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Department of Molecular Sciences
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Sammanfattning

Fokus för denna uppsats var på kvantifiering av matsvinn och utvärdering av den använda mätmetoden i storkök. I mätmetoden ingick vägning av matavfallet på Kevinge Förskola och Kevingeskolan samt observation; en jämförelse av mätdata med statistik över insamlat matavfall av Danderyds kommun; beräkning av receptkostnader och totalkostnad för all konsumerad mat (frukost, lunch och mellanmål); samt svinnkostnader från hela produktionen på Kevinge Förskola. Data från den beräknade genomsnittskonsumtionen på Kevinge Förskola, och den kommunala matavfalls-statistiken för båda enheterna användes för att beräkna saknade värden och mängden av osorterat matavfall.

Det totala uppmätta matsvinnet på Kevinge Förskola (K.F.) var 396 kg genom 16 veckor, och på Kevingeskolan (K.S.) 733 kg genom 7 veckor. Det beräknade genomsnittliga svinnet per portion var 69 gram vid K.F., medan det var 55 gram vid K.S. Skillnaden mellan värden för det vägda och det insamlade avfallet var 137 kg (28 % av det insamlade avfallet) på K.F., och 449 kg (38 % av det insamlade avfallet) vid K.S. Detta utgjorde den oregistrerade delen av matavfallet på båda platserna. På K.F., där en kostnadsanalys också utfördes, har en extra kategori av osorterat matsvinn också identifierats.

Metoden av daglig mätning och regelbunden kostnadsberäkning av svinn verkade vara effektiv för att minska matsvinnet i K.F. under mätperioden. En sådan trend var inte märkbar på K.S. under datainsamlingsperioden, där daglig utvärdering av svinnmängder och kostnadsanalys inte genomfördes. I jämförelse med resultat av tidigare studier där endast vägning genomfördes under korta tidsperioder verkar uppskattningar av matavfall på ett storkök vara mycket mer tillförlitliga och användbara med denna longitudinella metod.

Som exemplet av datainsamlingen på K.F. visade, verkar det finnas en möjlighet att avslöja systematiska fel i dataregistreringen. Genom longitudinella studier i framtiden kan det vara möjligt att avslöja systemfel i storköks-produktion och komma med anpassade förslag till att minska svinn i storköks-enheter. Den testade datainsamlingsmetoden verkade lovande med tanke på användbarhet av insamlat data. Det optimala kategoridjupet för kontinuerlig datainsamling verkar tillåta registrering av olika kategorier som uppstår dagligen. Svinnet behöver bli sorterat under dagen i valda kategorier så som tallrikssvinn och serveringssvinn. Kategorier som inte är mätbara dagligen typiskt – förvaringssvinn, säkerhetssvinn och beredningssvinn från kök – kan standardiseras efter en kortare tidsperiod av fortsatt mätning, och även beredningsavfall från renseri kan följas närmare med denna metod.

Ytterligare fynd var att svinnkostnader och svinnmängder korrelerade starkt (Pearson's r = 0,67) inom data från Kevinge Förskola. När det gäller sambanden mellan svinnkategorier behövs det möjligen mer känsliga databehandlings-verktyg för att kunna bryta ner kostnadsdata till datapunkter som är lämpliga för svinnkostnadsanalyser ur miljösynpunkt (som kan översättas i CO_2-ekvivalenter direkt). Andra fynd var att observationer i olika faser av produktionen och under konsumtion kan avslöja ett flertal skäl till uppkomst av svinn och erbjuda varierade strategier för att på ett effektivt sätt minska svinnet på lång sikt.

Abstract

Focus of this paper was on waste quantification and evaluation of the used measurement method for large scale catering units. The method included daily measurement of food waste at Kevinge Kindergarten and Kevinge School as well as observation; a comparison of data with statistics over collected food waste by the municipality of Danderyd; calculating recipe and consumption costs for all consumed food (breakfast, lunch and afternoon snacks); as well as total waste costs from the food production at Kevinge Kindergarten. Data from the weekly average food consumption calculations at Kevinge Kindergarten, and municipal waste collection statistics for both units served as control measures for calculating the missing values and unsorted food waste.

