shows some examples from the dishes served in ORG case.

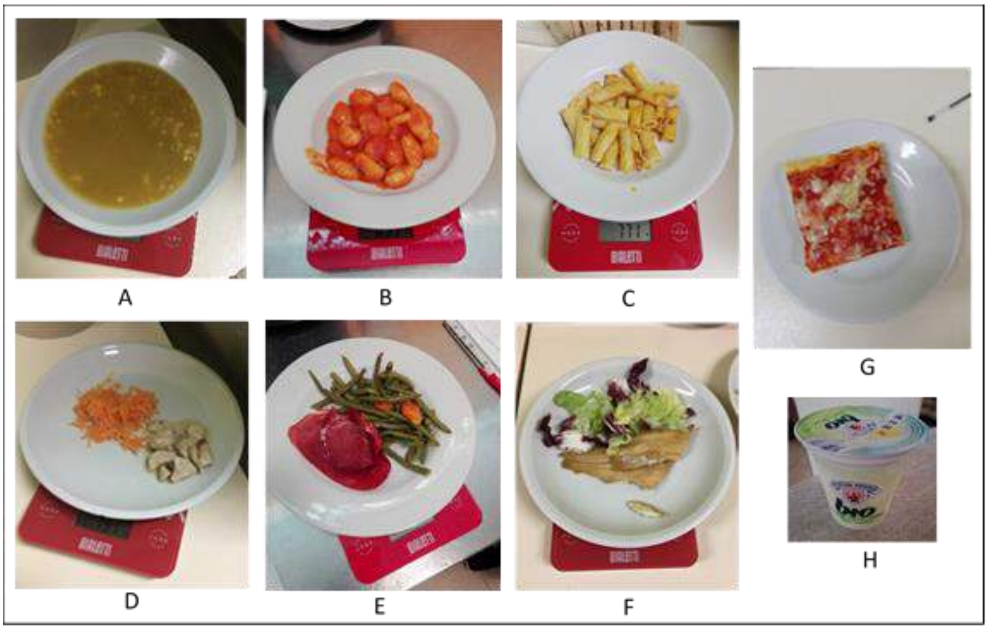

Figure 73. Some dishes from ORG case.
First courses: A, vegetable soup with millet; B, dumplings with tomato sauce; C, Bolognese pasta. Second courses with the vegetables: D, baked turkey nuggets with orange and carrots; E, bresaola with stewed string beans and carrots; F, plaice fillet with salad. Semi-unique dish: G, pizza. Dessert: H, banana yoghurt.

Among all the food items served in ORG case (Table 18), chocolate pudding (10.9%) and pizza (11.3%) showed the lowest waste percentages, while tangerine (82.5%), followed by plaice fillet (68.9%), were the most wasted. Within the starchy food category, the vegetable soup with millet reached the highest waste percentage (42.7%), slightly higher than pasta with tomato sauce, aubergines and ricotta (41.8%), while lasagne with tomato sauce as the least wasted (14.9%). The protein-based dish showed the highest waste range in which the extremes are represented by tuna (13.7%) and plaice fillet (68.9%). In particular, 7 out of 12 food items served as protein-based dish were wasted more than 40%, while all the vegetables served as side dish showed waste percentages exceeding 45%.

Starchy food	Bread	Rice with saffron	Lasagne with tomato sauce	Vegetable soup with brown rice	vegetable soup with millet	Rice with EVO oil	Dumplings with tomato sauce	Pasta with olive oil/butter	Wholemeal pasta with pesto	Pasta with tomato sauce, aubergines and ricotta	Bolognese Pasta	Smashed potatoes	Boiled potatoes
Waste (kg)	34.12	22.90	9.51	26.68	29.11	23.49	38.70	9.06	6.49	12.14	3.60	4.11	5.76
Waste %	41.81	36.88	14.91	38.33	42.65	27.07	37.84	20.12	32.51	41.77	17.15	21.54	35.10

Protein-based dish	Omelette	Robiola cheese	Stracchino cheese	Grana Padano PDO cheese	Baked turkey nuggets with orange	Turkey with tomato sauce	Roasted beef	Bresaola (salted ad dried beef)	Squids	Tuna	Plaice fillet	Peas
Waste (kg)	8.53	6.14	5.87	1.76	3.73	5.06	1.26	5.98	2.19	3.36	5.56	10.74
Waste %	47.65	40.16	65.71	43.13	14.63	43.25	13.87	28.60	30.04	13.68	68.85	48.26

Vegetable - side dish	Stewed chard	Cabbage salad	Salad	Carrots	Stewed string beans and carrots	Baked vegetables
Waste (kg)	14.33	7.34	2.44	22.94	15.12	5.96
Waste %	61.10	56.13	56.39	45.80	56.61	56.06

Fruit	Orange	Tangerine	Apple	Banana
Waste (kg)	55.21	11.77	91.82	22.01
Waste %	55.70	82.49	57.54	33.30

Dessert	Yoghurt	Chocolate pudding
Waste (kg)	9.58	4.14
Waste %	24.79	10.86

Other	Pizza
Waste (kg)	3.28
Waste %	11.32

Table 62. Food waste reported according to each food item served in both schools and seasons referred to Lucca ORG case.
Data are expressed as amount of food waste (kg) and waste percentage (%) computed across schools and seasons. If the same food item has been served in both weeks and/or in both schools, waste quantity (kg) is reported as the sum of all data, while in the formula used to compute waste %, the serving size (g) of each food item has been calculated as mean of all serving size referred to the same food.

5.4.3. *Commentary comparing LOC-ORG and ORG case*

According to the results elaborated for LOC-ORG and ORG, within the starchy food category bread showed a similar percentage of waste, with values of 47.5% and 41.8% for LOC-ORG and ORG, respectively. Although it is possible to highlight some similarities between the waste percentages reported for similar food items served as protein-base dish in the two case studies (e.g. baked turkey cutlet for LOC-ORG and baked turkey nuggets with orange), higher proportions were mostly reported for ORG. In addition, results suggest that pupils' consumption of vegetables served in LOC-ORG reached higher percentages than ORG. With regard to the fruit category, the waste percent values computed for ORG were up to 50% higher than those calculated for LOC-ORG. Finally, the "dessert" and/or "other" categories showed the lowest percentages of waste in both cases.

5.5. Nutritional impact of Plate Waste at Parma LOC-ORG and Lucca ORG schools

This section reports the analysis of the nutritional composition of the school meals plate waste, and its implications for students' nutritional intake. In Section 4, the nutritional composition of the daily menus at LOC-ORG and ORG case schools was analysed. This showed that the vast majority of daily menus in both cases complied with Health Ministry recommendations. However, plate waste rates can affect the actual nutritional intake of children from school meals, compared with what is intended by the menu design. The loss of energy and nutrients depends on the proportion of energy and nutrients in the meals and individual components of the meals, as well as the amount of plate waste of individual meal components. Therefore, in order to estimate the influence of food plate waste on the loss of energy and nutrients, the nutritional composition of the plate waste was estimated. Table 19 and Figure 12 show the results for energy and macronutrients.

Parameter (average ± SD)	Nutritional composition of served lunches per child		Nutritional composition of plate waste per child		Difference between FCA of served lunch and plate waste Δ (%)	
	LOC-ORG	ORG	LOC-ORG	ORG	LOC-ORG	ORG
Energy (kcal)	674 ± 182	691 ± 74	184 ± 39	249 ± 55	521 ± 70 (74)	442 ± 80 (64)
Total proteins (g)	28.8 ± 8.9	26.9 ± 4.7	6.9 ± 1.9	9.1 ± 3.1	23.6 ± 4.8 (77)	17.8 ± 4.1 (66)
Total carbohydrates (g)	104.1 ± 12.1	103.6 ± 13.3	28.5 ± 6.0	37.3 ± 8.5	75.6 ± 10.3 (73)	66.2 ± 13.5 (64)
Dietary fibre (g)	12.9 ± 3.5	9.4 ± 3.3	3.9 ± 1.4	4.1 ± 1.7	9.0 ± 2.7 (70)	5.3 ± 2.0 (57)
Total fat (g)	20.4 ± 7.1	20.8 ± 4.6	1.4 ± 1.0	7.7 ± 2.8	17.8 ± 9.6 (75)	13.1 ± 3.5 (63)
Saturated fatty acids (g)	23.1 ± 10.4	5.8 ± 3.2	5.4 ± 1.8	2.1 ± 1.5	5.6 ± 5.5 (77)	3.7 ± 2.0 (64)

Table 63. Nutritional composition of served lunches and plate waste (average of 20 lunches in LOC-ORG and in the ORG model).
Data are expressed as average ± SD and as percentage of waste. FCA: Food Composition Analysis.

From the analysis of the difference between the FCA of served lunch (FCA) and plate waste (Table 19), children in Parma are estimated to consumed 74% of the total planned energy at lunch. Proteins and saturated fatty acids showed the highest intake (77%), followed by total fat (75%) and carbohydrates (73%). In accordance with data on plate waste where vegetables were shown to have the highest amount of waste, dietary fibre was the food component with the lowest intake (70%) compared to the planned fibre content.

Consistent with the waste data collected, the percentages of the energy and nutrient intakes of the lunches served in Lucca (ORG model) were lower than those of Parma, (LOC-ORG model) (Table 19). On average, children consumed only 64% of the total planned energy at lunch. In addition, a slightly higher intake (66%) was reported for proteins compared to carbohydrates (64%) and fat (63%). Similarly, to what was already mentioned in Section 4, the dietary fibre was the nutrient with the highest amount of waste and the lowest level of intake (57%). To compare more easily the energy and macronutrient loss due to plate waste in Parma and Lucca cases is presented graphically in Figure 12.

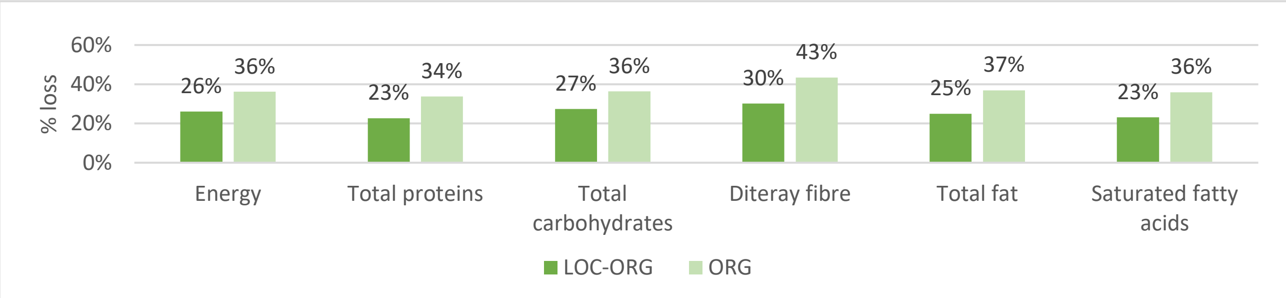

Figure 74. Losses of energy and macronutrients of school lunches (average of 20 lunches in LOC-ORG model and 19 lunches in ORG model).
Data are expressed as percentage of loss for each category of macronutrient.

From the analysis of the nutritional losses associated with the collected plate waste, a higher nutritional loss was reported for the ORG compared to LOC-ORG model, due to higher energy and nutrient losses with the loss of energy and macronutrients compared to the total meal served being 10% greater in the ORG compared to LOC-ORG schools (36% *vs.* 26%) (See Figure 12). Similar percentages were reported for total proteins and carbohydrates, for which the loss was around 25%

for LOC-ORG and around 35% for ORG. As in LOC-ORG, the loss of proteins in ORG was the lowest across the analysed nutrients (23% and 34%, respectively), while the loss of dietary fibre was the highest (30% and 43%, respectively), in accordance with plate waste data. Regarding fats, the percentage loss was similar for total fats and saturated fatty acids across both cases, though higher in the ORG than LOC-ORG model (25% and 23%, respectively for the ORG model and 37% and 36% for the LOC-ORG). With regard to the loss of vitamins and minerals due to plate waste in both cases. In Parma case, the actual pupil intake of vitamins and minerals from served lunches, equated to 2/3 or more of each micronutrient intended from the menu (Table 20). Vitamin D and vitamin B_{12} registered the highest intake, respectively 84% and 82%, in accordance with the preferential consumption of protein-based foods by children than other food categories. On the contrary, consistent with the high fruit and vegetable waste, vitamin C (66%) had the lowest intake. Among the minerals, sodium and potassium had the lowest intake (70% and 71%, respectively) followed by calcium and iron (73%). In the Lucca ORG model a larger variability was reported in terms of differences between the FCA of served lunches and plate waste for vitamin and mineral intake of served lunches (Table 20). Vitamin C and vitamin A were the vitamins with a lower intake, respectively 52% and 53%, while only vitamin D registered an intake higher than 70%. As for the LOC-ORG model, among minerals, calcium (59%), potassium (60%), iron (61%), and sodium (61%) were the least consumed.

Nutrient	Nutritional composition of served lunches		Nutritional composition of plate waste		Difference between FCA of served lunch and plate waste Δ (%)	
	LOC-ORG	ORG	LOC-ORG	ORG	LOC-ORG	ORG
Vit A (mg)*	0.92 ± 0.67	0.54 ± 0.34	0.28 ± 0.23	0.27 ± 0.23	0.63 ± 0.45 (71)	0.27 ± 0.17 (53)
Vit B_1 (mg)	0.51 ± 0.17	0.46 ± 0.15	0.14 ± 0.03	0.18 ± 0.06	0.38 ± 0.15 (72)	0.28 ± 0.11 (60)
Vit B_2 (mg)	0.43 ± 0.15	0.39 ± 0.10	0.12 ± 0.04	0.14 ± 0.05	0.32 ± 0.11 (73)	0.25 ± 0.09 (63)
Niacin (mg)	0.61 ± 0.84	0.58 ± 0.75	0.15 ± 0.24	0.19 ± 0.25	0.46 ± 0.64 (76)	0.39 ± 0.55 (65)
Vit B_6 (mg)	0.8 ± 0.3	0.8 ± 0.2	0.20 ± 0.11	0.29 ± 0.09	0.58 ± 0.26 (74)	0.52 ± 0.17 (63)
Folate (µg)	118.81 ± 38.73	96.07 ± 43.80	38.38 ± 19.92	41.74 ± 23.5	80.43 ± 29.08 (68)	54.33 ±28.64 (57)
Vit B_{12} (µg)	2.53 ± 4.27	1.36 ± 0.71	0.38 ± 0.54	0.42 ± 0.32	2.15 ± 3.73 (82)	0.94 ± 0.59 (69)
Vit C (mg)	82.87 ± 36.87	47.15 ± 26.61	29.12 ± 24.85	23.99 ± 18.32	53.75 ± 29.33 (66)	23.16 ± 12.97 (52)
Vit D (µg)	0.32 ± 0.36	0.81 ± 1.84	0.05 ± 0.05	0.17 ± 0.28	0.27 ± 0.31 (84)	0.65 ± 1.58 (73)
Na (mg)	630.10 ± 142.47	642.69 ± 348.38	185.04 ± 54.64	235.89 ± 100.03	445.07 ± 115.26 (70)	406.79 ± 301.93 (61)
K (mg)	1335.53 ± 389.99	1076.57 ± 292.87	383.97 ± 163.44	422.10 ± 130.57	951.56 ± 312.85 (71)	654.47 ± 207.84 (60)
Ca (mg)	368.03 ± 212.70	292.28 ± 132.43	95.18 ± 42.21	117.47 ± 60.26	272.85 ± 174.31 (73)	174.81 ± 84.85 (59)
Mg (mg)	45.91 ± 22.89	42.10 ± 18.42	11.52 ± 6.20	15.92 ± 10.49	34.40 ± 17.28 (75)	26.18 ± 11.09 (63)
P (mg)	510.75 ± 103.20	422.80 ± 68.18	121.74 ± 31.51	151.78 ± 47.75	389.01 ± 89.50 (76)	271.02 ± 53.32 (64)
Fe (mg)	5.41 ± 1.83	4.01 ± 1.25	1.43 ± 0.37	1.57 ± 0.62	3.97 ± 1.55 (73)	2.44 ± 0.77 (61)
Z (mg)	3.30 ± 0.80	3.41 ± 1.15	0.73 ± 0.25	1.14 ± 0.40	2.57 ± 0.67 (78)	2.27 ± 0.86 (66)
Cu (mg)	0.31 ± 0.24	0.33 ± 0.31	0.06 ± 0.06	0.11 ± 0.09	0.23 0.19 (81)	0.24 0.23 (66)

Table 64. Micronutrient composition of served lunches and plate waste (average of 20 and 19 lunches in LOC-ORG and in the ORG model respectively).
Data are expressed as average ± SD and as percentage of waste. FCA: Food Composition Analysis.

* the vitamin A value is expressed as retinol equivalent (RE).

To compare more easily the energy and macronutrient loss due to plate waste in Parma and Lucca cases, Figure 13 presents a graphical comparison.

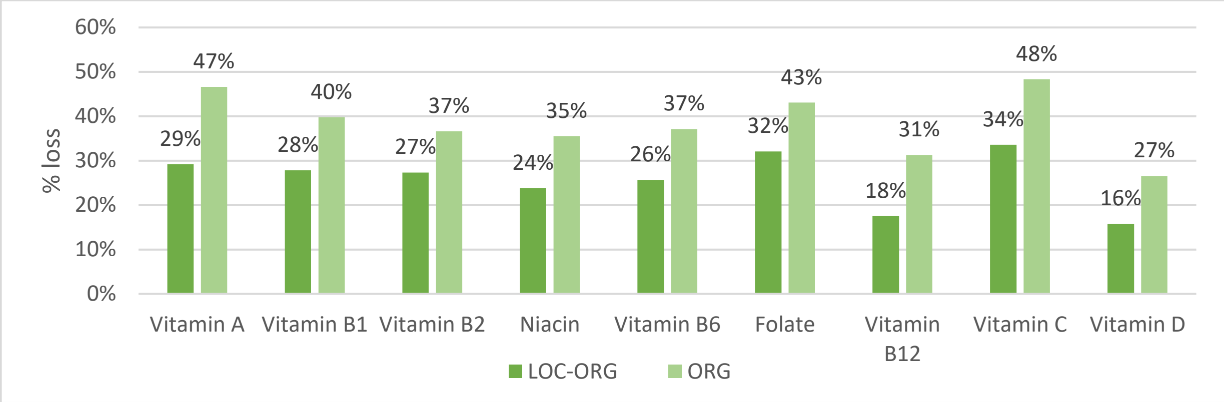

Figure 75. Losses of vitamins of school lunches (average of 20 lunches in LOC-ORG model and 19 lunches in ORG model).
Data are expressed as percentage of loss for each vitamin.

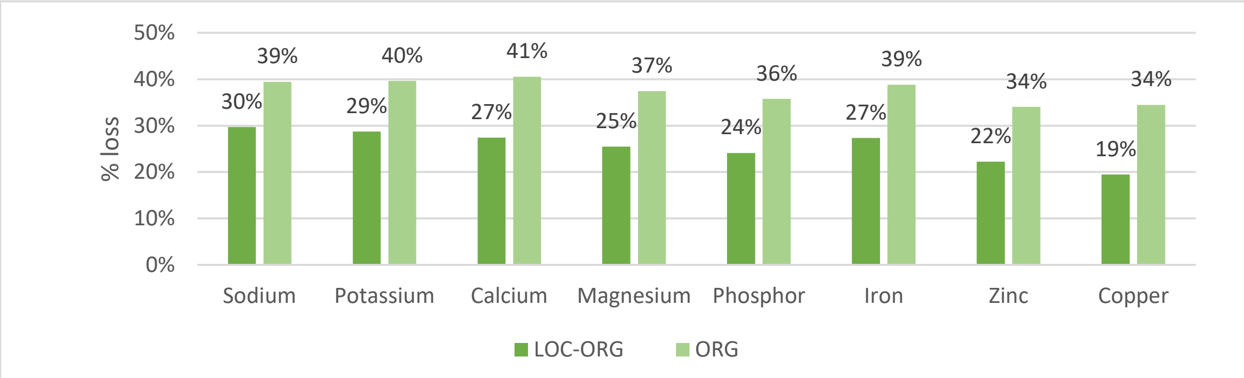

Figure 76. Losses of minerals of school lunches (average of 20 lunches in LOC-ORG model and 19 lunches in ORG model).
Data are expressed as percentage of loss for mineral.

Figure 13 shows the percentage of losses of vitamins of school lunches due to plate waste. The percentage of loss of vitamin C was the highest in both cases (48% in the ORG model and 34% in the LOC-ORG). Similarly, a high loss of vitamin A was observed in Case 2 (47%), while was slightly lower for Case 1 (29%). On the contrary, vitamin D and vitamin B_{12} reported the lowest percentage of waste. The reported data are consistent with those reported in Section 4.1. As shown for vitamins, losses of minerals of school lunches were higher in the ORG model than in the LOC-ORG one, reaching values ranged between 34% and 41% and between 19% and 30%, respectively (Figure 14). Similarities were found between the two cases: copper and zinc were the minerals with the lowest percentage of loss (19% and 22% in the LOC-ORG and 34% in the ORG model), while sodium, calcium, iron and potassium reported the highest.

5.6. Environmental Impact of Plate Waste at LOC-ORG and ORG schools

Food waste has direct and indirect effects on the environment, leading to consequences for natural resources at the global level (e.g. water depletion and climate change). Here, we estimated the environmental impact of food waste as the CO_2 emissions from the production and transportation to schools of the food that ended up being wasted, as well as the management of the waste itself.

Consistent with the estimation of emissions for Italy in D6.3, we used the emissions factors provided by specific Italian studies, BCFN Double Pyramid database, the Environmental Product Declaration (EPD) database, LCA-Food database, and Ecoinvent database. In this way, we made the most accurate estimations for the Italian context. The emissions factors for the management/disposal of the waste were derived from Moult et al (2018)[27]. This study proposes specific factors for five different types of food waste, which were relevant to the different categories of waste we collected in D6.2.

Briefly, the method to estimate the embodied carbon of the food waste was as follows. First, in order to make results linkable to the carbon footprint results generated in D6.3, we based the estimation on not just two, but all five schools comprising the samples in Parma and Lucca case studies (i.e. ParmaSchools One to Five, and LuccaSchools One to Five). We also made the estimates for the whole academic year, rather than the specific weeks of plate waste data collection. For both, we made the calculations by aggregating pro rata the volumes of plate waste recorded over two weeks for the two schools in each case study. Therefore, the total waste volumes reported in this section are higher than the volumes in the other sections of 6.2. The waste rates of individual food items within each food category (e.g. beef within the 'meat and fish' category) were estimated either from the direct observations of the plate waste data collectors in WP6.2 (where possible) or by inspecting the relevant ratios of the food procurement data collected as part of D6.3 (guided by the menus/recipes).

Having determined which food items comprised all the categories of the waste in each case, and in which proportions, an average emissions factor per kg (EF) for each food category was calculated by dividing the total production emissions generated by all the items in the waste food category (in kgs CO_2eq) by the total volumes of those items procured for the five schools in each case. In this way, the average EF for each food category took account of the varying proportions of specific food items within the waste category, and their specific EFs. If the waste food category only included one item (e.g., milk), the actual EF for this item was used as the category EF. Next, by multiplying the average EF for each food category by the total volumes of waste recorded for those food categories in each case, the total production-related embodied carbon emissions for each food waste category were calculated. The same methodology was followed to calculate the transport-related embodied carbon emissions for each food waste category. Finally, the embodied emissions relating to the food waste itself (i.e. transportation and handling of the waste) were added. All three components of the embodied carbon emissions (food production, transportation and waste disposal) were then summed to get the total embodied carbon emissions of the food waste in each case.

Table 21 shows the embodied carbon emissions of the food waste in LOC-ORG case, for five schools over one year. <u>It can be seen that the total embodied emissions were 90,247 kgs $C0_2$eq, equivalent to 0.34 kgs $C0_2$eq per meal.</u> <u>This represented 36% of the total $C0_2$ emissions of the entire LOC-ORG meals service</u> (252,395kg, as reported and discussed in D6.3 Italy Country Report). These results indicate a strong effort is needed to minimize the food waste in LOC-ORG schools, not just for improving the nutritional intake of children, but also for getting a better environmental sustainability of the school meals service.

In more detail, Table 21 shows the embodied emissions related to the production and processing of the wasted food represented 96% of the total waste CO_2 burden. Of these, starchy carbohydrates registered the highest proportion (about 76% of total emissions). Starchy-based dishes comprised an average emission factor of 2.08 $kgCO_2eq/kg$ of food waste. Meat and Fish based plates contributed 12% to the total embodied carbon. The transportation emissions for the food that ended up wasted were a very small proportion of total embodied carbon (2%), as were emissions due to management

[27] Moult, J. A., et al, Food Policy 77 (2018): 50-58.

and disposal of the food waste (3%). The low carbon composting system adopted in Parma helps to explain the latter result. However, overall, each kg of food waste produced by the Parma school meals service corresponded to 1.68 $kgCO_2$ emissions.

Waste Categories	Volume (kg)	Embodied Emissions (kgs CO_2eq)	Embodied Emissions per Average Meal (kgs $C0_2eq$)
Starchy Food (fresh potatoes, bread, rice, pasta, flour)	31,302	65,327	0.34
Starchy Food with Veg	6,927	11,625	
Starchy Food with Meat, Fish or Cheese	16,389	36,843	
Vegetables	17,084	10,193	
Meat and Fish	3,017	10,666	
Soups			
Desserts (cakes, dairy puddings)			
Juices			
Transport from central kitchen to schools		1,542	
Waste handling		2,519	
TOTAL	51,403	90,247	

Table 65. Estimated embodied carbon in plate waste in LOC-ORG case schools, per year (n=5 schools).

Table 22 shows the embodied carbon emissions of the food waste in ORG case, for five schools over one year. It can be seen that the total embodied emissions were 46,256 kgs $C0_2eq$, equivalent to 0.37 kgs $C0_2eq$ per meal. This represented 35% of the total $C0_2$ emissions of the entire ORG meals service (as reported in D6.3 Italy Country Report). As in LOC-ORG case, these results indicate it is necessary to identify strategies for minimizing food waste in the ORG school meals service, because it appears environmentally unjustifiable and inefficient.

In more detail, Table 22 shows the embodied emissions related to the production and processing of the wasted food represented 92% of the total waste CO_2 burden. Of these, starchy carbohydrates and meat and fish registered the highest proportions (about 72% of total emissions). Starchy-based plates comprised an average emission factor of 1.67 $kgCO_2eq/kg$, whereas for meat and fish based plates the average impact was 4.41 $kgCO_2eq/kg$ of food waste. The third most emissive food waste category was dessert accounting for 16% of the total food waste emissions. Taken together, fruit and vegetables represented about 13% of the total impact, although the quantity of food waste produced by these categories was more than 50% of the total weight of food waste. Indeed, the average emission factors for the fruit and vegetables based plates were 0.34 and 0.35 $kgCO_2eq/kg$ respectively. The transportation emissions related to the wasted food represented a very small proportion of total embodied carbon (5%), as did emissions relating to the disposal of the food waste (3%). This latter impact was due to the composting system adopted in ORG that contributed to mitigate the impact in food waste treatment. Overall however, each kg of food waste produced by the ORG school meals service corresponded to 1.34 $kgCO_2$ emissions.

Waste Categories	Volume (kg)	Embodied Emissions (kgs CO_2eq)	Embodied Emissions per Average Meal (kgs $C0_2$eq)
Starchy Food (fresh potatoes, bread, rice, pasta, flour)	10,235	17,086	0.37
Starchy Food with Veg	2,456	2,564	
Starchy Food with Meat, Fish or Cheese	621	867	
Vegetables	15,888	5,497	
Meat and Fish	3,022	13,325	
Soups			
Desserts (cakes, dairy puddings)	2,518	6,580	
Juices			
Transport from central kitchen to schools		2,216	
Waste handling		1,552	
TOTAL	31,664	46,256	

Table 66. Estimated embodied carbon in plate waste in ORG case schools, per year (n=5 schools).

The food waste composition of Parma and Lucca presented a different pattern (Figure 15). In Parma, the most carbon emissive food categories were the starchy food, while in Lucca meat and fish based plates contributed to the most to total food waste emissions. It is noteworthy that meat and fish included in starchy food plates explain the high emissions for this category. For Parma, the emissions associated with unique plates, such as cous-cous with meat, was probably overestimated due to the limited time-span along which the food waste analysis in the schools has been carried out. In any case, in Parma, meat and fish based plates showed a low level of emissions (12.4% of the total production emissions), while in Lucca the % was much higher (31% of the total production emissions). This result is due to the higher CO_2 emissive products included in Lucca's meat and fish plates. In fact, the average emission for meat and fish plates in Lucca is 4.4 kgCO_2/kg in comparison to 3.5 kgCO_2/kg for Parma. In particular, the food items that contributes within the "meat and fish" plates category to the highest CO_2 emissions in Lucca are meat and fish (50%), and soft and hard cheese (37%). Furthermore, the share of meat and fish plates in Lucca is higher than in Parma (9.5% versus 5.9%).

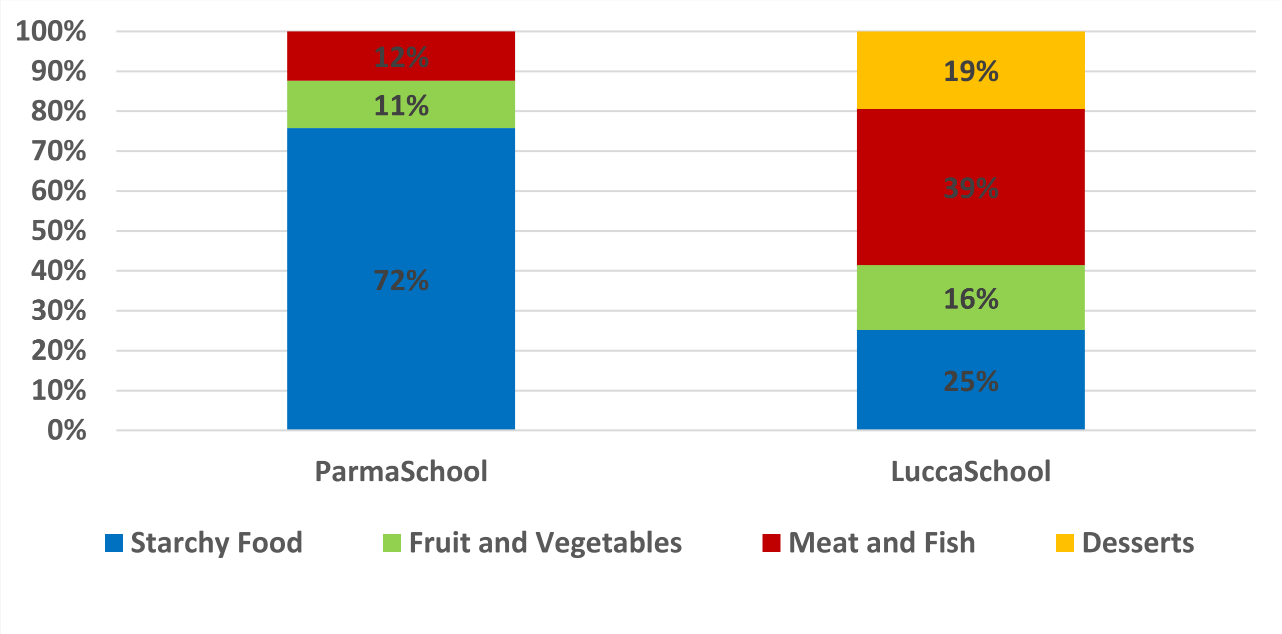

Figure 77. Food waste CO_2 burden shares comparison.

LOC-ORG differed from ORG also in terms of food waste carbon emission intensity. The food waste CO_2 burden per kg of food waste in ORG was 17% lower than in LOC-ORG (1.46 kgCO2eq/kg vs. 1.76 kgCO2eq/kg). This reflects the different composition of the food waste. In LOC-ORG, the average carbon emission factors for fruit and vegetables based plates was significantly higher than in ORG. The present analysis reveals that the level of food waste for both the school meals services is remarkable, and requires the new and effective strategies from the City Councils and the catering firms for minimizing the volumes of foods that currently end up in waste disposal.

5.7. Economic Impact of Plate Waste at LOC-ORG and ORG Schools

Wasted food in schools represents an economic failure of the school meals service. In other words, where there is high food waste, the technical specifications of the school meals service procurement contract do not appear to be enough to 1) avoid and/or eliminate food waste, or 2) commit the school meals service supply chain to new methods/techniques of menu design, meal preparation and distribution. Beyond health risks, the low nutritional intake by children from lunches due to food waste implies greater food expenditure for families to compensate for what their children do not eat at school. In this section, we report the results of the economic losses associated with the collected plate waste in both our LOC-ORG and ORG cases. For each food category we estimated the total cost of the collected food waste using the average unit cost for each food item included in the school lunch menus. Specifically, an average price per kg for each waste food category was estimated through the market price of each food items retrieved from the statistics provided by the Institute of agri-food market services (ISMEA[28]). The same approach was adopted for calculating the distribution of the economic value of the school meals service contract discussed in D6.3. The total cost of each waste food category was summed to derive the estimate of the total cost of all the food waste in each case. As with the calculation of the embodied carbon in the food waste, we estimated the economic impacts of the waste for all five featured school in LOC-ORG and ORG cases, for a whole school year.

[28] http://www.ismea.it/

Table 23 shows the economic impact of food waste estimated for one year in the five LOC-ORG schools. It shows that the total cost of the wasted food was €84,806, equivalent to €1.65 per meal. This represents 18% of the total school meals budget, and 27% of the full price of a meal to parents (€6.18).

In more detail, the food category that contributed most to the total economic loss from the waste was starchy food (56% of the total cost). In this category, starchy food with meat represented about 40% of the total economic loss from plate waste, followed by starchy food with vegetables (25%). Bread represented in the starchy food category was about 19% of the economic loss, followed by Parmigiano-Reggiano at 13%. Each food category comprised the food items used as ingredients in the preparation of the plates assigned to each specific food category. Although meat and fish based plates represented a share of less than 6% of the total weight of collected plate waste, they accounted for 21% of the total food waste cost. In this category, the most costly wasted food item was the cod fish (47% of the total cost). Fruit and vegetable based plates represented 22% of the total cost.

Waste Categories	Volume (kg)	Average Cost per kg (€)	Total Cost (€)	Cost per Average Meal (€)
Starchy Food (fresh potatoes, bread, rice, pasta, flour)	31,302	1.53	47,730	1.65
Starchy Food with Veg	6,927	1.71	11,816	
Starchy Food with Meat, Fish or Cheese	16,389	1.18	19,340	
Vegetables	17,084	1.11	18,974	
Meat and Fish	3,017	6.00	18,102	
Soups	0			
Desserts (cakes, dairy puddings)	0			
Juices	0			
TOTAL	51,403		84,806	

Table 67. Estimated Financial Impact of Plate Waste at LOC-ORG case schools (Parma), per year (n=5 schools).

Table 24 shows the economic impact of the food waste for the five ORG schools over one school year. As can be seen, the total cost of the waste food was €88,381, equivalent to €2.79 per meal. This represents 34% of the total school meals budget, or 56% of the full price of a meal to parents (€5.00).

In more detail, the food category that exhibited the highest economic loss due to food waste was the starchy food (40% of the total cost). In this category, starchy food with meat represented 7% of the plate waste cost, whereas starchy food with vegetables was 18% of the total plate waste. Canned tomatoes were the most costly food item in the starchy plate waste with almost 22% of that spend on this category estimated to be wasted. Recall that each food category comprised the food items used as ingredients in the preparation of the plates assigned to each specific food category. Although meat and fish based plates showed a share of less than 10% of the total volume of food waste, they accounted for 21% of the total food waste cost. In this category, the most expensive food item was the fresh cheese (stracchino and robiola accounting for 35% of the total cost), followed by turkey meat (13%) and bresaola (11%). Fruit and vegetable based plates represented 21% of the total cost, while wasted desserts showed a share of 19%.

Waste Categories	Volume (kg)	Average Cost per kg (€)	Total Cost (€)	Cost per Average Meal (€)
Starchy Food (fresh potatoes, bread, rice, pasta, flour)	10,235	3.37	34,521	2.79
Starchy Food with Veg	2,456	2.49	6,121	
Starchy Food with Meat, Fish or Cheese	621	3.86	2,396	
Vegetables	15,888	1.18	18,721	
Meat and Fish	3,022	6.15	18,585	
Soups				
Desserts (cakes, dairy puddings)	2,518	6.57	16,554	
Juices				
TOTAL	31,664		88,381	

Table 68. Estimated Financial Impact of Plate Waste at ORG case schools (Lucca), per year (n=5 schools).

The cost per kg of food waste was 69% higher in ORG case than in LOC-ORG. This was due to the different compositions of plate waste across the two cases, which affected the unit cost of each item and thus the calculation of the total plate waste cost. More specifically, for ORG, all the food categories showed a higher average cost per kg of food waste than for LOC-ORG except for vegetables. This depended on the type of plates and the ingredients used for their preparation. The higher costs registered per kg of food waste applied was confirmed also by the cost per meal: in ORG, the estimated cost of collected plate waste/ meal was more than double that of LOC-ORG (0.70 €/meal in ORG and 0.32 €/meal in LOC-ORG).

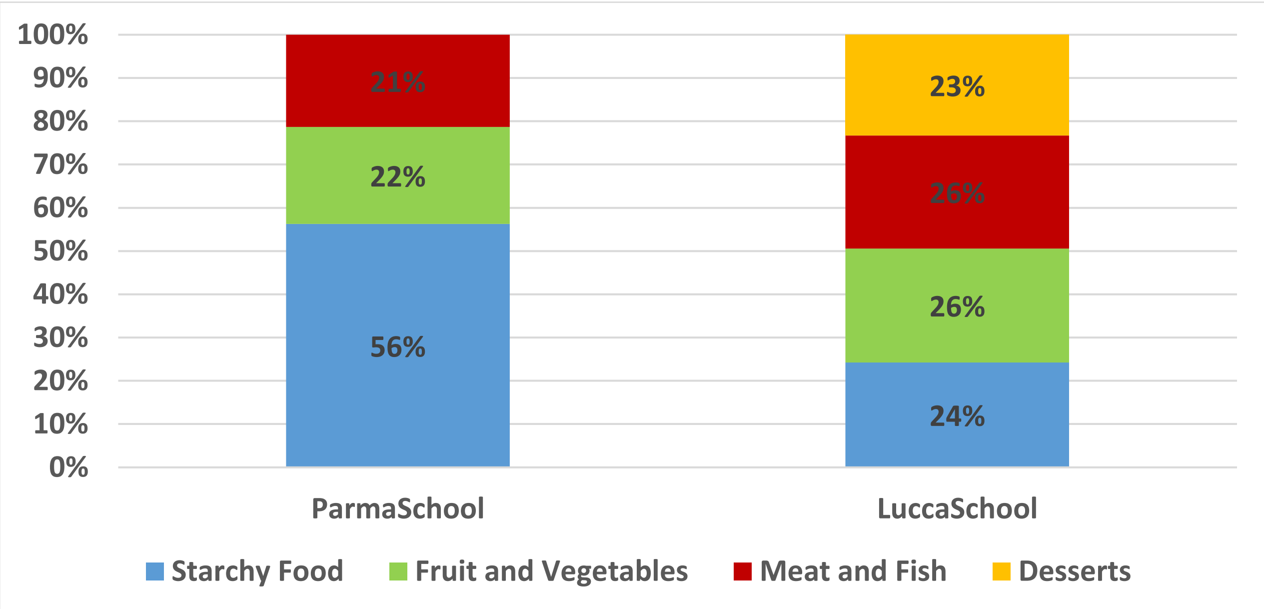

Figure 78. Food waste cost shares comparison.

The distribution of food waste costs across food categories was similar across the cases. As Figure 16 shows, except for dessert, the distribution of costs by category was comparable. However, ORG showed much higher cost compared to LOC-ORG that greatly affected the socio-economic sustainability of the entire school meals supply chain. In both cases, the weight of costs due to plate waste on the contract budget was significant, but for ORG it reached a very high level. According to our estimates, for ORG the total economic loss associated with collected plate waste as a proportion of the total supply budget was 34%. In both cases, these results suggest a rethink is necessary of the school meals service organisation, with the aim to reduce the food waste and, thus, the economic inefficiency associated with the current system.

5.8. Environmental and Economic Impacts under Difference Waste Scenarios

To explore what would happen to the environmental and economic impact of food waste if the school meals service underwent changes in organisation, we undertook two "what if" scenarios. First, we assumed that the quantity of wasted bread can be halved by a better procurement planning. Under this scenario, LOC-ORG Case would reduce waste-related carbon emissions by 4%, and food costs by slightly more than 5%. For ORG Case, carbon emissions and economic costs would reduce by 2.3% and 2.5% respectively. Second, we tested a scenario where the plate waste of the entire starchy food category is halved. In LOC-ORG case, the waste-related carbon emissions would drop by 36%, and food costs by more than 28%. For ORG case, this scenario would mean a reduction in waste-related carbon emissions of 19% and a reduction in food waste costs of 20%.