The total measured waste at Kevinge Kindergarten (K.K.) was 396 kg through 16 weeks, and at Kevinge School (K.S.) 733 kg through 7 weeks. The calculated average waste per portion was 69 grams at K.K., while it was 55 grams at K.S. The difference between measured and collected waste data was 137 kg (28 % of the collected waste) at K.K., and 449 kg (38 % of the collected waste) at K.S. This constituted the unrecorded portion of the food waste at both locations. At K.K., where a cost analysis was also executed, an added category of unsorted food waste was also calculated with an estimated quantity of 4 % of the municipally collected organic waste.

The method of daily measurement combined with periodical waste cost calculations seemed effective towards minimizing food waste at K.K. Such a trend was not visible at K.S. under the data collection period, where waste measurement data were not evaluated daily and costing was not executed. In comparison with results from previous research based on weighing under short periods of time, estimates of food waste at a school kitchen could prove much more reliable with this longitudinal method. The potential to reveal systematic mistakes seems to be verified from the example of the data base collected at K.K. through a longer time interval. Through longitudinal studies in the future, it could be possible to reveal systematic reasons to food waste and offer suggestions to solve such problems in large scale catering units.

The data collection method tested in this study seemed viable when looking at components as well as at the whole usability of the achieved data. The optimal category depth for short and long term data collection seems to allow registering different waste categories which tend to be produced daily and can be sorted during the day, such as plate waste and canteen/bar waste. Categories which are not typically measurable daily - storage waste, safety waste and preparation waste - can be standardised after continued measurement for a shorter time interval. Even peel waste can be followed up more closely with such a method.

Additional findings were that wastage costs and quantities of waste correlated strongly (Pearson´s r=0,67) when looking at the data from Kevinge Kindergarten. Regarding correlations between waste categories, possibly more sensitive processing tools are necessary to break down cost data to data points suitable for environmental cost analyses (e.g. in CO_2.Equivalents). Other findings were that observations into different phases of production and consumption suggest multiple reasons of wastage and offer various strategies for minimizing waste effectively on the long run.

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Definitions

Food losses

Food losses refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain (FAO, 2011).

Food waste

Waste composed of raw or cooked food materials and includes food materials discarded before, during or after food preparation, in the process of manufacturing, distribution, retail or food service activities, and includes materials such as vegetable peelings, meat trimmings, and spoiled or excess ingredients or prepared food (FUSIONS, 2014).

Large scale catering establishment

Large scale catering establishment is a facility such as a hospital, school, military, personnel or lunch restaurant that caters for all meals eaten outside the home. There are large scale catering establishments available both in public and in the private sector and can vary in scope, objectives and equipment (NE, 2015)

Avoidable food waste

Waste from kitchen and from guests. Food thrown out that could have been consumed if they were handled differently. Food which was edible before being thrown away. Food that has been disposed of because it has become inedible for one of several reasons, including overestimation of need and poor storage. Food and drinks that are thrown away despite still being edible (FUSIONS, 2014).

Unavoidable food waste

Waste arising from food preparation that is not, and has not, been edible under normal circumstances (e.g. bones, egg shells, pineapple skins). Not edible food waste from preparation and consumption. Waste due to meal preparation and which is not edible under normal circumstances. Components of food that would not be considered edible under any circumstances. Waste deriving from the preparation of food or drinks that are not, and could not, be edible (FUSIONS, 2014).

Possibly avoidable waste

Food that some people eat and others don't. Food and drinks that some people consume and some do not or food that can be edible, if cooked one way instead of another (FUSIONS, 2014).

Collected waste

Collected waste is the food waste collected by the municipality, usually on a once/twice weekly or monthly basis for recycling purposes.

Recorded waste

Recorded waste defined for the purposes of this paper include all food waste that was measured in the catering facility during and after production and consumption.

Unrecorded waste

Unrecorded waste consisted of food waste that was discarded but not recorded. It was the part of the food waste that did not appear registered in any recordings of food waste, but was later calculated by indirect methods based on purchase data, recipes and average consumption calculations in this study.

Unsorted food waste

Food waste that is thrown out together with other household wastage and thus it is not collected separately as organic food waste by municipality.

Plate scrapings/plate waste

Plate scrapings or plate waste refers to the part of the meal that is placed on the plate but is not eaten by guests (i.e. plate scrapings collected after meals). Even paper napkins can sometimes be included in this category (Modin, 2011).

Canteen waste/bar waste

These terms refer to food wastage occurring during and after serving meals in canteens/from bars and even at classrooms in schools and in kindergartens (Modin, 2011).

Preparation waste

In school and kindergarten kitchens and mostly all large-scale catering units there usually are separate work stations responsible for different parts of the production. The vegetable and fruit preparation unit is separate from the other parts of production due to food hygiene reasons. In this paper, the term preparation waste refers to the part of food wastage that occurs in the kitchen during production, such as food scraped from pots and canteens and is not served, frying residues, excess food that gets thrown out, egg shells, parts of meat that is cleaned and thrown out, burned food etc. This category doesn´t include peel waste coming from the fruit and vegetable preparation unit, where only unavoidable waste is produced.

Peel waste

Peel waste is the part of wastage that is produced during preparing fruits and vegetables in the separate fruit and vegetable preparation unit (Modin, 2011).

Storage waste

Storage waste is the food that must be thrown out because of quality defects due to inappropriate or excessive storing (passing best before dates) (Modin, 2011).

Safety waste

The food waste resulting from planned and unplanned excess production (accommodating for extra guests and extra served portions) that is placed in canteens to be served if necessary but is never eaten.

Fluid/liquid food waste

Fluid or liquid waste refers to all food waste in liquid form such as milk, yoghurt, food dished up and non-solid parts of soups, which cannot be sorted and is washed down into the sewage system (Modin, 2011).

Introduction

Food waste contributes to a significant waste of resources, considering the direct financial impact on the food production units, the environmental impacts of the production as well as leading to access work in handling of food which then is not consumed. Even the costs of management of the food waste add up to the wastage (SEPA, 2015).

From an environmental point of view, minimized wastage of food means decreased energy and raw material consumption, as well as decreased emissions from production and handling of food. To date, very limited investigations have been made into the composition of food waste, which is why estimates are very hard to make about the real costs of food wastage for the environment (Modin, 2011).

As the Swedish Environmental Protection Agency estimates, halving the amount of wastage of food from the school kitchens would translate into a minimized climate impact in the order of 10 000 to 30 000 tonnes of carbon dioxide equivalents per year (SEPA, 2009). According to the agency´s estimates, there is potential to minimize losses by an average of 50 %, that is, between 5 000 and 15 000 tonnes of food in school kitchens (SEPA, 2015).

The Swedish municipalities have a certain control capacity over generation of food waste in school kitchens, being that many schools are under municipal supervision. Most other waste flows in the community are not accessible the same way for centralized actions. Minimizing food waste from school catering also is supposed to be accommodated in Swedish municipalities´ strategical action plans towards applying national climate and environmental targets (SEPA, 2014).

Some of the key success factors the SEPA suggested towards minimized wastage in the school kitchens are the commitment of politicians, policy makers, business managers and kitchen staff, an all-inclusive approach to students' dining experience with tasty food of good quality, calm dinner environments and visibility of the amount of wastage (SEPA, 2015).