6. CONCLUSIONS AND RECOMMENDATIONS

Plate waste generated by children during their in primary school lunches has been evaluated using a multi-target approach, taking into consideration the features of the public food procurement model linked to geographical and cultural aspects, including the environmental peculiarities associated to the school meals served by the catering service. Considering all these variables, this study collected, analysed, evaluated and compared children plate waste and nutritive value of primary school lunches referring to two different public food procurement models (LOC-ORG *vs.* ORG) considering the nutritional, environmental and economic perspective and in particular the nutritive and economic loss, and embodied carbon, associated with the collected waste.

The two food procurement models reported different results. The total waste in the LOC-ORG model was lower compared to the ORG model, not only for values obtained across the two schools and seasons, but also considering the schools and weeks individually. The reasons for these differences are not fully explained by the study though it is plausible that the higher share of local/traditional quality products (i.e. Geographical Indications) which children were more familiar with, in the LOC-ORG model may help explain some of the difference. Across food categories, the most wasted category was starchy food-bread in LOC-ORG, and fruit in ORG, while the least wasted category, across both cases, was protein-based dishes. Nevertheless, differences were observed amongst dishes of the same category: simple recipes, such as pasta/rice with olive oil were the least wasted while more complex recipes like gnocchi with tomato reached a quite high waste percentage.

The percentage of plant-based plate waste (i.e. fruit and vegetables) was notably higher in ORG, where pupils consumed less than 50% of the average portion served. However, the problem of vegetable waste was evident in all schools to a lesser or greater extent and appears to be related strongly to children's liking and picking behaviour. A potential strategy to increase vegetables consumption may be to serve the side-dish at the beginning of the lunch, taking advantage of the moment when pupils feel hungriest, a strategy already suggested in the literature[29]. The issue of serving dessert is worth reflection as in the ORG model dessert is served in exchange for fruit once/twice a week and this could also be a reason for the higher level of ORG higher fruit waste collected. Limiting dessert to special occasions, as done in the LOC-ORG model, may be a worthwhile strategy to encourage daily fruit consumption, educating children to consider the dessert as a food for a special occasion and not as part of thei daily lunch routine.

Finally, the "other" category (unique and semi-unique dish) registered the lowest levels of waste. Even though it was served on only one occasion for both LOC-ORG schools, it seems that a unique dish may represent an efficient strategy to reduce the food leftover serving the first and second course with side dish in a single plate. This suggestion come from the observation of the canten environment when pupils where it was often observed that the canteen was quite chaotic and nosiy, both factors which can distract, disturb influence and influence children's eating and canteen behaviour. Hence, it is posited that it may be easier for them being concentrate on eating and limiting food waste when receiving a unique dish in a single plate instead of receiving the menu across multiple plates and spread over time.

Beyond these considerations, overall, the planned lunch menus fell within the national nutritional recommendations, with slightly higher compliance in LOC ORG (95%) compared to LOC-ORG (90%) though the collected plate waste did represent a clear nutritive loss with the estimated actual nutritive intake being between 60-75% of planned total energy, macronutrient and micronutrient intake. A possible way of improving energy and nutrient intakes and of the nutritional values of lunches could be a re-thinking of the National Guidelines concerning standards portions. In fact, the Italian recommendations for energy and nutritional content of school lunches the same for all students of the primary schools, from 6 to 11 years old, while different standard portions should be indicated for pupils attending primary school due to different requirements depending on the age, e.g. from 6 to 8 and from 8 to 11.

With regards to the environmental impact, different patterns were found between the cases: while for LOC-ORG the most carbon emissive food categories were starchy food and "other" food, for ORG meat- and fish-based plates and starchy food were highest in terms of total food waste emissions. The different composition of the food waste reflects the food waste CO_2 burden with this burden being 17% lower in the ORG compared to LOC-ORG model.

From an economic perspective, the two food procurement models were found to be very different, not only in terms of the cost of food waste but also in terms of the economic loss per meal. The cost per kg of food waste was 69% higher in the ORG than in the LOC-ORG, due to the different food items composition of plate waste, costlier in the ORG than in the LOC-ORG. The plate waste economic value represents a significant share of the total school meals service budget. In the LOC-ORG, about 18% of the entire budget is spent for food that will become plate waste, whereas in the ORG case the share increases reaching 34% of the total budget. The study has highlighted that food waste data in both school meal services was relevant from an economic efficiency perspective and requires both the City Council and Cater to explore and develop a new and effective strategy for minimizing the weight of food wasted in school canteens.

Moreover, beyond the different categorisation of the procurement models, some subject-dependent and independent variables should be considered in order to understand food waste determinants,

[29] Elsbernd et al, Appetite 96 (2016): 111-115.

according to the conception of Lévi-Strauss that "food preferences differ to one another and taste is culturally and socially controlled"[30]. Above all, the educational context can influence the amount of food waste as it can be related to child preference and behaviour. It should be underlined that a consolidate program of food and environmental education has been carried out by the University staff, involving all Parma Primary schools since 2009 (LOC-ORG model). In this case, the growing awareness amongst children on nutritional issues may be affected their food habits and their behaviour towards plate waste and may go some way to explain the difference between the cases. On the other hand, a detailed food education course is not provided as part of the Lucca primary school programs (ORG model). Thus, the higher food waste may be also due to a lower perception and awareness about nutritional and environmental issues. Moreover, teachers play a key-role during the school lunch not only addressing children to not waste, but also by encouraging fruit and vegetable intake. In support of this position, beyond the different fruit consuming time - as a snack during the mid-morning break or after lunch - the large waste variability found between the classes of the same school is strictly dependent on the teachers' involvement and care in preparing and peeling the fruit for the different classes. Finally, in the school with the lowest percentages of fruit waste, the school headmaster has forbidden pupils to bring in their own snack to school, as a deliberate strategy to discourage other food (primarily junk food) in favour of fruit.

In the analysis of the social context influencing food waste, it should be noted that there are different waste management practices in operation and different approaches to sustainability issues between the catering firms. In LOC-ORG the percentage of waste in school canteens was measured and assessed on a monthly basis by the catering firm, in order to help optimize the preparation and the distribution of the meals and the planning of the menus. Moreover, once children had concluded the lunch at school canteen, they had the responsibility to differentiate leftover food into separated bins. On the other hand, the ORG procurement has activated a pilot project in some schools where the undistributed food (e.g. bread and fruit) was provided to third sector associations but without any involvement from the children. However, in the remaining schools, the rest of the prepared and not consumed food was not recycled for human consumption but eliminated following the separate waste collection plan applied by the municipality. In addition, only in the second selected ORG school are older students used to help to clean up the canteen, clearing the tables at the end of the service, while in the LOC-ORG schools children helped every day.

In conclusion, according to our results, the inclusion of a higher quantity of products originating from the local territory seems to contribute to a greater acceptability of the school menus and consequently to a lower food waste. In addition, new national guidelines for school canteen should be issued, not only to reduce food waste but also to differentiate children nutritional needs according to the age. From the other side, nutritional and environmental education should be integrated into primary school programs in order to increase awareness about nutrition and food waste in both children and teachers. A re-planning of the school meals service organisation is essential to decrease the inefficiency of the current system and to reduce food waste and its consequent nutritional, environmental and economic losses.

[30] Lévi-Strauss, C. 1992. The raw and the cooked. Introduction to the science of mythology. Harmondsworth: Penguin Books

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REPORT EVALUATING THE NUTRITIONAL IMPACT OF THE DIFFERENT MODELS OF PSFP IN A SCHOOL CONTEXT:

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EXTENDED ABSTRACT

This report presents the methods and results of WP6.2 Strength2Food project in Serbia. The overall aim was to collect, calculate, and evaluate data relating to the nutritional composition of school meals, the plate waste from school meals, and consequent nutritional, economic and carbon impacts, for selected elementary schools in Serbia. The research also explored the effect of PSFP model on the nutritional impacts of the school meals. In Serbia, each elementray school is responsible for, and independently organises, their own food procurement and school meals service. For the purposes of this study, the menus and plate waste of 4 schools were investigated, each drawn from the sample of schools used in Serbia WP6.3. The analysed schools represent two types of procurement model, a LOC model (in which more than 70% of food (by value) is procured from suppliers less than 15 km distant from the school) and a LOW model, in which at least 30% of food (by value) is procured from suppliers at least 15 km distant from the schools. The specific schools in LOC case were OŠ “Dositej Obradović” and OŠ “Ljuba Nenadović” and in LOW case they were OŠ “Pavle Savić” and OŠ “Gavrilo Princip”. All schools are located in the city of Belgrade.

To assess the planned nutritive values of the school meals, a sample of 40 daily lunch menus (20 per case) was selected, and each menu analysed in terms of the energy, macronutrients and micronutrients provided. These results were then compared with World Health Organisation (WHO) recommendations for the nutritional profile of school lunches, to calculate the percentages of daily menus per case that complied with the recommendations. The analysis found that only 25% of daily menus in both LOC and LOW cases met recommended energy levels, with equal proportions of the remaining menus containing either too many or too few calories. Furthermore, although the daily menus contained recommended levels of protein, they were slightly higher in fat and lower in carbohydrates compared with recommended levels. Between 25% and 35% of menus were also too high in saturated fatty acids, and 30-40% provided too little fibre. No significant differences were found between the cases in terms of their macro-, and micronutritional profiles.

For plate waste, a field study was conducted in the 4 selected schools across two seasons, in order to capture the typical seasonal variety of Serbian school lunch menus and the ranges of foods used. For each school, plate waste was collected daily over two 1-week periods (one in December 2017, one in April 2018), to give a plate waste dataset of 10 days per school, 20 days per case and 40 days in total. Each day, data were obtained relating to the meal normatives for the menu, and then samples of 5 served meals were weighed and measured, to establish a benchmark weight for each portion. Plate waste was then collected from all students at the end of the lunch service and classified into eight food categories. Finally, the weight of collected plate waste for each defined food category was measured using a (digital) kitchen scale and the total number of portions served recorded. The total weights and compositions of the waste were then analysed for LOC and LOW cases.

The research found that the collected plate waste in LOC schools represented 19% of total food served, whereas in LOW schools plate waste was higher at 32% of total food served. Therefore, the quantities of plate waste in LOC case were much smaller than in LOW case - indeed the LOC waste rate was amongst the smallest of all WP6.2 case studies. In terms of the composition of collected waste, the two cases were very similar: in both, vegetables (including salad) comprised the largest proportion of the total waste (44% in LOC, 37% in LOW), followed by starchy carbohydrates including bread (21% in LOC, 23% in LOW), and then meat and fish (17% in both cases). For the remaining categories, soup represented a slightly greater proportion

of total waste in LOC case than LOW case (11% vs. 7%), whereas fruit was a smaller proportion (5% vs. 13%).

In terms of the nutritional losses due to the plate waste, in LOC case, children’s actual macronutrient intake was 78-85% of planned intake, whilst actual intake of selected micronutrients was 79-88% of planned intake. In LOW case, where the rate of plate waste was much higher, actual macronutrient and micronutrient intake was only 64-71% of what was planned. According to our estimations, the higher plate waste rates in LOW case were also found to embody a greater carbon emissions burden compared with LOC case (0.42 kgs C02eq vs. 0.32 kgs C02eq), as well as represent a greater cost burden (0.19 per average meal vs. 0.12). Therefore, the research found that rates of plate waste in PSFP have important consequences for nutritional loss, as well as environmental and economic impacts.

Reflecting on the reasons for the differences in plate waste between LOC and LOW cases, we did not identify any clear link to the procurement model adopted. Instead, other factors appeared more influential, such as the level and quality of interaction between kitchen staff and children (observed to be higher in the LOC schools), the efforts of staff to encourage children to eat healthy components of the meals (observed to be high in the LOC schools) and length of lunchtime period (shorter in LOW schools).

In conclusion, based on the sample of schools studied here, the nutritional impacts of school meals services in Serbia can certainly be improved, both in terms of the planned nutritive values in menu design, as well as the rates of plate waste. Adjustments could be made to menus to achieve a better balance of macro and micronutrients in meals, though introducing nutritionally improved menus will require care by cooks to avoid greater food rejection rates. For plate waste reduction, although some actions have major resource implications, and in the present circumstances may be unrealistic to implement (e.g. making more time for meals, employing more kitchen staff), actions such as encouraging more interactions between kitchen staff and pupils would be more feasible to implement. As the research found that procurement model type, *per se*, did not explain the differences in meal nutritional contents and plate wastes of the LOC and LOW case schools, we recommend the above actions to stakeholders of any PSFP model of school meals services, as a means to improve their nutritional impacts.

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List of Abbreviations and Acronyms

EUR – EURO

F&V – FRUIT AND VEGETABLES

FCA – FOOD COMPOSITION ANALYSIS

LOC – LOCAL MODEL OF PROCUREMENT, IN WHICH >70% OF FOOD (BY VALUE) IS PROCURED FROM SUPPLIERS <15KM DISTANT FROM THE SCHOOL

LOW – NON-LOCAL MODEL OF PROCUREMENT, IN WHICH AT LEAST 30% OF FOOD (BY VALUE) IS PROCURED FROM SUPPLIERS AT LEAST 15KM DISTANT FROM THE SCHOOL.

PSFP – PUBLIC SECTOR FOOD PROCUREMENT

RSD – SERBIAN NATIONAL CURRENCY – DINAR

OŠ – PRIMARY SCHOOL

WHO – WORLD HEALTH ORGANISATION

1. INTRODUCTION

This report presents the methods and results of WP6.2 Strength2Food project in Serbia. The overall aim was to collect, calculate, and evaluate data relating to the nutritional composition of school meals, the plate waste from school meals, and consequent nutritional, economic and carbon impacts, for selected elementary schools in Serbia. The research also explored the effect of PSFP model on the nutritional impacts of the school meals. In Serbia, each elementary school is responsible for, and independently organises, their own food procurement and school meals service. For the purposes of this study, the menus and plate waste of 4 schools were investigated, each drawn from the sample of schools used in Serbia WP6.3. The analysed schools represent two types of procurement model, a LOC model (in which more than 70% of food (by value) is procured from suppliers less than 15 km distant from the school) and a LOW model, in which at least 30% of food (by value) is procured from suppliers at least 15 km distant from the schools. The specific schools in LOC case were OŠ "Dositej Obradović" and OŠ "Ljuba Nenadović", and in LOW case they were OŠ "Pavle Savić" and OŠ "Gavrilo Princip". All schools are located in the city of Belgrade.

To assess the planned nutritive values of the school meals, a sample of 40 daily lunch menus (20 per case) was selected, and each menu analysed in terms of the energy, macronutrients and micronutrients provided. These results were then compared with World Health Organisation (WHO) recommendations for the nutritional profile of school lunches, to calculate the percentages of daily menus per case that complied with the recommendations.

For the plate waste, a field study was conducted in the 4 selected schools in two phases. The first phase was conducted during December 2017, while the second phase was carried out during April 2018. The key reason for repeating the same process in both phases was the fact that the menu choices in Serbian schools are largely dependent on the part of the year in which they are served, i.e. they are seasonal in character. The analysis of data collected during both winter and spring periods provides more accuracy, as well as a wider range of food items used for the preparation of student meals. Researchers collected plate waste generated from the daily school lunch services in each school for 2*1 week (Mon-Fri) periods, one week per season (Spring/Summer (April 2018) & Autumn/Winter (Dec 2017)). This generated a total waste dataset of 10 days per school, 20 days per case and 40 days in total. The daily measurement process consisted of several steps. Firstly, kitchen staff provided the normatives used for meal preparation. Secondly, a sample of 5 lunch meal portions were weighed and measured, to establish a benchmark weight for each daily menu. Thirdly, plate waste was collected from all plates and classified into eight food categories, namely: (1) soup, if served, (2) meat and fish (all meat and meat products, fish and fish products, and poultry and poultry products); (3) vegetables as part of a main course (easily-separated vegetables, mixed vegetable stews, legume stews); (4) starchy carbohydrate components that couldn't easily be divided, e.g. rice and pasta dishes, with peas, mixed vegetables, etc; (5) fresh and processed salad side dishes; (6) bread, typically served with every meal; (7) a dessert of either fresh fruit, a pudding, cake/pastry slice or other confectionary product; (8) a calorific drink (i.e. not water). Finally, the weight of the collected plate waste for each defined food category was measured using a (digital) kitchen scale and the total number of portions served recorded.

In collaboration, the research team and school principals predefined the visit schedules for each school. The measurement process was explained in advance and the kitchen staff were asked for permission, and agreed to prepare in advance, access for the research team to some of their equipment. This greatly contributed to the overall efficiency of the plate waste data collection. The equipment consisted of small containers and large bins for plate waste disposal (8 in total), a big spoon for food sorting, a set of (digital) kitchen scales, a notebook and a pencil.

Thereafter, the measurement process followed the steps described above. Firstly, kitchen staff provided the normatives (including recipes where available) used for meal preparation. Secondly, on a daily basis, 5 meal portions were weighed in order to establish the control variables (standards). After finishing their lunch, all children taking lunch that each day were asked to bring their trays/plates to the waste station. The research team then separated the plate waste into 8 waste bins, one for each food category. After each daily lunchtime service was complete, each food category bin was weighed using a digital kitchen scale and the head cook provided final confirmation of the total number of meals served. In some schools, the researchers were given additional instructions, due to hygiene reasons. In OŠ "Ljuba Nenadović" researchers had to wear protective footwear covers and hairnets when entering the prefood preparation facilities, while in OŠ "Pavle Savić" access to kitchen facilities was denied to non-employees, so the sampling and measuring was conducted by the kitchen staff.

This report is divided into seven parts. Firstly, an introductory discussion and overview of standard school food policies in Serbia is outlined. Next, detailed profiles of the 4 schools across the 2 cases is provided. We then present the results of the nutritional composition analysis of menus and the collected plate waste. Next we present the analysis of nutritional and financial losses and embodied carbon associated with the collected plate waste. Finally, we present key conclusions and recommendations to improve the nutritional intake and reduce plate waste in schools.

2. SCHOOL FOOD POLICIES IN SERBIA

From the 15th September 2018, a new Serbian *Rulebook on the organization, realization and monitoring of eating of elementary school students* (hereafter referred to as the Rulebook) came into the force in Serbia. The Rulebook, developed and passed by the Ministries of Education and Health in Serbia, advises on, and provides recommendations for, the preparation and organization of Serbian primary school meals. Currently, schools are not obliged to comply with the standards and recommendations outlined and many schools, lacking in key resources, equipment and facilities, would find it very resource intensive to comply. Accordingly, Serbian primay schools are now permitted to:

a) prepare meals in their own kitchen;
b) prepare meals in thier own kitchen collaboratively with other organizations who organized meals service for their pupils;
c) procure meals from suppliers registered for the production and distribution of food.

The Rulebook includes food based and nutrient recommendations (See Table 1 and 2) and normatives for school meals. These include:

1. Recommended daily intake of energy and macronutrients by children's age and gender
2. Recommended daily intake of micronutrients by children's age
3. Recommended representation of specific food groups in the planning of daily and weekly menus for pupils
4. Recommended food types in the planning of students‘ eating
5. Types of foods that are not recommended
6. Recommended food types per meal

Table 1. Recommended daily intake of energy and macronutrients according to children's age and gender

Age	Gender	Energy		Carbohydrate		Fat		Protein	
(years)									
		kcal/day	kJ/day	% E/ day	g/ day	% E/ day	g/ day	% E/ day	g/ day
7–9	Boys	1970	8242	>50	>246.3	Up to 30	65.7	10–15	49.3–73.9
	Girls	1740	7280	>50	>217.5		58.0		43.5–65.3
10–13	Boys	2220	9288	>50	>277.5		74.0		55.5–83.3
	Girls	1845	7719	>50	>230.6		61.5		46.1–69.2
14–18	Boys	2755	11527	>50	>344.4		91.8		68.9–103.3
	Girls	2110	8828	>50	>263.8		70.3		52.8–79.1

Table 2: WHO Recommended daily intake of micronutrients by children's age

	Age (years)		
	7–9	11–13	14–18
Vitamin A (retinol), ß-carotene (μg RE)	0.8	0.9	1.03
Vitamin D (calciferol) (μg)	5	5	5
Vitamin E (tocopherols) (mg equiva.)	9.5	12	13.25
Vitamin K (μg)	30	40	57.5
Vitamin B1 (tiamin) (mg)	1	1.1	1.2
Vitamin B2 (riboflavin) (mg)	1.1	1.3	1.4
Niacin (mg equiva.)	12	14	15.75
Vitamin B6 (pyridoxine) (mg)	0.7	1	1.4
Folic acid (μg equiva.)	300	400	400
Pantothenic acid (mg)	5	5	6
Biotin (μg)	15–20	20–30	27.5–47.5
Vitamin B12 (cobalamin) (μg)	1.8	2	3
Vitamin C (mg)	80	90	100
Sodium (mg)	1380	1380	1600
Chlorides (mg)	690	770	830
Potassium (mg)	3800	4500	4700
Calcium (mg)	900	1100	1200
Phosphorus (mg)	800	1250	1250
Magnesium (mg)	170	240	342.5
Iron (mg)	10	13.5	13.5
Iodine (μg)	130	150	175
Fluorine (mg)	1.1	2	3.05
Zinc (mg)	7	8	8.38
Selen (μg)	20–50	25–60	27.5–65
Copper (mg)	1.0–1.5	1.0–1.5	1.0–1.5
Manganese (mg)	2.0–3.0	2.0–5.0	2.0–5.0
Chromium (μg)	20–100	20–100	30–100
Molybdenum (μg)	40–80	50–100	50–100

Moreover, schools need to take into account several additional factors when planning school meals namely: age of child; number of pupils of certain age; period of time that children spend in school; and educational and other on, and extra, curricula initiatives for teaching children about optimal nutrition. Parents are obliged to provide a school with information if their child has special nutritional needs: allergies and intolerance to specific food types; gluten enteropathy (celiac disease); diseases and conditions requiring a special hygienic-dietary regime: obesity, diabetes, chronic kidney disease, dyslipidemia, metabolic syndrome, and so forth.

The Rulebook advises that school menus should be developed by a nutritionist/dietician or by the kitchen staff, except for students with special nutritional needs. Procurement of all products and services related to school meal provision should be carried out in accordance with national public procurement law.

In addition, the Rulebook, in its closing articles, gives advice on monitoring rules, specifying that both internal and external control should be in place and performed by a competent (and approved) institution such as the Institute for Public Health. Internal controls are also advised to regulate and manage:

1. quality control of meals, i.e. chemo-bromatological analysis of samples of meals (breakfast, snack, lunch) taken by random sample method and laboratory determination of their energy and nutritional value (contents of proteins, carbohydrates, fats, salts etc);
2. control of sanitary and hygienic conditions of food preparation and distribution in accordance with HACCP standards or in accordance with the principles of good hygiene and manufacturing practice, based on risk assessment, comprising: analysis of microbiological correctness of swabs taken from working surfaces, accessories, hands and noses of employees in kitchens; control of microbiological correctness of foods and of ready meals.

External controls are reported on, in terms of nutritional intake drawn from nutritional data of food stuffs consumed, laboratory analysis of meals and results of control of sanitary and hygienic conditions. Internal control consists of: the control of foods at delivery; control of documentation – health safety certificates and declaration of delivered foods; and control of food preparation and distribution. Internal control is performed by school based employees who are in charge of receiving, preparing and serving school meals. Table 3 details the types of foods recommended in the Rulebook.

Table 3. Recommended food types for the planning of students' nutrition

Food Groups	Recommended Foods
Cereals, cereal products, potatoes	Whole grain cereals (wheat, rice, corn, barley, oats, rye, millet, buckwheat) cooked in soup, as an addition to meat, fish, vegetables (instead of bread) or as treats (sutlias, koh ...) Bread, pasta and other products of whole-grain cereals, cereal flakes, pulp, muesli ... Potatoes - boiled, baked in shell, mashed potatoes. Frying of potatoes in deep oil is not recommended.
Vegetables	All types of seasonal fresh or frozen vegetables, boiled in water, steamed or pressurized. Use cooking water for soups and sataras. Whenever it is possible, use vegetables in a fresh form.
Beans	Cooked, dry, in the form of spreads
Fruits	All kinds of seasonal fresh or frozen fruit. Roasted or prepared in the form of a compote without adding of sugar. Freshly squeezed fruit juices. Nuts and seeds. Marmalades / jams without artificial flavours and sweeteners. Fruity treats with minimal amounts of sugar. Dried fruit served in moderate amounts
Milk and milk products	All types of milk and fermented dairy products with at least 2.8% of milk fat. Sweet and chocolate dairy drinks are not recommended. All kinds of fresh and semi-hard cheese.

Meat	The first category of boneless meat – Meat of poultry (turkey, chicken), veal and lamb, red meat: beef, pork – lean meat
Fish	Only bone-free fish. To prepare fish pate, use fish from cans (sardines, tuna and mackerel).
Egg	Thermically well-processed - hard boiled, scrambeled, omelette and as the part of recipes of complex dishes.
Fats and oils	Only vegetable oils: sunflower, olive, corn ... Butter and pork fat in small quantities.
Spices and supplements feed	Iodized salt, spices, seeds
Beverages	Drinking water, hot or cold herbal tea, sweetened with honey.

Source: Government of Republic of Serbia, 2018

Before the Rulebook was issued, there was no Serbian legislation in place to regulate nutritional intake in schools. The legal acts managing this field crossed the domains of Ministry of Education, Science and Technological Development and include: normatives for the collective nutrition of children in child focused institutions (including schools) (Ministry of Education, 2015), the Rulebook on standards of the quality of nutrition of pupils and students (Ministry of Education, 2011), as well as the Rulebook on the accommodation and nutrition of students (Ministry of Education).

However, these 3 documents are predominantely related to the regulation of eating of kindergarten or university students. Therefore, the development and adoption of the Rulebook for the organization, delivery and monitoring of primary school food is a significant step forward Serbian public policy. Nevertheless, previous experiences demonstrate that constant monitoring and control of the application of the rules is vital, this this stage should be specifically addressed.

Lunches in Serbian primary schools characteristically have the following components: soup (thick or a broth with noodles), a main course (usually meat and one or more vegetables, sometimes prepared separately, but also with meat and vegetables prepared together to save time and resources), a side salad of vegetables often pickled during the winter months, a dessert of either a piece of fresh fruit or a slice of cake/pastry or a biscuit/confectionary, often with chocolate or a pudding, usually made by adding dried ingredients to milk. Bread of some kind accompanies nearly all meals and water is available as a drink. As an alternative to meat and vegetables, sometimes pasta or rice dishes are given, and occasionally meat is replaced with either a legume dish (usually beans or peas, but also occasionally lentils) or a pasta and cheese dish. Fish is also given occasionally instead of meat. Three types of fish are given for school meals: filleted frozen fish (such as hake or catfish), battered fishcakes and fish fingers. All are usually fried – cooks say that frozen fish collapses during cooking unless it is battered first. Depending on the menu, one or other of these components may be omitted, particularly if the main course is very calorific, such as pasta.

3. PROFILE OF LOC MODEL SCHOOLS

Within LOC model, we have analysed two schools OŠ "Dositej Obradović" and OŠ "Ljuba Nenadović". Both are located in the city of Belgrade.

3.1. School Profiles

OŠ "Dositej Obradović" is one of the oldest primary schools in Belgrade. It is located in Voždovac municipality, one of the biggest and most developed Belgrade municipalities and whose inhabitants average net monthly salary, having seen positive growth over the last 5years, currently equates to €418/month, which is in line with the average national monthly income of €421. This school has a pupil role of 471 children. with 123 1st and 2nd graders , 108 3rd and 4th graders and 228 5th-8th graders. Extended stay is organized for pupils oacross the first 4 grades[31]. Daily, 38% (83) of 1st-4th graders use the extended stay service during which they all receive a daily breakfast, lunch and one snack. The snack and breakfast are both priced at €0.58 (0.70 RSD), while daily cost of lunch is €1.67 (200 RSD). Generally, parents are responsible for paying for school meals (so called 'children dinar' through cash payments made to a special current account (assigned account for this purpose).

Throughout its long history, OŠ "Ljuba Nenadović" has changed its appearance as well as its location. Currently, it is located in one of Belgrade's largest municipalities, Čukarica, whose inhabitants average net salary, having seen positive growth over the last 5years, equates to €382/month, slightly below the national average (€418/month). "Ljuba Nenadović" school belongs to a group of bigger schools with a current pupil roll of 1204 students across 1st to 8th grade with 289 1st and 2nd graders, and 285 3rd and 4th graders. It provides extended stay for 1st and 2nd grade children[32] with approximately 180-200 pupils are currently using the extended stay service (62-69%) though uptake can, and does, vary significantly from one day to another. Parents are required to notify the school 1 day in advance if their child will be absent from school and if advance notice is not provided a charge for lunch is made. As part of the extended stay service, a daily breakfast, lunch and 1 snack is prepared and served. There are two shifts of extended stay children: one shift starts at 07.00 and end at 13:45, while the second shift starts at 11:30 until 17:30. Depending on different shifts, children take breakfast and lunch or lunch and snack as a combination. The lunch is the only mandatory meal in the extended stay. Price of the lunch snack is €0.25 (30 RSD), breakfast costs €0.50 (60 RSD), while the price of lunch is €1.42 (170 RSD).

3.2 Approach to Food and Sustainability Issues

Through in depth interveiws with school staff, it was established that OŠ "Dositej Obradović" has not previously, nor is currently, implementing any food and sustainability related initiatives apart from what is addressed in the schools formal biology curricula. Staff acknowledged that participation in the Strength2Food project has raised awareness about the importance of these issues. In response, the schools reports that they are planning to develop, and deliver, several educational classes with the goal of raising their children's awareness about healthy food and healthy eating habits in general.

[31] Extended stay service is available to the children of the higher grades as well, but they usually do not eat at school kitchen, but in the nearby bakeries.

[32] Although students from third and second grad may apply for extended stay, number of children who apply is insignificant.

Through interviews with school staff, it was established that OŠ “Ljuba Nenadović” has previously, and is currently, engaged in multiple food and sustainability initiatives and projects. Every school year, several days are selected and dedicated to healthy nutrition (Food day, Healthy food day etc.). On these days, students, together with their teachers, organize various activities such as: lectures about healthy nutrition, healthy food exhibition, creating healthy recipes and similar activities. The school biology and chemistry teachers play an important role in organizing these food related events.

Figure 79. Food and health actions conducted in Ljuba Nenadovic school

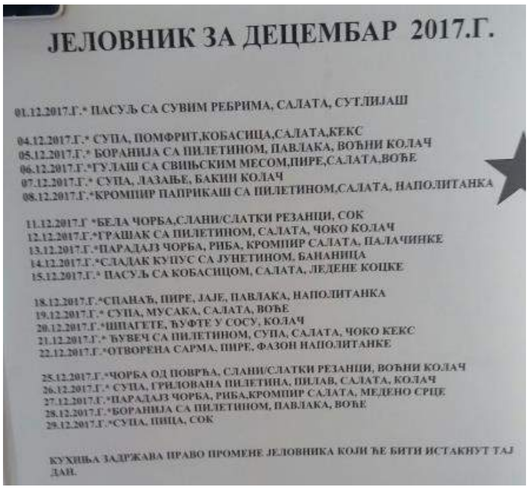
Source: Ljuba Nenadovic school, http://osljubanenadovic.nasaskola.rs/galerija/?strana=2

3.3.Organisation of School Meals

Menu planning in Dositej Obradović is led by the school cooks, conducted once per month five days before the introduction of the next month’s menu and involves the planning of all meals to be served in that next month. Upon the completion of each monthly menu, it is displayed on the canteen door so the parents have access to it. It is important to note though that menus are rarely modified and in the cases when modifications have happened, it was mainly due to untimely food delivery or reasonable complaints from the parents.

In addition to school cooks, a local health inspector plays an active role in menu planning regularly advising the school on food combinations and healthy ways for preparing meals. For example, on the recommendation of the Health Inspector, the kitchen staff are now using grease-proof paper during the meal preparation process process reducing oil and animal fat usage. Juices have been replaced with lemonade, as well. This school does not repeat menus, instead every month a new menu plan is created. When it comes to menu cycles, they are mostly determined by the available groceries at a particular time of the year (e.g. sauerkraut and podvarak are common in the winter period). The lunch consists of three courses: first course is the soup, second one is the main dish (e.g. meat and vegetables) while the third course is a dessert (e.g. fruit or cake). Additionally, children have bread and drinks (usually a lemonade) as well. The bread is served at the children's tables prior to the start of lunch, while the glasses of lemonade are put on the specific table from which children take them on their own. An example of the school's daily menu for one day (picture, Figure 2) in the first week of December 2017 (Table 4) and the month of December (Figure 2) are presented below.

Figure 80. An example of Dositej Obradović school meal in December 2017 and monthly menu for December 2017



ЈЕЛОВНИК ЗА ДЕЦЕМБАР 2017.Г.

01.12.2017.Г.* ПАСУЉ СА СУВИМ РЕБРИМА, САЛАТА, СУТЛИЈАШ

04.12.2017.Г.* СУПА, ПОМФРИТ,КОБАСИЦА,САЛАТА,КЕКС
05.12.2017.Г.* БОРАНИЈА СА ПИЛЕТИНОМ, ПАВЛАКА, ВОЋНИ КОЛАЧ
06.12.2017.Г.*ГУЛАШ СА СВИЊСКИМ МЕСОМ,ПИРЕ,САЛАТА,ВОЋЕ
07.12.2017.Г.* СУПА, ЛАЗАЊЕ, БАКИН КОЛАЧ
08.12.2017.Г.*КРОМПИР ПАПРИКАШ СА ПИЛЕТИНОМ,САЛАТА, НАПОЛИТАНКА

11.12.2017.Г *БЕЛА ЧОРБА,СЛАНИ/СЛАТКИ РЕЗАНЦИ, СОК
12.12.2017.Г.*ГРАШАК СА ПИЛЕТИНОМ, САЛАТА, ЧОКО КОЛАЧ
13.12.2017.Г.*ПАРАДАЈЗ ЧОРБА, РИБА, КРОМПИР САЛАТА, ПАЛАЧИНКЕ
14.12.2017.Г.*СЛАДАК КУПУС СА ЈУНЕТИНОМ, БАНАНИЦА
15.12.2017.Г.* ПАСУЉ СА КОБАСИЦОМ, САЛАТА, ЛЕДЕНЕ КОЦКЕ

18.12.2017.Г.*СПАНАЋ, ПИРЕ, ЈАЈЕ, ПАВЛАКА, НАПОЛИТАНКА
19.12.2017.Г.* СУПА, МУСАКА, САЛАТА, ВОЋЕ
20.12.2017.Г.*ШПАГЕТЕ, ЋУФТЕ У СОСУ, КОЛАЧ
21.12.2017.Г.* ЂУВЕЧ СА ПИЛЕТИНОМ, СУПА, САЛАТА, ЧОКО КЕКС
22.12.2017.Г.*ОТВОРЕНА САРМА, ПИРЕ, ФАЗОН НАПОЛИТАНКЕ

25.12.2017.Г.*ЧОРБА ОД ПОВРЋА, СЛАНИ/СЛАТКИ РЕЗАНЦИ, ВОЋНИ КОЛАЧ
26.12.2017.Г.* СУПА, ГРИЛОВАНА ПИЛЕТИНА, ПИЛАВ, САЛАТА, КОЛАЧ
27.12.2017.Г.*ПАРАДАЈЗ ЧОРБА, РИБА,КРОМПИР САЛАТА, МЕДЕНО СРЦЕ
28.12.2017.Г.*БОРАНИЈА СА ПИЛЕТИНОМ, ПАВЛАКА, ВОЋЕ
29.12.2017.Г.*СУПА, ПИЦА, СОК

КУХИЊА ЗАДРЖАВА ПРАВО ПРОМЕНЕ ЈЕЛОВНИКА КОЈИ ЋЕ БИТИ ИСТАКНУТ ТАЈ ДАН.

Note: Menu is comprised of: beans with sausage and smoked ribs, cabbage salad, bread and a chocolate cake

Table 4. Dositej Obradovic Menu from 1st Week in December 2017

	Menu for the first week in December
04.12.2017.	Soup, french fries, sausage, salad, cookie
05.12.2017.	Green beans with chicken, sour cream, fruit cake
06.12.2017.	Goulash with pork meat, mashed potatos, salad, fruit
07.12.2017.	Soup, lasagna, a galette
08.12.2017.	Potato stew with chicken meat, salad, cookie

In "Ljuba Nenadović" school, the kitchen staff (two cooks), as well as chemistry and biology teachers, are all involved in menu planning and developments. According to them, the health inspector makes a significant contribution to the menu planning process by providing recommendations and suggestions. Menus are planned on weekly or bi-weekly basis and are of seasonal character. Aside from the standard menus, specific meals are prepared for children with health problems (i.e. allergies, diabetes) and for children who fast[33]. The daily menu usually consists of three courses: soup, main dish (e.g. meat and vegetables or some cooked meal) and dessert. When it comes to dessert, according to employees, children are mostly served with fruit rather than cake. The example of weekly menu is depicted in Figure 3 and Table 5.

[33] This is an insignificant number of students

Figure 81. Example of Ljuba Nenadović school meal for December 17, 2017 and a weekly menu

Note: Menu is comprised of: beans with smoked meat, pickle cucumbers salad, bread and an apple

Table 5. Example of Weekly menu from April 2018

	Menu for one week in April
16.04.2018.	Vegetable pottage, macaroni and cheese, mandarin
17.04.2018.	beef steak, peas side dish, cucumber salad, pudding
18.04.2018.	Chicken soup, potato stew with chicken meat, beet salad, sweet pie
19.04.2018.	gulas with beef meat, macaroni, mixed salad, banana
20.04.2018.	Bean with smoked meat, cabbage salad, juice, fruit cake

3.4.Kitchens and Canteens

Dositej Obradović school has its own kitchen facilities, situated within school building. The kitchen is well equipped and the employees have at their disposal: seven professional tables for food preparation, two dishwashers, three refrigerators (one large and two smaller ones)[34], freezer, professional stove, five ovens, as well as many small kitchen appliances, which make the children meals preparation process more efficient. In order to have more light, canteen walls are brightly painted. Food ingredient preparation is done manually (peeling, chopping etc.) and the school kitchen is used exclusively for food preparation and meal serving and does not have any additional purposes. After the work is done, the kitchen is closed. Currently, two cooks work full time in this school kitchen. Beside food preparation, their responsibilities also include hygiene maintenance, disinfection of tables, and direct communication with suppliers, classification of food ingredients from supplier's deliveries. Both cooks have passed HAACP training and undergo regular smear sample test every six months to ensure quality and safety improvement in food preparation process.

Ljuba Nenadović kitchen is on the school premises. The kitchen has two entrances, one from the school building and one through the back entrance. Kitchen facilities are comprised of the working area where the food is prepared, the canteen area where children eat meals and two toilets. The working area is equipped with quite old kitchen utilities including: refrigerator,

[34] All food items are stored separately, more precisely, every refrigerator is used for specific food category.

stove, kitchen sink, plates and cutlery. There is also a potato peeler machine, but it is currently not in use as there is not enough space in the kitchen for the machine and no drain, which the machine requires. The kitchen owns a fryer, but 13L of oil is required for frying whihc has to be replaced after each frying. This is too expensive for the school, and therefore, the fryer is not in use. According to the kitchen staff, kitchen equipment has not been renewed for a long time (from time to time someone donates used appliances which are newer than the existing ones, but are still outdated).

Figure 82. Ljuba Nenadović kitchen (food preparation area)

The second part of the kitchen facilities at Ljuba Nenadovic is the canteen. It has tables with four stools which the kitchen staff often rearrange into rows of tables to make the lunch rush less crowded (See Figure 5 below). Beside its main purpose, the canteen space is used for parent-teacher meetings, diploma giving ceremonies, student award presentations etc. The school is outgrowing its current space, is struggling to accomodate its growing number of pupils and is having to make temporary adjustments to cope. The kitchen employs one full time cook and one full time cook assistant, whose main roles include food preparation, kitchen cleaning, food procurement and primary communication with suppliers.

Figure 83. Table arrangement before lunch service at Ljuba Nenadovic

3.5.Lunchtime Service

Lunchtime in Dositej Obradović school is fixed, taking place from 12:30 to 13:00. All the pupils are served at the same time in the canteen, therefore each child has upto 30 minutes to eat their lunch. Service method often depends on the meal type served that day. If soup or other hot, liquid meal is on the menu, the cooks serve the meals. More precisely, in order to achieve maximum safety, the cooks approach every student and pour the soup to a plate or lay the full plates on the table (Figure 6 on the left). The main dish (e.g. two side dishes and meat) is not served by the cooks, instead children approach the kitchen and wait in line for their portion (figure 6 on the right). Fruit and lemonade are served on a specific table from which children can take them after the main dish. Cooks place the bread onto the children's tables before the lunch starts.