In today´s research, different approaches have been introduced with aim to improve production quality and minimize food waste in schools and pre-schools. Certain attempts have been made to define quality demands, and to develop tools for decision makers to design more appealing meals to children’s taste preferences; as well as to reorganize dining environments (Grac & Bergentz, 2013; Patterson *et al.*, 2013).

Other approaches have addressed the problem of food wastage by attempting to acquire general, estimated background data about food waste proportions and presumed reasons of food wastage. These estimates served as grounds for solutions offered to different target groups for minimizing waste (SEPA, 2015; Modin, 2011).

More detailed information has only recently been attempted to be assessed through weighed waste registration, while many of the methods used had focused on selected parts of wastage that was estimated to be dominant (Dekker & Fröman, 2014; Mattisson, 2015). However, such incomplete assessments based on partial

evaluations might limit our understanding of a multitude of possible reasons to wastage, with potentially just as important components of wastage as the selected ones existing. Thus, we miss the opportunity to effectively minimize food waste in schools and pre-schools.

As pointed out by the Swedish Environmental Protection Agency, more quantitative data collecting alternatives need to be developed which should support assessing specific and reliable measurement of various products (SEPA, 2014). The need to verify assumptions and confirm current understanding with greater precision and unbiased monitoring is emphasized in the report as well. Even an advance of research areas need to be assigned to develop tools and measures towards achieving lasting results, where behavioural changes of personnel could be followed as well.

SEPA´s report (2009) suggests that an all-inclusive approach towards school food production can contribute to minimized waste and minimized environmental impact, just as to catering units´ improved economy and to better health status as well as performance among pupils. Authors suggest furthermore that measures to minimize waste in school kitchens could influence other sectors of society as well, such as families through the children and food suppliers through demand (SEPA, 2009).

Aims and Objectives

The aim of this paper is to develop a viable method for detailed and longitudinal data collection about food wastage quantities in large scale catering facilities such as school and kindergarten kitchens in Sweden for research and development purposes.

The following objectives were set:

- Evaluate effectiveness of method towards minimizing food waste in application and towards collecting data for standardised waste calculations
- Achieve database with as complete and continuous data collection points as possible
- Specify optimal category depth for short and long term data collection
- Evaluate the need for routines and documentation supporting data collection activities
- Observe conditions supporting or hindering data collection
- Register relevant information towards further developing the method to achieve a flexible and useful tool for kitchen staff

The questions this study aimed to answer were if this method can be used to achieve reliable and broad data about food waste in large scale catering settings; if continuous food waste registering can in fact contribute to development by minimizing food waste effectively; if there is a correlation between wasted meal quantities and waste costs in economic measures; as well as if it possible to use the

here given categories for calculating environmental costs from the discussed settings, based on the data collection method.

Background

> *"Food security is a major concern in large parts of the developing world. Food production must clearly increase significantly to meet the future demands of an increasing and more affluent world population."" one of the first mean[sic] to fight imbalances and reduce tensions between the necessary increase in consumption and the challenging increase in production, is to also promote food loss reduction which alone has a considerable potential to increase the efficiency of the whole food chain. In a world with limited natural resources (land, water, energy, fertilizer), and where cost-effective solutions are to be found to produce enough safe and nutritious food for all, minimizing food losses should not be a forgotten priority." (Gustavsson et al., 2011).*

As the Food and Agriculture Organisation of the United Nations´ (FAO) estimates, approximately one third of the food produced for human consumption is lost or wasted globally, amounting to around 1.3 billion tons of food waste per year (Gustavsson et al. 2011). Though Lundqvist et al. (2008) include animal feed in their definition of food waste, authors assess that we potentially could be saving approximately 50 % of the food wastage through the entire food supply chain (EP, 2013).

The SEPA has suggested a milestone target regarding food waste, describing one of the targets as minimizing food losses by at least 20 % by 2015 in Sweden compared with 1990 (Stare et al., 2013).

In the current national and international debate, a wide range of approaches to reduce food waste have already been introduced - persuasive, cooperative, regulatory, economic, organisational and technical measures. Among the different strategies identified by the European Union´s project 'Technology options for feeding 10 billion people - Options for Cutting Food Waste" carried out by the Institute for European Environmental Policy, some of the most relevant ones for this paper were setting mandatory targets for food waste reduction, improving the existing data basis and establishing a systematic monitoring to measure progress (EP, 2013).

As pointed out in the FAO study, today´s research reveals that the lack of reliable data hinders us from developing and implementing measures to minimize food waste. Development of standardised methods for collecting and calculating data on food waste generation is an urgent necessity (European Parliament, 2013).

Common methods for quantifying wastage include material flow analysis (MFA), interviews and questionnaires, waste recording and waste collection (Eriksson, 2012). To date, food waste research regarding large scale catering has predominantly been based on waste collection statistics, regulatory publications, literature reviews and reports on good examples of attempts to minimize waste in

large scale catering units. Some waste recording studies have also been executed in this field of work, the methods used however were varied and selective regarding range and scope (SEPA, 2011, Dekker & Fröman, 2014; Modin, 2011).

SEPA points out the importance of ensuring that assumptions and data used in monitoring do not affect the findings of the monitoring. They also emphasize the fact that it is necessary to monitor behavioural changes on the long run, considering the risk that effects of measures meant to stimulate changed behaviours fade over time. Thus, studying actual behaviour by using for example walk-along-studies would serve better in the form of direct observation of behaviour instead of interviews, they suggest (SEPA, 2014).

Using recipes is an important means to work effectively, ascertain nutrition quality and minimize waste. To begin with, usage of recipes is crucial for being able to plan and order systematically and effectively. Also, organizing and delegating the work load becomes easier when relying on recipes (Hellström & Sundbladh, 2011).

Material

Kevinge School kitchen is a food production unit that at the time of the study produced 1000 lunch meal portions/day for four school canteens in the proximity. The other unit chosen for this study was Kevinge Kindergarten which is an independent food production unit producing 85 portions/day. In this unit, food is served to the children in the classrooms, as it is most common in Swedish kindergartens. The author of this paper was working as a cook at Kevinge Kindergarten where she executed the food waste weighing for this study herself. The differing conditions and equipment available in these two units made it necessary to customise the data collection detail level somewhat to match the two participating units´ production profile.

A specially designed digital scale called Matomatic was developed by the company Mat och mätteknik i Uppsala AB [Food and Measurement Technology in Uppsala LTD], for measuring food waste in schools. This product is still in its development phase and as such, it is unavailable on the market yet. Matomatic consists of a digital scale connected to a digital display and a numeric pad. The categories associated with the numbers can be customised to fit conditions at various catering units. A prototype was placed in the catering units participating in the study. Two versions of numeric pad settings were tested: a nine-number pad at Kevinge School, and a six-number pad at Kevinge Kindergarten. Two sets of category lists were developed at start up. The chosen categories were as listed in Table 1a and 1b below.

Table 1 a. Used categories for weighing food waste before correction

Kevinge Kindergarten	Kevinge School
1. Plate scrapings	1. Plate scrapings
2. Canteen/bar food waste	2. Canteen/bar food waste
3. Safety food waste	3. Safety food waste
4. Storage waste	4. Preparation waste
5. Container (minus 0.25 kg, std. value)	5. Peel waste (Unavoidable waste)
6. Other	6. Storage waste
	7. Container (minus 1.5 kg, std. value)
	8. Container (minus 0.25 kg, std. value)
	9. Other

After one week into ongoing measuring at Kevinge Kindergarten, it became clear that it was not practically feasible to separate plate scrapings from canteen/bar food waste coming from the classrooms where the meals were eaten. Thus, the two categories were merged into a shared category (Plate scrapings and canteen food waste) for the entire measuring. As it is part of the teachers´ role to take care of child/toddler groups while serving food to them and feeding them during meals, it seemed hard to find a way for them to separate waste into different category containers during cleaning up, which is why this decision proved necessary. The finally chosen and used category lists were as indicated in Table 1b.