Figure 84. Dositej Obradovic - different service methods for soup and main dish

Twice a week, children can choose an alternative dish component (for example, if a child does not like potato salad the alternative is rice, or if a child does not like macaroni with cheese, he/she can eat sweet macaroni). All food prepared for that day is kept in large containers from which the cooks fill the children's plates with predefined portions. They do not use a kitchen scale, instead they use already tested standard measurement dishes (glasses, ladles, spoons etc.) to serve portions approximate to the predefined portions. The portions are not varied based on children's age or gender, however, they may differ depending on a childs appetite. More specifically, if the children are hungry even after finishing the standard portion, they can ask for, and be served, an extra main dish by the cooks (according to cooks, there are situations where some children take triple portions, if it is available).

When pupils finish their meal, they are responsible for taking their tray to the waste station themselves. The entire process is managed in a pretty organized manner, since the cooks as well as the children are familiar with their responsibilities. To help manage the flow of children through the canteen, not all children arrive for lunch at the same time, with a schedule managed by teachers who bring their chidlren to the canteen. There is at least one teacher present during every lunch service and he/she is responsible for maintaining order in the canteen. Lunch time lasts for approximately 30 minutes. When it comes to breakfast and lunch snack, there is a greater degree of flexibility in planning and service. Thus, the lunch snack is organized as a buffet breakfast and children can choose between several options and, in the case of the breakfast, children, parents and the cooks are often deciding on food choice together.

The children were observed to have excellent relationships with the kitchen staff. When they asked for a refill on some dishes, the cooks always provided more, although children did not often ask. On the other hand, cooks often encouraged and cajoled children to finish eating the food components which are unpopular amongst children, like cabbage, podvarak etc. Additionally, to encourage children to consume more healthy foods (fruit, vegetables etc.), the kitchen staff decorated served fruit and vegetables (e.g. with smiley faces) in order to attract the children's attention. A great testimony of excellent interaction between the students and the kitchen staff is a statement given to *Politika* newspaper in which the students said that the canteen was one of their favourite places in the school.

In Ljuba Nenadović school the lunch break, attended by the great number of students, lasts for one hour (from 12:00 to 13:00). Similar to the previously described school, before the lunch starts, the cooks prepare trays with soup and serve them on the tables. Children do not get trays with full lunch content. Beside soup, bread and salad are also served. Baskets are put on each table with bread cut into slices (without the two ends of bread). Children do not eat much of the bread and/or salad provided. Children often do not like soup, so they immediately return soup or eat half a portion of a soup. After soup, children go to a large table where they can pickup the main meal. They then carry the meal to the table and eat it. If someone wants more food, he/she can come to the cooks and ask for another portion of meal. After the main meal, they go to the large table again to pick up the dessert (Figure 7). Drinks (usually fruit juice or tea) are located on a separate table and children can take them during the lunch. In that case, the children go to the main table only when getting drinks, fruit or dessert.

Figure 85. Main table, from which children can take fruit or dessert (Ljuba Nenadović school)

Lunchtime in Ljuba Nenadović school is also fixed, taking place from 12:00 to 13:00 . Since the pupils are split into two groups, each group has 30 minutes for lunch with all the children in each group being served at the same time in the canteen. Although the cooks follow predefined normatives, not every portion is measured. In order to equalize the quantity of portions handed to every student and, simultaneously, fit the portions to the normative, each server uses predefined measurement tools (ladle, spoon, etc.). Considering the fact that approximately 180 students consume the lunch, for the purpose of better organization, the pupils have their lunches in groups. The groups are not formed based on the class the pupils go to, but based on the teacher who takes the children to lunch (when one group of students finish the lunch, next class starts the lunch). The teachers are present during the lunch breaks, while the kitchen staff were not observed communicating deeply with the children. Sometimes, children are encouraged by teachers and/or kitchen staff to eat more or try something new, but they do not insist on it. However, in both LOC schools, a great gratitude and trust towards kitchen employees was observed. The following picture (Figure 8) shows a thank-you note from students and teachers to the kitchen staff.

Figure 86. Thank-you note for the kitchen staff of Ljuba Nenadović school

3.6. Waste Management and Plastics Use

According to LOC school officials, less than 10% of food is estimated to be left-over after the lunch. Leftover prepared food is often served to cleaning staff or underprivileged students (two to three students). The remaining leftovers and wasted food is disposed of in the waste containers. In one school the destination of the waste is landfill.

Usage of plastic overall and plastic containers is avoided in both schools. Plastic is used only for a short periods of time e.g. large containers in which side dishes are served or the containers for fruit. The food is kept there only for the duration of lunch.

Figure 87. Plastic container usage in LOC model schools

Also, the plastic cups used to serve some puddings are not recycled and instead disposed of with the rest of waste. Food which is kept for a longer periods of time is never stored in plastic containers in either of the LOC schools.

3.7. School Fruit and Vegetables Scheme

As Serbia is not an offical member of the EU 28, Serbian schools are not eligible to participate in the EU School Fruit and Vegetable Schemes. The provision and promotion of fruit and vegetables are very dependent on school policy. Generally, fruits and vegetables were offered in both LOC schools. In Dositej Obradović school, children are offered fruit at least twice per week, although they prefer to eat sweets while vegetables are served on average up to three to four times per week. In Ljuba Nenadovic children are offered, and were observed consuming, fruits and vegetables (as a salad or a side dish) regularly. For both LOC schools, vegetables are in the top four meals that children do not like, especially: green beans, peas, beans, beet, etc. According to the cooks, the children prefer fruit over vegetables. In Ljuba Nenadović school, the kitchen staff have tried to slice, and serve, fruit in smaller pieces before lunch and this had a positive effect, though it is not regularly done due to the lack of time and because some children bring fruit from home and eat it on the next break.

4. PROFILE OF LOW MODEL SCHOOLS

The two schools that comprised the LOW model case for this research were Pavle Savic and Gavrilo Princip. Both these schools are located in the city of Belgrade, but in different municipalities to each other, and to LOC model schools.

4.1. LOW School Profiles

Pavle Savic school is located in the Municipality of Zvezdara, inside the region of the capital of Serbia. The Municipality of Zvezdara covers an area of 3,165 hectares (about 1% of total Belgrade area), with a population of around 150,000 (about 10% of total Belgrade population). According to the Statistical yearbook, 38,982 of the population were employed in 2012 (~26%), while the active population is 47,297 persons. Zvezdara remains to be one of the most densely populated municipalities in Serbia, with a positive birth and migration rate. As many areas of modern Zvezdara municipalities were villages and rural areas annexed to it in the 1950s, the entire southern and eastern sections are without industry, while industrial facilities are mostly grouped in two sections. The average salary in Zvezdara is significantly higher than national average and there are 14 elementary and 9 secondary schools in Zvezdara municipality.

Pavle Savic school is attended by approximately 1730 pupils with 448 1st and 2nd graders and 432 3rd and 4th graders. Only lunches are served in schools, with no breakfast or snacks offered. During three months of research, the number of served lunches varied from 62 to 91 per day, with a daily average of 80. Uptake from 1st to 4th grade is estimated at 18.5% with 64% of extended stay pupils taking lunch.

Gavrilo Princip school is located in Zemun municipality which covers an area of 15,356 hectares, and is inhabited by a population of 152,950. Zemun is one of the most developed municipalities in the country, with developed industries in almost every section. Average monthly net salary is €460, above the national average (national average is €421). Zemun has two large and growing industrial zones. Industries include: heavy agricultural machines and appliances, precise and optical instruments and automatized appliances, clocks, busses and other heavy vehicles, pharmaceuticals, plastics, shoes, textile, food, candies and chocolate, metals, wood and furniture, recycling, beverages, chemicals, building materials, electronics, leather, etc. There are approximately 840 children who attend Gavrilo Princip school. In this school, two meals are organized a day – snack and lunch. Lunch is served to about 145 children, with 34% uptake for grade 1-4 children.

4.2. Approach to Food and Sustainability Issues

While Pavle Savic school reported no food and sustainability initiatives, they engage a nutritionist to prepare normatives and guidelines for school food for the cooks. Furthermore, they promote through their website the national project *"Let's make our children move"*, supported by, amongst others, the Serbian Ministry of Education. Moreover, they have organized ecological workshops (more details on this are given in Section 4.6) to promote cleaning and green energies (See figure 10).

Figure 88. Training materials for the programme "Let's make our children move"

Source: Pavle Savic school, https://ospavlesavic.files.wordpress.com/2017/03/prezentacija-projekta-pokrenimo-nasu-decu.pdf

Similar to Palvic Savic school, Gavrilo Princip school reported no specific food and sustainability actions and/or initiatives. On reviewing the school's voluntary activities it was clear that it was more focused on the charity actions of helping underpriviliged children. That said, one class was organized called the Autumn Joy Workshop, where children made various creations from fruits and vegetables, together with their parents and grandparents.

Figure 89. Autumn Joy Workshop in Gavrilo Princip school

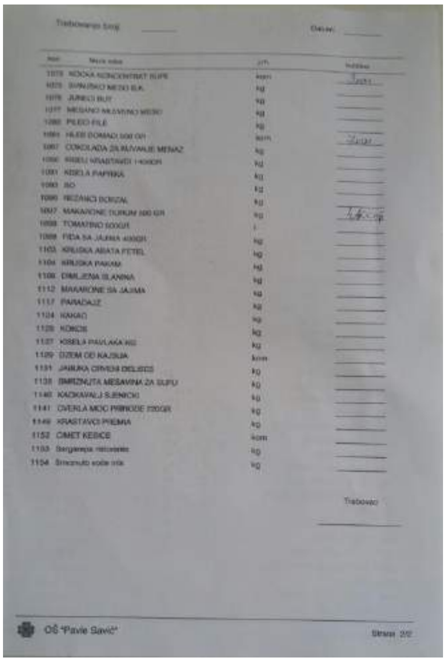
Source: Gavrilo Princip school, http://osgavriloprincip.znanje.info/428-Aktivnosti/5203-Prvo_cetiri

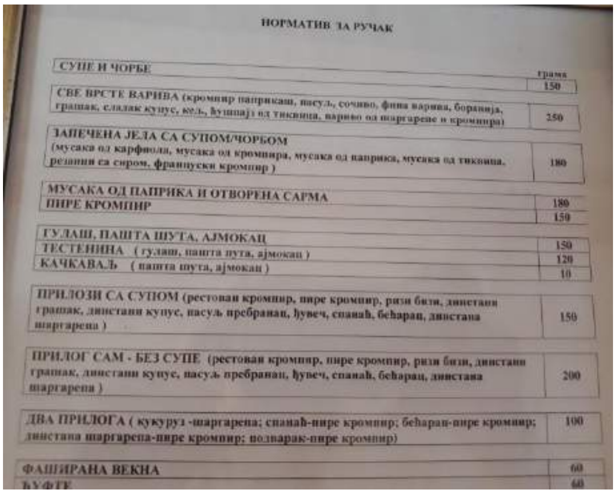
4.3. Organisation of School Meals

As previously noted, in primary school Pavle Savić the number of served meals varies from day to day, mostly due to illness of children. Therefore, every day around 6 p.m. cooks get information about the number of children who will have a lunch in the school following day. Cooks multiply the number of meals with the size of a portion and get the total quantity of food that should be prepared. According to this information, they contact their suppliers for procurement of necessary ingredients. The average price of a lunch is €1.50 (180 RSD) which is fully paid by parents.

Menus are planned on a weekly basis by the cooks, according to the normatives (examples provided in Figure 12) and guidelines prescribed by a nutritionist. The nutritionist is contracted and is not an employee of the school.

Figure 90. Example of normatives – food and meals types and quantities (gs) for Pavle Savic and Gavrilo Princip schools





НОРМАТИВ ЗА РУЧАК

	грама
СУПЕ И ЧОРБЕ	150
СВЕ ВРСТЕ ВАРИВА (кромпир паприкаш, пасуљ, сочиво, фина варива, боранија, грашак, слатак купус, кељ, ђувеч од тиквица, вариво од шаргарепе и кромпира)	250
ЗАПЕЧЕНА ЈЕЛА СА СУПОМ/ЧОРБОМ (мусака од карфиола, мусака од кромпира, мусака од паприка, мусака од тиквица, резанци са сиром, француски кромпир)	180
МУСАКА ОД ПАПРИКА И ОТВОРЕНА САРМА	180
ПИРЕ КРОМПИР	150
ГУЛАШ, ПАШТА ШУТА, АЈМОКАЦ	150
ТЕСТЕНИНА (гулаш, пашта шута, ајмокац)	120
КАЧКАВАЉ (пашта шута, ајмокац)	10
ПРИЛОЗИ СА СУПОМ (рестован кромпир, пире кромпир, ризи бизи, динстани грашак, динстани купус, пасуљ пребранац, ђувеч, спанаћ, беһарац, динстана шаргарепа)	150
ПРИЛОГ САМ - БЕЗ СУПЕ (рестован кромпир, пире кромпир, ризи бизи, динстани грашак, динстани купус, пасуљ пребранац, ђувеч, спанаћ, беһарац, динстана шаргарепа)	200
ДВА ПРИЛОГА (кукуруз -шаргарепа; спанаћ-пире кромпир; беһарац-пире кромпир; динстана шаргарепа-пире кромпир; подварак-пире кромпир)	100
ФАШИРАНА ВЕКНА	60
ЋУФТЕ	60

Guidelines provided by the nutritionist stipulate that the following recommendations should be taken into account when designing school meals to ensure the meals adhere to the principles of good diet and are benefical for health. :

1. *To eat fruit 15-30 min before the meal or 3h after the meal;*
2. *To drink water before meal or 1-2 h after the meal*
3. *Start the meal with the salad*
4. *From time to time use whole grain and corn bread; prepare cakes of whole grain flour, use olive oil for the salads and vegetable dishes, use whole grain rice*
5. *Avoid the preparation of fried meat and fish; Do not add browned flout to dishes;*
6. *Use herbs to spice up dishes, such as: basil for fresh salad, oregano for dishes with pasta: spagetti, goulash, tomatoe sauce, etc., mint for beans and parsley to every dish.*

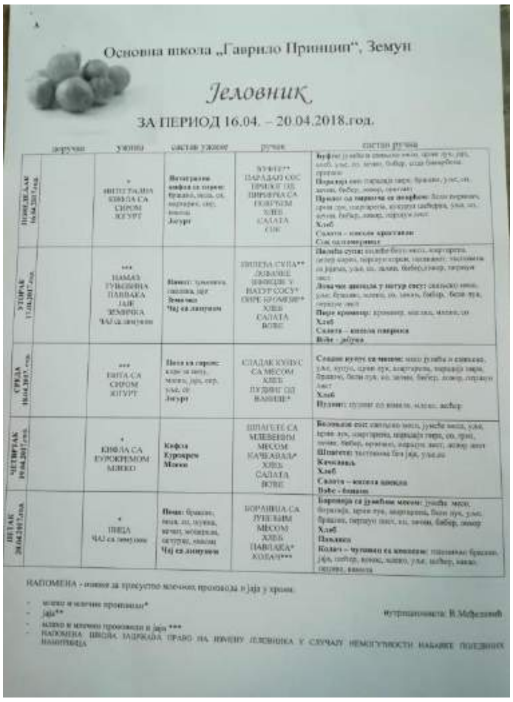
Despite the recommendations listed above, the analysed menus (Table 6) show that salad is not served at the beginning of the meal (as recommended by the nutritionist), while bread is always served (even with pasta and potato-based dishes). Dessert is usually fruit based, though cakes are occassionally served.

Table 6. Examples of menus in Pavle Savić school

Day	Menu 1 Autumn-Winter 2017	Menu 2 Spring-Summer 2018
Monday	Vegetable soup, macaroni and cheese, bread, salad, fruit	Beans, cabbage salad, bread, fruit
Tuesday	Peas with beef meat, bread, fruit	Vegetable soup, pilaf of whole grain rice and chicken breasts, salad, bread, fruit
Wednesday	Tomato soup, baked fish, rice, salad, bread, fruit	Stew with potatoes and beef meat, salad, bread, cake
Thursday	Chicken soup, potato moussaka, salad, bread, fruit	Chicken soup, sarma of sauerkraut, bread, fruit
Friday	Cooked pork meat, cooked carrot, sour cream, bread, fruit	Schnitzel in the sauce, cooked green beans, bread, cake

In Gavrilo Princip, lunch is served to 145 children, at a price of €1.67 (200 RSD). Every day lunch is prepared for all children (145 children), no matter how many of the 145 children are in attendance and come to lunch. Lunches are fully paid for by the parents. Meal portions are standardized per meal component and quantity, according to normatives (Figure 13). Meat is served on 4 out of 5 days with some Mondays offering a meat-free dish. The menus are prepared by a contracted nutritionist on the weekly basis who is not a school employee. Besides the list of the dishes served, each meal provides specification of the ingredients and allergens present in the lunch, as depicted in the Figure 13 (columns 5 and 6 in the left hand side picture).

Figure 91. Example of the weekly menu in Gavrilo Princip school


Основна школа „Гаврило Принцип", Земун
Јеловник
ЗА ПЕРИОД 16.04. – 20.04.2018.год.

Day	Lunch
Monday	Meat balls, tomatoe sauce, rice with vegetables, bread, salad, juice
Tuesday	Chicken soup, schnitzel in the sauce, mashed potatoes, bread, salad, fruit
Wednesday	Cooked cabbage with meat, bread, vanilla pudding
Thursday	Spagetti Bolognese, hard cheese, bread, salad, fruit
Friday	Green beans with beef meat, bread, sour cream, cake

4.4.Kitchens and Canteens

In Pavle Savic, meals are prepared in the school's own kitchen, which is very modestly equipped. There is a boiler, a stove, a refrigerator and three ovens. The school kitchen has no specialist equipment for food preparation except a mixer. Food preparation is done manually (peeling, chopping, etc.) and the kitchen space has no heating system. There is also a storage space equipped with a dozen shelves. Canteen walls are painted in bright colours. Tables in the canteen are designated for four persons, made of wood and accompanied by four children-size chairs (Figure 14). Considering that the children are divided in groups during the lunch, according to school employees, organization is fairly good and there is no crowd in the canteen.

Figure 92. Equipment of kitchen and canteen in Pavle Savic school

Gavrilo Princip school has its own kitchen on the school premises. The kitchen is equipped with machines for peeling potatoes, cutting cabbage and salads, and a mixer. There is no dishwasher, though the cooks discussed how they would find a dishwasher very helpful, given the large number of meals prepared and dishes used on a daily basis. There is a plan to purchase a special convection oven with larger capacities. In this specific appliance, cooks would be able to bake a dozen portions of food at the same time, while the final product would be of the same quality for all children. Beside food preparation, the cooks' responsibilities encompass hygiene maintenance, disinfection of tables, direct communication with the nutritionist, and classification of food ingredients from suppliers' deliveries. The school's canteen is child friendly, very colourfully decorated and contains children-size-adjusted elements and furniture. All tables seat 4-6 children at any one time and there is plenty of space between tables so that children can easily pass by and move around the canteen.

Figure 93. Canteen in Gavrilo Princip school

4.5.Lunchtime Service

Only one lunch dish is served daily in Pavle Savic school. Lunch is served from 11:30 to 13:00, so it lasts for a total of 90 mins. Children are divided into two groups, with each group having 45 minutes on average to eat their lunch. Portions of meal are standardized by meal content and quantity and cooks have precise normatives per portion, for instance, size of served macaroni is 200 g per portion. Although portions are equal for all children no matter their age, if children request, cooks can serve them extra portions. Therefore, portions are adjusted to children's appetite only if specifically are asked for. Children do not get trays with full lunch content. Firstly, soup is served at the children's tables after which the cooks serve the main meal with bread and salad, and at the end of the lunch, dessert is given (usually a piece of fruit). Pieces of bread are provided for all four children on the same plate (Figure 14), while salad and meals are served individually. In this school there are no drinks served during the lunch. During the soup and fruit servings, cooks have interaction with the children. During the lunch, cooks encourage children to eat everything which was served to them, frequently using the argument that their parents payed for it.

We found the same situation in Gavrilo Princip. Only one lunch dish is served daily, however, one child has diabetes, so his meal was adjusted (he did not get cake as a dessert, but fruit). Also, if someone fasts for religious reasons, they are given a different type of meal. Before the children arrive, cooks serve soup (if it is on the menu), and the main meal with bread and salad on the tables. Dessert (cookies or fruit) is served on common plates, so one plate belongs to one class. In this school, drinks are served during the lunch. The type of drink served depends on the season (tea or hot milk during the winter and juice during the summer). Drinks are located on a separate table and children take them on their own.

In both LOWschools, once their have finished their lunch, the children move their plates and cutlery from the table and the kitchen staff clean the canteen (and the dishes and cutlery). Lunch is organized from 12:00 to 13:15 in two rounds, each lasts for 35 min. Children who spend time in extended stay in school start their lunch at 12:35. After lunch, usually two more classes are organized in school. Staff usually do not not provide suggestions or encouragement about the food to children during lunchtime.

4.6. Waste Management and Plastics Use

All utensils and cutlery used for cooking and serving in both LOW schools are made of metal. However, according to the cooks in both schools, there are no restrictions or guidelines on the use of single use plastic. In both schools the kitchen/food waste is disposed of in containers together with general non food waste produced in schools, following the same protocols and using the same services. In Pavle Savic school, there are situations where the food waste is given to the nearby neighbour who feeds the dog with it. One 2nd grade class from Pavle Savic school visited Belgrade Fair and participated in the ecological workshop organized by City sanitation services, where they discussed sustainable ways of trash disposal (See Figure 16).

Figure 94. Ecological workshop with pupils from Pavle Savic school

Pavle Savic school, https://ospavlesavic.wordpress.com/активности/еколошка-радионица-2-10/

4.7. School Fruit and Vegetables Scheme

As Serbia is not an offical member of the EU 28, Serbian schools are not eligible to participate in the EU School Fruit and Vegetable Schemes. The provision and promotion of fruit and vegetable is very dependent on school policy. In both LOW schools, fruit and fresh vegetables were served at nearly every lunchtime. Besides salad, vegetables are also served as the part of the main dish, usually cooked (not fried or baked). There is significant presence of legumes in the menus. Apples represent the primary fruit served, while cabbage (cooked or fresh) and cucumber (pickled or fresh) are the most common served vegetables.

5. NUTRITIONAL COMPOSITION OF MENUS IN CASE SCHOOLS

This section presents the results of the nutritional composition analysis of the selected menus from the LOC and LOW schools. The results show the intended nutritive profile of school lunches at the selected case schools, based on the assumption that children consumed the full standard portions. As described previously, food composition analysis was carried out on 40 daily menus (over two weeks/seasons), 20 in LOC Schools and 20 in LOW Schools.

The analytical procedure was as follows. First, the food composition of each of the 40 daily menus was confirmed via three sources: meal normatives provided by the four schools, portion weights recorded by University of Belgrade (BEL) during the plate waste study, and photographs of lunches awaiting the arrival of children for lunch These data were then entered into a bespoke database and analytical tool (foodpbf.com) created by University of Zagreb (ZAG) for the Strength2Food project. Using this tool, the nutritional profile of each of the LOC and LOW menus was analysed to produce a full energy, macro- and micronutrient profile of a standard portion of each analysed menu. First stage analysis, undertaken by ZAG, used this tool to compare these profiles with WHO nutritive guidelines, which, at the time of analysis, were the referent standards for Serbian school food (Table 3, 7). Since completion of the 1st stage nutritional composition analysis, the Ministry of Education, Science and Technological Development (a Strength2Food partner) introduced, for the first time (September 2018) Serbian specific regulations for meal nutrition in primary schools (MPNTR, 2018[35]) (See Table 8). These regulations were developed by a Ministry working group who took advice from Strength2Food project partners. For the purposes of the nutritional analysis reported, the new Serbian specific standards were not used as the nutritional compositional analysis (1st stage) was completed in advance of the release of the new Serbian standards. Instead, the nutritional composition of Serbian School meals was calculated using portion sizes and normative quantities obtained through the plate waste study, reference tables from the EuroFIR database for Serbia (accessible to members at http://www.eurofir.org) and the WHO standards (Table 7).

A 2nd stage analysis is underway led by Serbian Strength2Food Parners, with support from ZAG, applying the new national Serbian nutritional guidelines for school food and also addressing formally with EuroFIR some specific identified data gaps in the most up to date EuroFIR Serbian database. Due to time constraints, this 2nd stage analysis is not complete and will be reported in subsequent scientific publications after the submission of D6.2.

Some further challenges were faced with the calculation of the nutritional profile of menus. Unfortunately, the schools sometimes used recipes for lunch that were not listed in the meal normatives. To address this issue, normatives for some meals were obtained from another school serving the same dish. In addition, portion weights did not always give reliable information on the quantities of individual ingredients used to make the dish. For example, a 150 ml portion of soup gave no information on the proportion of ingredients used to prepare it. To address this issue, photographs of the meals were used to aid confirmation of quantities of ingredients used for meal components, using known diameters of bowls and plates, and assuming a food density of 1 g/cm^3, in cases where the normative and recipe data were not available or not followed. Therefore, Food Composition Analysis (FCA) of the 20 lunches per case is based on best estimates of the quantities of ingredients used. Data for FCA of school meal nutrient composition are based on these portion sizes, normative quantities and reference

[35] Rulebook on Detailed Requirements for Organizing, Implementing and Monitoring Nutrition of Pupils in Elementary School. "Official Gazette of RS", no. 68/2018 of 7.9.2018

tables from the EuroFIR database for Serbia (accessible to members at http://www.eurofir.org) and using the WHO standards (Table 7).

Table 7: WHO Food and Nutrition Recommendations for school lunch energy intake and macronutrients for 7-9 year olds (of average physical activity)

Component	Serbia
	WHO - Food and nutrition policy for schools lunches for 7-9 years
Energy	30 % of EAR
	501-612 kcal
Proteins	not less than 30% of the RNI
	>8.49 g
Total fat	not more than 30% of food energy
	17-20 g
Saturated fatty acids	not more than 10% of food energy
	6-7 g
Carbohydrates	not less than 55% of food energy
	69-84 g
of which sugars	
Fibre	not less than 30% of the reference value >4.47 g
	not less than 40% of the RNI >3.48 mg
Iron	not less than 35% of the RNI >245 mg
Calcium	not less than 30% of the RNI >150 µg
Vitamin A	not less than 40% of the RNI >120 µg
Folate	not less than 35% of the RNI >10.5 mg
Vitamin C	

EAR- Estimated average requirement
RNI- Recommended Nutrient intake for Children and Adolescents

Table 8: Recommended daily energy intake and macronutrients according to gender and age of children (of average physical activity)

Age (years)	Gender[a]	Energy (E)		Carbohydrate[b]		Fat[c]		Protein[d]	
		kcal/day	kJ/day	% E/day	g/day	% E/day	g/day	% E/day	g/day
7-9	M	1970	8242	>50	>246.3	≤30	65.7	10-15	49.3-73.9
	F	1740	7280	>50	>217.5		58.0		43.5-65.3
10-13	M	2220	9288	>50	>277.5		74.0		55.5-83.3
	F	1845	7719	>50	>230.6		61.5		46.1-69.2
14-18	M	2755	11527	>50	>344.4		91.8		68.9-103.3
	F	2110	8828	>50	>263.8		70.3		52.8-79.1

Customised according to WHO (2006). Food and nutrition policy for schools. A tool for the development of school nutrition programmes in the European Region. Copenhagen, World Health Organization Regional Office for Europe

[a] M male, F female
[b] Of which free sugars <10% E/day, fibre >10g/1000kcal/day
[c] Of which saturated fats <10% E/day, trans fats <1% E/day
[d] Of total daily quantity of protein at least 50% muct contain high biological value proteins. The proportion of proteins can be up to 20% daily energy intake.

In the results that follow (Figures 17-23), the proportions are presented of daily menus across both cases that were found to meet the recommended WHO energy, macro- and micronutrient thresholds as shown in Tables 7. To begin with however, a consolidated summary is presented of the energy, macro- and micronutrient profiles of an average daily menu in LOC and LOW schools, respectively (Table 9). These data were produced by averaging the energy, macro- and micronutrient profiles of all 20 daily menus in LOC schools, and LOW schools, respectively. The results are expressed per standard portion as average ± standard error. These data are based on average weights per meal of 495 g and 417 g for LOC and LOW schools respectively (reported in Section 5.1).

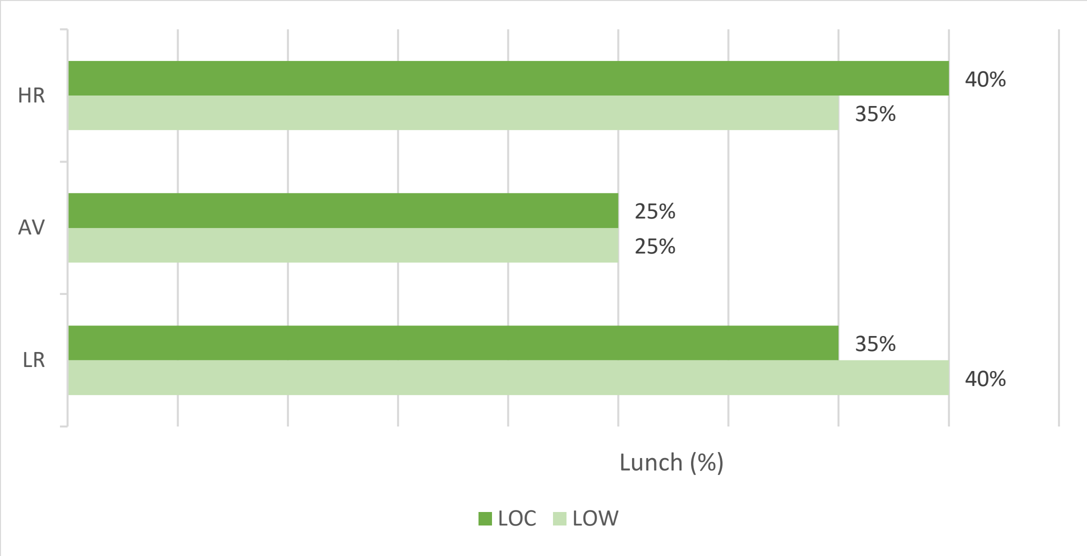
Parameter (average ± SD)	**LOC**	**LOW**	**ω^2-ANOVA**
ENERGY and MACRONUTRIENTS			
Energy (kcal)	561.04 ± 185.81	546.08 ± 113.36	0
Total proteins (g)	22.47 ± 5.11	21.92 ± 6.20	0
Total carbohydrates (g)	72.04 ± 20.20	64.17 ± 17.22	0
Dietary fibre (g)	6.77 ± 3.73	5.71 ± 1.63	0
Total fat (g)	19.57 ± 11.80	22.09 ± 7.88	0
Saturated fatty acids (g)	4.77 ± 3.21	4.79 ± 2.58	0
VITAMINS			
Vitamin A (μg RE)*	56.89 ± 58.51	124.37 ± 260.40	0.0009 (no effect)
Vitamin B_1 (mg)	0.42 ± 0.18	0.49 ± 0.27	0

Vitamin B_2 (mg)	0.29 ± 0.09	0.32 ± 0.16	0
Niacin (mg)	6.14 ± 3.40	6.44 ± 3.75	0
Vitamin B_6 (mg)	0.49 ± 0.27	0.43 ± 0.30	0
Folate (µg)	78.97 ± 37.50	88.92 ± 59.89	0
Vitamin B_{12} (µg)	1.22 ± 1.28	1.15 ± 0.94	0
Vitamin C (mg)	38.37 ± 24.09	41.60 ± 42.37	0
Vitamin D (µg)	0.42 ± 0.33	0.26 ± 0.25	0
MINERALS			
Sodium (mg)	661.46 ± 310.47	748.02 ± 281.80	0
Potassium (mg)	922.10 ± 329.96	850.25 ± 358.29	0
Calcium (mg)	148.06 ± 61.81	112.58 ± 55.08	0.0011 (no effect)
Magnesium (mg)	88.04 ± 22.60	75.31 ± 25.22	0
Phosphor (mg)	307.21 ± 97.18	289.68 ± 79.88	0
Iron (mg)	3.33 ± 1.35	3.49 ± 0.83	0
Zinc (mg)	2.85 ± 1.39	2.99 ± 1.34	0
Copper (mg)	0.22 ± 0.12	0.19 ± 0.09	0

Table 9. Average energy and nutritive value of school lunches (n=20) per PSFP model

* Vitamin A data for carrots are missing from these LOC and LOW case average nutritional values.
Statistics:
ANOVA ω^2 significance values are in the following ranges:
0 - 0.063 not significant differences (no effect)
0.063 – 0.14 significant differences (medium effect)
>0.14 significant differences (high effect)
ANOVA ω^2 statistics was selected because of low bias and non-parametric correlation showing true relationship between data sets.

As Table 9 shows, for the menus analysed, the average lunch in both LOC and LOW schools contained slightly more calories than recommended for 7-9-year-olds, though macro-nutrients were generally within the recommended ranges. For both cases, school lunches were slightly low in Vitamin A (this is a provisional result due to missing data specifically on Vitamin a in the EuroFIR databased for Serbia) and considerably below the recommended quantities of vitamin D. Other vitamins were, on average, either at or above the recommended amounts. Both LOC and LOW school lunches were high in sodium, but below recommended quantities for potassium, calcium and the trace element copper. Other minerals were either at or above recommended quantities. No significant differences were found between LOC and LOW schools for any nutritional components (Table 9). The next part of the results shows the percentages of daily menus that met the nutritional recommendations set out in Tables 7 and 8. First, Figure 17 shows the proportion of daily lunches in LOC and LOW schools that met the recommended adequate calorie content, using a range of 501-612 kcal for adequate values (AV). It can be seen that only 25% of the analysed lunches in both cases were within recommended calorie levels. An equal proportion of menus in both cases contained calorie levels that were either above or below recommended levels.



Note: HR – higher than recommendation, AV- adequate value, LR – lower than recommendation; Food and nutrition policy for schools

Figure 95. Distribution of energy values of school lunches (n=20) per PSFP model according to WHO recommendation

Next we report the protein, fat and carbohydrate content of daily menus at LOC and LOW schools, as proportions of total energy intake, compared against WHO recommendations. Figure 18 shows that while protein levels were found to account for 16% of energy intake across both LOW and LOC schools, which is in line with WHO recommendations, total fat, on average, was found to contribute 36%, and 31%, respectively of energy intake. This is slightly above the WHO recommendations. For carbohydrates, on average, 47% and 51% of energy intake comes from carbohydrates in LOC and LOW menus, respectively. Both these proportions are below the recommended minimum of 55% (Food and nutrition policy for schools, WHO).

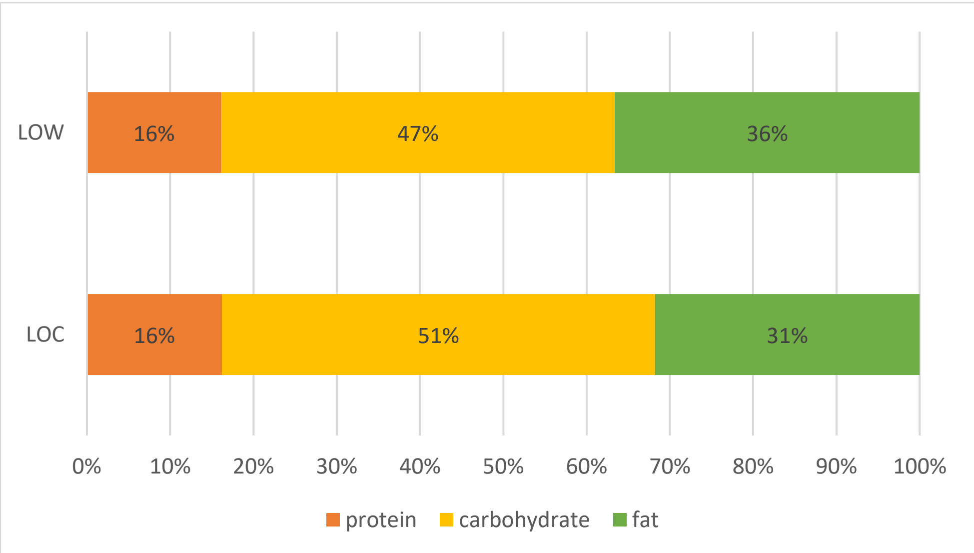
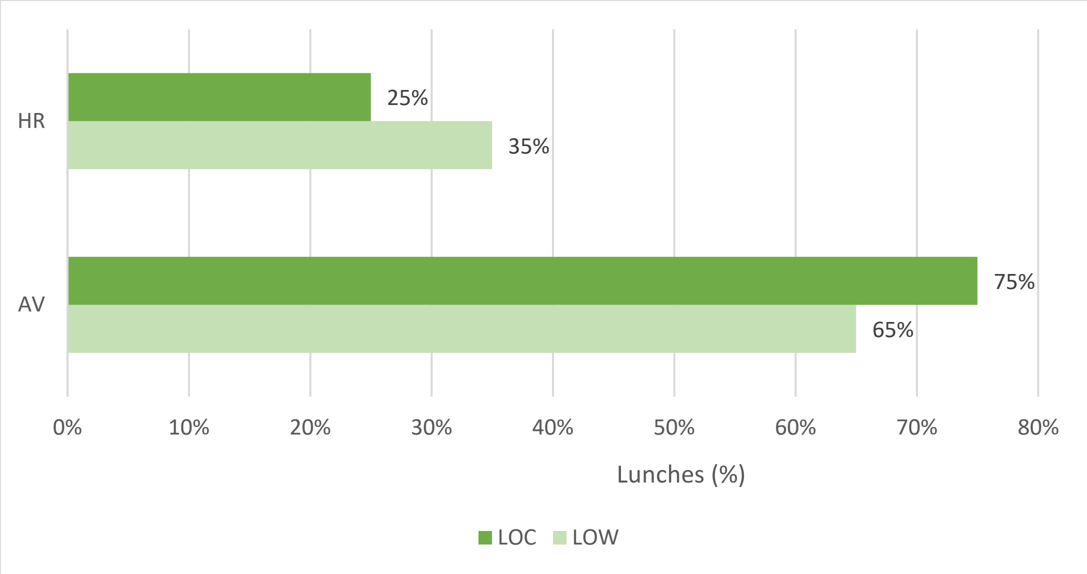


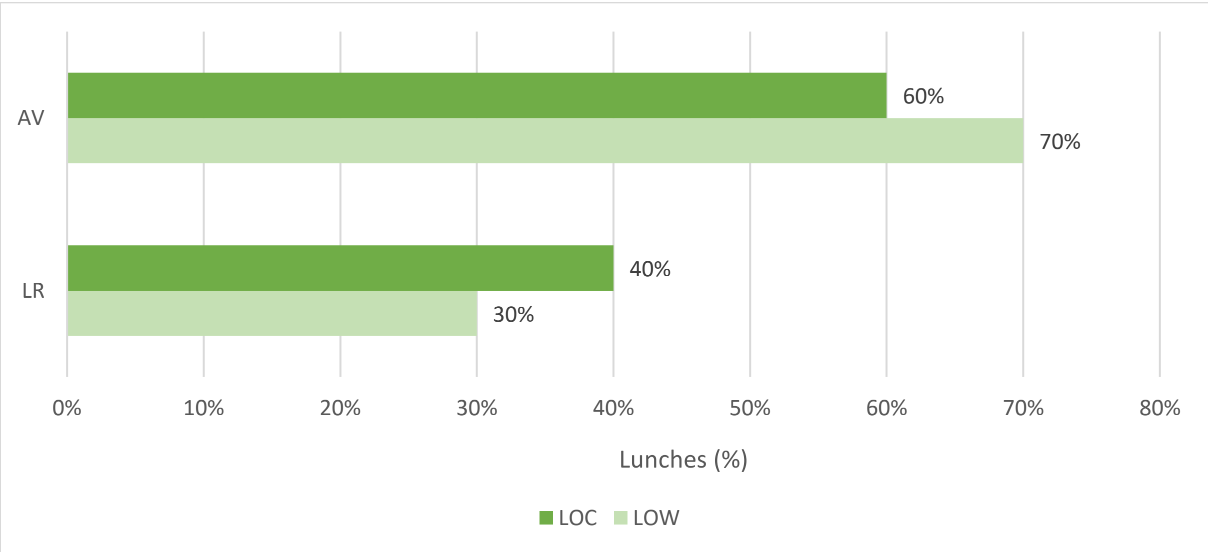
Figure 96. Average distribution of macronutrients of school lunches (n=20) per PSFP model



Note: HR – higher than recommendation, AV- adequate value; Food and nutrition policy for schools

Figure 97. Distribution of saturated fatty acids values of school lunches (n=20) per PSFP model according to WHO recommendation

Next we report the proportion of daily menus in LOC and LOW schools that met the WHO recommendations for levels of saturated fatty acids. As illustrated in Figure 19, 25%, and 35%, respectively of analysed meals were found to have higher than recommended levels of saturdated fat (no more than 10% of food energy). One explanation could be the quantity of full-fat dairy products and meat offered as part of the analysed meals.



Note: AV- adequate value, LR – lower than recommendation; Food and nutrition policy for schools

Figure 98. Distribution of dietary fibre values of school lunches (n=20) per PSFP model according to WHO recommendation

Finally we report the proportion of daily menus at LOC and LOW schools that met the WHO recommendation for levels of dietary fibre. There are increasing concerns about insufficient fibre intake in Serbian diets. While on average the fibre content of the analysed menus was of acceptable levels across both cases (Table 9), around one third of the analysed menus were found to have lower than recommended levels of fibre (Figure 20), with LOC schools having more lunches low in fibre than LOW schools. This is likely due to the larger quantities of fresh fruit and vegetables given to children in LOW school lunches (169 g vegetables/LOW child/day, compared with 140 g/LOC child/day).

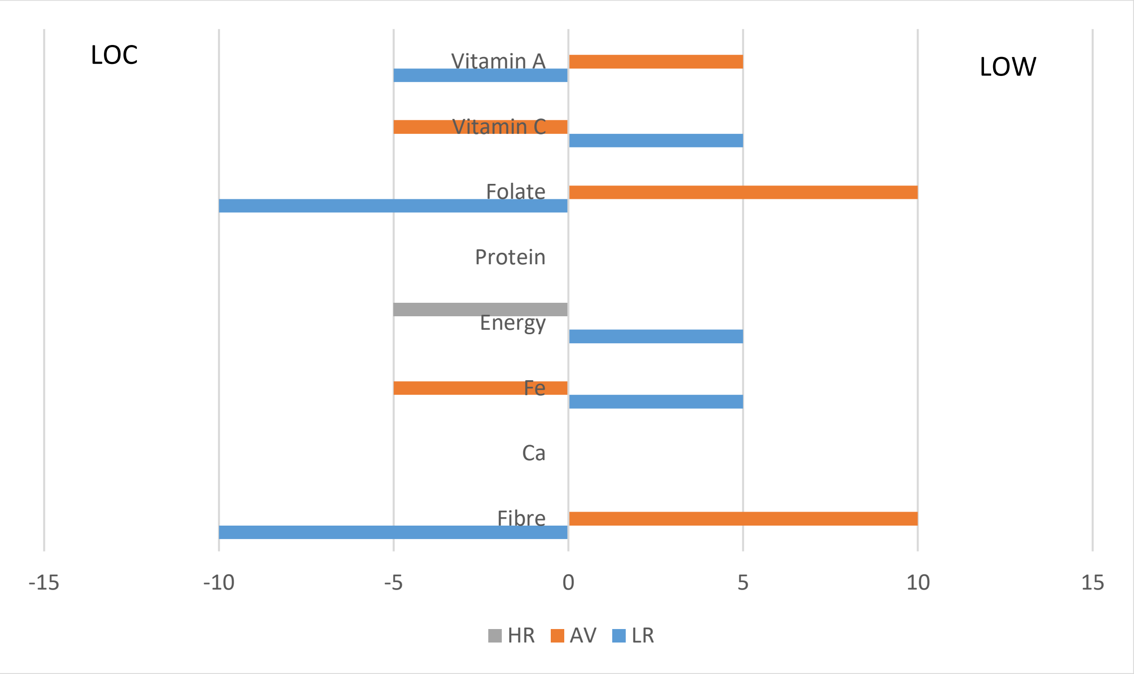


Figure 99. Micronutrient Frequency Difference Between LOW and LOC Models

Note: HR – higher than recommendation, AV- adequate value, LR – lower than recommendation; Food and nutrition policy for schools

Figure 21 shows that while overall no significant differences were observed between LOC and LOW models in terms of micronutrient content, it is worth noting that some differences (up to 15%) in content levels were observed for vitamin A, folate, energy, iron, calcium and fibre between the models. No differences between models were observed for vitamin C and protein. For example, for vitamin A 18 menus from LOW model are LR (blue bar), 2 are AV (orange bar) and no menus are HR (grey bar), and 19 menus from LOC model are LR, 1 is AV and no menus are HR. So you can see the difference is only in one menu and that is 5 % for LR and also one menu (5%) for AV. Therefore 5% AV is more frequent in LOW model while 5% LR is more frequent in LOC Model. No difference is observed for HR.

Finally, we report the percentage of daily meals in LOC and LOW cases that met the WHO recommendations for vitamins and minerals. For school lunches, WHO has recommendations for three vitamins (folate, vitamin A and C) and two minerals (calcium and iron). Figures 21 and 22 present these results. For folate and vitamin A (Figure 21), the large majority of analysed menus were below the recommended values: 18 and 16 menus, respectively, for folate from LOC and LOW model schools, and 19 and 18 menus, respectively, for vitamin A from LOC and LOW schools. However, for vitamin C, almost all meals across both models were found to have adequate levels. For iron (Figure 22), across both LOC and LOW schools, only 50% of meals were found to have adequate iron levels. Regarding calcium, without exception, all meal Ca^{2+} contents were below recommended levels, which is of significant concern for rapidly growing children.

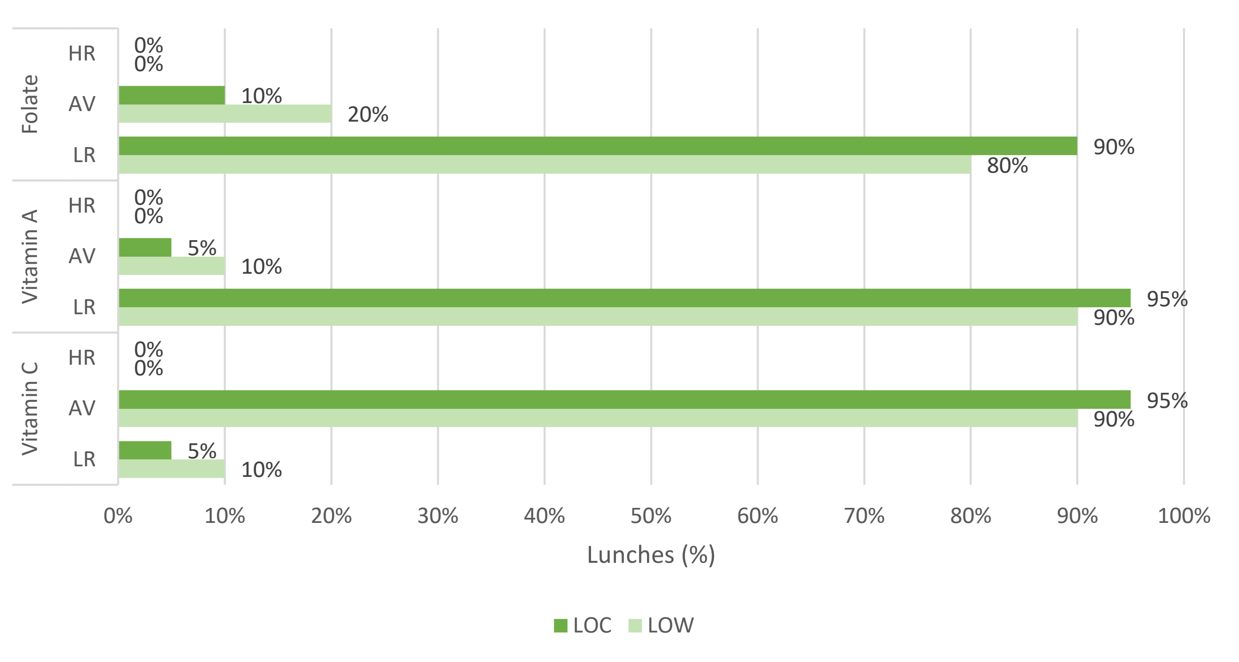


Figure 100. Frequency differences (%) between LOW and LOC model schools in selected vitamin contents of meals in relation to recommended values (20 meals per model)

Note: HR – higher than recommendation, AV- adequate value, LR – lower than recommendation; Food and nutrition policy for schools

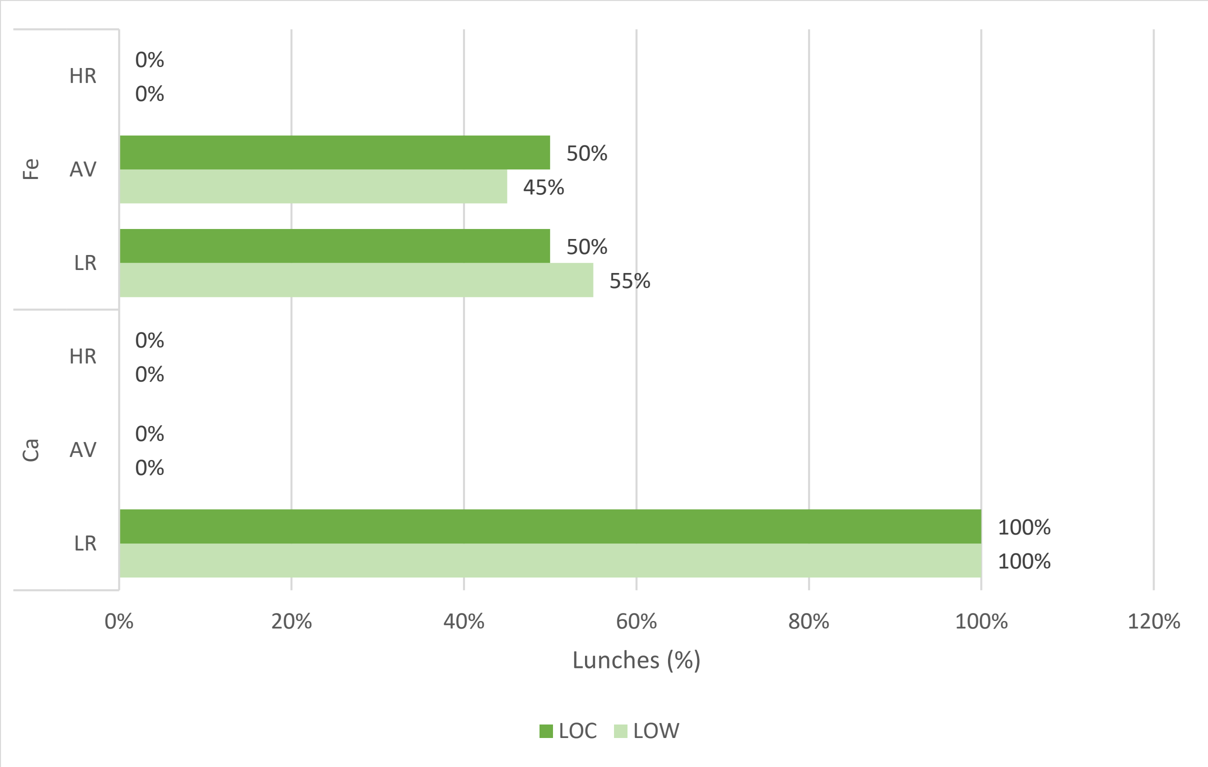


Figure 101. Frequency differences (%) between LOW and LOC model schools in selected mineral contents of meals in relation to recommended values (20 meals per model)

Note: HR – higher than recommendation, AV- adequate value, LR – lower than recommendation; Food and nutrition policy for schools

To summarise, the nutritional composition of the average lunche across the LOC and LOW schools were very similar in terms of overall energy and macronutrient contents, and close to recommended quantities. However, in terms of specific daily menus, both LOC and LOW case schools had menus with higher than recommended levels of saturated fat and lower than recommended levels of fibre. Our analysis indicates that differences between LOC and LOW schools was not due to features inherent in the PSFP models *per se*, but to the menu preferences of the cook in each school, together, sometimes, with input from an external nutritionist.

6. PLATE WASTE IN LOC AND LOW SCHOOLS

6.1. Plate Waste Methods

This section reports the results of the plate waste study conducted in the LOC and LOW schools. As explained in Section 1, the plate waste study was conducted during the 2017/18 school year in four schools (2 LOW and 2 LOC), profiled in Sections 2 and 3. These schools also provided the menus from which the food composition analysis was conducted. A detailed description of the methodology is provided below. As far as we are aware, no previous studies of plate food waste generated in Serbian primary schools have been undertaken. Hence, this study is the first comprehensive study that attempts to quantify the proportion of primary school lunches not eaten by children.

Although edible food waste in school kitchens is generated at several levels (food delivered but never used, peelings/trimmings/discards, food prepared but not served, and served food not eaten by children (plate waste)), this study focused only on plate food waste due to its direct impact on a child's nutritional intake while at school and on meal planning and economics. In preparation for the plate waste study, a preliminary, fact finding Strength2Food survey of primary schools in Serbia was conducted in 2016/17 where, amongst many questions, the participating schools were asked to estimate the proportions of plate waste generated in their school. Of the 94 participating schools who prepared lunches in their own kitchens, over three quarters (76%) estimated that plate waste amounted to no more than 10% of served food, while the remaining 24% estimated that plate waste amounted to no more than 20% of served food.

As per the workplan for WP6.2, plate waste was collected in the 4 participating schools across 2*1 week periods (where a week equaled 5 consecutive school days from Monday to Friday), a spring/summer week and an autumn/winter week, giving a total of 10 days/school and 20 days/case. For LOC schools and LOW schools, plate waste was collected from 1306 and 1995 plates respectively (750 for Dositej Obradović, 556 for Ljuba Nenadović, 716 for Pavle Savić and 1279 for Gavrilo Princip) which represented all children taking school lunches on each data collection day. Across both cases, the majority of children were in 1st and 2nd grade and aged between 7-8 years.

On each data collection day, and for each meal served, five reference meal portions for each meal component were weighed by the research team in advance of lunchtime service. However, it was clear from the photographs of prepared dishes taken before children arrived that the portions served differed somewhat from the reference portions (for example depth of soup in bowls) measured by the research team. This is illustrated in Figure 24 for a dish at Gavrilo Princip school. Thus, photographs of the meal were used for checking quantities used for meal components, using known diameters of bowls and plates, and assuming a food density of 1 g/cm^3. For example, the weight of the weighed portion in the *ca* 16 cm-diameter dish shown in Figure 24 (left image), 346 g, is equivalent to a depth of *ca* 1.72 cm [346/(8*8*π)]. Depth of the served portion (Figure 24, right image), at *ca* 0.9 cm, is equivalent to only *ca* 160 g (allowing for the sloping side of the plate).

Figure 102. A weighed portion of French beans with veal (left image) compared with a portion waiting for children to arrive (right image)

A modified aggregate selective plate waste method (Comstock et al., 1979) was used to collect plate waste data. As plates were returned to the kitchen, the different components of food waste left on the plates/trays were separated, where practicable, into containers (bowls or plastic bags) across eight food categories: (1) soup, if served, (2) meat and fish (all meat and meat products, and fish and fish products); (3) vegetables as part of a main course (easily-separated vegetables, mixed vegetable stews, legume stews); (4) starchy carbohydrate component that could not easily be divided, e.g. rice and pasta dishes, with peas, mixed vegetables, etc; (5) fresh and processed salad side dishes; (6) bread, typically served with every meal; (7) a dessert of either fresh fruit, a pudding, cake/pastry slice or other confectionary product; (8) a calorific drink (i.e. not water). The school lunch generally comprised components from four or five of these 8 food categories (range 3-6 components).

Two aspects of the school lunch provision process presented particular problems for recording reliable plate waste. Fruit and cake/pastry desserts were often provided in bulk containers/trays by the servery for children to help themselves, and not all children took fruit. In addition, children were often allowed to take fruit with them to eat after the lunch break. It is also not known whether every child took a portion of cake/pastry. A second problem, particular to some schools, was central provision of bread and salads (such as sliced cucumber, pickled gherkins, beetroot) on the tables for children to help themselves, as shown in Figure 25. Typically, more bread and salad was available than the quantity specified in the normative.

Figure 103. Lunches at LOC schools Dositej Obradović (A) and Ljuba Nenadović (B), and LOW schools Pavle Savić (C) and Gavrilo Princip (D), showing centrally-placed dishes of bread and salad for several children

Average % waste per food component per meal served was determined by dividing the total waste collected by the number of meals served, expressed as a percentage of the initial served portion weight. The plate waste results are reported as follows. First, the total weight of planned food served and total collected plate waste across LOC and LOW schools, respectively, are presented in terms of total volume (kg), average/meal served (g), and as a proportion of total planned weight of food served. Secondly, we report the breakdown of plate waste collected by food category composition examining the differences, where found, across both cases. Thirdly, we illustrate differences in collected plate waste across different daily menus. Fourthly, we present our analysis of the nutritional losses associated with the plate waste and finally, we present our analysis of the financial cost of, and levels of embodied carbon attributed to, the total collected plate waste.

6.2. Total Plate Waste in LOC and LOW schools

While daily, one set meal is generally offered in Serbian schools, many meal components were served across the full data collection period. Many of these served components contain water (and sometimes oil, such as deep-fried fish fingers) as well as the initial ingredients. Therefore, calculations of the economic and nutritional consequences of plate waste need reliable information on menu normatives as well as portion sizes given to children. For various reasons, these were not always available (see Section 5), so some data had to be estimated, mainly from photographs of served meals.

Table 10. Quantities of meals served and plate waste across all food categories and both seasons in two schools per case (20 days per PSFP case)

	LOC	LOW
No. of meals served	1306	1995
Total planned weight of food served (kg)	646.0	831.7
Average weight of meal served (g)	494.6	416.9
Collected plate waste (kg)	119.9	269.3
Average collected plate waste/meal served (g)	88.9	132.3
Percentage plate waste	18.7	31.5

Table 10 reports, for the full plate waste data collection period, total weight of collected plate waste for LOC and LOW case alongside the total number of meals served, the total planned weight of food served (kg); the average planned weight of food/meal served (g); the average weight of collected plate waste/meal served (g); and collected plate waste as a proportion of total planned weight of food served (%). As the total number of meals served was greater in LOW case, the total planned weight of meals served and total weight of collected plate wastes were inevitably higher. Interestingly though, the average planned weight of food/meal served was 19% higher in LOC (496.6 g) than LOW case schools (416.9 g), though it is important to note that large differences in average planned weights of food/meal served were found between the two LOC schools with a range of 371-581 g/meal served. Average plate waste in LOW schools (132.2 g) was considerably higher (76%) than in LOC schools (88.9 g); however, there is no indication that these differences are associated with, or were influenced by, PSFP model. Instead lunch service factors including length of lunch break, level and type of staff encouragement of children and canteen design and layout are all more likely factors that contribute to, and influence levels and composition of collected plate waste.

6.3. Total Plate Waste by Food Categories in LOC and LOW schools

In this section, we present a detailed analysis of the compositional breakdown of the plate waste in LOC and LOW schools across the 8 food categories. Category plate waste data can be represented in two ways, which we report separately. First, we report the category waste as a proportion of the total waste for each case (Table 11) for the eight categories used (with desserts divided into fruit and non-fruit desserts). Then we report on the weights and/or percentages of waste to portions served, within each food category (Table 12).

Table 11. Plate wastes according to food category at collection time and their % contributions to total plate waste across two seasons in both schools per case (20 lunches per PSFP case)

Food categories	LOC		LOW	
	kg	%	kg	%
Soups	12.5	11.1	18.7	6.8
Starchy foods	7.2	6.4	38.1	13.9
Vegetables	38.8	34.4	43.1	31.0
Meat and fish	19.0	16.9	46.3	16.9
Salads	11.3	10.0	16.8	6.1
Bread	16.3	14.4	24.1	8.8
Fruit	5.9	5.3	35.4	12.9
Other desserts	1.6	1.5	9.5	3.5
Total Plate Waste	112.7	100	273.7	100

As Table 11 shows, across both cases, vegetables were the largest component (by weight) of collected plate waste (34.4% (vegetables) + 10.0% (salads) = 44.4%, LOC, and 31.0% (vegetables) + 6.1% (salads) = 37.1%, LOW), generating on average 40.7% of total collected plate waste, over twice as much as any other meal component. The second largest proportion of plate waste was meat and fish (protein) (16.9% for both LOC and LOW) followed by bread (11.6% on average across LOC and LOW) and starchy food (10.1% on average). The remaining food categories, namely fruit (9.1% on average), soups (8.9%) and non-fruit desserts (2.5%), collectively generated 20.5% of total plate waste collected across both cases.

Next we present results, across both cases, on how much waste was generated within each food category, as a proportion of the total weight of food served per category. For this, plate waste was analysed in two ways: by meal components (the eight components described above), and by food categories. Quantities of each component served and the component food waste generated are presented in Table 12. Category 8 (calorific drinks) is not included as a fruit juice (orange) was served on only one day in both LOC and LOW schools, and fruit juice waste was not recorded on one of those two occasions.

Plate waste food categories	Soups	Meat and fish	Vegetables	Starchy dishes	Side salads	Bread	Desserts
LOC case schools							
No. of served portions	344	1197	789	453	828	1166	1236
Total weight of served portions (kg)	65.3	98.8	179.6	81.9	48.3	43.8	96.9
Average weight of served food category/portion served (g)	189.8	82.5	227.6	180.8	58.3	37.6	78.4
Total weight of plate waste (kg)	12.5	19.0	38.8	7.2	11.3	16.3	7.6
Average plate waste/ served portion (g)	36.3	15.9	49.2	16.0	13.6	14.0	6.1
Proportion of plate waste/served portion (%)	19.2	19.2	21.6	8.8	23.3	37.1	7.8
LOW case schools							
No. of served portions	547	1719	1240	732	1122	1869	1856
Total weight of served portions (kg)	71.4	148.8	197.0	121.3	42.9	65.9	173.8
Average weight of served food category/portion served (g)	130.5	86.6	158.9	165.7	38.2	35.3	93.6
Total weight of plate waste (kg)	18.7	46.3	84.9	38.1	16.8	24.1	44.9
Average plate waste/ served portion (g)	34.1	26.9	68.5	52.0	14.9	12.9	24.2
Proportion of plate waste/served portion (%)	26.2	31.1	43.1	31.4	39.0	36.7	25.8

Table 12. Quantities of planned served foods and plate wastes according to plate waste sampling category across two seasons in both schools per case (20 lunches per PSFP case).

The main findings from Table 12 are as follows. Firstly, as more meals are served in LOW schools, the numbers of portions were greater in LOW schools for all food categories. Consequently, the total weight of each meal component served over the 20-day period was greater in LOW than LOC schools, except for side salads. Secondly, average portion weights varied according to food categories, and were greater in LOC schools for (1) soups, (3) vegetables, (4) starchy dishes, (5) side salads and (6) bread, while portion weights for (2) meat and fish and (7) desserts were greater in LOC school meals. The larger vegetable portion weights in LOC schools were due to much larger quantities of water present in some LOC school vegetable dishes. Thirdly, average weights of food wasted per meal component were similar in LOC and LOW schools for (1) soups, (5) side salads, and (6) bread. However, for (2) meat and fish, (3) vegetables, (4) starchy dishes and (7) desserts the average weight of food wasted/food category was greater in LOW than LOC schools. Fourthly, LOW schools were found to have higher percentages of waste as a proportion of food served per food category than LOC schools across all categories except for bread. For (3) vegetables, (4) starchy dishes and (7) desserts, the differences in % waste between LOW and LOC schools were over two-fold.

An additional piece of analysis was conducted on the Serbian waste data to identify whether there were any significant differences in plate waste by food category between LOC and LOW. Using Analysis of variance (ANOVA) combining plate waste across all food categories showed a highly significant difference in plate waste between LOC and LOW schools (P<0.001), with LOW schools having 55% more plate waste. Thus, apart from bread (Table 8), plate waste for all other food categories was at least 43% higher in LOW schools. Plate waste was also analysed in terms of menu normatives for each lunch over two weeks in each of the LOC and LOW schools. Thus, this analysis took account of individual meal ingredients and whether they were fresh or processed foods. The food categories were:

- A - Ambient foods (typically with long room temperature shelf lives)*
- B - Bread
- FV - Fresh vegetables*
- PV - Processed vegetables (frozen, pickled, canned)*
- FM - Fresh meat and fish
- PM - Processed meat and fish
- D - Dairy products (milk, jogurt, cream, butter, cheese)
- E - Eggs
- FF - Fresh fruit
- PF - Processed fruit (frozen, canned, juices)
- RM - Ready-made foods such as pastries, cakes, biscuits
- SF - Other starchy foods – potatoes, pasta/noodles, rice

* excluding potatoes, pasta and rice

Plate wastes per food category based on normative ingredient weights are shown cumulatively for each school in LOC and LOW models in Figure 26, ranked according to decreasing food waste [note that no processed fruit waste was present – either zero, not present or not recorded]. This also demonstrates the increased wastes from LOW model schools, which had more plate waste in every food category except ready-made foods (biscuit and confectionary desserts).

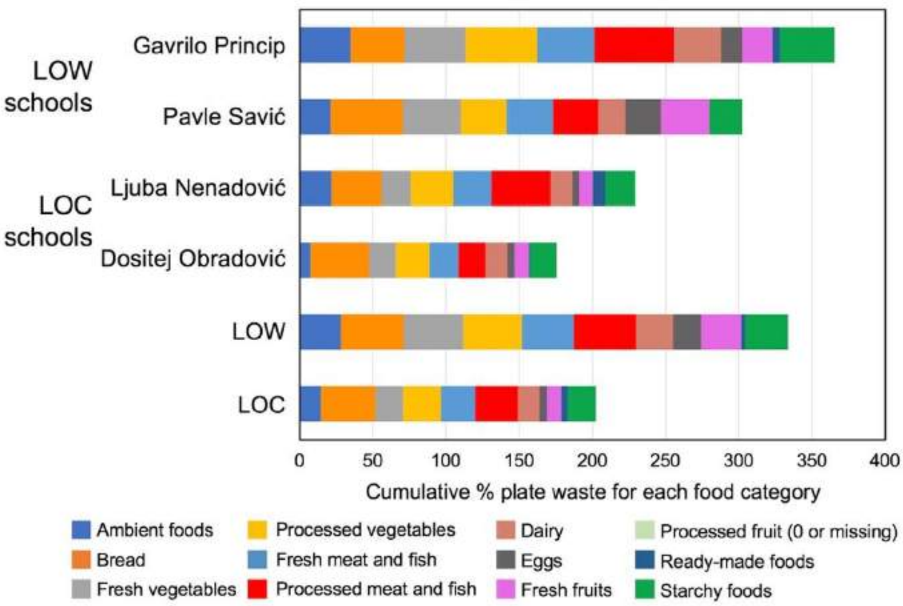


Figure 104. Cumulative % plate wastes for 12 food categories for each school, and LOC and LOW school mean cumulative food category plate wastes

Regarding % plate waste/served portion for normative ingredients, bread was again the largest plate waste food category in both LOC and LOW schools, with approx. 40% wasted (43.3% LOW schools, 37.3% LOC schools). The second largest food waste category was processed meat, with 42.5% and 29.7% wasted in LOC and LOW schools, respectively. In LOW schools, two other food categories generated at least 40% waste: fresh vegetables (40.4%) and processed vegetables (40.0%). The corresponding food category wastes in LOC schools were 19.1% and 25.9% respectively. The next largest food category % waste was, overall, fresh meat (35.5% LOW and 23.0% LOC schools), followed by other starchy foods (29.5% LOW and 19.7% LOC).

The wastes for ambient foods (28.0%, LOW and 14.4%, LOC) were due mainly to more sunflower (cooking) oil per meal being wasted by LOW schools (32.8%, 1.75 g/meal) than LOC schools (19.5%, 0.61 g/meal). Flour and sugar were the next largest ambient ingredient wastes per meal, again with waste being greater for LOW schools: flour – 19.6%, 1.25 g/meal (LOW) and 14.4%, 0.75 g/meal (LOC), and sugar – 12.9%, 1.34 g/meal (LOW) and 5.8%, 0.45 g/meal (LOC).

Dairy produce plate waste was 25.3%, LOW schools, and 14.7%, LOC schools. Although over a quarter of fresh fruit was recorded as wasted in LOW schools (27.4%), compared with only 10.0% in LOC schools, these data will be particularly unreliable because of the way in which fresh fruit was given to children (see above). No processed fruit waste was recorded in either LOC or LOW schools, though very few lunch menus contained any processed fruit.

During the sampling period, eggs were never served as eggs in their own right, but occasionally as components of other dishes, so 19.1 (LOW) and 4.5 (LOC) % waste for eggs represent wastes for dishes including eggs as an ingredient according to the normative. Ready-made foods generated low plate wastes in each PSFP model schools: only 4.4% and 2.5% in LOC and LOW schools, respectively, no doubt reflecting the children's preference for sweet foods.

6.4. Commentary on How Waste Differed Across Menus in LOC and LOW Schools

As discussed in Section 2, lunches in Serbian primary schools characteristically have the following components: soup (thick or a broth with noodles), a main course (usually meat and one or more vegetables, sometimes prepared separately, but also with meat and vegetables prepared together to save time and resources), a side salad of vegetables often pickled during the winter months, a dessert of either a piece of fresh fruit or a slice of cake/pastry or a biscuit/confectionary, often with chocolate or a pudding, usually made by adding dried ingredients to milk. Bread of some kind accompanies nearly all meals and water is available as a drink. As an alternative to meat and vegetables, sometimes pasta or rice dishes are given, and occasionally meat is replaced with either a legume dish (usually beans or peas, but also occasionally lentils) or a pasta and cheese dish. Fish is also given occasionally instead of meat. Three types of fish are given for school meals: filleted frozen fish (such as hake or catfish), battered fishcakes and fish fingers. All are usually fried – cooks say that frozen fish collapses during cooking unless it is battered first. Depending on the menu, one or other of these components may be omitted, particularly if the main course is very calorific, such as pasta.

The frequency of various types of meal component and individual foods served during the 20 days of data collection are presented in Table 13. Soups and pasta dishes were served in a quarter of the menus offered across the LOC and LOW schools. Meat and vegetable main course dishes were served in three quarters of menus offered while the remaining 25% was either fish with vegetables or no meat or fish dishes (either legumes or pasta with cheese). Meats used in main courses were divided fairly evenly between beef (veal), pork (fresh or dried/smoked) and chicken (white meat or legs). LOC and LOW schools differed very little in the frequencies of these types of dish. Minced meat (often beef and pork mixed) was sometimes used to make pasta bolognaise, meat balls or sarma, though this was more frequent in LOW rather than LOC schools. A rice main course was served four times in LOW schools, but only twice in LOC schools.

Meal component/ingredient	LOC total number of menus	LOW total number of menus
Soups	5	6
Pasta dishes	5	4
Rice dishes	2	4
Meat+vegetables:	15	16
beef+vegetables	4	4
pork+vegetables	5	4
chicken+vegetable	4	2
minced meat	2	4
Fish+vegetables	2	1
No meat or fish	3	3
Cheese dishes	3	1
Side salad:	13	11
cabbage salad	3	3
pickled gherkins	3	3.5
beetroot	0	3
tomato+cucumber	1	0
pickled peppers	0	1.5
potato salad	2	0
lettuce	4	0
No salad	7	9
Fruit:	7	14
apple	3	5
pear	0	2
banana	2	5
orange/mandarin	2	2
Cakes/pastries	9	4
Ready-made dessert	2	1
Puddings	1	1
No dessert	1	0
Bread	18	20
Vegetables as part of the main course:		
Peas	2	1
Potato	2	3
Cabbage	1	1
Carrot	0	2
Haricot beans	3	1

French beans	0	2
Kale	0	1
Spinach	0	1
Mixed vegetables	5	1

Table 13. Meal components, major ingredients and their frequencies of occurrence in lunch menus of both cases (total menus 20 per PSFP model)

A side salad was given on 13 and 11 occasions in LOC and LOW schools respectively, with a wide range of vegetables used across the schools. Chopped cabbage and pickled gherkins were the most popular salads, and frequencies of other salads varied from school to school, with one LOC school, for example, choosing to give summer salad vegetables (lettuce, cucumber and tomato) during December. Pickled beetroot (LOW schools) and red peppers (one LOW school) were also given as side salads.

Desserts consisted of fresh fruit or flour-based products. LOW schools gave fruit twice as much (14) compared to LOC schools (7). One LOC school (Dositej Obradović) served fresh fruit on average only once a week, whereas Pavle Savić (LOW) served fresh fruit on average four times a week. It is a pity that this school has now stopped (2018-2019 school year) using its kitchen to provide meals and is instead using an external caterer – a consequence of recently-introduced Ministry of Education (a Strength2Food partner) restrictions on non-teaching personnel in schools. Only one school (Dositej Obradović, LOC) gave lunch on one occasion without any dessert with the same school also serving two meals without any bread during the two weeks.

Analysis of the types, and frequencies, of vegetables served with the main course showed considerable differences between LOC and LOW schools. While small quantities of carrots and onions were included as ingredients in many dishes, it was not possible to separate them for food waste measurements. Therefore, vegetables listed in Table 13 represent vegetables that formed major components of main lunch dishes. Several vegetables were unique to LOW schools (carrots, French beans, kale and spinach, mainly in Gavrilo Princip lunches) during the data collection weeks. In contrast, nearly all the main courses with mixed vegetables were in LOC schools. Most potatoes served as a main course addition were mashed (made from boiled potatoes for all study schools, rather than instant mash, which some schools use to save time).

Meal component/ingredient	LOC % plate waste	LOW % plate waste
Soups	17.4	21.0
Pasta dishes	16.2	30.2
Rice dishes	16.9	27.3
Beef	30.4	57.9
Pork (including dried/smoked)	42.9	32.3
Chicken	26.9	30.3
Minced meat dishes	13.7	29.0
Cabbage salad	21.9	42.3
Pickled gherkins	57.0	41.6
Apples	21.2	32.0
Bread	37.1	40.6
Vegetables with main course	20.2	40.7
Potato with main course	13.3	38.4

Vegetables differing between LOC and LOW*	22.5	46.3

Table 14. Percentage plate wastes for meal components and major ingredients in LOC and LOW model schools#.

Data for foods where LOC school plate waste exceeds LOW school plate waste are shown in red text.
* For LOC schools, five meals of mixed vegetables from Table 13 and for LOW schools, one meal of mixed vegetables, plus French beans, kale and spinach.

As shown in sections 6.2 and 6.3, table 10 shows that average collected plate waste per meal served was considerably higher in LOW compare to LOC schools. The differences are not believed to be due to overall meal size and children not being able to eat the quantities of food given to them as the school giving the largest lunch portions overall was LOC school Dositej Obradović (581.1 g/meal), yet this school had the lowest % plate waste of all 4 schools (18.0%). Some of the differences could be due to overall differences between LOC and LOW schools in their menus, with ingredient frequencies illustrated in Table 9, and this may explain the differences between LOC and LOW schools in plate wastes for some of the main lunch ingredients.

In Table 14, LOW school plate waste was greater than LOC school plate waste for all food categories except pork and pickled gherkins. However, under the category "pork", both LOC schools included several meals using dried or smoked pork (such as smoked bacon or dried ribs) and these were evidently not liked by children. Pickled gherkins were also not liked by children in general, with no significant differences in pickled gherkin waste across the schools.

Even for the same dishes used in both LOC and LOW schools, such as lean pork and mashed potatoes, spaghetti bolognaise and macaroni cheese, plate waste was higher in the LOW model schools. For desserts, apple waste was also greater in LOW schools, even though in one LOW school (Gavrilo Princip) apples were cut in half to make them easier for children to eat. Nevertheless, differences in apple waste between LOC and LOW schools were not significant.

Differences between LOC and LOW schools in the type of vegetables used with main courses could explain some of the differences in % plate waste between case schools. LOW case schools showed more variety in the vegetables used, with four vegetables given with main courses being unique to LOW schools (carrots, French beans, kale and spinach), all of which generated plate wastes of at least 25% (despite one school cook trying to make the vegetable more palatable by mixing it with mashed potato). In contrast, LOC schools used mixed vegetables much more frequently, and these generated relatively small plate wastes. The contrast between these types of vegetable additions is illustrated in Table 10, showing a difference between LOC and LOW schools of over two-fold: 22.5% and 46.3%, respectively.

The time given for lunch was greater in LOC schools than in LOW schools: 40 and 50 min in LOC schools (Dositej Obradović and Ljuba Nenadović, respectively), compared with 30 min (Pavle Savić) and only 15-20 min (Gavrilo Princip) in LOW schools. Therefore, lack of time to eat the meal could explain the differences in plate waste, especially for Gavrilo Princip. Even so, soups, the first course, also generated slightly more plate waste in LOW than LOC schools: 17.4% and 21.0%, respectively, but the difference was not significant. Thus, lack of time to finish the meal in LOW schools seems likely to have been a factor in generating more plate waste for the main courses and desserts (at least apples).

From the observations of lunchtime service, it is clear that school lunch is a social occasion with many children concentrating on talking instead of eating, with few children attempting to finish up a course when told it was time to go. Addiitonal insights supporting the negative association between talking and eating comes from another primary school, in Novi Sad, which is part of our wider project. Figure 27 shows three tables immediately after lunch, and only two plates (diagonally across the table from each other, circled) have been essentially emptied of food. The remaining four plates on each table contain significant quantities of waste food, a couple of them looking as though they have hardly been touched. This is consistent with children talking to the person next to them, while those not talking get on with eating. Nevetheless, occasionally children in our plate waste study schools would come to the servery to ask for more!

So, to summarise, the % plate waste differences between LOC and LOW case schools are likely, in part, to be due to variation in vegetables used in main courses, some differences in the length of the lunch times between case schools, as well as differences in social, environmental or organisational factors, such as interactions between kitchen staff and children, discussed in section 3. Dositej Obradović kitchen staff were particular good at encouraging children to eat more of their meals.

Further information on why collected plate waste was higher in LOW rather than LOC schools may come from WP9.1.1, once food preference results from children in these schools have been analysed. The analysis of child preferences should highlight whether our plate waste schools differ in their children's food preferences both in general, and specifically for, those children who have lunches in school.

Figure 105. Three representative tables at Kosta Trifković school, Novi Sad immediately after the end of lunch showing wide variation in the amounts of plate waste generated. Empty bowls are circled.

6.5. Nutritional Impact of Plate Waste

Inevitably, any loss of food via plate waste means children are getting fewer calories and associated macro and micro nutrients then planned from their school lunch. Quantities of ingredients in menu normatives were used to calculate the losses of total energy (calories), macro- and micro-nutrients attributed to the collected plate waste.

Losses of total energy, macro- and micro-nutrient intake attributed to collected plate waste are presented in Tables 15 and 16 respectively. The overall average total energy intake per meal served (kcals), after adjustments for total energy loss attributed to collected plate waste, was 448 and 361 kcal for LOC and LOW schools respectively (Table 15). Both these values are below the recommended minimum total energy intake for school lunch (501 kcal, Section 5, Table 7), resulting in an estimated energy intake of around 80% and 65% of recommended lunch energy intakes for LOC and LOW schools respectively. Plate waste losses also attributed to lower than recommended intakes for all macro-nutrients, though average total protein quantities were still within an acceptable range across both cases. For other macro-nutrients, intakes from lunches in LOW schools were particular low, with only 60% recommended intake for carbohydrates, with a beneficial reduction of saturated fatty acids to less than 60% (Table 15), well below the maximum saturated fats content recommended for lunch (6 g, 30% recommended daily saturated fat content given in Table 7). The much larger macro-nutrient losses for children in LOW schools are illustrated in Figure 28. Note that the component experiencing the greatest intake loss is dietary fibre, a nutrient component already of major concern due to the gradually reducing in fibre intake by children in Serbia in recent years. Nevertheless, Table 15 shows that intake of dietary fibre while still within acceptable levels for children in LOC schools, LOW school children are estimated to be consuming only 70% of recommended dietary fibre levels.

Table 15. Nutritional composition of served lunches and plate waste compared with recommended quantities for lunch in LOC and LOW model schools (average of 20 lunches per model)

Parameter (average ± SD)	Nutritional composition of served lunches		Nutritional composition of plate waste		Nutritional composition of food consumed (% original FCA)		Nutrients consumed as % recommended for lunch*	
	LOC	LOW	LOC	LOW	LOC	LOW	LOC	LOW
Energy (kcal)	561 ± 186	546 ± 113	113 ± 55	178 ± 72	448 ± 143 (80)	368 ± 11 (67)	75.8-85.8	62.3-70.5
Total proteins (g)	22.5 ± 5.1	21.9 ± 6.2	4.4 ± 1.4	7.1 ± 4.2	18.1 ± 4.4 (80)	14.8 ± 5.5 (68)	81.5-138.2	66.7-113.0
Total carbohydrates (g)	72.0 ± 20.2	64.2 ± 17.2	15.7 ± 8.7	21.3 ± 6.9	56.3 ± 13.8 (79)	42.9 ± 15.7 (65)	76.3-86.4	58.1-65.7
Dietary fibre (g)	6.8 ± 3.7	5.7 ± 1.6	1.5 ± 0.9	2.0 ± 0.7	5.3 ± 3.1 (78)	3.7 ± 1.5 (64)	98.7-101.5	68.9-70.9
Total fat (g)	19.6 ± 11.8	22.1 ± 7.9	3.3 ± 2.7	6.9 ± 4.2	16.3 ± 9.6 (83)	15.2 ± 6.5 (69)	82.7-93.7	77.2-87.4
Saturated fatty acids (g)	4.8 ± 3.2	4.8 ± 2.6	0.8 ± 0.8	1.4 ± 1.2	4.0 ± 2.6 (85)	3.4 ± 2.0 (71)	60.6-69.0	51.5-58.6

* Ranges based on recommended ranges from Table 5, section 4.