Table 1 b. Used categories for weighing food waste after correction

Kevinge Kindergarten	Kevinge School
1. Plate scrapings and canteen/bar food waste	1. Plate scrapings
2. Safety food waste	2. Canteen/bar food waste
3. Storage waste	3. Safety food waste
4. Container (minus 0.25 kg, std. value)	4. Preparation waste
5. Other	5. Peel waste (Unavoidable waste)
	6. Storage waste
	7. Container (minus 1.5 kg, std. value)
	8. Container (minus 0.25 kg, std. value)
	9. Other

Weighing typically took daily 10-15 minutes at Kevinge School and 1 minute at Kevinge Kindergarten. In the kindergarten, waste could be collected in one or two containers during dishing up due to smaller quantities and a simpler weighing method. In comparison, in the school, the whole salad/lunch bar, the plate scrapings, peel waste and any other containers were weighed, which took more time. Collecting waste from different work stations also took some additional time. As such, the total time addition to the usual workload was a maximum of 20 minutes per day under the data collection period at Kevinge School. The method supplied a rather broad dataset.

Method

Daily weighing of food waste was executed for 16 weeks at Kevinge Kindergarten, between 16th October 2014 and 13th February 2015, and for 7 weeks at Kevinge School, between 20th October 2014 and 11th December 2014, in Danderyd Municipality, Stockholm, Sweden. Food waste mass data were collected at Kevinge Kindergarten and at Kevinge School. At the same time, insights about each production day were registered in form of observations, notes and comments of personnel during and after production. As control data, collected food waste mass statistics supplied by the municipality were used for making eventual underreporting visible after the measurement periods. Material necessary for the cost calculations - menus, recipes, product price information, internal order sheets and waste percentage statistics - was collected parallel to or following the weighing periods. Observations and feedback from personnel was integrated into data evaluation and development consequently.

For each recipe from Kevinge Kindergarten, the cost and prepared mass quantities were calculated daily. Revisions to recurrently used recipes had been made when necessary, integrating eventual observations as well, such as corrections of quantities or ingredients. In addition, a weekly standardised cost-calculation balance sheet template was developed based on average consumption, to get a more complete estimate over the total food service purchases and waste costs of the production unit.

Costs for lunch salad bars have not typically been detailed in cost calculations for food waste in previous research. Also, in Swedish schools and day-care, some breakfast is occasionally, and an afternoon meal is typically offered to children every day. These latter components have most often been omitted from previous food waste calculations, due to challenges to add the measurement of fluid waste to the work load of the kitchen staff or to the time limitations between meals for further data collection. Therefore, creating a detailed balance sheet template was important for evaluating the method´s potential for assessing the waste from the total production in such measurement settings as well. Even developing ways to estimate unrecorded and unsorted waste in the production units became possible based on the tested method. Peel waste data were estimated with help of the nutritional management calculation program Dietist XP to calculate the total waste mass for the food items listed in the standard data sheet template which can´t always be measured. This served as a complement to measurement data.

Results from Kevinge Kindergarten were analysed in the first section of the paper, while in the second section, a part measurement described compared results from the catering units involved in the data collection project.

Delimitations

Testing through daily measurement of food waste was executed under 16 weeks in Kevinge Kindergarten, as well as under 7 weeks in Kevinge School. Liquid food was not included in the mass measurements for this study, due to the known technical difficulties regarding this portion of the waste. The breadth and depth of data acquired was quite massive and the measurement methods at the two restaurants were somewhat different, therefore the analysis in the first section of the paper focused only on results from Kevinge Kindergarten. In the second section, a part measurement offered a comparison of results from the units involved in the data collection.