Table 16. Micronutrient composition of served lunches and plate waste compared with recommended quantities for lunch in LOC and LOW model schools (average of 20 lunches per model)

Parameter (average ± SD)	Nutritional composition of served lunches		Nutritional composition of plate waste		Nutritional composition of food consumed (% original FCA)		Nutrients consumed as % recommended for lunch*	
VITAMINS	LOC	LOW	LOC	LOW	LOC	LOW	LOC	LOW
Vitamin A[#] (μg RE)	56.9 ± 58.5	124.4 ± 260.4	6.4 ± 6.1	68.9 ± 212.9	50.5 ± 53.4 (86)	55.5 ± 68.7 (71)	33.7	37.0
Vitamin B_1 (mg)	0.42 ± 0.18	0.49 ± 0.27	0.09 ± 0.05	0.18 ± 0.14	0.33 ± 0.14 (79)	0.31 ± 0.19 (65)	110.0	103.3
Vitamin B_2 (mg)	0.29 ± 0.09	0.32 ± 0.16	0.05 ± 0.02	0.12 ± 0.12	0.24 ± 0.08 (82)	0.20 ± 0.09 (66)	72.7	60.6
Niacin (mg)	6.1 ± 3.4	6.4 ± 3.7	1.1 ± 0.8	2.3 ± 1.8	5.0 ± 2.7 (88)	4.2 ± 2.7 (67)	138.9	116.7
Vitamin B_6 (mg)	0.49 ± 0.27	0.43 ± 0.30	0.08 ± 0.05	0.14 ± 0.09	0.41 ± 0.23 (83)	0.29 ± 0.24 (66)	195.2	138.1
Folate (μg)	79.0 ± 37.5	88.9 ± 59.9	13.7 ± 7.6	33.9 ± 30.2	65.3 ± 32.3 (82)	55.0 ± 36.7 (63)	72.6	61.1

Vitamin B_{12} (µg)	1.22 ± 1.28	1.15 ± 0.94	0.19 ± 0.21	0.31 ± 0.28	1.03 ± 1.09 (85)	0.84 ± 0.75 (61)	190.7	155.6
Vitamin C (mg)	38.4 ± 24.1	41.6 ± 42.4	5.4 ± 4.5	17.8 ± 31.9	33.0 ± 22.5 (85)	23.8 ± 14.7 (63)	137.5	99.2
Vitamin D (µg)	0.42 ± 0.33	0.26 ± 0.25	0.08 ± 0.07	0.08 ± 0.08	0.34 ± 0.26 (79)	0.18 ± 0.19 (70)	22.7	12.0
MINERALS								
Sodium (mg)	661 ± 311	748 ± 282	165 ± 83	252 ± 135	496 ± 248 (75)	496 ± 233 (66)	119.8	119.8
Potassium (mg)	922 ± 330	850 ± 358	158 ± 79	299 ± 187	764 ± 272 (83)	551 ± 269 (65)	67.0	48.3
Calcium (mg)	148.1 ± 61.8	112.6 ± 55.1	30.8 ± 15.2	38.3 ± 21.8	117.4 ± 50.9 (79)	74.3 ± 41.4 (65)	43.5	27.5
Magnesium (mg)	88.0 ± 22.6	75.3 ± 25.2	15.2 ± 5.8	26.0 ± 12.7	72.8 ± 19.7 (83)	49.3 ± 19.7 (65)	142.7	96.7
Phosphorus (mg)	307 ± 97	290 ± 80	56 ± 21	97 ± 50	251 ± 81 (82)	193 ± 68 (67)	104.7	80.4
Iron (mg)	3.3 ± 1.3	3.5 ± 0.8	0.67 ± 0.31	1.22 ± 0.58	2.6 ± 1.1 (80)	2.3 ± 0.7 (66)	86.7	76.7
Zinc (mg)	2.9 ± 1.4	3.0 ± 1.3	0.49 ± 0.33	0.89 ± 0.72	2.4 ± 1.1 (83)	2.1 ± 1.1 (69)	114.3	100.0
Copper (mg)	0.22 ± 0.12	0.19 ± 0.09	0.03 ± 0.02	0.05 ± 0.03	0.19 ± 0.10 (88)	0.14 ± 0.08 (69)	42.2-63.3	31.1-46.7

* Ranges based on recommended ranges from Table 5, section 4.
[#] Vitamin A data for carrots are not included.

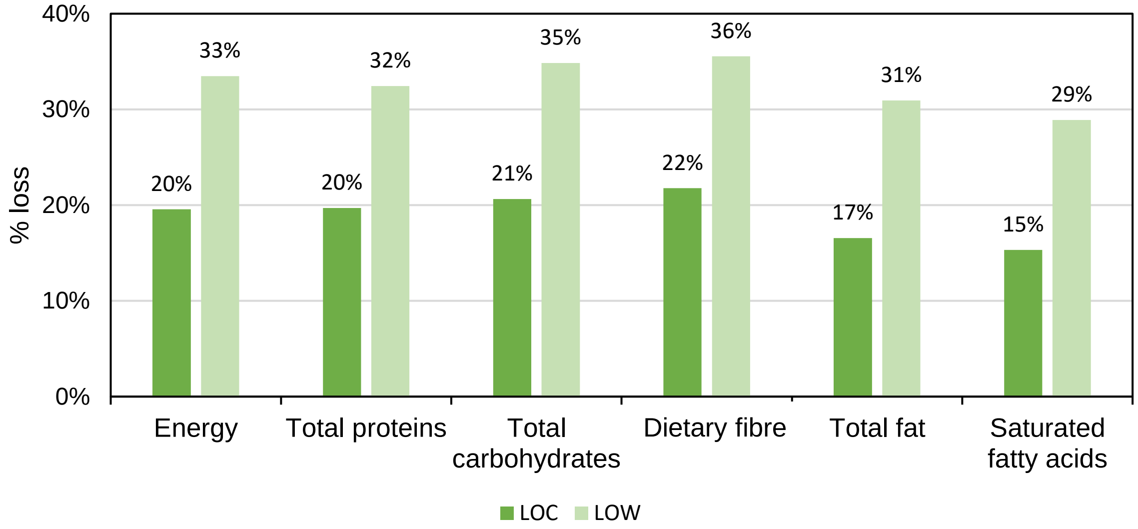


Figure 106. Losses of energy and macronutrient from lunch plate wastes at LOC and LOW schools (data are means of 20 lunches per model)

Plate waste losses of vitamins and minerals reflected those of macro-nutrients (Figure 29), with considerably greater losses in LOW compared with LOC schools: typically around 35% and 18% losses for LOW and LOC schools, respectively. Despite these plate waste losses, several vitamin and mineral intakes for lunch were within or greater than recommended levels for lunch across both cases, where lunch is assumed to deliver 30% of the recommended daily intake, and that specifically intake of vitamins B_1, B_6, B_{12}, C and niacin were within acceptable levels after plate waste had been accounted for.

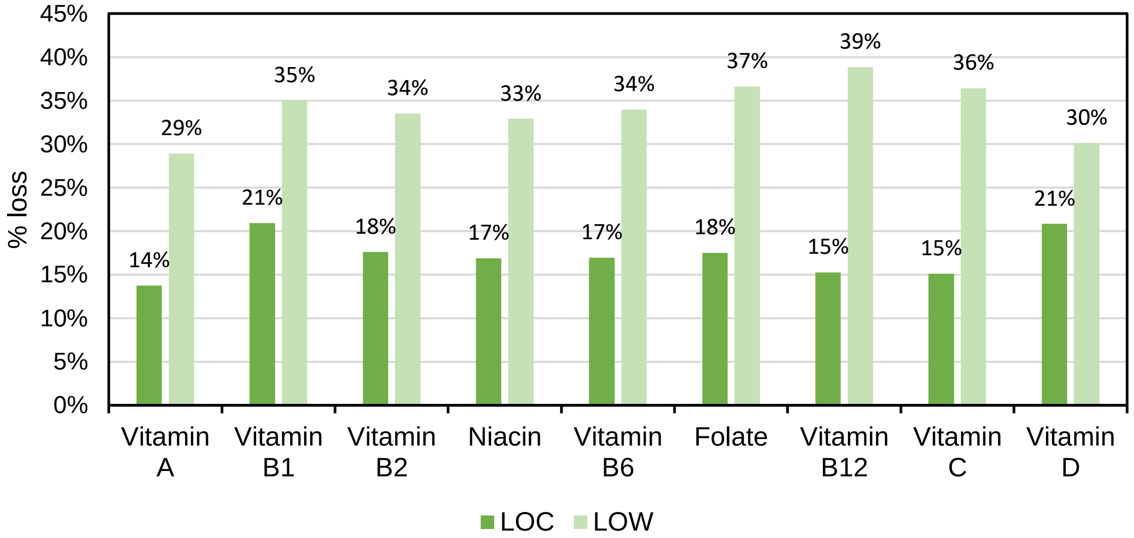


Figure 107. Losses of vitamins from lunch plate wastes at LOC and LOW schools (data are means of 20 lunches per model)

In contrast, levels of vitamins A, B_2, D and folate were below recommended quantities especially for vitamins A and D where intake was approimately 37% of recommended levels.

Results for Vitamin A are, however, provisional due to missing values in the EuroFIR database, and will be investigated in the 2nd stage nutritional analysis to be conducted by Strength2Food Serbian Partners and ZAG team. However, vitamin A contents do not include data for carrots, so no conclusions can be drawn on these differences in vitamin A content shown here.

The major sources of vitamin D are oily fish, such as tuna, and this is given (canned in oil or as a paté) in some Serbian schools, including Ljuba Nenadović and Gavrilo Princip. However, this is given exclusively for either breakfast or snacks, and is not used for lunches. Tuna is the only major source of natural vitamin D in the Serbian school meal diet. Milk in Serbia is not fortified with vitamin D as it is in some countries, such as Sweden, Finland and USA. It is unlikely that the deficiency in vitamin D in school lunches will be made up by meals eaten outside schools. Vitamin D deficiency is becoming a concern in Serbia, and high levels of vitamin D-deficiency in young adults hawere reported by Milovanović *et al*. (2015a, b).

Minerals (sodium, magnesium, zinc and for LOC schools also phosphorus) were at acceptable levels after accounting for plate wasts. Potassium, calcium and copper, already below recommended levels in meals served, were reduced by plate wastes to 67%, 43% and around 50% of recommended intake levels in LOC schools, respectively and to 48%, 27% and around 40% in LOW schools, respectively (Figure 30). Iron intakes, although at acceptable levels in served meals, were reduced by plate wastes to around 80% of recommended levels for both LOC and LOW schools. The low levels of calcium intake is a concern, though milk or yogurt (around 180-200 ml, providing around 250 mg additional calcium) are frequently served to children during their snack breaks, which were not included as part of this detailed nutritional compositional analysis.

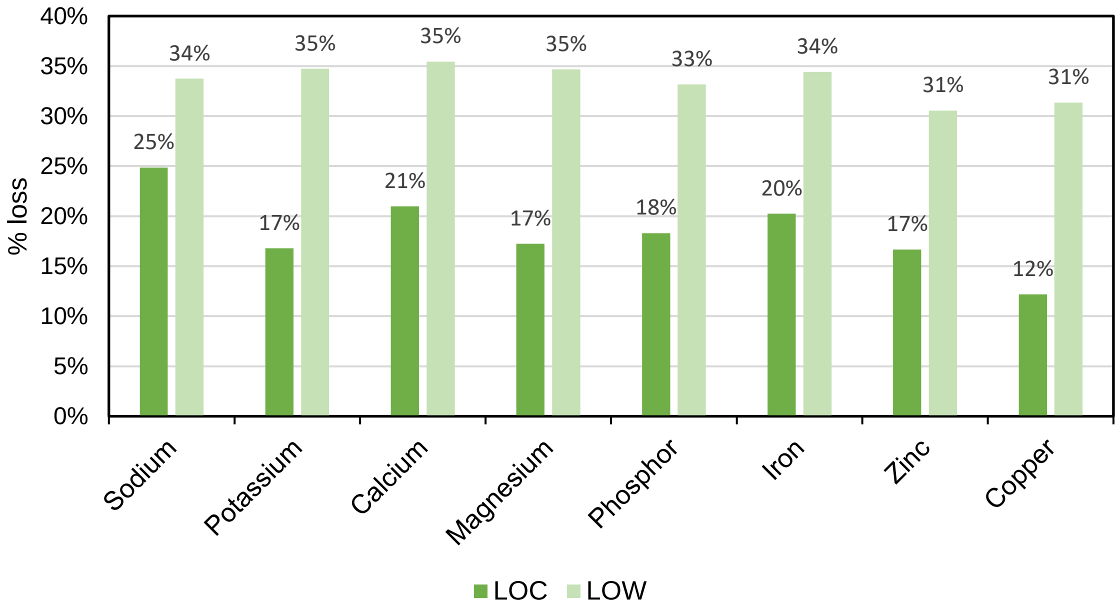


Figure 108. Losses of minerals from lunch plate wastes at LOC and LOW schools (data are means of 20 lunches per model)

Nutritional implications of plate waste for each food category are shown in Figure 31, which shows macro-nutrient contents of what was eaten as proportions of macro-nutrient contents of served meals for each of eight food categories. Several food categories were not included as they either did not vary much between LOC and LOW schools (bread, 56.3-65.6%), or were very minor components of meals (eggs and processed fruit, less than 5% meal weight) or had missing data for some schools (processed fruit, ready-made meals).

Proportions eaten were frequently very similar for each macro-nutrient because of the similarity in composition of foods making up the food category, such as fresh meat and fresh fruit. Two food categories (processed meats and ambient foods) showed diversity amongst macro-nutrients in proportions eaten. In particular carbohydrate losses of processed meats were less than other macro-nutrients for Ljuba Nenadović, and fat intake losses for ambient foods were greater than for other macro-nutrients in Pavle Savić lunches (caused by relatively large plate wastes for meals containing sunflower oil). Note that fresh meats contain no carbohydrate or fibre, and dairy products also normally contain no fibre.

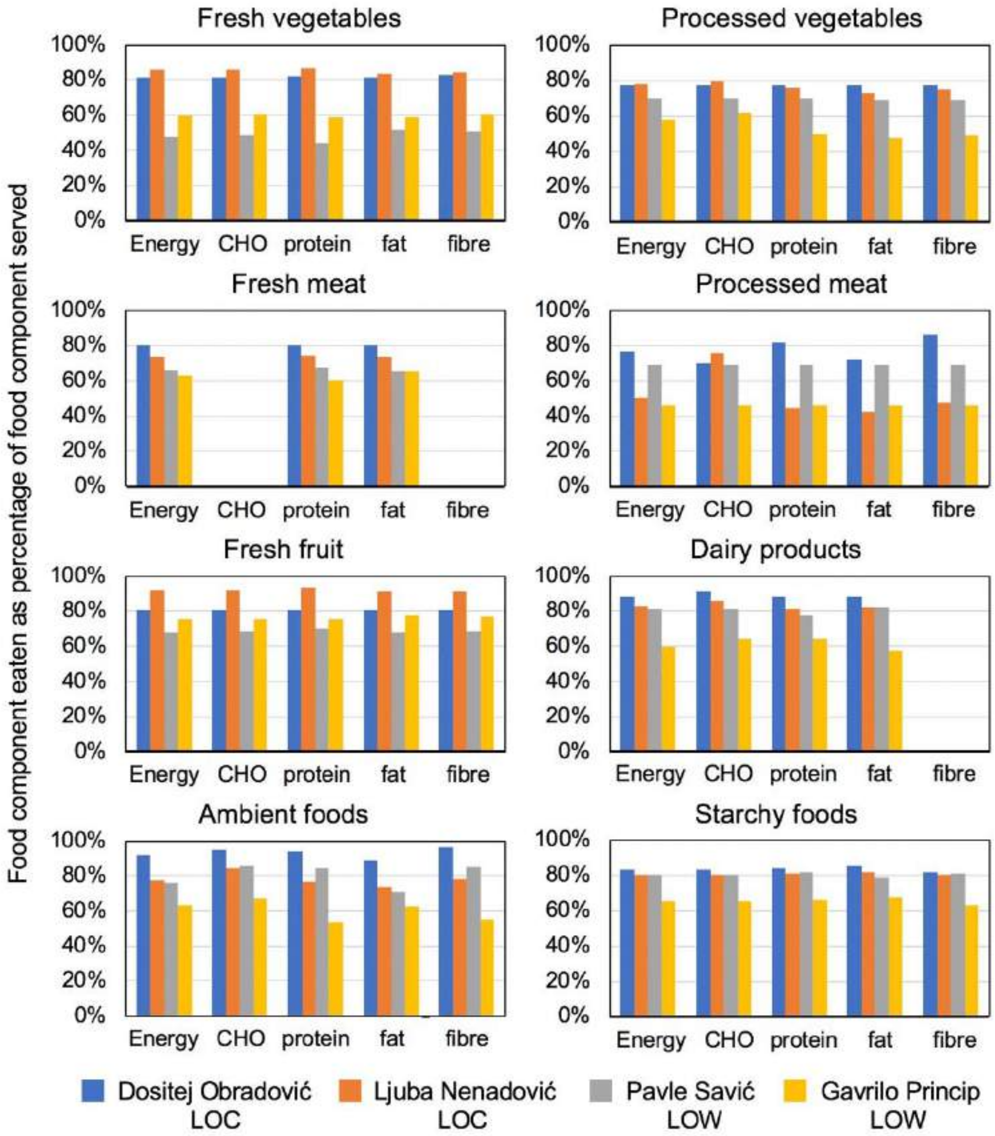


Figure 109. Weight of food categories eaten expressed as a percentage of weight of food category served

For five food categories, the LOW model school Gavrilo Princip had the lowest proportional intakes for all five macro-nutrients: processed vegetables (PV), fresh meat (FM), dairy products (D), ambient foods (A) and starchy foods (SF). The other LOW school, Pavle Savić, had the lowest proportional intakes for fresh vegetables (FV) and fresh fruit (FF). Large differences in plate waste nutrient losses between LOC and LOW schools were clearly evident for vegetables, though differences between LOC and LOW schools were less dramatic or clear for other food categories, though for every food category plate waste nutrient losses were greater in LOW than in LOC schools (Table 17). By far the greatest difference in food intake losses between LOC and LOW schools was for fresh vegetables (FV) (nearly 30% difference). The smallest difference between LOC and LOW school nutrient losses was for bread (B). Macro-nutrient component differences between LOC and LOW schools for other food categories were typically around 15%.

Case	FV	PV	FM	PM	SF	FF	D	E	B	RM	A
LOC	83.6	76.5	77.1	64.8	82.0	86.4	86.1	95.4	62.7	94.4	85.7
LOW	54.2	61.2	64.8	57.4	72.8	72.5	71.1	80.7	59.8	84.2	70.5
Diff*	29.4	15.3	12.3	7.4	9.2	13.9	15.0	14.7	2.9	10.2	15.2

Table 17. Proportions of food components eaten for lunches in LOC and LOW schools (%). (Food codes are explained in section 6.4).

* Diff is difference between LOC and LOW proportions (LOC-LOW) in %.

In conclusion, recommended calorie and nutrient contents for primary school lunches in the recently-published Serbian Ministry of Education, Science and Technological Development regulations (Službeni glasnik 2018), and as per the WHO standards, assume no plate waste. It is clear from our plate waste study that considerable quantities of nutrients (energy, macro and micro) are wasted because children don't eat everything they are given. Levels, and composition of, plate waste varied considerably from school to school, irrespective of whether schools were LOC or LOW cases, though on average more plate waste was collected, and more nutrients lost in LOW compared with LOC schools. Higher plate waste nutrient losses in LOW case schools are largely atrributed to initiatives of the cooks trying to get the children to eat more nutritious vegetables, or because time and resource pressures to feed all children at once. Some of the micro-nutrient intakes were worryingly low, not just because of plate waste, but because of poorly balanced vitamin and mineral contents in the menus offered.

6.6.Carbon Impact of Plate Waste

In this Section, we report our analysis of the carbon impact of collected plate waste. In 6.3 Serbia Country Report, we estimated the carbon emissions resulting from the transportation and disposal activities for the plate waste, and used this estimate as part of our calculation of the carbon emissions linked to the whole school meals supply chain for LOC and LOW cases. Here, we were interested in estimating the amounts of embodied carbon in the plate waste: i.e. the emissions associated with the production, processing and transportation of the foods that ended up as plate waste in the LOC and LOW case schools.

Briefly, the method to estimate the embodied carbon of the food waste was as follows. First, we made estimates for the 2 LOC and 2 LOW schools for the whole academic year (36 weeks), rather than the specific weeks of plate waste data collection. We made this calculation by multiplying *pro rata* the volumes of plate waste recorded over two weeks for the two schools. Therefore, the total waste volumes reported in this section are higher than the volumes in the other sections of this report. The waste rates of individual food items within each food category (e.g. beef within the meat and fish category) were estimated either from observations made from plate waste data collection (where this was possible) or from the proportions of specific food items given in menu/recipe information.

Having determined which food items comprised all the categories of collected plate waste in each case, and in which proportions, an average emissions factor per kg (EF) for each food waste category was calculated by dividing the total production emissions generated by all the items in the waste food category (in kgs CO_2eq) by the total weights of those items procured for the two schools in each case. In this way, the average EF for each food category took account of the varying proportions of specific food items within the waste category, and their specific EFs. If the waste food category only included one item (e.g., milk), the actual EF for this item was used as the category EF. Next, by multiplying the average EF for each food category by the total weight of collected plate waste recorded for each food categories in each case, the total production-related embodied carbon emissions for each food waste category were calculated. The same methodology was followed to calculate the transport-related embodied carbon emissions for each collected plate food waste category. Finally, the embodied emissions relating to the food waste itself (i.e. transportation and disposal of the waste) were added. All three components of the embodied carbon emissions (food production, transportation and waste disposal) were then summed to get the total embodied carbon emissions of the collected food plate waste in each case. Table 18 shows the results for both PSFP cases.

	LOC schools*			LOW schools*		
Waste category	Weight (kg)	Total CO_2eq (kg)	CO_2eq per average meal (kg)	Weight (kg)	Total CO_2eq (kg)	CO_2eq per average meal (kg)
Fresh fruit and vegetables	3202	2626		6649	4455	
Processed fruit and vegetables	835	1335		1823	2899	
Dairy	349	1663		817	3596	
Eggs	18	55		46	209	
Fresh meat	1050	7441		2222	20223	
Processed meat	313	1721		440	2892	
Bread	1227	2172		2214	3941	
Ambient	854	1665		1841	4345	
Ready-made foods	34	93		53	133	
Plate waste disposal		10159			21226	
TOTAL	7881	28930	0.32	16106	63919	0.42

Table 18. Estimated embodied carbon in plate waste in LOC and LOW case schools, per year and per meal (2 schools per case)

* 23508 and 35910 lunches per year for 2 LOC schools, combined, and 2 LOW schools, combined.

As Table 18 shows, we estimate that the total annual plate waste for 2 LOC case schools (7881 kg) contained embodied emissions of 28930 kgCO_2eq, which equates to 0.32 kgCO_2eq per average meal. The largest contribution to the total embodied carbon emissions was waste disposal (35%), followed closely by total meat (32%). Ambient foods (including bread), and fresh and processed vegetables combined contributed similar, smaller, amounts (13% and 14% respectively). Dairy, eggs and ready made foods all contributed very small amounts to total embodied carbon. The contribution of waste disposal was high because one of the schools used landfill as the waste disposal method, which is has a very high carbon burden.

For the 2 LOW schools, we estimate that the total annual plate waste (16106 kg) contains 63919 kgCO2eq of embodied carbon emissions equating to 0.42 kgC02eq per average meal served. Therefore, LOW case schools were found to have higher levels of embodied carbon emissions in their collected plate waste than LOC schools. This result is in line with expectations, as LOW schools generated higher quantities of waste. In LOW case schools, total meat was the largest contributor to total embodied carbon emissions, although waste disposal was only slightly smaller (36% vs 33%). Ambient foods including bread, and fresh and processed vegetables combined contributed modest smounts (13% and 12%, respectively). As in LOC case schools, dairy, eggs and ready made food all contributed very small amounts to embodied carbon emissions. Also like LOC case, the contribution of waste disposal was high because landfill disposal method was used by one school, which has a very high carbon burden.

6.7.Economic Impact of Plate Waste

In this Section, we report our analysis of the financial cost of the plate waste in LOC and LOW case schools. Data on an annual basis were calculated using cost/unit weight (volume) without VAT (typically 10% for fresh foods and staple foods, such as flour, and 20% for processed foods) from school food contracts with suppliers and total annual quantities for each food item given in procurement tender documentation. Costs on a per meal basis were calculated using plate waste data, menu normative weights per ingredient and ingredient cost/unit weight. [Note, cost/unit weight for some processed foods could be incorrect because of the way contract costs were presented: packet weights and kg unit weights were both provided and it was not obvious which of the two the cost referred to – cost/packet or cost/kg.] A conversion rate of 120 RSD/euro was used to convert prices to euros. Table 19 shows the results.

Waste categories	Annual weight bought (kg)		Annual weight wasted (kg)		Average cost per kg (€)		Annual cost of food bought (€)	
PSFP model	LOC	LOW	LOC	LOW	LOC	LOW	LOC	LOW
Fresh fruit and vegetables	3401	6075	542	2186	1.05	0.85	3661	5006
Processed fruit and vegetables	1290	3307	273	993	2.18	1.57	2517	4137
Dairy	513	1636	58	503	1.96	1.55	1001	2067
Eggs	134	306	7	43	1.71	1.33	208	383
Fresh meat	1685	2482	369	903	4.48	3.99	7604	9957
Processed meat	362	151	137	75	3.91	3.48	1406	580
Bread	1353	2893	508	1078	0.52	0.58	709	1678
Ambient	1185	1669	147	504	1.27	1.75	1348	2901
Ready-made foods	39	136	2.3	29	3.09	0.88	134	120
Starchy foods	2631	3000	530	982	1.27	1.17	1918	2209
TOTAL	12593	21655	2574	7297			20506	29037

Table 19. Annual quantities bought and wasted per food category and average food category costs in LOC and LOW case schools

As Table 19 shows, as more children eat school lunches in LOW compared with LOC schools (on average 65.3 and 99.7 lunches per day are served in LOC and LOW schools, respectively), considerably more food (by weight) was bought by LOW schools across every food category except processed meats. Even so, proportionally more food was bought by LOW schools than indicated by the differences in numbers having lunches: 53% more having lunches, but 72% more food bought.

These differences between LOC and LOW schools were magnified further once food waste was considered. On the basis of percentage plate waste per food category during the plate waste study, the total annual collected plate food waste was estimated to be three times larger in LOW compared with LOC schools. Again, the only food category not showing more plate waste from LOW schools was processed meats. The food category generating the greatest wastes in both case schools was fresh fruit and vegetables with a staggering estimated 2 t/year in the two LOW schools combined, 4-times as much as in the two LOC schools combined.

Interestingly, unit food prices were greater in LOC than in LOW schools for eight of the 10 food categories, and as such there is no evidence that the extra distance travelled by food to LOW schools resulted in increased prices. Not surprisingly, fresh meat unit prices were much greater than unit prices for any other cost category. The rather high unit cost for ready-made foods in LOC schools was due to a single food item (powdered puddings), which were more expensive than the biscuits used occasionally by LOW schools. The higher unit food prices in

LOC schools reduced the difference in total annual cost of foods bought between LOC and LOW schools to 42% (Table 19).

Waste categories	Annual cost of food wasted (€)		% food budget wasted		Average cost per meal* (€)		Average waste cost per meal* (€)	
PSFP model	LOC	LOW	LOC	LOW	LOC	LOW	LOC	LOW
Fresh fruit and vegetables	548	1768	15.0	35.3	0.10	0.12	0.01	0.04
Processed fruit and vegetables	501	1276	19.9	30.9	0.05	0.08	0.01	0.02
Dairy	114	602	11.4	29.1	0.04	0.03	0.01	0.01
Eggs	10	55	5.0	14.3	0.01	0.00	0.00	0.00
Fresh meat	1661	3631	21.8	36.5	0.19	0.19	0.04	0.07
Processed meat	531	294	37.8	50.7	0.06	0.03	0.02	0.01
Bread	267	625	37.7	37.3	0.02	0.02	0.01	0.01
Ambient	192	873	14.3	30.1	0.02	0.03	0.00	0.01
Ready-made foods	6	26	4.2	21.6	0.01	0.01	0.00	0.00
Starchy foods	367	681	19.1	30.9	0.08	0.07	0.01	0.02
TOTAL	4197	9831	20.5	33.9	0.58	0.57	0.12	0.19

Table 20. Estimated annual financial impact of plate waste per food category on LOC and LOW case schools and costs per meal

* Calculated as the average cost/meal for the food category cost in each LOC and LOW school, which is based on the average food category cost for lunches during the 10-day sampling for each school.

Table 20 compares the impact of plate waste on school food budgets. Because of the greater number of lunches served in LOW schools and their generally higher % plate wastes (section 5.2), the predicted annual cost of waste food, from plate waste only, was considerably greater in LOW schools, a difference of 2.3-fold between LOW and LOC schools. The food category generating by far the greatest financial loss was fresh meat, which accounted for 40% and 37% of the total food waste cost for LOC and LOW schools, respectively.

In both LOC and LOW schools, the food category generating the greatest % monetary waste was processed meat, with over 50% of the money spent on processed meats being wasted by LOW schools. However, processed meat represented only 13% and 3% of total food waste costs in LOC and LOW schools, respectively. Bread generated the next greatest % financial loss (37.7 and 37.3%, respectively, in LOC and LOW schools), though in absolute terms the low unit cost of bread meant this contributed only 6% to the total food waste cost for both PSFP model schools. Overall, LOC and LOW schools are losing 20.5% and 33.9%, respectively, of their total food budgets on waste food.

For the large majority of children getting school lunches, the only source of funding comes from parents. Thus, for the two LOW schools, nearly a third of the money given by parents for their children's lunches is wasted (30.4% and 32.5% in Pavle Savić and Gavrilo Princip, respectively). Nevertheless, the cost of the food for school lunches in Serbia is relatively low by European standards, being calculated from quantities used in menu normatives and plate waste data to be only 0.58€ and 0.57€ in LOC and LOW schools, respectively (Table 16) though it is worth noting that the cost/kg for every food category except bread and ambient foods was on average 25% higher for LOC compared with LOW schools, though the total costs/meal are similar across both cases due to differences in the proportions of food category ingredients. Nevertheless, because of the greater plate waste for LOW schools, the cost of food wasted per meal is still greater for LOW than LOC schools (€0.19, compared with €0.12, Table 16).

Despite Ministry regulations requiring schools to charge parents only for the cost of the meal ingredients, our four case schools were all charging parents around €1.67 (200 RSD) per child per day (Dositej Obradović 200 RSD, Ljuba Nenadović 170 RSD, Pavle Savić 210 RSD and Gavrilo Princip 200 RSD). Even though a few unit weight prices may be incorrect (because of ambiguity in contract food prices, explained above) and other food waste sources not measured in our study will incur economic losses, both of which could increase the real cost per prepared meal, parents in our four schools are still likely to be paying over twice the cost of the food ingredients used per meal. Although Pavle Savić reduced its lunch prices to 180 RSD (€1.50) early in 2018 after receiving meal cost information from the Strength2Food project, this school is now using a caterer to supply lunches.

Meal prices are always of concern to parents when it comes to the selection of the winning bidder for school food procurements, and the school food procurement committees appear always to feel obliged to select the lowest bidders, irrespective of any food quality criteria that may have been given in the tender documentation. Clearly, our data in Table 16 indicates that selecting winner bidders while taking food quality criteria into account need not lead to more expensive meals, as far as charges to parents are concerned.

With regard to reducing the financial implications of plate waste, clearly the priority is to reduce fresh meat and fish plate waste. Of the usual types of fresh meat used for school lunches, beef (veal) created the largest % plate waste (48%), especially when served as chunks of meat. Dishes with minced meat created the lowest levels of plate waste (around 20%). Chicken created less plate waste than either beef or pork, and is also the lowest CO_2 polluter during production. Reducing the number of meat main courses to four per week would also reduce the financial cost of plate waste. Therefore, financial savings by reducing fresh meat plate waste could easily be achieved by our schools by discussing selective changes to lunch menus with them.

Finally, we would like to acknowledge the cooperation and considerable patience of the kitchen staff of primary schools Dositej Obradović, Ljuba Nenadović, Pavle Savić and Gavrilo Princip who facilitated BEL staff to collect information on plate waste whilst managing the provision of lunches to dozens of children during very limited time periods, and in often cramped working environments.

7. CONCLUSIONS AND RECOMMENDATIONS

The objective of WP6, Task 6.2 was to evaluate the impact of public sector food procurement strategies on the nutritive value of school meals utilising food composition analysis. Of the four models available, in Serbia almost no organic food is bought for any school meals (though we are currently discussing with some schools in Novi Sad opportunities for introducing organic products without having a significant impact on meal costs). Therefore, the only PSFP models available for comparison in Serbia were LOW (lowest price) with LOC (local/short chain). As current Procurement Law in Serbia requires, or at least is generally interpreted by schools to mean, that the lowest bid has to be accepted, the designation of a school as LOW or LOC will depend on whether any winning bids for a particular year came from local or distant suppliers. Therefore, we would not expect the PSFP procurement model *per se* to have any impact on either the nutritive value of school meals or the proportion of meals wasted by children. Nevertheless, the four schools used in this study have shown differences with respect to meal nutrition and plate waste, and understanding the reasons for these differences will help us to make recommendations for future practices to improve meal nutrition and reduce the nutritional, environmental and economic impacts (and associated losses) from plate food waste.

The comparative analysis of schools in the two models revealed that there were no significant differences in the food preparation and serving processes, though the times given for lunch were shorter in LOW than LOC schools (a feature of individual school circumstances). Moreover, kitchen facilities appear to be similarly (under)equipped, containing only the most important appliances, such as stove, refrigerator and oven. It was observable that the kitchen equipment did not depend on the number of meals prepared daily, which could be assumed to be an important factor. Nevertheless, schools in better off neighbourhoods (considered in terms of the average net salary of the municipality) tended to have finer furnishings – including dishwasher machine, peeling machine, etc.

All investigated schools had their own in-house canteens, with tables designed either in rows or individually with children-adjusted size of chairs. Decoration of these facilities varied substantially, given that in some schools the canteen was fully arranged in cream and brown colours, while in others it was much more bright-coloured. Provided that ambient significantly influences eating atmosphere, while investments in furnishing details can be quite low, it is worth schools considering to improve their serving premises with some vivid elements (including children's drawings related to the food and healthy diet).

In three out of the four schools, a generally low level of interaction of kitchen staff with children was observed (though this is not so with other schools taking part in Strength2Food). As cooks can substantially impact on chidren's food choices (as demonstrated in Dositej Obradović school), more communication and positive interaction with, and encouragement for, the children during lunchtime would be helpful. Moreover, teachers present in the canteens during the meal could also put more effort into encouraging children to try new food, eat vegetables and soup, consume a whole portion, etc.

Nevertheless, two major obstacles are present for schools giving meals in their own kitchen. The first is current regulation[36] governing the ratio between pupil numbers having lunch and the number of full-time equivalent kitchen staff (cooks and servers). This regulation has the following text regarding the employment of kitchen staff: "For preparing and serving a meal, a school has one employee for 180 pupils or one person employed for serving a meal for 360

[36] [Footnote: [1] "Pravilnik o kriterijumima i standardima za finansiranje ustanove koja obavlja delatnost osnovnog obrazovanja i vaspitanja." p5, Article 13. Published with modified text in "Sl. glasnik RS", no. 45/2018, which came into force 21 June 2018, to be applied from 1 September 2018.]

pupils." i.e. for a school to have one full-time cook and one half-time server, it needs to provide at least 180 meals per day. None of the schools in our plate waste study provided that many lunches. In reality, school directors "borrow" other non-teaching staff to help in the kitchen because of the impossibility of providing the required number of meals within the time available, especially if all dirty plates and cutlery need to be washed by hand because the kitchen has no dishwasher. We know of one well-respected cook at a school in Novi Sad who gets to school at 04:00 every morning and leaves at 14:00. Salaries for these cooks are close to or at the minimum wage (see D6.3 Serbia Country Report), and they are responsible for the health and safety of all the children they feed. Under these conditions, it is not surprising that school directors struggle to fill kitchen staff vacancies when cooks leave or retire, and many school cooks are close to retirement age. It is for this reason that our LOW school "Pavle Savić" has now given up using its kitchen to provide lunches and from the 2018-2019 school year is instead using a caterer.

The second obstacle is pressure of time to organise the whole meal cycle (in some cases, a consequence of the first problem – lack of enough kitchen staff). Some schools need several meal sittings to cope with the numbers with the canteen spaces available and this inevitably means pressure to get the meals out, get the children eating, get them out, clear away plates, and prepare for the next sitting as quickly as possible.

Finally, it was noticeable that schools, except Ljuba Nenadovic, do not have much experience in the organization of activities for the promotion of healthy diet and sustainability issues to children. Even though many schools in Serbia (Appendix 1) share enthusiasm for such actions and they are willing to put their efforts and resources into achievement of these goals, more coordinated action at the national level is needed. The recent introduction of *Rulebook on the organization, realization and monitoring of eating of elementary school students* represents the first valuable step toward this goal, which should be followed also by organization of the control body which would monitor the application of the rules.

In terms of menu design, the quantity of food given for each meal is typically sufficient for a child's lunch energy needs, though plate waste reduces that nutritional intake to less-than-recommended quantities for all macro-nutrients, and just giving larger portion sizes to compensate for plate waste seems unlikely to help much. The existing menus at these four schools for those two sampling weeks were consistently deficient in several vitamins and minerals (particularly folate, vitamin D, calcium, potassium and frequently iron). Intake of dietary fibre was also below recommended levels in many menus. While kindergartens employ nutritionists to ensure that meals given to children in kindergartens are nutritionally balanced, no such support is currently provided by either central or local governments to primary schools. Schools that provide their own meals to children have to rely on help from either a school biology teacher (Ljuba Nenadović) or a local friendly nutritionist (Gavrilo Princip), or other non-formal arrangement for nutritional advice.

Although it would be relatively straightforward to redesign menus to reduce vitamin and mineral deficiencies, the challenge would be to persuade children to accept any changes to their menus, as Gavrilo Princip demonstrated with its relatively high rejection rates for vegetables. Increasing uptake of vitamin D during school lunches could present an additional challenge of increased costs – the best sources of vitamin D being highly-expensive oily fish such as salmon and tuna. Even those schools that give canned tuna occasionally in breakfasts and snacks do not use tuna packed in water, but rather in oil which is cheaper but tends to lower the tuna vitamin D content.

Plate waste for meats was highest for beef (veal), and lowest for minced meats and then chicken. All four schools used all those meats. Evidently, plate waste could be reduced by reducing the amount of beef (as steaks or chunks), and increasing dishes with either minced meats or chicken. Changing to less beef and more chicken would also have both environmental and economic benefits, as explained in D6.3. On the other hand, replacing red meat with white (chicken) meat would aggravate the existing tendency for iron deficiency in school lunch menus.

In terms of canteen/service improvements, it is easy to tell schools to allow more time for lunches to give children longer to eat what they are given, but reorganising kitchen staff and facilities to cope with more children at once (to reduce the number of sittings), and consequent timetable rescheduling may not be feasible. Also, more interactions between staff and children may help encourage children to eat more of their lunches, but may not be realistic within the existing tight schedules to feed all the children in the shortest time possible. In any case, our survey of only four schools in Belgrade sampled for only two weeks of the school year is probably too limited to be able to judge whether these recommendations are either relevant or possible for the other hundred or so Serbian schools providing lunches for children in their own kitchens. Note that several ideas to improve children’s eating habits are being tested as part of Task WP9.1.1.

The Ministry of Education and Science says it wants to encourage schools that have kitchens currently not in use to use them to provide meals for its children and to encourage those schools already preparing meals for their pupils to continue, as all the food poisoning outbreaks in kindergartens and schools in recent years have been caused by food provided by external caterers. However, it is difficult to see how the Ministry’s aim could be achieved without providing financial resources in some way (for renovated facilities, equipment and extra or better-paid staff) which, under present circumstances, is unlikely to happen. Although some local authorities are able to help their schools financially, this is not universal. Nevertheless, improving the nutritional quality of existing school meals should be possible without incurring considerable extra costs for schools.

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APPENDICES

Appendix 1.

Good practices on healthier meals in Serbian primary schools (from a survey completed by 778 schools).

Good practice	No. of answers which listed the particular good practice
Education on the healthy diet – within classes or on the specific lectures (conducted by teachers, experts, institutes, etc.)	143
Organization of the events (e.g. fairs) and celebration of certain days (Day of the healthy food, Apple day, etc.)	101
Provision of certain sorts of food (mostly fruit and dairy products, but also whole wheat pastry) with meals in schools	25
Ban of certain food products (e.g. soda, snacks, sweets, etc.)	7
Adjustments of the menus to the wishes of children and parents (menus co-creation with parents and kids)	20
Nutrionists, pediatric nurses or other experts prepare menu	9
Children prepare food from time to time with their teachers	20
Many of children eat in school canteena which ensures higher quality of their diet	14
Local suppliers/caterers are used which positively influence freshness and quality of meals	13
There are donors who cover some parts of the meals' costs	7
Schools participate in various regional or national projects (e.g. Honey breakfast, Let's grow up healthy, etc.) on healthier eating	20
Promotional material (e.g. flyers, posters, etc.) is distributed	10
Children participate in the contests on healthy eating	9

The Strength2Food project in a nutshell

Strength2Food is a five-year, €6.9 million project to improve the effectiveness of EU food quality schemes (FQS), public sector food procurement (PSFP) and to stimulate Short Food Supply Chains (SFSC) through research, innovation and demonstration activities. The 30-partner consortium representing 11 EU and four non-EU countries combines academic, communication, SMEs and stakeholder organisations to ensure a multi-actor approach. It will undertake case study-based quantitative research to measure economic, environmental and social impacts of FQS, PSFP and SFSC. The impact of PSFP policies on nutrition in school meals will also be assessed. Primary research will be complemented by econometric analysis of existing datasets to determine impacts of FQS and SFSC participation on farm performance, as well as understand price transmission and trade patterns. Consumer knowledge, confidence in, valuation and use of FQS labels and products will be assessed via survey, ethnographic and virtual supermarket-based research. Lessons from the research will be applied and verified in 6 pilot initiatives which bring together academic and non-academic partners. Impact will be maximised through a knowledge exchange platform, hybrid forums, educational resources and a Massive Open Online Course.

Strengthening European Food Chain Sustainability by Quality and Procurement Policy

Deliverable No: D6.2

EVALUATING THE NUTRITIONAL IMPACT AND PLATE WASTE OF THE DIFFERENT MODELS OF PSFP IN A SCHOOL CONTEXT:

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28. **CPR**, Consortium of Parmigiano-Reggiano (Italy)
29. **ECOZEPT**, ECOZEPT (Germany)
30. **IMPMENT**, Impact Measurement Ltd (United Kingdom)

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EXTENDED ABSTRACT

The study was conducted in England (NorthSchool) and Scotland (ScotSchool) in primary schools adopting one of two contrasting PSFP models: (i) a local model (LOC, NorthSchool), in which the procurement contract specified a minimum proportion of total foods to be sourced from within an area local to the schools, and (ii) a low cost model (LOW, ScotSchool), in which the procurement contract made no local sourcing specification.. The study analysed the nutritional composition of a sample of main meal and dessert menu options offered by NorthSchool (LOC) and ScotSchool (LOW) (33 menus options per region), examined the volumes, and composition, of 40 days of collected plate waste (20 days per case region) and estimated the nutritional loss, embodied carbon and financial loss attributed to the collected plate waste.

Nutritional composition analysis of a sample of menu options from NorthSchool (33 menu options) and ScotSchool (33 menu options) found that on average school lunches, across both cases, were broadly in line with Scottish Nutrient Standards except for Total Carbohydrates (below the minimum target of 74.3g/meal served) and Saturated Fatty Acids (above maximum target of 6.8g/meal served). The average weight of an LOCSchool lunch (329g) is 78g more than LOW (252g) providing slightly more energy (49kcal) per average lunch portion (625kcal±159 – LOC; and 576±71), LOW). Overall in terms of energy, 45%, and 60%, of LOC and LOW school lunches respectively, were found to meet the recommended energy thresholds while 35% (LOC), and 25% (LOW) were below and 20% (LOC), and 15% (LOW), above recommendation. The average energy contribution from carbohydrate was 45% for LOC, and 46% for LOW, which is slightly below national recommendation. Both LOC and LOW School lunches were found to acquire on average 38% (LOC), and 35% (LOW) of food energy from total fat which slightly exceeds national recommendation. In terms of protein, both LOC and LOW school lunches excced national recommendation for total proteins with on average 25± 4.2 (LOC) and 29.7 ± 3.18 (LOW) grms of total protein per lunch menu analysed. This is well in excessive of the recommended minimum of 8.5g and equates to 16%, and 21% of food energy coming from proteins. The majority of LOC (90%) and LOW (100%) school lunches were estimated to exceed recommended levels for saturated fatty acids. All LOC and LOW menus analysed were found to be in line with recommended dietary fibre content.

It is worth noting that while little or no refusal of meals components at service was observed in LOCSchool, significant refusal of meal components, especially of hot/cold vegetables, was observed in LOWSchool and as such the actual school lunch energy and nutritive intake of LOWSchool children is highly likely to be lower than that presented in Table 20. Some interesting differences between the regions were identified. While average planned weight of food/meal served in NorthSchool (329g/meal served) was 77g more than in ScotSchool (252g/meal served), the nutritional composition analysis found that on average NorthSchool lunches had lower average energy (kcal), less total proteins (g) and less total carbohydrates (g) than ScotSchool. An explanation is that NorthSchool children receive a greater quantity, and range, of food types per meal served due to SchoolCater menu and receipe innovations and a very strong emphasis on cooking from stratch including making daily homemade dessert options. Thus. while the NorthSchools meals weight more (by volume), they are less calorific and lower in protein and carbohydrates due to higher quantities of fresh ingredients, in particular vegetables, incorporated into NorthSchool recipes. In comparision, ScotSchool kitchens cook much less from stratch buying in more premade and frozen produce, offering a more limited range of homemade dessert options (2 compare to 5/week in NorthSchool) and engaging, only recently, in imited menu innovation in recent years.

While collected plate waste as a proportion of total weight of planned food served is similar in NorthSchool (26%) and ScotSchool (25%), the average collected plate waste per meal served is 23g higher in North School (87g) than ScotSchool (64g). The distribution of collected plate waste was also found to be very different with LOCSchool collected plate waste (by weight) being reasonably well distributed across the 6 food categories with: 37% coming from starchy carbohydrates, 26% from vegetables, 13% from fruit, 11% from meat, 12% from dessert and 1% from other (i.e. cheese) while LOWSchool collected plate waste (by weight) was much more unevenly distributed with 61% coming from starchy carbohydrates, 6% from vegetables, 10% from fruit, 15% from meat, 7% from dessert and 1% from other (i.e. cheese). Large differences in the proportions of collected plate waste by food category were found between the regions for Starchy Carbohydrates (NorthSchool: 37%; ScotSchool: 61%; Difference: -24%) and Vegetables (NorthSchool: 26%; ScotSchool: 6%; Difference: 20%). An explanation for the differences in starchy carbohydrate vegetable waste proportions is portion size adjustment practice and schoo caterer policy regarding chidlren's right to completely refuse vegetables and not take them onto their plate (LOWSchool). Interestingly, and related to in particular to starchy carbohydrate plate waste composition, different patterns of main meal choice emerged within, and between the regions. While a clear preference for the hot meal option emerged in NorthSchool D (82.5%), this preference changed in NorthSchool E (64.5%) and was even more pronounced in ScotSchool A&E, with 57.5% and 57% respectively. These patterns directly impact the type, and quantities of, starchy carbohydrates with more bread and potatoes served (via sandwiches and baked potatoes) as the rate of hot option selection drops.

In terms of nutritional losses from plate waste, average energy losses of 18%, and average overall macronutrient losses of 12% to 26% per served meal were calculated. Total protein and carohydrate losses were 17% (LOC) and 15% (LOW) and 21% (LOC) and 26% (LOW) respectively. Fibre loss was 26% and 19% for LOC and LOW schools while loss of total fat was similar between both cases at 15% (LOC) and 14% (LOW) in LOC respectively. Such as with total fat, the losses of saturated fatty acids are similar with 13% and 12% losses in LOC and LOW schools respectively. Due to the complexity of the UK menu data and the significant number of daily menu options offered, it was not possible to estimate, for the collected data, the losses of vitamins and minerals associated with the collected plate waste.

In terms of <u>economic impact</u>, we estimated the cost of the plate waste in both LOC and LOW cases, for five schools over one whole school year. Across the 5 LOC schools, a total annual plate waste of 11,228 kgs was estimated, generating an estimated total cost of £21,559. This equates to 27% of the total school meals budget and £0.21 per average meal. As the price of a school lunch in LOCSchools is £2.00 (€2.27), this means that in LOCSchools, 10.5% of the full price paid ends up as plate waste. Across the 5 LOW schools, a total annual plate waste of 16,604 kgs was estimated, with an estimated total cost of £40,211. This equates to 13% of the total school meal budget and £0.19 per average meal. As the price of a school lunch in LOWSchool is £1.95-£2.00 (€2.21-€2.27), this means that in LOW schools, 9.5-9.7% of the full price paid ends up as plate waste.

In terms of environmental impact, we estimated the carbon emissions embodied in the plate waste in LOC and LOW cases, for five schools over one whole school year. Across the 5 LOC schools, the total estimated annual plate waste (11,228 kgs) was estimated to contain embodied carbon emissions of 27,295 kgs$C0_2$eq, which equates to 0.27 kg$C0_2$eq per average meal or 23% of total embodied emissions of total food procured. Across the 5 LOW schools, the total estimated annual plate waste (16,604 kgs) was estimated to contain embodied carbon emissions of 44,386 kgs$C0_2$eq, which equates to 0.21kg$C0_2$eq per average meal, or 17% of total embodied emissions of food procured.

In reflecting on these results and acknolwegding that the emerging similarities and differences in school meal service delivery across LOCSchool and LOWSchool, a number of identified school meal procurement, food service and environmental factors may help explain why the type and quantity of, and nutritional, carbon and financial loss associated with, collected plate waste varies between cases.

Firstly, the estimated weight of planned food and average collected plate waste per meal served was 73g and 23g higher in LOCSchool compared to LOWSchool.

Secondly, while LOWSchools had recently started to invest in, and develop, a more systematic, creative and nutritionally grounded approach to menu development, the catering firm supplying the meals in LOC case (SchoolCater) already had an established, rolling programme of menu innovation and development.

Thirdly, seasonal menu adjustment is normal practice in LOCSchool as SchooCater develops 2*3 weekly menu cycles per academic year (Autumn/Winter Nov –March; Spring/Summer April – Oct) to reflect changing seasonal preferences, produce availability and increase variety in their school meal offering. In contrast, ScotSchool case has 1*3 week menu cycle covering the full academic year.

Fourthly, interesting differences in meal selection were observed within, and between, LOCSchool and LOWSchool with these differences directly impacting the type, and quantities of, starchy carbohydrates served. As more bread and potatoes were chosen by children (via sandwiches and baked potatoes), the hot option rates dropped, which in turn impacted on the compositional make-up of collected plate waste.

Fifthly, while both LOC and LOWSchool offered a diverse choice of up to 6-10 different hot/cold vegetable options per day, only LOCSchool children, in accordance with SchoolCater policy, were required to accept at least 1 portion of hot/cold vegetables with their meal. No such ScotSchool policy existed, and very high hot/cold vegetable refusal rates were observed as as a consequence. Therefore, it is posited that the quantities of hot/cold vegetables consumed in ScotSchool were much lower compared to NorthSchool who, based on an average estimated served portion of 50g and an average collected vegetable waste per meal served of 23.8g, were found to be consuming around 50% of their served vegetable portion.

Sixthly, whilst both LOC and LOW cases offered a diverse daily range of hot/cold vegetables, the presence of this choice alone, in the absence of a vegetable acceptance policy (as per LOCSchool) did not appear, from observations, to be sufficient to drive higher hot/cold vegetable acceptance rates in LOWSchool.

Seventhly, there was variation between and within the schools in LOC and LOW cases, in terms of the design of, available space in, and distribution and positioning of food, along the canteen food service lines. This was observed to impact children's engagement with and accessibility to different options, in particular fruit.

Eighthly, in 2017/18, it was normal practice in LOWSchools to wrap all sandwiches, cut fruit and burgers (where offered) in plastic wrapping prior to service, and to serve yoghurt in single-use pots. This generated significant non-food plastic waste. Some changes were observed in the 2018/19 school year, where a fruit platter and sandwich trial were underway. Based on observations, the trialled changes appeared to helping reduce the amount of non-food waste generated, and also improved the visual appearance and ease of consumption of cut fruit. No plastic wrapping of food was observed in LOCSchools, though yoghurts were served in single use plastic pots in LOCSchool D. The majority of yoghurt was made in house and served in reuseable bowls in LOWSchool E.

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List of Abbreviations and Acronyms

DCC: Durham County Council

IC: Inverclyde Council

LA: Local Authority

S2F: Strength2Food

UK: United Kingdom

1. INTRODUCTION

This report presents the findings of S2F WP6.2 research into the nutritional and plate waste outcomes of primary school food chains in the UK. Using case studies, a pair of contrasting procurement models were analysed: (i) a local model (LOC), in which the procurement contract specified a minimum proportion of total foods to be sourced from within an area local to the schools, and (ii) a low cost model (LOW), in which the procurement contract made no local sourcing specification. In both cases, our research involved analysing plate waste and measuring the nutritional composition of school lunch menus for each case region.

The LOC study was conducted in County Durham, north east England. This area was chosen because the local authority (LA) was known to be actively engaged in addressing sustainability issues, including in relation to its procurement practices for school food. As a result, this case represented the LOC procurement model of the pair of UK cases. The fieldwork for the Durham (LOC) study commenced in autumn 2016 with telephone interviews and desk research. Thereafter, the bulk of the primary data collection for D6.2 was conducted between April and November 2018.

The LOW study was conducted in Inverclyde (IC), a region in west central Scotland. This area was chosen because the local authority (LA) was known to be interested in measuring the sustainability impacts of its school meals supply chain, although to date had not actively pursued any alternative procurement practices. As a result, this case represented the LOW procurement model of the pair of UK cases. The fieldwork for the IC (LOW) case study commenced in autumn 2017 with a depth interview with members of IC LA, and desk research. Thereafter, the bulk of the primary data collection was conducted between February and October 2018.

For both cases, the fieldwork was broken into three main components. First, and in collaboration with D6.3, a total of 25 face-to-face interviews with 30 informants, from the LA and main catering firm supplying meals, wholesaler managers, farmers, processors, school headteachers and kitchen staff were conducted (For full details see Tregear et al. (under reveiw) - D6.3. UK National Report part of 6.3 deliverable, Strength 2 Food). These interviews provided the main source of information about school meal policy, menu innovation and development, nutritionally approved recipes, strategic and operational insights into how school lunch service is delivered, the school specific systems including practical facilities, ordering systems, staffing and available space and time and an opportunity to observe a full lunch service in 10 schools across the two case regions. Second, for 4 (from 10) selected schools (2/ region), we collected plate waste for 10 days per school (2 weeks, 1 spring/summer; 1 autumn/winter) with all collected plate waste separated into bins, and weighted for, six food categories (Fruit; Vegetables; Stratchy Carbohydrates; Meat, Fish and Protein (MFP); Dessert; and Other). Third, using menu and recipe data (where available) supplied by the LA or private caterer, supplementary data from the School Food Standards for England and Wales and Scotland (School Food Plan, 2015; Healthy Eating in Schools, 2008)), and a bespoke Nutritional Analysis tool, *Food Explorer*, developed by ZAG, the planned weight (grms) per meal served, the total weight of food served per day (based on the actual meal choices selected) and the average nutritional profile of schools meals offered were calculated.

2. SCHOOL FOOD POLICIES IN THE UK

Different statutory school food standards operate across the UK. In Scotland, LA's are required to ensure that all school meals meet the nutritional and food-based standards as laid out in the Healthy Eating in Schools Guide published in 2008 (Healthy Eating in Schools, 2008). A Scottish government funded, and managed, inspection service inspects an ad hoc sample of schools annually for compliance with Scottish school food nutritional and food-based standards. In addition, the Healthy Living Survey is conducted annually since 2003 (on 1 random day/year) in all state funded Scottish schools (including 2498 state funded primary schools) estimates, and tracks changes in, primary school meal uptake across Scotland (Health Living Survey, 2018). In 2018, average school meal uptake in Scottish state funded primary schools (for those children in school on the census day) was 48% (Healthy Living Survey, 2018). Responsibility for the design and delivery of Scottish school meals is devolved to the 32 Scottish LAs with most having in house school meal design and delivery teams though only some employ trained nutritionists and/or dieticians. Despite this lack of in house nutritional expertise, all Scottish LA's are required to conduct, and provide documentary evidence that, their school lunch menus are nutritionally analysed on an annually basis. Approximately 60% of Scottish state funded primary schools have in-house kitchen facilities. Scottish LAs, who fund, and are supported by, Scotland Excel, the Centre of Procurement Expertise for Scotland's local government sector, participate in national procurment frameworks for procuring the majority of school food though in some regions, and for some fresh items such as bread, fruit and/or veg, locally managed procurement frameworks have been developed. Generally, Scottish LA's supplement school meal budgets from their general LA budgets topping up the income received via central government funding for key stage 1 pupils (4-7 year olds) and for children qualifying for free school meals and the income generated from the agreed daily school meal charge for all other children (on average £2.05/child/day in Scotland). More detailed analysis of the Scottish school meal system and food procurement processes see Tregear et al. (2017), deliverable 6.1 of the S2F project.

In 2014, new statutory school food regulations for England and Wales were issued (The requirements for School Meal Regulations, 2014; Long, 2019). In practice, the regulations (and associated legislative text) were codified into a set of food-based standards which specify the frequency (min and/or max), and types, of food which should (and should not) be served in English and Welsh schools (School Food Standards (England and Wales), 2015). Through careful development, the recommended nutritional profile of school meals is delivered, where standards are met, without the need for separate nutritional standards within the statutory school food regulations. As in Scotland, an annual survey is conducted across all English schools (including in 16,766 state funded primary schools as of January 2018) to collect statistics on pupils and their characteristics including eligibility rates for free school meals (Schools, pupils and their characteristics (England), 2018). The survey, conducted annually since 2002 (on 1 random day/year in January) does not, unlike its Scottish counterpart, capture school meal uptake statistics for England. Most English LA's outsource school food catering to private caterers who are: 1) appointed after full formal tendering processes; 2) expected to, and responsible for, operating to statutory food-based standards; and 3) set, and monitored against, key performance indictors deemed relevant by each LA. Generally, private caterers do not receive additional grants from the LA's to support school meal provision, and are solely reliant on the income generated from school meals via central government funding for key stage 1 pupils (4-7 year olds), funding for children qualifying for free school meals and agreed daily school meal charge for all other children (on average 1.90/child/day). The proportion of English schools with in house kitchens is currently unknown and average school meal uptake is estimated at 65%. More detailed analysis of the English school meal system and food procurement processes see Tregear et al. (2016), deliverable 6.1 of the S2F project.

As part of the UK wide, government funded Universal Free School Meal Scheme, all children aged between the ages of 4-7 (in key stage 1 (KS1) - Reception to Year 2 in England; P1-P3 in Scotland)) are entitled to free school meals. Older children (7+) (Key stage 2 and above; Year 3 in England; P4 in Scotland) are only eligible for free school meals if their parents meet strict criteria as outlined by the UK and Scottish parliment respectively. According to the Healthy Living Survey (2018), 37.4% of Scottish children, across all state funded primary and secondary schools, are eligible to receive free school meals including all P1-P3 children (4-7year olds) who qualify for universal free school meals with 80% of those eligible taking lunch on the Feb 2018 census date. In England, according to the Schools, Pupils and their Characteristics (2018) annual survey, 14.2% of children in state funded nursery and state funded primary schools are known to be eligible for, and claiming, free school meals (Schools, Pupils and their Characteristics, 2018).

3. PROFILE OF CASE SCHOOLS

3.1. Case 1

3.1.1. NorthSchool D & E

In case 1 (LOC), two NorthSchools (D&E) participated in the plate waste study. Table 1 outlines their profile in terms of size, average % of school roll taking school meals, average number of school meals served/day, and % of children in receipt of free school meals. The price of a daily school lunch in NorthSchool is £2.00 (€2.28)/per day

	School Roll	Average % Uptake of School Meals (n/day)	% of children in KS2 receiving free school meals
NorthSchool D	178	60% (107/day)	16%
NorthSchool E	303	55% (167/day)	34%

Table 69: NorthSchool Profile

NorthSchool D is located in a rural market town in the far south west of County Durham. A relatively affluent area serving a predominantly rural hinterland with approximately 60% of children coming from within, and 40% coming from outside, the local school catchment area. A high proportion of children come from farming/agricultural backgrounds. The school has 178 pupils, slightly above the DCC average, with 16% claiming free school meals. The school has, in the past, pursued several food and health related initiatives, including gardening and cooking clubs, however these were very dependent on the voluntary input of specific staff members, and ceased when those staff left. The head teacher expressed enthusiasm for food related projects, but explained other initiatives are currently being prioritised as due to the relatively affluent, rural catchment and the schools large outdoor play facilities, NorthSchool D children are perceived to be in good health, get lots of fresh air, exercise and play and are considered to have a good knowledge of where food comes from, As such, while NorthSchool D has a school lunchbox policy, in line with the guidance issued by DCC, it does not need to actively police this and in fact has found that it is self-policing as the children are attuned to the no chocolate rule. School meal uptake is 60%, which is lower than average for schools in the DCC.

NorthSchool E is located 3kms from Durham city in an area of relatively high deprivation, with 34% of pupils claiming free school meals. The pupil roll is 303, making it one of the larger schools in the DCC. In line with DCC's school packed lunch policy, NorthSchool E developed a school specific food policy and actively enforces a healthy packed lunch policy, using pupil members of the School Nutritional Action Group (SNAG) to help monitor packed lunches in the canteen, and encourage their peers to make healthier choices. The school has a gardening club, an active Outdoor Play and Learning Programme (OPAL), weekly access for all children to an onsite swimming pool, a suite of daily/weekly sports clubs and an all school weekly health club on Friday afternoons. It also runs a weekly Healthy Eating and Good Manners award given to pupils who are judged to have made good choices and/or behaved well in the canteen. However, much of the other food-related initiatives in the school revolve around activities targeting at risk pupils (malnourishment/food poverty), such as their funded breakfast and holiday hunger clubs. During plate waste data collection, the average uptake of school meals was 55%.

3.1.2. Approach to Food and Sustainability Issues

Table 2 summaries the food and sustainability related initiatives undertaken by NorthSchools D&E outlining the nature of the initiative, how each initiative has been funded, the current status and who is leading the initiative.

Initiative	School ID	Description and Funding	Status	Lead
Breakfast Club	NorthSchool D & E	NorthSchool D do not receive any funding. Approximately 25-30 children per day pay to attend breakfast club from 8am. NorthSchool E receive funding from Greggs (a north east based bakery company) to deliver a free Breakfast Club with Sport. Approximately 50 children per day attend from 8am.	Ongoing	Breakfast Club Staff
School Theme Days	NorthSchool D & E	Children In Need Day (prepared Pudsey Biscuits); Wallace and Gromit Children's Charity Pasta King Day (served Wallace and Gromit Pasta Dish as main meal)	Ongoing	SchoolCater, Suppliers and/or Head Teacher
Fruit and Milk Scheme	NorthSchool D (KS1 only) & E	EU; NorthSchool E uses top up funding from Greggs to pay for additional fruit. Fruit is freely available for children to snack on between 9-3pm everyday.	Ongoing	School Staff and Kids
The Daily Mile	NorthSchool D & E	An country wide initiative developed to encourage schools to faciliate pupils walking/running a mile every day. No funding required.	Ongoing	Teaching staff
Gardening Club	NorthSchool E	NorthSchool D are currently exploring options and the caretaker is developing a small school garden. They are looking to encourage parent/grandparent	Ongoing	Caretaker

		volunteers to support this initiative going foward. NorthSchool E receives funding from Children in Need to deliver a joint pupil-parent gardening club.		
Tasting Evenings (Parents)	NorthSchool D and E	Costs covered by SchoolCater	Ongoing	SchoolCater
Cooking Club	NorthSchool D	General school budget	No	Teaching staff
Eco Friendly School	NorthSchool E	General school budget	Ongoing	LA & Head Teacher
School Nutrition Advisory Group (Children)	NorthSchool E	n/a	Ongoing	
Monitored School Packed lunch Policy	NorthSchool E	n/a	Ongoing	Head Teacher
Lets Get Cooking	NorthSchoolE	Embedded within Science curricula; General school budget	Ongoing	Teaching staff and Senior Leadership Team
Canteen Health Eating and Good Manner Award – Golden Table	NorthSchool E	n/a	Ongoing	Lunchtime Supervsior

Table 70: NorthSchool Food and Sustainability Issues

3.1.3. Organisations of School Meals

SchoolCater delivers all school catering services in NorthSchools. For each academic year, two 3 week menu cycles for Spring-Summer (April – Oct) and Autumn-Winter (Oct – March) are served across all NorthSchools. In line with statutory school food standards for England and Wales (and the associated food-based standards), SchoolCater develops new and revised nutritionally compliant and cost analysed hot meal, sandwich and dessert options per menu cycle including innovating with: meat substitute options (i.e. quorn meatballs in tomato sauce and noodles), vegetarian options (i.e. cheese and onion pie), 50/50 dessert options (i.e. apple crumble and custard where 50% ingredients were apple; oaty biscuits and raisins/orange segments) and vegetable packed sauces (i.e. pizza topping sauce contains 17g of hidden vegetables per serving of pizza (grated carrots and courgettes)). In NorthSchool, a set of core meal components are agreed between DCC and School Cater which must be offered in all NorthSchools. In addition, each NorthSchool can choose from a set of offered optional components based on their profile and school preferences (i.e. specific dishes; number of hot meal options served; provision of a sandwich option). After consultation between the Unit Manager, Head Teacher and School Cater, the final menu for each NorthSchool is agreed and published on the school website. See Appendix 1 for a sample weekly menu form Autumn/Winter 18/19 NorthSchool D&E.

Daily, NorthSchool children choose from 2-3 hot meal options (including one vegetarian hot meal (where required) and occassionally Jacket Potatoes (NorthSchool D&E)). As an alternative to a hot meal, some NorthSchools children (including NorthSchool D&E) can select a sandwich option (bread; rolls or baguettes) with between 1-3 filling options (usually egg mayo, ham, turkey, cheese or tuna mayo). For the new Autumn/winter 18/19 menu, DCC requested that Schoolcater explore removing the sandwich option from across all NorthSchools. After consultation, approx. 75% of NorthSchools opted to remove the sandwich option from their menu. The remaining schools continue to offer a sandwich option due to child preference and/or concerns that school meal uptake would drop significantly if removed with both NorthSchool D&E retaining the sandwich option for the autum/winter 18/19 menu cycle.

Depending on the main meal option chosen, children select from the available daily (stratchy) carbohydrates options including: mashed, creamed, roast or boiled potatoes; jacket potato wedges; chips; rice; pasta; pastry (i.e. quiche; pie) or garlic bread. All NorthSchool children must accept at least one portion of hot vegetables (i.e. cabbage; sweetcorn, garden peas; mixed vegetables; baked beans; cauliflower; green beans; carrots; broccoli; parsnips) or salad (i.e mixed peppers; spring onions; watercress; carrot batons; cucumber; lettuce; tomatoes; boiled eggs; homemade coleslaw; homemade potato salad) onto their plates/trays. In addition, NorthSchool E children are actively encouraged to take two or more portions with those selecting the sandwich option (approx. 50%) required to accept two portions of hot/cold vegtables. Daily, all NorthSchools prepare homemade freshly baked bread (plain; wholemeal; cheesy) and children are free to help themselves at service.

All NorthSchool children are entitled to take a dessert and can choose from between 2-3 daily dessert options: 1) homemade cake or ice cream related options (i.e. apple crumble and custard; Rice Krispie cakes; Fruit salad and Vanilla Ice Cream); 2) Low Fat/Fat free fruit yoghurt (strawberry; peach and passion fruit); or 3) Fresh fruit (i.e. whole apples (red and green); bananas; whole kiwis; whole mandarin oranges; raisins). While NorthSchool D buys premade yoghurt in single serve plastic yoghurt pots, NorthSchool E produces most of its own yoghurt in house using EasiYo powder[37] and equipment (rented annually via SchoolCater) serving their yoghurt in reuseable plastic bowls reducing waste from single use plastic yoghurt pots. NorthSchool E SchoolCater staff make up a batch of plain EasiYo yoghurt once every 2 weeks mixing it, as required, with diffferent EasiYo flavourings. They are very content with how easy it is to make and store, how well it keeps. And report that each batch lasts 8-10 days depending on demand as it has proved very popular with NorthSchool E children.

Tapwater is the only lunchtime drink option available in NorthSchools. Reusable plastic cups are pre-poured by SchoolCater staff with children picking up their drink at the end of the food service line. For the youngest children (nursery and reception; 3-5 year olds), cups of tap water are delivered to their tables by their lunchtime supervisors. Additional jugs of water are available during service and children can serve themselves or request more water from their lunchtime supervisors. Most NorthSchools participate in the EU Milk scheme with the youngest NorthSchool D&E children receiving milk, outwith of lunchtime service.

[37] (https://uk.easiyo.com/)

3.1.4. Kitchen and Canteens

All NorthSchools have onsite kitchens equipped and maintained by DCC. Each school kitchen is defined as a unit and SchoolCater operates approximately 203 units across the NorthSchool estate. SchoolCater employs all the school based catering staff (between 1-5/school) a unit manager in each responsible for the financial and operational management of their unit including all ordering/stock management, deliveries, waste management, unit administration and production and service of daily schools meals for their unit. At least one lunchtime supervisor is employed in each NorthSchool to: 1) manage the flow and behaviour of children, the canteen side service line and the waste station; and 2) provide encouragement and support to the children to eat their school lunches. Not employed by SchoolCater, instead, the lunchtime supervisors are directly employed by each NorthSchool using funding from their core educational grant. Class teachers, special needs assistants and/or teaching assistants also provide additional support for, and encouragement to, the youngest children (Nursery and Reception, 3-5yr olds) or children with special educational needs. Table 3 outlines staffing provision and how lunchtime service is managed (time and number) in NorthSchool D&E.

	Average No. of School Meals served/day	**Lunch Time Service Period**	**School based School Cater Canteen Staff (including Unit Manager)**	**Lunchtime Supervisiors (NorthSchool employees)**	**No. of Staff on Hot Counter**	**No. of Staff on Cold Counter**	**No. of Daily Lunchtime Services (approximately 15 mins/service)**
NorthSchool D	107 (60%)	Approx. 11.45-1pm	2	2-3 + teaching staff with nursery and reception kids only	1	1	5
NorthSchool E	167 (55%)	Approx. 11.15-1pm	3-4	1 + teaching staff with nursery and reception kids only	2	1	5

Table 71: NorthSchool D&E Canteen Staffing

In NorthSchool D, the canteen is a multi-use space used also for school assemblies, physical education, drama, exhibitions and reading. All children eat their lunch in this canteen including those with school lunchboxes. This space is usually handed over to SchoolCater staff by 11am who then set it up as a canteen putting out nine 12 seater rectangular tables (providing a total of 108 seats for a school size of 178), the waste station (i.e. food waste bin; non-food waste bin; bowls for used cutlery; tray for used cups; and space for used plates and bowls) and the food service line (i.e. food options; trays; cutlery; pre-poured water). The food service area is compact yet open. The space and number of seats available, how child flow is managed and the extensive outdoor playground all combine to faciliate a calm, unrushed canteen environemnt in which NorthSchool D children have plenty of space and time to eat their lunch, don't have to worry about finding a seat, are very sociable with each other, are relaxed about finding space and equipment, and have plenty of time, and space, to play outside.

Figure 110: Canteen Images from NorthSchoolE

NorthSchool E has a light, airy single use canteen permanently set up with an open canteen service line. While the smallest children can struggle to see over the top of the service line, SchoolCater staff assist them by lifting up and showing them the different options (especially the hot vegetables). NorthSchool E uses trays with multiple compartments with children receiving, at the same time, their main course and dessert on their tray. In NorthSchool E, 3 SchoolCater staff manage the food service line with one on hot main option and hot veg; one on cold main option and one on dessert. All children use the canteen for their lunch (school meals or lunchboxes) though in dry weather children are permitted to eat their lunch outside in a covered terrace area with outdoor seats and tables. There are thirteen 8 seater round tables (total of 104 seats for a school roll of 303) including the golden table reserved for children (and their chosen friend (1/selected child) selected the previous week (Friday each week) for their good choices, behaviour and manners in the canteen. Space is limited as only 104 can be accomodated at anyone sitting. There is strict management of the sittings by the main lunchtime supervisor and year groups need to be ready and lined up outside the canteen in advance of their timeslot.

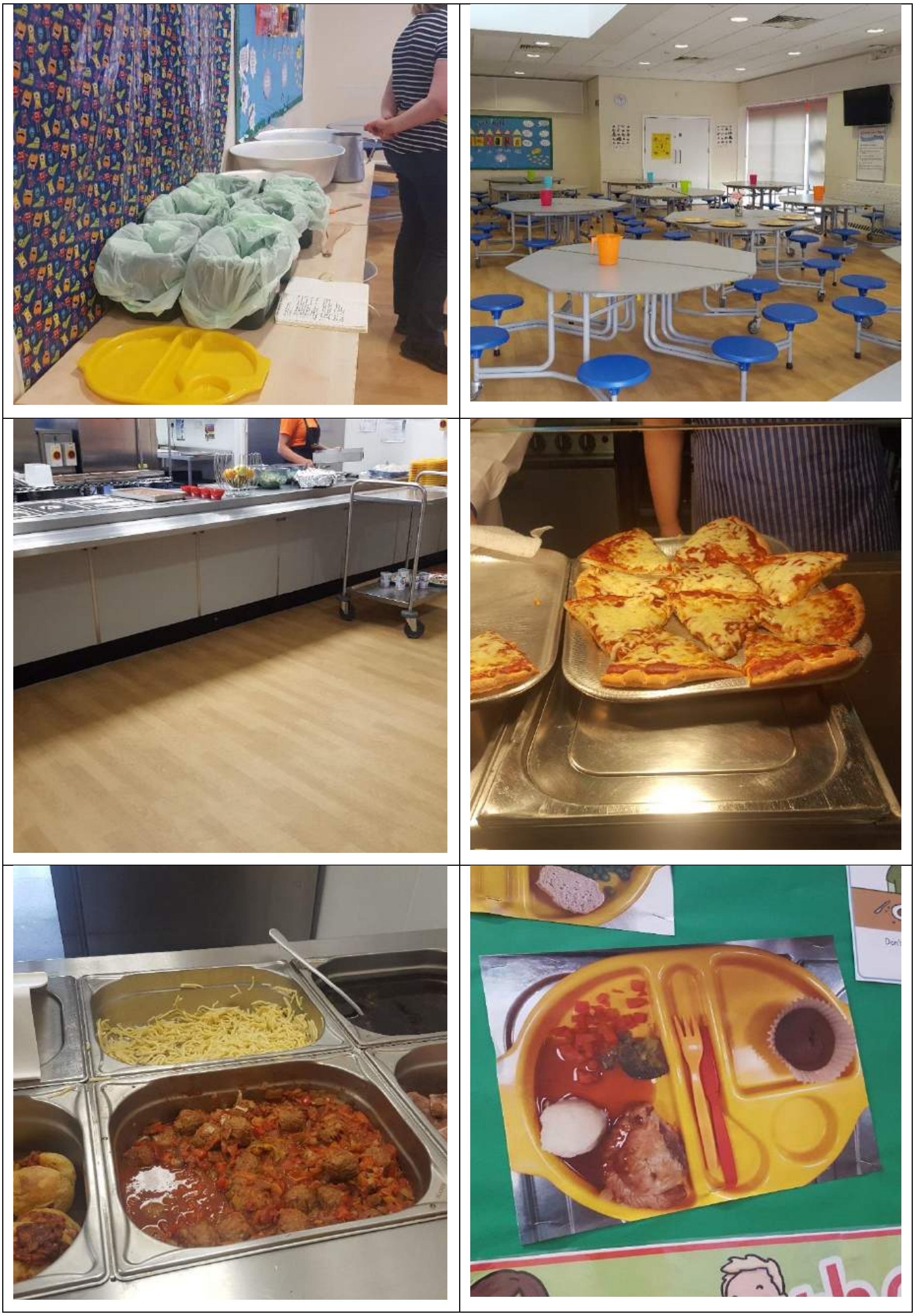

Figure 111: Canteen Images from NorthSchoolE

3.1.5. Lunchtime Service

Different school meal ordering systems are in operation across NorthSchool ranging from: no pre-ordering (NorthSchool D), on the day pre-ordering (children select lunch first thing in the morning – paper or electronic based system; NorthSchool E) and paper or electronic based parental pre-ordering system (other NorthSchools). Where payment is required (those children in KS2 and above who are not eligible for free school meals), parents are required to register for, and pay, via the online ParentPay system as cash payments were phased out in 17/18.

In NorthSchool D, children do not pre-order, instead making daily meal choices as they line up in the canteen. The unit manager plans quantities based on past selections and while this system offers optimal just-in-time choice and generally works well in a school of this size (approx. 100-110 meals served per day), it is challenging when new menu options are first introduced (i.e. Stuffed Tikka Wrap on new 18/19 autumn/winter). In addition, it can make it difficult for the unit manager to always ensure children get their 1st choice though from observation the children were rarely disappointed. All children are greeted individually by the Unit Manager who explains the available choices serving them their selected hot/cold main meal option and hot vegetables where selected. The Unit Manager then passes this plate along the service line to her catering assistant who manages cold vegetables and dessert sections. After completing the order, the catering assistant places the main plate and selected dessert (bowl, yoghurt pot or whole piece of fruit) onto the tray and the children take their tray picking up their cup of water and cutlery as they go to sit down. Some children (Year 1-2 especially) were observed struggling to balance their full trays when picking up their drink and cutlery. In NorthSchool D, the nursery and reception classes arrive first at 11.45am. Generally they take 15-20 mins to eat their lunch (with support from the lunchtime supervisors, their class teacher and teaching assistants). All nursery and reception children remain in the canteen until the class have finished their meals. They are then all brought out to by a lunchtime supervisor for supervised play. Year 1-6 start arriving in random order depending on what they have been doing prior to lunchtime, when they want to play and how quickly they can get from their classroom to the canteen. They are free to come to the canteen as they please and do not have to line up in year group order though generally they do,especially years 1-4. Between 12.05-12.30pm, there is a steady stream of year 1-6 children through the canteen and children have received and eaten their lunch by 1pm at the latest.

In NorthSchool E, a paper based pre-ordering system was used until July 2018. Each child selected their lunch choice in the morning (in their classrooms) and choices were past to the kitchen by 9.30-10am. The children were given a coloured band to denote which main meal they had ordered though problems were encountered as children were found to be swaping, or losing, their colour bands and in some cases requesting a different meal to that which had been prepared for them resulting in delays and confusion during the very busy lunch service. In July 2018 (during the first week of plate waste data collection), NorthSchool E started trailing a new electronic based daily ordering system called CYPad. This trail was successful and the system is fully adopted as the schools lunch ordering system. Through the CYPad system, children make their lunchtime choices each morning using a classroom based IPad/tablet. The choices are linked uniquely to each child and the data is transferred to both Parent Pay (where appropriate to calculate bill) and the kitchen (by 10.30am at the latest) who are also connected to the CYPad system. When a child reaches the front of the queue, using a canteen based IPad/tablet, they find, and select, their name. The catering staff view, and confirm, their choice on a 2nd IPad/Tablet on the kitchen side of the service line. From year 1 upwards, children self manage the CYPad system and due to system constraints, all children must go through in year group order. A lunchtime supervisor or class teacher helps the youngest children (nursery and reception; 3-5 years old) to find their names on the with the CYPad system.

Children line up in their year group order picking up a compartentalised tray and their cutlery (reusable plastic for younger children; metal for older children). Three SchoolCater employees (including the unit manager) manage the service line starting with meal choice confirmation. Hot food (main meal and vegetables) is served first with the tray being passed along the food service line. The staff speak to each child individually helping them to choose their lunch and where appropriate, encouraging them to try new options. For some of the smallest children, the NorthSchool E service line is too high to see all available options and as in NorthSchool D, SchoolCater staff help them where needed. Lunchtime is staggered in NorthSchool E starting with the nursery class at 11.15am followed by reception at 11.30am. Both nursery and reception must be finished and left the canteen by 11.55am. At 12 noon, year 1 and 2 start their lunch break and arrive in the canteen where they are served in their year groups. They have approximately 15 minutes to queue up for, select and eat their lunch. Year 3-6 start to come through in their year groups between 12.15-12.45. All children have received their school lunch by 12.45pm and normally lunch service is completed, and the canteen emptied, by 1pm.

For NorthSchool D&E, portion size adjustment of the stratchy carbohydrate option was observed and confirmed by the unit managers. Nursery, reception and KS1 children receive smaller portions of carbohydrates than KS2 children as per the portion size recommendations listed in the School Food Plan for England and Wales (School Food Plan, 2015). There is no obvious adjustment of other main meal component portions as these are carefully prepared in accordance with approved portion controlled SchoolCater recipes.