All-inclusive cost and food waste calculations were executed on budget level of the production unit of Kevinge Kindergarten in focus. Executing even Kevinge School´s recipe development and cost to food waste analysis was not possible in the given time frame. No information was available about costs over services offered by any companies providing similar services for this study, thus financial costs of the method as a product itself were not evaluated in the paper.

Due to the level of this study, no consequence analysis was done, being that only one case study of two restaurants was executed, and thus it would not be realistic to leap to conclusions. However, the observed results could provide grounds to further investigations into the viability of this type of methods in the future.

Results

Kevinge Kindergarten

Measurement data from weighing the food waste after lunch meals was registered in an Excel data-sheet. As the data showed, under 16 weeks, 396 kg food waste was measured in total in Kevinge Kindergartens kitchen. The weighed food waste quantities consisted of 376 kg plate scrapings and canteen waste, 34 kg safety food waste and 3 kg storage waste. Calculating a weekly average from these data would give 24.8 kg food waste per week, or 5 kg per day. The total measured waste mass, 396 kg, accounted for 25 % of the total mass from the produced lunch meals. This waste percentage was in line with former research showing quite similar results in day-care settings (Mattison, 2015.)

However, the sum of the total mass of consumed foods through the day, as well as the total produced waste from both the lunch meals and the weekly average consumption for the production unit led to an interesting observation. The collected waste from all the consumed foods in this unit was shown to be in fact only 16 % of the total quantity of all the consumed foods during the measurement period. This percentage was calculated from the all-inclusive balance sheets and the measured data. Even if certain adjustments appeared be necessary in continued use of similar methods, this result could suggest that an all-inclusive calculation method like the one tested in this study would probably offer grounds

to more useful, accurate and transparent cost evaluation alternatives for food waste in large-scale kitchen units than previous, selective methods.

Furthermore, the usual method estimates a production unit´s food waste costs as equalling the same proportion from the budget costs as the measured percentage of the lunch waste from the total lunch production. This method seems to be misleading, as it might lead to overestimation of food waste quantities and costs, based on the above-mentioned observation.

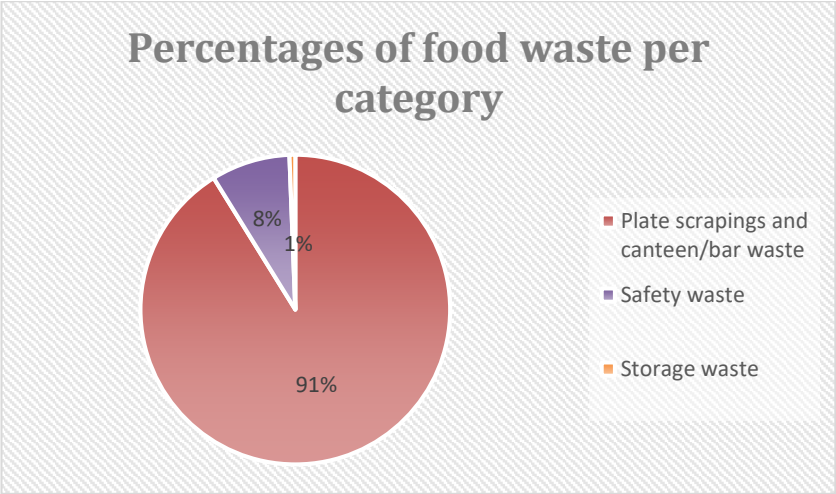

Figure 1. Relative percentages of measured food waste per category at Kevinge Kindergarten.

The average daily weighed food waste mass was calculated to be 5 kg, while the highest value was 13 kg and the lowest 2 kg/day. As seen in figure 1, waste from plate scrapings and canteen/bar waste constituted most of the measured food waste (91%), while safety food waste was 8 % and storage waste was 1 %.

A small part of the measured mass of plate scrapings and canteen/bar waste came from fruit peels and breakfast plate scrapings, due to the mentioned technical challenges for the teachers to separate waste during the daily routines. Even preparation waste from the kitchen was included partially, due to practical reasons.