In NorthSchool D, a team of 2-3 lunchtime supervisors help manage the canteen and provide support and encouragement to children. All children in nursery and KS1 must confirm with a lunchtime supervisor that they have eaten sufficient amounts of their main meal, request approval to move onto their dessert and obtain permission to finish their meal, go to the waste station and head out to play.

In NorthSchool E, one lunchtime supervisor manages the canteen side lunch service and she is supported during the early part of service by class teachers, special needs assistants and/or teaching assistants for nursery and KS1 children (up to year 2; 7-8years old). For both NorthSchools (D&E), lunchtime supervisors provide support throughout service though supervision is lighter for older children. While all NorthSchool D children and all nursery and KS1 children in NorthSchool E nursery and KS1 children must confirm with a lunchtime supervisor that they have eaten sufficient amounts of their main meal, request approval to move onto their dessert and obtain permission to finish their meal, go to the waste station and head out to play, KS2 kids (aged 8 and above) at NorthSchool E are free to decide themselves when they have eaten enough. In NorthSchool D&E, the children are responsible, no matter what their age, for bringing their trays to the waste station. In NorthSchool E, all children self-manage the disposal of their food, non-food waste, reusable plates, cups and cutlery, while in NorthSchool D Year 5 children (9-10year olds) work on a rota providing support, and managing the, waste station including scrapping plates of food and non-food waste. During data collection, the research team managed the NorthSchool D waste station without help from year 5 children.

3.1.6. Waste Management and Plastics Use

Both NorthSchools have one waste station which the children and lunctime supervisors use to dispose of plate waste (i.e food and non food (yoghurt pots)), lunchbox leftovers and packaging, left over water and to collect used plates, bowls and cutlery. All plate food waste is collected in a designated food waste bin which is weighted and recorded daily (as is associated counter and kitchen waste). All food waste (plate; counter; kitchen) is transfered to large outdoor food waste bins which are emptied weekly by a local commercial waste organisation who SchoolCater have contracted to collect, and process, all NorthSchool food waste via anerobic digestion. Non food waste is generally collected in one bin and disposed of via the general waste stream. No sorting of non-food waste for recycling was observed. It is worth noting though that very little non-food waste was observed in NorthSchools as SchoolCater practices minimise waste by using reuseable cups, not serving milk in cartons, limiting the use of single use plastic yoghurt pots and not wrapping (with paper or plastic) sandwiches, burgers or fruit. In fact, most non food waste observed was actually generated by lunchbox children.

3.1.7. School Fruit and Vegetable Scheme

In the NorthSchool A-E Head Teacher interveiws, and through observations during plate waste data collection, experiences of the School Fruit and Vegetables Scheme were explored. The broad view was that the scheme is a worthwhile and positive initiative, and that the fruit is generally well-received by children. NorthSchools generally receive a weekly delivery of fruit, which is unpacked and distributed sometimes direct to classrooms and sometimes served as part of a morning 'fruit bar', along with milk, in the school hall. Head teachers were somewhat divided over the impact of the scheme on children's wider eating habits. For example, one commented that the scheme encourages healthy eating by invoking positive peer pressure as some children will try fruits they might not otherwise choose, because they see their friends eating them. However, another remarked that it was hard to judge the impact of the scheme on wider choices as their school has a healthy snack policy and children are already eating healthy snacks in school

In NorthSchool D, fruit is always well-received with a good range of choice provided including fruits which the kids may not normally encounter and the head teacher reported positive peer pressure with kids trying new/different fruits because they see their friends trying them. In North School E, fruit, funded by this scheme, is delivered once per week and provided daily to children. To fund this daily provision, top up funding from a local commercial sponsor, Greggs, is used. The house captains unpack, plate up the fruit and take it round to classrooms daily, where kids freely help themselves throughout the school day. It goes down well and fruit selections change seasonally and can include strawberries, peas and tomatoes. Importantly though, the EU fruit scheme is not the only way children are supported, and facilitated, to increase their consumption of fruit and vegetables in NorthSchool. Other mechanisms, managed by SchoolCater, include: making fruit available as a daily dessert option; the development, and weekly provision, of innovative 50:50 fruit based dessert recipes where 50% of the ingredients are fruit; and the requirement that all children must accept at least one portion of vegetables (hot or cold) onto their plate with their main meal. In NorthSchool D&E, the impact of these initiatives were observed with no child observed refusing their required portions of vegetables, at least 6-10 different fruit and vegetable choices available daily, on average 20% of children chossing whole fruit as their dessert option, and 2 of the 5 cooked dessert options offered from Sept 2018 (Autumn/Witer 18/19 menu) were 50/50 fruit based deserts. Table 4 presents the observed range of fruit and vegetables offered to children in NorthSchool D&E.

	Fruit	Vegetables
NorthSchool D	• Apples • Pears • Bananas • Strawberries • Kiwis • Mandarin Oranges	• Cucumber • Lettuce • Carrots • Peppers • Spring Onions • Carrot • Tomatoes • Cauliflower • Cabbage • Sweetcorn • Mixed Veg • Green beans • Water Cress
NorthSchool E	• Apples • Pears • Bananas • Oranges	• Lettuce • Tomatoes • Cucumber • Peppers • Broccoli • Sweetcorn • Carrots • Cabbage • Garden Peas • Mixed Veg • Celery • Baked Beans • Spring Onions • Cauliflower • Parsnips • Swede

Table 72: Range of Fruit and Vegetables served NorthSchool and ScotSchool

Overall while the Fruit Scheme was viewed positively by NorthSchool A-E head teachers, it is difficult to disentangle the specific impact of the scheme from other fruit and vegetable based initiatives, wider school food policies and other environmental factors.

3.2. Case 2

3.2.1. ScotSchool A & E

In case 2 (LOW), ScotSchools A&E participated in the plate waste study. Table 5 outlines their profile in terms of size, socio-demographic profile, average % of school roll taking school meals, the average number of school meals served/day, and % of children in receipt of free school meals. The price of a daily school lunch in ScotSchool is £1.95-£2.00 (€2.21-€2.27).

	School Roll	Average % Uptake of School Meals (n/day)	% of children in KS2 receiving free school meals
ScotSchool A	229	71% (162/day)	51%
ScotSchool E	200	61% (122/day)	14%

Table 73: NorthSchool Profile

ScotSchool A is a co-educational, denominational (Catholic) primary school located in the large town of Greenock, in central Inverclyde. As of Oct 2018, it had 229 pupils, making it a medium-sized school in the IC. The area in which School A is located exhibits high levels of deprivation, and 51% of pupils are claiming free school meals. ScotSchool A has a number of health and food-related initiatives, including the "Daily Mile" walk/run for all pupils, a health group promoting healthy lunch/snack choices, and a well-attended breakfast club (up to 80 children get breakfast every morning for a cost of £1/child). However, the head teacher notes that they have not placed a huge priority on such issues in the past due to more pressing concerns regarding pupil attainment. During plate waste data collection, uptake of school meals was on average 61%.

ScotSchool E is a co-educational, non-denominational primary school serving a local village, and surrounding rural communities, in the east of IC. As of October 2018, the school had 200 pupils, making it a small to medium-sized school in IC. The area served by ScotSchool E is affluent, with low levels of deprivation, and only 14% of pupils are claiming free school meals. The head teacher has a personal enthusiasm for, and professional interest in, food and health issues, and was successful in winning funding for a 'Grow It, Cook It, Eat It' programme of activities. From this grant, kitchen resources to support cookery classes were acquired (both as part of curriculum and after school), and a new school gardening/growing project is being funded. The latter project is a collaboration between volunteer parents, a local gardening club and a social enterprise, who have pledged their time/expertise to help maintain the site. ScotSchool E places importance on healthy eating but has not had to introduce initiatives such as a packed lunch policy or monitoring of lunchtime choices as the general perception of the head teacher is that pupils make good choices. Across the plate waste data collection, average uptake of school meals was 61%.

3.2.2. Approach to Food and Sustainability Issues

Table 6 summaries the range of food and sustainability related initiatives undertaken by NorthSchools D&E outlining the nature of the initiative, how each has been funded, the current status and who is leading the initiative.

Initiative	School ID	Funding	Status	Lead
Breakfast Club	ScotSchoolA	IC run the breakfast club, staffed by two of the ScotSchool A catering assistants. Parents pay £1/child/day. Up to 80 children per day attended. Budgets under pressure and some items have increased in cost due to rising food prices (i.e. Shredded Wheat)	Ongoing	LA Catering Staff
School Theme Days	ScotSchool A&E	No additional funding required and agreed between school and Head Cook.	Ongoing	LA Catering Staff and/or Head Teacher
Fruit and Milk Scheme		See 3.2.7	Ongoing	School Staff and Kids
Gardening Club	ScotSchoolE	Received £3000 from the Scottish Food for Thought Business in the Community initiative. Working in partnership with teaching staff, parents, local organsiations (Chefs; Horticultural society; The Haven Charity) to deliver their *Lets Grow Together and Cook Together*. Funding has helped to buy necessary equipment for cooking aspects. Partners are supporting with garden development (i.e. poly tunnel; raised beds)	Ongoing	Teaching Staff
Tasting Lunches (new starters) and Evenings (Parents)	ScotSchool A&E	No additional funding required and agreed between school and Head Cook.	Ongoing	LA Catering Staff and/or Head Teacher
Cooking Club	ScotSchool E	See Gardening Club.	Ongoing	Teaching Staff
Partents Council and Parent Partnership	ScotSchoolE	No additional funding required.	Ongoing	Head Teacher and Parents
UN Rights Respecting School Accrediation	ScotSchool A&E	No additional funding required.		Teaching Staff

Holiday Lunch Club	ScotSchool A	Funded via Attainment Challenge project targeting schools in deprived areas. Upto 70% of pupils in ScotSchool A fall into the most deprived category. Lunch provided on some days during the holiday.		LA Catering Staff and/or Head Teacher

Table 74: ScotSchool Food and Sustainability Initatives

3.2.3. Organisations of School Meals

IC has provided an in-house school meal service since the LA was created in 1996, employing all onsite kitchen staff in schools, and contracting directly, via national framework procurement contracts, with suppliers. 18 out of the 20 ScotSchool primary schools have on-site kitchens with the remaining 2 served by their next nearest school with a kitchen. In 17/18 all ScotSchools developed, in collaboration with IC, their own bespoke school lunch menu. In 18/19, this system was changed in an attempt to bring greater consistency across ScotSchools and manage the increasing regulatory burden associated with meeting statutory food-based and nutrient standards in Scotland in particular in relation to providing for special diets. There is now one menu across all ScotSchool's with some flexibility in terms of the number of daily options served. In July 2018, all ScotSchool canteens received a IC developed recipe book of nutritionally compliant recipes which head cooks are expected, where feasible, to follow. See Appendix 2 for a sample weekly menu from 18/19 for ScotSchool D&E. Traditionally menu innovation and development at IC was limited and while all main menu components were nutritioanlly analysed and compliant with nutritional standards (assessed using Nutmeg – nutritional analysis software used by Scottish Local Authorities), schools were not following a standard recipe book. In recent years, more resources have been put into innovating the menu options and developing new nutritionally compliant hot meal and dessert options per menu cycle including: the use of meat substitute products (i.e. quorn tikka wrap), development of more vegetarian options (i.e. creamy pasta bake with garlic bread), changes to how sandwich options are served (i.e. children can take between 2 and 4 quarters and can have a mix of fillings) and the trial provision of mixed fruit platters on canteen tables for children to freely choose from.

Daily, ScotSchool children choose from either soup and main meal or main meal and dessert with most opting for the latter. They choose from a total of 9 main meal options including up to 3 hot meal options (including one vegetarian hot meal (where required), Jacket Potatoes with up to 3 filling options (cheese; tuna mayo; chicken mayo; beans) or a sandwich option (sandwich; wrap; baguette; toastie) with up to 3 filling options (ham; cheese; tuna). Depending on which main meal option is chosen, children select from the available daily carbohydrates option including: mashed, boiled or roast potatoes; chips; rice; pasta; noodles or garlic bread. A good range of hot vegetables (i.e. cabbage; sweetcorn, garden peas; mixed vegetables; baked beans; cauliflower; green beans; carrots; broccoli; parsnips) and/or salad (i.e. mixed peppers; spring onions; watercress; carrot batons; cucumber; lettuce; tomatoes; boiled eggs; homemade coleslaw; homemade potato salad) are offered daily in all ScotSchools and children are free to ask for multiple portions if they choose. In accordance with the Scottish School Food Standards, a minimum of 2 types of fruit and vegetables (hot or cold) must be made available daily in all ScotSchools but ScotSchool children are not required to accept any fruit and/or vegetables (hot or cold) with their school lunch. High refusal rates for fruit, and in particular hot and/or cold vegetables, were observed in ScotSchools A&E, though it was not possible to systematically record the level and type of refusal due to time and personnel contraints.

While a soup or dessert option is offered to ScotSchool children, most choose dessert selecting from up to 3 daily dessert options including: 1) cake or ice cream related options (i.e. apple crumble and custard; Iced sponge; Fruit salad and Vanilla Ice Cream) (offered on 2 of 5 days/week); 2) Fat free fruit yoghurt (strawberry; peach and passion fruit) (offered ever day); and/or 3) Fresh fruit (i.e. whole apples (red and green); bananas; whole kiwis; whole mandarin oranges; raisins) (offered every day). All ScotSchools serve pre-made yoghurt in single use plastic pots.

Tap water, served in single use plastic cups, and single serve plain and flavoured (chocolate and strawberry) milk (189ml) and 50/50 juice cartons (200ml; 3 flavours) are provided in ScotSchool A. In ScotSchool E, only single serve plain milk cartons and tap water (jugs on the table with some reuseable plastic cups) are available after the parents council requested the removal of flavoured milk and 50/50 juice in 17/18. It is worth nothing though that in ScotSchool E the water jugs are quite heavy to lift especially for younger children, there was limited reuseable cups (approx. 6 per 12 seats) and the reuseable cups and jugs are not always replaced, and/or topped up, between sittings. Milk and juice cartons are stored in a chiller cabinet at the start of the food service line in ScotSchool A and at the end in ScotSchool E. ScotSchool E children were observed finding it difficult to open the chiller cabinet, take out their milk while balancing their full trays.While in ScotSchool A, most children took a drink from the available selection, the most popular being milk (plain or flavoured) or juice, a smaller proportion of ScotSchool E children had a lunchtime drink. ScotSchool E catering staff noted that milk consumption had dropped since the removal of the flavoured milk option. These observations raised concerns that ScotSchool E children may not be sufficently hydrated though after discussions with the the Head Teacher it was confirmed that all children have a reuseable water bottle in their classrooms which they drink from regularly, and freely, throughout the day.

3.2.4. Kitchen and Canteens

All school based catering staff (between 1-5/school) in IC are employed by the LA and each kitchen is managed by a Head Cook who is responsible for the operational management of their kitchen. This includes: all ordering/stock management, receiving deliveries, managing waste, unit administration and production and service of school lunches for their unit. ScotSchool head cooks, unlike NorthSchool unit managers, are not financially responsible for their kitchens nor are they required to keep daily/weekly paperwork on how much is spent per meal served. In most ScotSchools, the head cook is responsible for the primary preparation of hot meals. Other preparation work, such as making, and wrapping, of sandwiches, chopping up fruit, preparing salad items, setting up food service counter, washing up, is undertaken by a team of catering assistants (number depends on school size). It is worth noting that most ScotSchool catering assistants work part-time with many holding down multiple jobs with the LA including running the breakfast clubs and/or cleaning the schools. Table 7 outlines staffing provision and how lunchtime service is managed (time and number) in ScotSchool A&E. Interestingly, while most ScotSchool catering assistants work part time, term time hours, the head cooks do not work term time only and can, and do, take annual leave during the school year. During school holidays, ScotSchool head cooks work out of specific school campuses providing lunches to those children participating in the attainment challenge programme and other school holiday based initiatives/clubs.

	Average No. of School Meals served/day	Lunch Time Service Period	School Canteen Staff (School Cater Enployees)	Lunchtime Supervisors (NorthSchool employees)	No. of Staff on Hot Counter	No. of Staff on Cold and Desert Counter	No. of Daily Lunchtime Services (approximately 15 mins/service)
ScotSchool A	162	Approx. 75 mins including Year 1 children	5 (including unit manager)	No lunchtime supervisors; School Janitor is present during lunch and manages the waste station; Teaching staff with nursery and reception kids only	2	2	4
ScotSchool E	122	Approx. 60 mins including Year 1 children	3-4 (including unit manager)	No lunchtime supervisors; Teaching staff with nursery and reception kids only; Head and Deputy Head have lunch most days in canteen towards the end of service	2	2	4

Table 75: ScotSchool A&E Canteen Staffing

In ScotSchool A, a dedicated single use canteen is permanently set up, has an open and low canteen service line and is used daily for the breakfast club. For ScotSchool E, the canteen is made up of two distinct spaces, a single use canteen with an overflow area in the next door mixed use assembly hall. The overflow area is completely unsupervised and usually there is a 2nd waste station in this area. During our plate waste data collection, this overflow waste station was closed and all students handed their trays to the research team for processing.

Figure 112: Canteen Images from ScotSchool A

The ScotSchool E service line is higher than ScotSchool A and is very tightly packed in the cold section with salad vegetables, fruit, yoghurt, dessert and the daily sandwich option competing for space and the children's attention. Interestingly, on days when hot desserts were served in ScotSchool E, the desserts were positioned before the hot main option in the service line and on these daysvery few children were observed considering the alternative yoghut or fruit dessert options.

Figure 113: Canteen Images from ScotSchool E

3.2.5. Lunchtime Service

In previous academic years, different school meal ordering and payment systems were in operation across ScotSchool. In 17/18, a new daily pre-ordering system was implemented by IC. Where payment is required (those children in P3 and above who are not eligible for free school meals), and since 17/18, ScotSchool parents must register for, and pay, via the online Parent Pay system as cash payments were phased out. This new payment system has generally been warmly welcomed though some parents have outstanding bills that IC are responsible for pursuing.

In ScotSchool A&E, an electronic pre-ordering system was introduced in 17/18 where each child selects their lunch choice in their classroom every morning with these choices electronically recorded and passed onto the kitchen by 10am. The children are given a coloured band to denote the main meal ordered and interestingly, unlike in NorthSchool E, band swapping was not reported as a problem. Children line up in their year group, pick up a compartmentalised tray and their cutlery (reusable plastic for younger children; metal for older children). Catering staff (including the head cook) manage the food service line in ScotSchool A&E. Hot food (main meal and vegetables) is served first with the tray passed along the food service line. The staff interact with each child individually helping them to choose vegetables, salad and dessert options. For some of the smallest children, the service line, in particular in ScotSchool E, is too high and catering staff help them to better view options where needed. In ScotSchool A, children pick up their chosen drink from a open chiller cabinet at the start of service whereas in ScotSchool E a closed chilled drinks cabinet is positioned at the end of the food service line. The children are first asked if they want soup (no more than 12 a day take the homemade soup served in single use polystrene cups) and are then given their chosen main meal option. Their tray is passed along the service line for hot vegetables or salad and then dessert (if selected). In ScotSchool A and E, three, and four, catering staff, respectively, manage the food service line (2-3 kitchen side; 1 canteen side) with 1-2 on hot main option and hot veg; 1 on cold main option and 1 on the canteen side serving desert. The catering assistants are aso responsible for washing up, and cleaning, during, and after, service.

In ScotSchool A, the canteen has six 12 seater rectangular tables, three 8 seater round tables and a 12 seater high stools counter giving a total of 108 seats for a school roll of 229. As space is limited, service is carefully managed and broken into 4*15min sittings. The youngest children always have lunch first with nursery and P1 children arriving between 12-12.15pm. A rota system operates from P2 upwards splitting the year groups across the remaining sittings and there is a continuous turnover of children through the canteen between 12.15-1pm with the last children finishing at approximately 1.15pm.

In ScotSchool E, there is a mix of seating with seven 12 seater rectangular tables (84 seats) in the main canteen and one 12 seater rectangular table and six 8 seater round tables (60) in the overflow area giving a total of 144 seats for a school roll of 200. In ScotSchool E, service is split into 4*15min sittings. The nursery and P1 children alwasy arrive first at 12noon. A rota system operates from P2 upwards splitting the year groups across the remaining sittings with a continuous turnover of children through the canteen between 12.15-1pm. Monday and Friday's are the busiest days in ScotSchool A&E with the canteen noticeable busier.

In both ScotSchool A&E, some children were observed, in particular the younger ones, finding some meal options more difficult and/or longer to eat than others. This was particularly evident for meal options where they had to cut up food items themselves especially meat and the ScotSchool A head teacher confirmed this noting how some children require extra help and encouragement especially on roast dinner days. No extra time is available for lunchtime service on busier days (normally Monday and Fridays) or on days where the meal options were observed to take longer to eat or require more cutting up. While we were not able to systematically observe how long the chidlren spent on the lunch time process, it was possible to estimate, from the first main sitting (P2 onwards) in both ScotSchools, that the first children coming to the waste station had spent as little as 8-10 mins in the canteen from from queuing for food, sitting down and eating to going to the waste station. On the other hand, and notwithstanding the space constraints, some children took much longer over their lunch (up to 30mins) with many taking their time over lunch and clearly enjoying the opportunity to talk with friends and teachers/lunchtime supervisors. No child, in either ScotSchool, was made to rush their lunch and none were made to leave the canteen before finishing their lunch even if their allocated sitting had ended.

While ScotSchool A does make some portion size adjustments between younger and older children especially for the carbohydrate option, no such adjustment was observed in ScotSchool E. In ScotSchool A, nursery, P1 and P2 children received a smaller portion of carbohydrates in line with portion size recommendations in Healthy Eating in Schools (2008). No obvious adjustment of main meal portions was observed as main meal component portions are produced in accordance with the new IC approved recipes.

Due to IC budgetary constraints, no lunchtime supervisors are employed in ScotSchools. As a result, catering and school staff work together to manage flow and behaviour in the canteen and along the service line. In ScotSchool A&E, encouragement and support with eating lunch is only provided to nursery and year 1 children via class teachers, special needs assistants and/or teaching assistants present during lunchtime service. In addition, the Head and/or Deputy Head teachers in ScotSchool A&E visit the canteen daily during lunch, providing ad hoc support and encouragement and in some cases (ScotSchool E in particular) eating their lunch in the canteen with the children during the latter part of service.

3.2.6. Waste Management and Plastics Use

In ScotSchool A&E, the children are trained to use the waste stations. In ScotSchool A only, the school janitor provides extra oversight of, and support at, the waste stations helping the children, where required, with waste disposal. Both ScotSchools have multiple waste stations to dispose of plate waste (i.e food and non food (yoghurt pots)), lunchbox leftovers, and non food waste (i.e. milk cartons, juice cartons; polystrene cups; plastic cutlery; plastic wrapping), and to stack reuseable plates, bowls and cutlery ready for washing. All plate food waste is collected in designated food waste bins though unlike NorthSchool the collected food waste is not normally weighed or recorded on a daily basis. All plate, counter and kitchen food waste is transfered to large outdoor food waste bins for weekly collection by IC for dispoal via anerobic digestion. Non food waste is collected in designated non-food waste bins at the waste stations and then disposed of via the general waste stream. Significant single use plastic waste was observed daily in ScotSchool A&E due to the use of single serve milk, juice and yoghurt cartons (including plastic straws); polystrene cups for soup; plastic wrapping for prepared sandwiches, burgers and cut fruit, and single use plastic cutlery (spoons only). No sorting of non-food waste for recycling was observed.

3.2.7. School Fruit and Vegetable Scheme

ScotSchool A run a Fruity Friday scheme. They used to get exotic fruit but now get simply bananas, apples and grapes as these are most popular with the kids. The Head Teacher feels that the provision, and consumption, of fruit, supplied by the scheme, has a positive impact on the children especially if provided in the morning as it helps them have something healthy to eat early in the day and can reduce the likelihood of them having less healthy snacks later in the school day. Interestingly, after the holidays when the first delivery has not yet arrived, kids will ask for it noticing and missing it when it is not available. In ScotSchool E, fruit used to come once a week on Fridays and the general perception was that the scheme had little impact, as to the children are already perceived to have healthy eating habits. So instead, ScotSchool E asked for, and was granted, permission by IC to change how they used the fruit funded by the scheme. It is now ordered for, and used in, the ScotSchool E cookery classes/clubs where children use it to make smoothies and desserts helping them to fine tune their food preparation skills (especially knife skills) and giving them hands on opportunities to learn about different fruits and vegetables and how they can use them in different recipes. The Head Teacher felt that as a result of this change they were making much more educational use of the fruit than previously. In addition, and throughout all ScotSchools, IC has started in 18/19 to put in place a number of fruit and vegetable based initiatives including: making fruit available as a daily dessert option, trialling small mixed fruit platters on the tables (new initiative in 18/19) in addition to the rest of their normal school meal (can have a dessert and fruit) and providing approximately 6-10 different fruit and vegetable choices (hot and cold) daily.

4. Nutritional Composition of Menus in Case Schools

This section presents the results of the nutritional composition analysis of NorthSchool and ScotSchool lunch menus. Unlike other partners in the S2F study where participating schools only offer one meal combination (one main and one soup/dessert) per day, UK schools offer multiple daily meal options. Daily, across both NorthSchool and ScotSchool, up to 27 different meal combinations are offered including up to: 3 hot meal options; 3 baked potato filling options, 3 sandwich filling options and 3 dessert/soup options. Multiple daily hot and cold vegetables options (up to 8 different types) are available across both regions though only NorthSchool children are required to accept at least one portion of hot/cold vegetables. For the purposes of nutritional composition analysis, and in order to calculate the planned energy and nutritive profile for both regions, it was assumed that all children, irrespective of the high observed hot/cold vegetable refusal rates in ScotSchools, accepted at least one portion of hot vegetables/main option chosen (including sandwiches) and as such, all nutritional calculations include energy and nutrient data for one portion of hot vegetables/main option served.

For NorthSchool, including NorthSchool D&E, and across the 4 weeks of plate waste data collection in July 2018 (2 weeks of 3 week Spring/Summer 2018 Menu Cycle) and Nov 2018 (2 weeks of 3 week Autumn/Winter 2018/19 Menu), 41 options (26 main; 15 dessert) were offered with the daily sandwich and baked potato options counted as one option each for analysis purposes. From the 6 weeks that make up the two 3 week NorthSchool Spring/Summer (Weeks 2 and 3) and Autumn/Winter (Weeks 1 and 3) menu cycles, a sample of 33 menu options (22 main meal, 11 dessert option) were nutritionally analysed. To simplify the data processing, a single meal option for the sandwich and baked potato options respectively was calculated using the most calorific filling offered. In NorthSchool, the cheese filling was the most calorific sandwich and baked potato filling offered and was thus used for energy and macronutrient calculative purposes. The 33 recipes selected were nutritionally analysed using menu and recipe data supplied by SchoolCater and supplemented, where required, with data from the statutory school food-based standards for England (School Food Plan, 2015).

For ScotSchool, including ScotSchools A&E, only 18/19 recipe data was available as prior to that the head cooks were not cooking from an agreed receipe book and menus varied by school. As all ScotSchools are now working to one agreed 3 week menu cycle/academic year using a common recipe book, nutritional composition analysis was conducted for all options offered for 2 of the 3 week 18/19 ScotSchool menu cycle (Weeks 3 and 1; 1st Oct -13th Oct 2018). Across this 2 week period, 33 meal options were offered including a soup, 28 main meal and 4 dessert options. As for NorthSchool, the energy and macro-nutritive profile of the sandwiches and baked potatoes were calculated using the most calorific fillings. In ScotSchool, the tuna mayo filling, and the coleslaw filling, were found to be the most calorific sandwich and baked potato fillings offered and thus were used for energy and macronutrient calculative purposes. All 33 recipes were nutritionally analysed using menu and recipe data supplied by IC and supplemented, where required, with recommendations from the statutory school food based standards for Scotland (Healthy Eating in Schools, 2008).

According to these statutory Scottish nutrient standards for school meals, an average school lunch (2 courses) should provide a third of the daily nutritional requirements of a primary school child. It is the responsibility of school caterers (in-house or private) to plan school lunch menus cycles that ensure the food and drinks offered comply with statuatory food-based standards and that over a school week the meal options average out to meet the statutory nutrient standards. Using the supplied receipe data and the bespoke nutritional analysis tool developed by ZAG, Food Explorer[38], the average energy and nutritive profile of NorthSchool and ScotSchool school lunches were calculated. After entering all ingredient data for the selected menu options per region (33 per region) into the Food Explorer database, a full energy and macronutritive profile for a standard portion/child for each menu option (soup, main or dessert) was calculated. For reporting purposes, only energy and macronutritive profiles are presented for the UK due to breadth of choice offered, and the high vegetable refusal rates observed in ScotSchool. For NorthSchools and ScotSchools respectively, drawing on the calculated energy and macronutritive profile from the main menu (22 and 28 respectively) and soup/dessert options (11 and 4 respectively) selected, a daily average energy and macronutritive profile for a 2 course school lunch, was calculated. For both NorthSchool and ScotSchool, table 8 presents average daily energy and macronutritive profiles for an average 2 course school lunch including the range for each energy and macronutritive category.

Parameter **(Average** ± SD**)**	**Scottish Nutrient Standards for School Lunches**	**NorthSchool (LOC)**	**ScotSchool (LOW)**
ENERGY and MACRONUTRIENTS			
Energy (kcal)	557 kcal	625 ± 159	576 ± 71
Total proteins (g)	Min of 8.5g	25.0 ± 4.2	29.7 ± 3.2
Total carbohydrates (g)	Min of 74.3 (not less than 50% of food energy)	69.9 ± 20.7	66.1 ± 10.9
Dietary fibre (g)	Min of 4.5	6.3 ± 1.5	6.0 ± 0.6
Total fat (g)	Max of 21.7g	26.7 ± 8.4	22.2 ± 4.8
Saturated fatty acids (g)	Max of 6.8 g	12.2 ± 4.2	10.9 ± 2.4

Table 76: Nutritional Composition of served lunches per child by Energy and Macronutritive Category

Based on the nutritional composition analysis for the sample of menu options analysed for NorthSchool (33 menu options) and ScotSchool (33 menu options) respectively, the average school lunch, across both regions, was found to be slightly above the acceptable range (as per the Scottish Nutrient Standards) for energy (Kcals), total fat (g) and saturated fatty acids (g) and slightly below recommendations for min target for Total Carbohydrates (74.3g) (Figures 5-8). The average weight of an NorthSchool lunch (329g) is 78g more than ScotSchool (252g) providing slightly more energy (49kcal) per average lunch portion (625kcal±159 – LOC; and 576±71), Scot). Overall in terms of energy, 45%, and 60%, of North and Scot school lunches respectively, were found to meet the recommended energy thresholds while 35% (North), and 25% (Scot) were below and 20% (North), and 15% (Scot), above recommendation. The average energy contribution from carbohydrate was 45% for North, and 46% for Scot, which is slightly below national recommendation. Both North and Scot School lunches were found to

[38] *For the UK analysis, the UK's approved national food composition database, the McCance and Widdowson's composition of foods integrated dataset on the nutritional content of the UK food supply, was used.*

acquire on average 38% (North), and 35% (Scot) of food energy from total fat which slightly exceeds national recommendation. In terms of protein, both North and Scot school lunches excced national recommendation for total proteins with on average 25± 4.2 (LOC) and 29.7 ± 3.18 (LOW) grms of total protein per lunch menu analysed. This is well in excessive of the recommended minimum of 8.5g and equates to 16%, and 21% of food energy coming from proteins. The majority of North (90%) and Scot (100%) school lunches were estimated to exceed recommended levels for saturated fatty acids. All LOC and LOW menus analysed were found to be in line with recommended dietary fibre content.

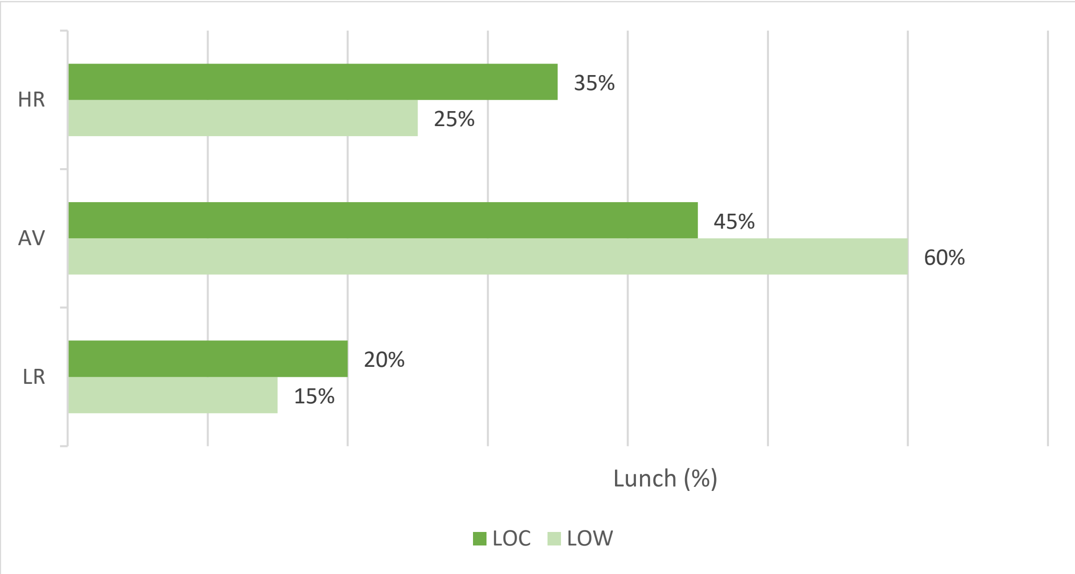

Figure 5: Proportion of UK daily menus across both cases/country that met National recommendations for total energy (Kcal)

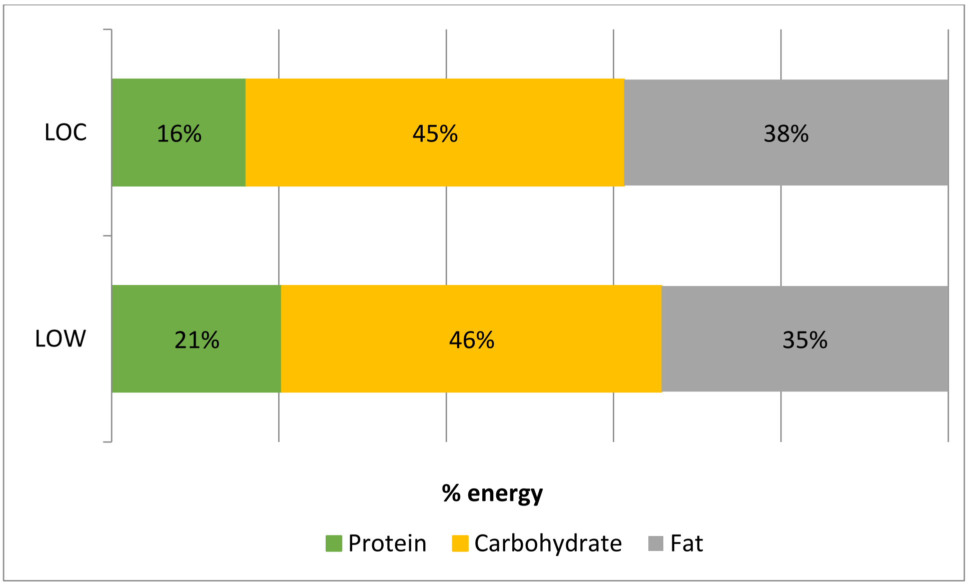

Figure 6. Average proportions of macronutrients in terms of % meal energy in daily menus of LOC and LOW cases

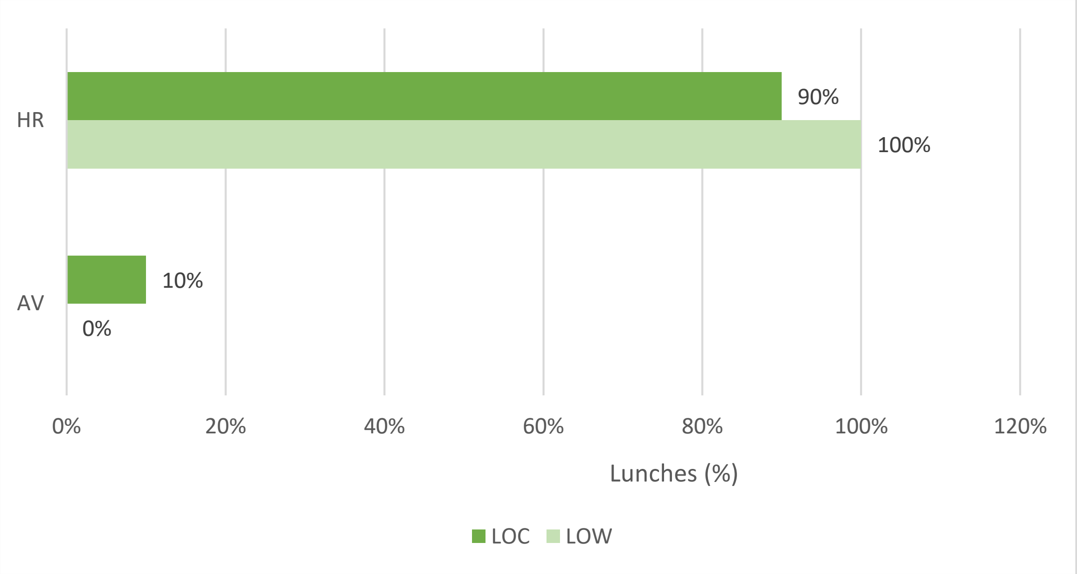

Figure 7: Proportions of UK daily menus across cases, and countries, that met National recommendations for saturated fatty acids

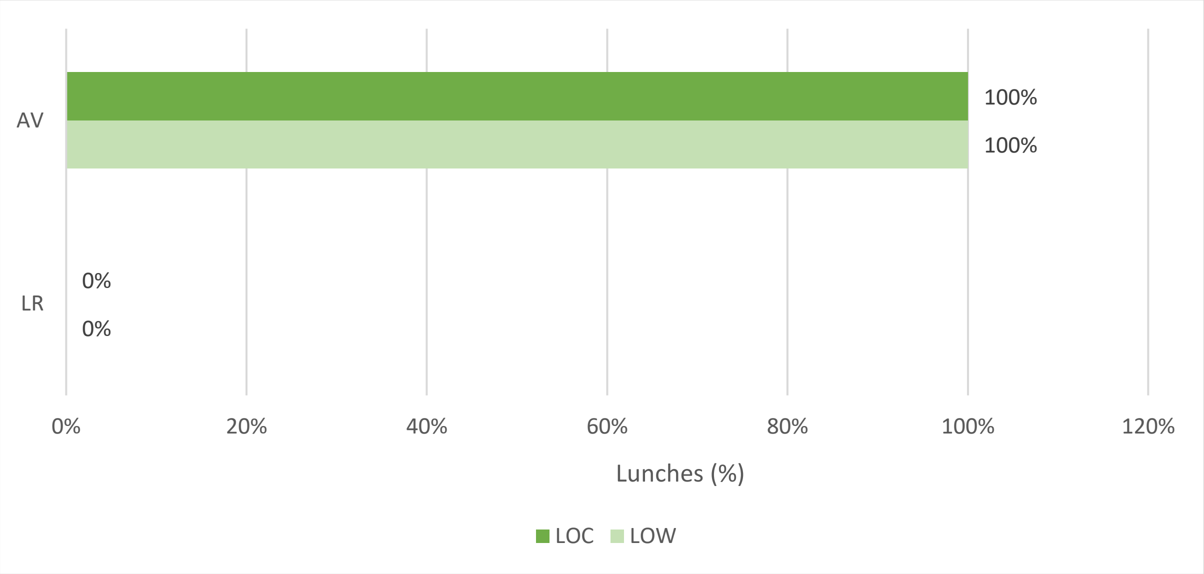

Figure 8: Proportions of UK daily menus across cases, and countries, that met National recommendations for dietary fibre

It is worth noting that while little or no refusal of meals components at service was observed in LOCSchool, significant refusal of meal components, especially of hot/cold vegetables, was observed in LOWSchool and as such the actual school lunch energy and nutritive intake of LOWSchool children is highly likely to be lower than that presented in Table 20. When compared, and based on the sample of menus analysed, ScotSchool school lunches were found to be on average delivering lower energy (kcal), less total carbohydrates, fibre, total fat and SFA and more total protein than NorthSchool. It is worth noting though that while little or no refusal of meals components at service was observed in NorthSchool, significant refusal of meal components, especially of hot/cold vegetables, was observed in ScotSchool and as such the actual school lunch energy and nutritive intake of ScotSchool children is highly likely to be lower than that presented in Table 8. In addition, the use of supplementary data was required when preparing the data, from ScotSchool recipes, for nutritional composition analysis as the available recipes did not cover all components of the menu options served and thus the available menus had to be supplemented with portion size recommendations from the Healthy Eating in Schools (2008).

5. PLATE WASTE IN CASE SCHOOLS

Section 5 reports the findings of the plate waste study conducted in NorthSchool (LOC) and ScotSchool (LOW) during Spring/Summer 17/18 (April – July 2018) and Autumn/Winter 18/19 (Oct – Nov 2018). In each of the four schools, 10 days of plate waste data were collected across 2*1 week periods (where a week equals 5 consecutive school days from Monday to Friday), a spring/summer week and an autumn/winter week, giving a total of 10 days/school and 20 days/case region. For NorthSchool D&E and ScotSchool A&E, plate waste was collected from 2624 and 2833 plates respectively and in both cases, the children were aged between 3-11 with waste collected from the trays of all children taking school lunches on each data collection day.

By adapting existing canteen waste stations, the research team (2 in the UK) set up one temporary plate waste collection site per canteen. Where canteens normally had multiple waste stations, additional stations were closed during the plate waste data collection. Children taking school lunches were instructed to bring their trays, when finished, to the plate waste station and hand them to the research team for processing. One researcher took the tray from the child and prepared it for scraping by removing any non-food items including non-food waste, cutlery and drinks containers/beakers. The trays were then passed to the 2nd researcher who physically separated and scraped the plate food waste into the appropriate food category specific waste bins namely: (1) fruit; (2) vegetables (including mixed vegetable stews, legume stews, vegetable soup, fresh and canned salads, beans/peas where served as a vegetable option; and side dishes that encourage the intake of vegetables and contain more than 30% of vegetables in the composition; (3) meat and fish (all meat and meat products, fish and fish products, and poultry and poultry products, eggs and meat substitutes (i.e. quorn); (4) starchy foods (e.g. bread, pasta, rice, potatoes, cereals, bakery products, main dishes mainly containing starchy foods with other items that couldn't been separated, e.g. pasta with Bolognese sauce, rice with vegetables); (5) desserts (foods that are part of the school menu and listed as "dessert", e.g. puddings, cakes, dairy desserts, fruit yoghurt); and (6) other food (i.e. cheese).

Once service was complete, and all trays/plates scraped, each bin was weighed using a digital weighting scale. The weight of collected plate waste/bin was recorded and the collected plate waste returned to canteen staff for normal processing. Confirmation of the final number of meals served and the breakdown by menu option was obtained from the unit managers/head cooks. Unfortunately, no records of the exact sandwich or baked potato filling selected by children are kept as filling selections are made at service and no breakdown by sandwich/baked potato filling could be recorded. The Unit Manager/Head Cook also confirmed the number of soups served (ScotSchool only) and where possible, the breakdown by dessert option offered (all North School children and majority of ScotSchool children).

In order to put the collected plate waste into context, a reference value against which to compare it was calculated. The chosen reference value was the total planned weight of food served. To do this, the total planned weight of food served/portion for each menu option offered (46 and 33 in NorthSchool and ScotSchool respectively; See section 4 for more details) was calculated using the precise recipe data supplied by SchoolCater or IC and supplementary data, as required, from the School Food Plan, England (2015) and the Healthy Food in Schools Guide, Scotland (2008). Where recommended portion size ranges where provided, the minimum portion size was used for calculative purposes and thus the total planned weight of food served represents a minimum value drawn from the precise recipe and supplementary data obtained. Using this data, and multiplying by the total number of meals served across each menu options offered (how many portions of each menu option were served during the data collection period), an estimated total planned weight of food served (kg) an estimated average planned weight of food/meal served per case region (across the 4 weeks of data collection) was calculated. Using these estimates as reference values, the proportion of the estimated total planned weight of food served collected as plate waste could then be calculated.

The plate waste results are reported as follows. First, the distribution of meals choices by main meal options offered is presented. Next, the total weight of planned food served and total collected plate waste across NorthSchool and ScotSchool, respectively, are presented in terms of total volume (kg), average/meal served (g), and as a proportion of total planned weight of food served (Section 5.2). Thirdly, we report the breakdown of plate waste collected by food category composition examining the differences, where found, between the case regions (Section 5.3). Fourthly, we present our analysis of the nutritional losses associated with the plate waste (Section 5.4) and finally, we present our analysis of the financial cost of, and levels of embodied carbon attributed to, the total collected plate waste (Sections 5.5).

5.1 Distribution of Meal Choices across Main Meal categories

To begin with, the distribution across the three broad main meal option categories offered was calculated with some interesting differences within, between the regions observed. Table 9 reports this distribution. Interesting, while a sandwich and/or baked potatoes option was offered in all 4 schools, different patterns emerged for main meal choice. While a clear preference for the hot meal option emerged in NorthSchool D (82.5%), this preference dropped in NorthSchool E (64.5%) and was even more pronounced in ScotSchool A&E, with 57.5% and 57% respectively. These patterns directly impact the type, and quantities of, starchy carbohydrates with more bread and potatoes served (via sandwiches and baked potatoes) as the rate of hot option selection drops.

Distribution of Main Meal Choice	**NorthSchool D**	**NorthSchool E**	**ScotSchool A**	**ScotSchool E**
Hot Meal Option (%)	**82.5** (2-3 options daily)	**64.5** (2-3 options daily)	**57.5** (2-3 options daily)	**56** (2-3 options daily)
Sandwich (%)	**16.5** (1 option/day)	**30.5** (up to 3 options per day)	**37** (up to 3 options per day)	**36** (up to 3 options per day)
Baked Potato (%)	**1** (not always available)	**5** (always available)	**5.5** (always available)	**8** (always available)

Table 77: Distribution of main meal choices across main meal options offered by School

5.2 Total Collected Plate Waste in Cases 1 and 2 (in grms/kgs and per meal served)

Table 10 reports, for the full plate waste data collection period, total collected plate waste for NorthSchool and ScotSchool alongside the total number of meals served, the average uptake of school meals as proportion of school roll, the total planned weight of food served (kg), the average planned weight of food/meal served (g), the total weight of collected plate waste (kg);

the average weight of collected plate waste/meal served (g); and collected plate waste as a proportion of total planned weight of food served (%).

PFSP model	**NorthSchool (LOC)**	**ScotSchool (LOW)**
No. of served meals in four weeks (n)	2624	2833
Average uptake of school meal as proportion of total school roll (%)	55	66
Total planned weight of food served in four weeks (kg)	863.1	713.9
Average planned weight of food/meal served (g)	329	252
Total weight of collected plate waste (kg)	227.1	181.5
Average collected plate waste/meal served (g)	87	64
Collected plate waste as a proportion of planned food served (%)	26	25

Table 78: Amount of served meals and plate waste across all food categories and both seasons in two schools per case

For NorthSchool, across 4 weeks of data collection (July 2018; Nov 2018), 2624 school meals were served, representing an average uptake of 55% and converting into 863.1kg of total planned weight of food served and an average of 329g of planned food/meal served. Across the 2624 meals, 227.1kg of plate waste was collected equating to 87g/meal served and 26% of the total planned weight of food served. For ScotSchool, across 4 weeks of data collection (April/May 2018; Oct 2018), 2833 school meals were served, representing an average uptake of 60% and converting into 713.9kg of total planned weight of food served and an average of 252g of planned food/meal served. Across the 2833 meals, 181.5kg of plate waste was collected equating to 64g/meal served and 25% of the total planned weight of food served. When compared, the average planned weight of food served/meal served in NorthSchool was on average 77g higher than ScotSchool with on average 23g more plate waste collected per meal served in NorthSchool. Further analysis of the food category breakdown is presented in Section 5.3.

5.3. Distribution of Plate Waste by Food Categories in Cases 1 and 2 (in grms/kgs and per meal served)

Across NorthSchool and ScotSchool, collected plate waste was separated into six distinct food categories. Table 11 presents a summary of total collected plate waste per food category (kg), the average plate waste/meal served/food category, the proportion of total collected plate waste by food category and the differences, where observed, in this distribution.

Food categories	LOC (n=2624 lunches)		LOW (n=2833 lunches)	
	kgs	%	kgs	%
Starchy food	85.6	37	110.4	61
Vegetables	62.3	26	11.6	6
Fruit	28.1	13	18.1	10
Meat	22.3	11	25.9	15
Desserts	26.9	12	13.0	7
Other food	1.9	1	2.6	1
Total waste	227.1	100	181.5	100

Table 79: Weight and Proportion of total plate waste by food category

While total collected plate waste as a proportion of total planned weight of food served was found to be broadly equivalent for both schools (26% for NorthSchool and 25% for ScotSchool), the average planned weight of food served/meal served and average weight of collected plate waste/meal served in NorthSchool were 75g and 23g higher, respectively, than in ScotSchool. Based on the total weight of collected plate waste (and associated canteen based observations), it is posited that NorthSchool children receive both a greater quantity (weight of food/meal served) and range of food types per meal served due to SchoolCater menu and receipe innovations and the very strong emphasis placed on, and NorthSchool staff skills in, cooking from stratch. To illustrate, let us consider the “Tomato and Cheese Pizza”, a menu option offered by both regions. In ScotSchool, premade pizza bases and topping sauce are bought and then assembled in-house. This is not the case in NorthSchool where both the pizza bases and topping sauces are made from scratch in each school kitchen. Recent SchoolCater led menu innovations require NorthSchool pizza bases to be homemade from a 50:50 white/wholemeal flour mix to increase fibre content and the topping sauce is loaded with 17g/portion of “hidden grated carrots and courgettes” adding flavour, natural sweetness and increasing the quantity, and type, of vegetables consumed.

Plate waste by food categories in 4 weeks	Starchy food	Vegetable	Fruit	Meat	Desserts	Other food
NorthSchool case						
Total number of served meals (n)	2624	2624	2624	2403	2735	2520
Total collected plate waste/food category (kg)	86	61	29	21	30	1
Average plate waste/meal served (g)	33	23	11	9	11	0.4
Proportion of total collected plate waste per food category (%)	29	43	16	14	12	2
ScotSchool case						
Total number of served meals (n)	2833	2833	2833	2833	2741	2830
Total Plate waste/food category (kg)	110	12	18	26	16	3
Average plate waste/meal served (g)	39	4	6	9	4	1
Proportion of Total Plate waste coming from each food category in two weeks (%)	31	8	9	13	7	5
NorthSchool vs ScotSchool						
Difference in total waste (%) per food categories between NorthSchool and LOW case	-2%	35%	7%	1%	5%	-3%

Table 12: Weight and Proportion of plate waste by food category

While NorthSchool collected plate waste, as a proportion of total weight of planned food served, is similar to ScotSchool, the distribution of collected plate waste across the 6 food categories is different. For NorthSchool, collected plate waste (by weight) was reasonably well distributed across the 6 food categories with 37% coming from starchy food, 26% from vegetables, 13% from fruit, 11% from meat, 12% from dessert and 1% from other (i.e. cheese). On the other hand, ScotSchool collected plate waste (by weight) was more unevenly distributed with 61% coming from starchy food, 6% from vegetables, 10% from fruit, 15% from meat, 7% from dessert and 1% from other (i.e. cheese). Large differences in the proportions of collected plate waste by food category were found between the case regions for Starchy Carbohydrates

(NorthSchool: 37%; ScotSchool: 61%; Difference: -24%) and Vegetables (NorthSchool: 26%; ScotSchool: 6%; Difference: 20%). An explanation for the differences in starchy food waste proportions is portion size adjustment practices. During the study, while starchy carbohydrate portion sizes adjustment depending on the age group served was observed in NorthSchool D&E and ScotSchool A, no such adjustments were observed in ScotSchoolE. The NorthSchool unit managers and the ScotSchool A head cook verbally confirmed these adjustment practice outlining that smaller portions of starchy carbohydrates are given to nursery and KS1 children and larger portion to KS2 children. All adjustments made were reported to be in line with portion size range recommendations which allow for variation according to age (School Food Plan, (2015); Healthy Eating in Schools (2008)). When the collected starchy carbohydrate plate waste is broken down by school, a very interesting pattern emerges. For NorthSchool D&E and ScotSchool A, on average 29-35g of starchy carbohydrate is wasted/meal served, rising considerably for ScotSchool E, where no portion size adjustment was observed, with on average 53g of starchy carbohydrates wasted per meal served.

Considering collected plate waste as a proportion of estimated food served per category, an interesting picture emeged. In NorthSchools, where overall levels of plate waste were 26% of planned food served, children wasted 43% of estimated served vegetables, 29% of estimated served starchy foods, 16% of estimated served fruit, 14% of estimated served meat and fish, 12% of estimated served dessert and 2 % of estimated other food. In ScotSchools, where overall levels of plate waste were 25% of planned food served, children wasted 31% of estimated served starchy foods, 13% of estimated served meat and fish, 8% of estimated served vegetables, 9% of estimated served fruit, 7% of estimated served dessert and 5% of estimated served other food.

In terms of collected vegetable plate waste, a few plausible explanations can shed light on the large differences in vegetable waste proportions (26% NorthSchool and 6% ScotSchool) observed between the regions. For NorthSchool, all children must accept at least one portion of hot/cold vegetables. This increases to 2 portions in NorthSchool E only for children who select the sandwich or baked potato option (on average 35.5%, See Table 9). ScotSchool children are not required to accept any hot/cold vegetables with high observed refusal rates for hot/cold vegetables. When the collected vegetable plate waste is broken down by school, an interesting pattern emerges. While in NorthSchool D, on average 15.6g of hot/cold vegetables were wasted/meal served, this figure was much higher in NorthSchool E with 28.6g of vegetable waste collected per meal served. For ScotSchool A&E, where children are not required to accept hot/cold vegetables, much lower weights of vegetable waste were collected in with on average 4.1g/meal served. Due to very high observed hot/cold vegetable refusal rates by ScotSchool children at service, very little hot/cold vegetables are actually being put on their plates and thus very little hot/cold vegetables were left on plates. As a result, it is understandable why the proportion of collected vegetable plate waste is so much lower in ScotSchool (6%) compared to NorthSchool (26%) as ScotSchool children are accepting (and consuming) much less hot/cold vegetables at school lunch despite a similar range of hot/cold vegetables being made available while NorthSchool is actively encouraging and requiring children to accept and try hot/cold vegetables every day.

5.4. Nutritional Impact of Plate Waste

This section reports the analysis of the nutritional composition of the collected plate waste, and the associated implications for nutritional intake. Loss of energy and nutrients depends on the proportion of energy and nutrients in the meals as a whole and per individual meal component, as well the amount of plate waste collected per food category. Therefore, in order to estimate the loss of energy and nutrients from collected plate waste, we estimated the nutritional composition of the plate waste. Using the FCA reported in Section 4, the nutritional composition of the collected plate waste per food category was calculated by multiplying estimated nutritional composition of each food category with the percentage of plate waste/planned food served per category. The estimated actual nutritional intake was then obtained by calculating the difference between estimated planned nutritional composition of each food category and the nutritional composition of collected plate waste per food category. The amount of energy and nutrients were summed at a daily level and average values calculated across the full data collection period. The ZAG team produced the following results by school and case for all partners: (i) a summary of the energy and nutrient profile of served lunches, (ii) a summary of the energy and nutrient profile of plate waste, (iii) a summary of the estimated actual energy and nutrient intake from the eaten food (i.e. planned less collected plate waste) (iv) percentages of consumed macro and/or micro nutrients, and (v) percentages of energy and macro and/or micro nutrients losses. For the UK only, and due to the complexity and number of menu options offered, the % of plate waste/food item per food category was estimated using the distribution of meals selected and the associated food components. The differences between nutritional composition of served items and the estimated nutritional composition of the collected plate waste was calculated with the difference between the two representing the estimated actual intake of energy and nutrients per meal served after adjustments were made for collected plate waste. The planned nutritional intake, estimated nutritional composition of collected plate waste and estimated actual nutritional intake per food category were summed up per meal per day to calculate a whole lunch profile. The average values of planned nutritional intake, estimated waste nutritional composition and estimated actual intake of energy and nutrients were then calculated using values that represented whole lunch. For the UK, 33 menus composed of multiple food components and across 33 offered main meal and desserts options were analysed per model, and against the national nutrient standards, with the results presented in Table 13 and 14.

Table 80: Nutritional composition of average school lunch, estimated nutritive losses from collected plate waste and estimated actual nutritive intake/meal served

Parameter (average ± SD)	Nutritional composition of served lunches		Nutritional composition of plate waste		Difference between FCA of served lunch and plate waste (Estimated Actual Average Nutritive Intake/Meal Served) Δ (%)		% Nutritive Loss from plate waste	
	NorthSchool (LOC)	ScotSchool (LOW)	NorthSchool (LOC)	ScotSchool (LOW)	NorthSchool (LOC)	ScotSchool (LOW)	NorthSchool (LOC)	ScotSchool (LOW)
Energy (kcal)	625 ± 159	576 ± 71	110 ± 35	104 ± 28	515 ± 138 (82)	472 ± 60 (82)	18	18
Total proteins (g)	25.0 ± 4.2	29.7 ± 3.2	4.1 ± 1.3	4.3 ± 0.9	20.9 ± 3.8 (83)	25.4 ± 2.9 (85)	15	17
Total carbohydrates (g)	69.9 ± 20.7	66.1 ± 10.9	14.7 ± 5.2	15.2± 5.6	55.3 ± 17.4 (79)	50.9± 9.4 (77)	23	21
Dietary fibre (g)	6.3 ± 1.5	6.0 ± 0.6	1.7 ± 0.5	1.1 ± 0.4	4.7 ± 1.2 (74)	4.9 ± 0.6 (81)	19	26
Total fat (g)	26.7 ± 8.4	22.2 ± 4.8	3.8 ± 1.6	3.1 ± 1.0	22.9 ± 7.4 (85)	19.1 ± 4.2 (86)	15	14
Saturated fatty acids (g)	12.2 ± 4.2	10.9 ± 2.4	1.5 ± 0.8	1.4 ± 0.6	10.7 ± 3.7 (87)	9.6 ± 2.0 (88)	13	12

In terms of nutritional losses from plate waste, average energy losses of 18%, and average overall macronutrient losses of 12% to 26% per served meal were calculated. Total protein and carohydrate losses were 17% (North) and 15% (Scot) and 21% (North) and 26% (Scot) respectively. Fibre loss was 26% and 19% for North and Scot schools while loss of total fat was similar between both cases at 15% (North) and 14% (Scot) respectively. Such as with total fat, the losses of saturated fatty acids are similar with 13% and 12% losses in North and Scot schools respectively. Micronutrients – Due to the complexity of the UK menu data and the significant number of daily menu options offered, it was not possible to estimate, for the collected data, the losses of vitamins and minerals associated with the collected plate waste.

Parameter (average ± SD)	**Scottish Nutrient Standards for School Lunches**	**Estimated Actual Average Nutritive Intake/Meal Served Δ (%)**		**Comparison to Nutrient Standards**	
		NorthSchool (LOC)	**ScotSchool (LOW)**	**NorthSchool (LOC)**	**ScotSchool (LOW)**
Energy (kcal)	557 kcal	515 ± 138	472 ± 60	Within +/- 10% of recommendation (9% below)	15% below recommended levels
Total proteins (g)	Min of 8.5g	20.9 ± 3.8	25.4 ± 2.9	Above recommended Minimum level	Above recommended Minimum level
Total carbohydrates (g)	Min of 74.3 (not less than 50% of food energy)	55.3 ± 17.4	50.9± 9.4	25% Below recommended Minimum level	32.5% Below recommended Minimum level
Dietary fibre (g)	Min of 4.5	4.7 ± 1.2 (74)	4.9 ± 0.6	Within +/- 10% of recommendation	Within +/- 10% of recommendation
Total fat (g)	Max of 21.7g	22.9 ± 7.4	19.1 ± 4.2	Within +/- 10% of maximum recommendation	17% below recommended maximum levels
Saturated fatty acids (g)	Max of 6.8 g	10.7 ± 3.7	9.6 ± 2.0)	57% above recommended Maximum level	42% Above recommended Maximum level

Table 81. Comparison between Scottish Nutrient Standards for School Lunches and Estimated Actual Average Nutritive Intake/Meal Served after adjustments for Plate waste

5.5. Economic Impact of Plate Waste

In this section, we report our analysis of the financial cost of the plate waste in NorthSchool and ScotSchool cases. The estimation was made at the full case level, i.e. for the five featured schools in each case (as described in D6.3), for one whole school year. This was done in order to make the results more relatable to D6.3 results. To estimate the cost of the plate waste, first, the quantities of plate waste recorded in the two D6.2 schools were aggregated, pro rata, to all five schools in each case for the whole school year. By this calculation, the total quantities of plate waste in NorthSchool and ScotSchool cases were 11,228 kg and 16,604 kg, respectively. Next, an average price per kg for each waste food category was calculated by dividing the total supply budget related to this category by the volumes of specific items procured within the category, in proportion to each other (the sources for the values were the procurement data collected for D6.3). In this way, the average prices per kg reflected the varying volumes of different food items procured within the category, and their specific prices. Finally, the total cost of each waste food category was summed to derive the estimate of the total cost of all the food waste in each case. Tables 15 and 16 present results for NorthSchool and ScotSchool cases, respectively.

Waste Categories	Volume (kg)	Average Cost per kg (£)	Total Cost (£)	Cost per Average Meal (£)
Fresh Vegetables	**1123**	**1.8**	**2021**	
Processed Vegetables	**2085**	**1.1**	**2294**	
Fresh Fruits	**328**	**1.8**	**590**	
Processed Fruits	**608**	**1.1**	**669**	
Fresh Meat & Fish	**615**	**7.2**	**4429**	
Processed Meat & Fish	**752**	**5**	**3759**	
Starchy Carbs (fresh potatoes)	**980**	**1.8**	**1764**	
Starchy Carbs (processed potatoes)	**576**	**1.1**	**633**	
Starchy Carbs (bread, rice, pasta, flours & mixes, and other ambient food)	**2889**	**1.1**	**3178**	
Dessert (fruits)	**193**	**1.45**	**280**	
Dessert (starchy carbs)	**967**	**1.8**	**1741**	
Dessert (dairy)	**48**	**1.8**	**87**	
Other	**63**	**1.8**	**113**	
TOTAL	**11228**		**21558**	**0.21**

Table 15. Estimated Cost of Plate Waste at NorthSchool (LOC) case, per year (n=5 schools)

In terms of economic impact, and presented in Table 15 and 16, we estimated the cost of the plate waste in both LOC and LOW cases, for five schools over one whole school year. Across the 5 LOC schools, a total annual plate waste of 11,228 kgs was estimated, generating an estimated total cost of £21,559. This equates to 27% of the total school meals budget and £0.21 per average meal. As the price of a school lunch in LOCSchools is £2.00 (€2.27), this means that in LOCSchools, 10.5% of the full price paid ends up as plate waste. Table 15 shows that the largest contributor to total waste cost is meat and fish (both fresh and processed), at 38%. Fruit and vegetables (both fresh and processed) and starchy carbs (all types) each contribute 26% of total waste cost.

Across the 5 LOW schools, a total annual plate waste of 16,604 kgs was estimated, with an estimated total cost of £40,211. This equates to 13% of the total school meal budget and £0.19 per average meal. As the price of a school lunch in LOWSchool is £1.95-£2.00 (€2.21-€2.27), this means that in LOW schools, 9.5-9.7% of the full price paid ends up as plate waste. Table 16 shows that the largest contributor to total waste costs is starchy carbs (all types), at 52%. Meat and fish (fresh and processed) was the second largest contributor (18%), followed by fruit and vegetables (fresh and processed) at 10%.

Waste Categories	Volume (kg)	Average Cost per kg (€)	Total Cost (€)	Cost per Average Meal (€)
Fresh Vegetables	262	1.5	392	
Processed Vegetables	582	2.8	1631	
Fresh Fruits	1100	1.5	1650	
Processed Fruits	194	2.8	543	
Fresh Meat & Fish	641	5.6	3588	
Processed Meat & Fish	1361	2.8	3812	
Starchy Carbs (fresh potatoes)	1376	1.5	2064	
Starchy Carbs (processed potatoes)	1376	2.8	3853	
Starchy Carbs (bread, rice, pasta, flours & mixes, and other ambient food)	5343	2.8	14960	
Dessert (yoghurt)	301	2.8	843	
Dessert (processed fruits)	301	2.8	843	
Dessert (mixed)	401	2.8	1123	
Milk	3225	1.4	4515	
Other	141	2.8	395	
TOTAL	16604		40211	0.19

Table 16. Estimated Cost of Plate Waste at ScotSchool (LOW) case per year (n=5 schools)

Comparing the estimated economic impacts of the plate waste at NorthSchool and ScotSchool cases, it is interesting that the cost burden per average meal for NorthSchool is slightly higher than Scotschool (£0.21 vs. £0.19). The key explanation for this is the higher proportion of meat and fish in the NorthSchool waste, which is the most expensive category. It is also interesting that the cost burden of the waste, as a proportion of the total meals budget is much higher at Northschool than ScotSchool (27% vs. 13%). The main explanation is that food supply costs represent a higher proportion of total budget (relative to staff costs) in NorthSchool case compared with ScotSchool case.

5.6. Environmental Impact of Waste

Food waste has direct and indirect effects on the environment, leading to consequences for natural resources at a global level. Here, we defined the environmental impact of food waste as being the carbon emissions (kgsC0_2eq) embodied in the waste, as derived from its production, transportation and disposal. To be consistent with the emissions estimates for the entire NorthSchool (LOC) and ScotSchool (LOW) school meal services, reported in D6.3, we used the same sets of emissions factors and calculation approach here, described below.

First, in order to make the analysis relatable to the carbon footprint results generated in D6.3, we made the estimation for all five featured schools in NorthSchool and ScotSchool cases (as described in D6.3), for one school year, rather than only for the specific schools/weeks of plate waste from the WP6.2 data collection. We did this by taking the volumes of plate waste recorded in the data collection and aggregating these pro rata to the other schools in each case, based on their meal uptake figures. We then multiplied these amounts by the correct number of weeks to arrive at a total waste volume for the whole school year in each case.

To estimate the carbon emissions embodied in these total waste volumes, we first inspected their compositions, and made estimates of the quantities of individual food items within each category of waste (e.g. beef within the ‘meat and fish’ category), based either on the direct observations of the plate waste data collectors in WP6.2 (where possible) or by inspecting the relevant ratios of the food procurement data collected as part of D6.3 (guided by the menus/recipes). Then, having determined which food items comprised all the categories of waste in each case, and in which proportions, an average emissions factor per kg (EF) for each food category was calculated by dividing the total production emissions generated by all the items in the waste food category (in kgs CO_2eq) by the total volumes of those items procured for the five schools in each case. In this way, the average EF for each food category took account of the varying proportions of specific food items within the waste category, and their specific EFs. If the waste food category only included one item (e.g., milk), the actual EF for this item was used as the category EF. The average EF for each food category was then multiplied by the total volumes of waste recorded for those food categories in each case, to give the total production-related carbon emissions embodied in each food waste category. The same methodology was followed to calculate the transport-related emissions embodied in each food waste category. Finally, the disposal-related emissions (i.e. transportation and handling of the waste itself) were added. All three components of the embodied carbon emissions (production, transportation and disposal of the wasted food) were then summed to get the total embodied carbon emissions of the waste in each case. Tables 17-19 report the results for NorthSchool and ScotSchool cases, respectively.

Waste Categories	Volume (kg)	Embodied Emissions (kg $C0_2eq$)	Embodied Emissions per Average Meal (kg $C0_2eq$)
Fresh Vegetables	1123	752	
Processed Vegetables	2085	4004	
Fresh Fruits	328	219	
Processed Fruits	608	1168	
Fresh Meat & Fish	615	4995	
Processed Meat & Fish	752	3631	
Starchy Carbs (fresh potatoes)	980	480	
Starchy Carbs (processed potatoes)	576	1508	
Starchy Carbs (bread, rice, pasta, flours & mixes, and other ambient food)	2889	5273	
Dessert (fruits)	193	202	
Dessert (starchy carbs)	967	2926	
Dessert (dairy)	48	151	
Other	63	701	
Plus waste handling co2eq		1284	
TOTAL	11228	27295	0.27

Table 17. Estimated embodied carbon in plate waste in NorthSchool (LOC) case, per year (n=5 schools)

Table 17 shows that across the 5 NorthSchools, the total estimated annual plate waste of 11,228kgs is estimated to generate embodied carbon emissions of 27,295 kgs$C0_2$eq, which equates to 0.27kg$C0_2$eq per average meal or 23% of total embodied emissions of total food procured. Table 17 also shows that the largest contributor to the embodied emissions in the waste was meat and fish (fresh and processed), at 32%, followed by starchy carbs (all types) at 27% and fruit and vegetables (fresh and processed) at 22.5%. Table 18 shows that across the 5 ScotSchools, the total estimated annual plate waste is of 16,604kgs and is estimated to generate embodied carbon emissions of 44,386 kgs$C0_2$eq, which equates to 0.21kg$C0_2$eq per average meal or 17% of total embodied emissions of food procured. Table 18 also shows that the largest contributor to the embodied emissions in the waste was starchy carbs (all types) at 45%, followed by meat and fish (40%).

Waste Categories	Volume (kg)	Embodied Emissions (kg CO_2eq)	Embodied Emissions per Average Meal (kg CO_2eq)
Fresh Vegetables	262	178	
Processed Vegetables	582	949	
Fresh Fruits	1100	748	
Processed Fruits	194	239	
Fresh Meat & Fish	641	5900	
Processed Meat & Fish	1361	5765	
Starchy Carbs (fresh potatoes)	1376	688	
Starchy Carbs (processed potatoes)	1376	3619	
Starchy Carbs (bread, rice, pasta, flours & mixes, and other ambient food)	5343	15681	
Dessert (yoghurt)	301	734	
Dessert (processed fruits)	301	370	
Dessert (mixed)	401	594	
Milk	3225	4967	
Other	141	1571	
Plus waste handling co2eq		2383	
TOTAL	16604	44386	0.21

Table 18. Estimated embodied carbon in plate waste in ScotSchool (LOW) case, per year (n=5 schools)

PFSP model	NorthSchool (LOC) (5 schools)	ScotSchool (LOW) (5 schools)
Total Number of meals served per day across case study schools	532	1099
Total Volume of Food Procured (kg) per academic year by case study schools	49,598	101,312
Total plate waste as proportion of total volume of food procured (%)	23	16
Total Original CO2eq (including waste before mitigation)	121,070	265,030
Total Waste CO2 Burden (CO2eq)	27,295	44,386
% proportion of waste burden from total original CO2 Burden	23	17
Waste CO2 burden per meal (CO2eq)	0.27	0.21
Total Financial Loss attributed to Waste (£)	21,559	40, 211
% proportion of total financial loss attributed to waste (financial loss) from total procurement budget (%)	27	13
Financial loss attributed to Waste per meal served (€)	0.24	0.21

Table 19: Synthesis of UK Carbon and Economic Impact of Plate Waste Results

6. CONCLUSION AND RECOMMENDATIONS

To conclude, Table 20 presents synthesis of all the key UK nutritional composition and plate waste result (including nutritive, financial and carbon impact) for both cases.

Variable	Parameter	NorthSchool (LOC model)	ScotSchool (LOWmodel)
Total No. of Scraped Plates		2624	2833
Average Weight of Planned Food/Meal Served (g)		329	252
Average Weight of Collected Plate Waste/Meal Served (g)		87	64
Collected plate waste as a proportion of planned food served (%)		26	25
Nutritional Loss	Energy (kcal)	110 ± 35 (18%)	104 ± 28 (18%)
	Total proteins (g)	4.1 ± 1.3 (17%)	4.3 ± 0.9 (15%)
	Total carbohydrates (g)	14.7 ± 5.2 (21%)	15.2± 5.6 (23%)
	Dietary fibre (g)	1.7 ± 0.5 (26%)	1.1 ± 0.4 (19%)
	Total fat (g)	3.8 ± 1.6 (15%)	3.1 ± 1.0 (14%)
	Saturated fatty acids (g)	1.5 ± 0.8 (13%)	1.4 ± 0.6 (12%)
Carbon impact	Total Waste CO2 Burden CO2eq	27,295	44,386
	% of waste burden from total CO2eq	23	17
	Waste kgCO2eq burden per meal	0.27	0.21
Economic impact	Total cost of waste (€)	21,559	40, 211
	% Total Waste financial loss from total supply budget	27	13
	Waste cost per meal (€)	0.24	0.21

Table 20: Synthesis of main UK reults by PFSP case

For NorthSchool, 26% of the estimated planned weight of food served per meal (329g) was collected as plate waste equating to 87g of plate waste per meal served with a waste composition profile of: 37% starchy carbohydrates, 26% vegetables, 13% fruit, 11% meat, 12% dessert and 1% other (cheese). From a nutritional, carbon, and financial loss perspective, the collected plate waste was estimated to represent a loss of: 13-26% of planned nutritive intake, 23% of total original CO2 burden (CO2eq) (0.27kgCO2eq wasted/meal served) and 27% of total supply budget (€ 0.24 wasted/meal served).

For ScotSchool, 25% of the estimated planned weight of food served per meal (252g) was collected as plate waste equating to 64g of plate waste per meal served with a waste composition profile of: 61% starchy carbohydrates, 6% vegetables, 10% fruit, 15% meat, 7% dessert and 1% other (cheese). From a nutritional, carbon, and financial loss perspective, the collected plate waste was estimated represent a loss of: 12-23% of planned nutritive intake, 17% of total original CO2 burden (CO2eq) (0.21kgCO2eq wasted/meal served) and 13% of total supply budget (€ 0.21 wasted/meal served).

In reflecting on these results and the emerging similarities and differences in school meal service delivery across NorthSchool and ScotSchool, a number of identified school meal procurement, food service and environmental factors may help explain why the type and quantity of, and nutritional, carbon and financial loss associated with, collected plate waste varies between cases.

Firstly, different weights of estimated planned food served and collected plate waste were found with 73g and 23g more respectively in NorthSchool than ScotSchool.

Secondly, while ScotSchool have recently started to invest in, and develop, a more systematic, creative and nutritionally grounded approach to menu development, SchoolCater have an established, rolling programme of menu innovation and development for NorthSchool where new or revised nutritionally compliant menu options are created per menu cycle including recent innovations aimed at: a) incorporating meat substitute products; b) increasing quantity and variety of vegetables in main meal recipes (17 g of hidden vegetables/portion in pizza topping sauce); and c) developing more 50:50 fruit based dessert options.

Thirdly, seasonal menu adjustment is normal practice in NorthSchool as SchooCater develops 2*3 weekly menu cycles per academic year (Autumn/Winter Nov –March; Spring/Summer April – Oct) to reflect changing seasonal preferences, produce availability and increase variety in their school meal offering. In contrast, ScotSchool has 1*3 week menu cycle covering the full academic year.

Fourthly, interesting differences in meal selection were observed within, and between, NorthSchool and ScotSchool. While a clear hot meal preference emerged in NorthSchool D with 82.5% children selecting this option, this preference dropped to 64.5% in NorthSchool E, 57.5% in ScotSchool A and 57% in ScotSchool E respectively. These differences in meal option selection directly impacts the type, and quantities of, starchy carbohydrates served with more bread and potatoes served (via sandwiches and baked potatoes) as hot option rates drops which in turn impacts on the compositional make-up of collected plate waste (estimated, based on observations, that more bread and potatoes were collected in starchy food bin in schools with higher rates of sandwich and baked potato selection).

Fifthly, while both NorthSchool and ScotSchool offer a diverse choice of up to 6-10 different hot/cold vegetable options per day, only NorthSchool children, in accordance with SchoolCater policy, are required to accept at least 1 portion of hot/cold vegetable with their meal. No such ScotSchool policy exists and very high hot/cold vegetable refusal rates were observed. As a consequence, it is posited that the quantities of hot/cold vegetables consumed in ScotSchool are much lower compared to NorthSchool who, based on an average estimated served portion of 50g and an average collected vegetable waste per meal served of 23.8g, were found to be consuming around 50% of their served vegetable portion.

Sixthly, whilst both offer a diverse daily range of hot/cold vegetables, the presence of this choice alone, in the absence of a vegetable acceptance policy (as per NorthSchool) does not appear, from observations, to be sufficient to drive higher hot/cold vegetable acceptance rates in ScotSchool.

Seventhly, the design of, available space in, and distributiona nd positioning of food, along the canteen food service lines varied within, and between NorthSchool and ScotSchool. High service lines (NorthSchool E and ScotSchool A&E), the positioning of hot dessert options at beginning of service line in ScotSchool E, the location, and ease of access to, the drinks chiller cabinet (start in ScotSchool A, end in ScotSchool E; NorthSchool A&E), different available drink options (water only in NorthSchool D&E; only plain milk cartons and water (in heavy jugs) on tables with insufficient cups in ScotSchool E; plain water and milk, flavoured milk and 50:50 juices available in ScotSchool A), separation between, and space for, cold sandwiches, cold vegetables, dessert and fruit (separation observed in North School A&E and ScotSchool D; no separation observed in ScotSchool A - very tightly packed cold option section, difficult to see, and evaluate the choice of cold vegetables, fruit and yoghurts offered); and the ScotSchool practice of wrapping cut fruit, sandwiches and burgers (where offered) in plastic were all observed to influence and shape the food service process, children's observed ability to engage with, and access the food and drink choices offered and the amount of non-food waste generated.

Eighthly, in 17/18, it was normal ScotSchool practice to wrap all sandwiches, cut fruit and burgers (where offered) in plastic wrapping prior to service and to serve yoghurt in single use pots generating significant non-food plastic waste. Some changes were observed in October 18/19 where a fruit platter and sandwich trial are underway. Most cut fruit was no longer being wrapped in plastic and instead mix fruit platters (no wrapping) were being place on tables and topped up at intervals during service. A sandwich trial was also in place in ScotSchool A&E where canteens were trialling a new practice of not wrapping cold sandwich options and allowing children to choose up to four sandwich quarters from the multiple available fillings if requested. Based on observations, these changes appeared to be already helping to reduce the amount of non-food waste generated and have improved the visual appearance of, and ease of consumption, of cut fruit. No plastic wrapping of food was observed in NorthSchool though yoghurts were served in single use plastic pots in NorthSchool D while the majority of yoghurt was made in house and served in reuseable bowls in NorthSchool E.

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APPENDICES

Appendix 1: Sample Weekly Menu for NorthSchool

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday
Starter	Soup of the Day	Soup of the Day	Soup of the Day	Soup of the Day	Melon
Option 1 (Red)	Chargrilled chicken with mash potato	Sausages and mash potato	Chicken curry with rice	Lasagne	Fish and Chips
Option 2 (Blue)	Macaroni Cheese(v)	Pasta Bake with Garlic bread(v)	Cheese and tomato pizza(v)	Fish fingers with mash potato	Chicken burger in a bun
Option 3 (Yellow)	Toasted sandwich	Panini selection	Sandwich selection	Baguette selection	Wrap selection
Baked Potato (Green)			Various fillings		
Served daily			Seasonal Vegetables, Fresh Fruit and Salad Bar		
Dessert	Fresh Fruit Yoghurt Jelly	Fresh Fruit Yoghurt Muffin	Fresh Fruit Yoghurt Jelly	Fresh Fruit Yoghurt Homemade biscuit	Fruity Friday Yoghurt

Appendix 2: Sample Weekly Menu for ScotSchool

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday
Starter	Soup of the Day	Soup of the Day	Soup of the Day	Soup of the Day	Melon
Option 1 (Red)	Chargrilled chicken with mash potato	Sausages and mash potato	Chicken curry with rice	Lasagne	Fish and Chips
Option 2 (Blue)	Macaroni Cheese(v)	Pasta Bake with Garlic bread(v)	Cheese and tomato pizza(v)	Fish fingers with mash potato	Chicken burger in a bun
Option 3 (Yellow)	Toasted sandwich	Panini selection	Sandwich selection	Baguette selection	Wrap selection
Baked Potato (Green)			Various fillings		
Served daily			Seasonal Vegetables, Fresh Fruit and Salad Bar		
Dessert	Fresh Fruit Yoghurt Jelly	Fresh Fruit Yoghurt Muffin	Fresh Fruit Yoghurt Jelly	Fresh Fruit Yoghurt Homemade biscuit	Fruity Friday Yoghurt

The Strength2Food project in a nutshell

Strength2Food is a five-year, €6.9 million project to improve the effectiveness of EU food quality schemes (FQS), public sector food procurement (PSFP) and to stimulate Short Food Supply Chains (SFSC) through research, innovation and demonstration activities. The 30-partner consortium representing 11 EU and four non-EU countries combines academic, communication, SMEs and stakeholder organisations to ensure a multi-actor approach. It will undertake case study-based quantitative research to measure economic, environmental and social impacts of FQS, PSFP and SFSC. The impact of PSFP policies on nutrition in school meals will also be assessed. Primary research will be complemented by econometric analysis of existing datasets to determine impacts of FQS and SFSC participation on farm performance, as well as understand price transmission and trade patterns. Consumer knowledge, confidence in, valuation and use of FQS labels and products will be assessed via survey, ethnographic and virtual supermarket-based research. Lessons from the research will be applied and verified in 6 pilot initiatives which bring together academic and non-academic partners. Impact will be maximised through a knowledge exchange platform, hybrid forums, educational resources and a Massive Open Online Course.