The average of all weighed food waste was calculated to be 69 grams per portion. The highest measured waste value was 151 grams per portion and the lowest was 24 grams per portion. The distribution of measured values varied strongly, which suggests that daily evaluation of reasons to wastage is necessary towards effectively minimizing food waste.

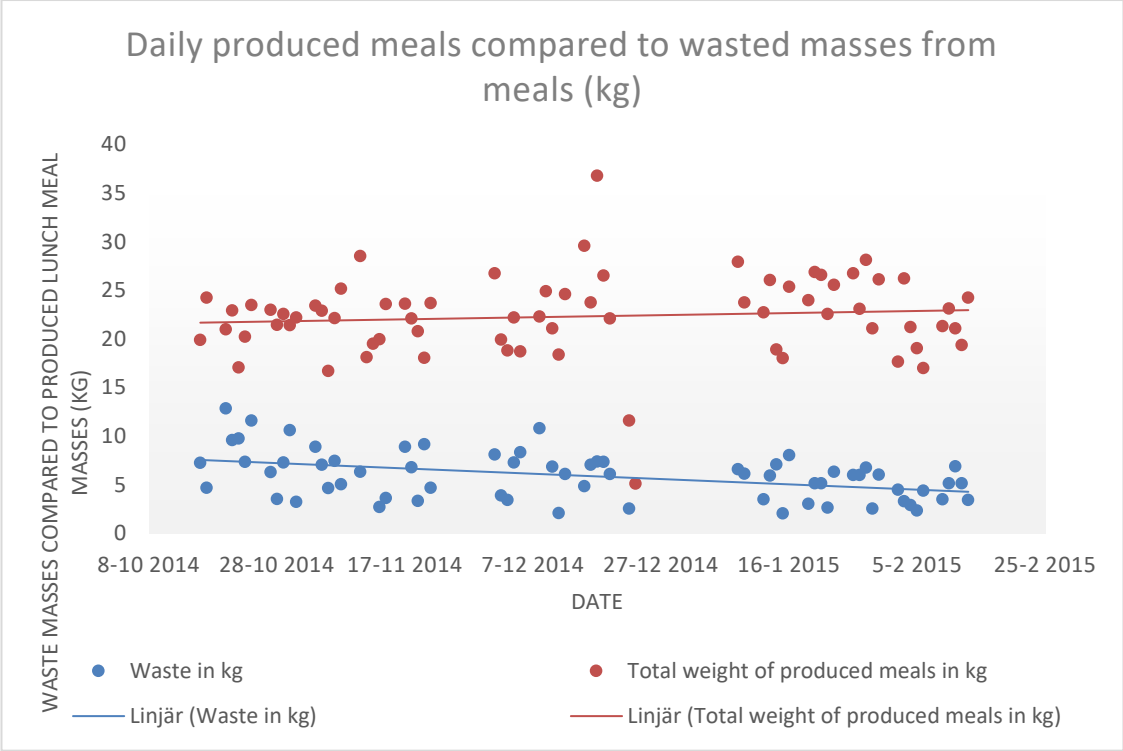

Figure 2. Diverging trends between the masses of produced lunch meals (kg) and wasted masses (kg) daily

As figure 2 illustrates, slightly diverging trends were observed when comparing quantities of produced lunch meals to measured food waste under the measurement period. At the beginning of the weighing, the average measured waste mass was 8 kg and the total produced lunch mass was 22 kg per day, while towards the end, daily average wasted mass was as low as daily 4 kg and the total produced lunch mass was 23 kg. Thus, a trend of relative reduction in wasted mass could be seen. While the produced quantities rose somewhat, weighed waste mass became lower. Such trends could perhaps express an improvement in resource management and in production quality. This effect could be explained by adjustments to better met needs of the lunch-guests during the measurement period, as the slightly growing quantity and proportion of the produced food consumed through time would suggest. Considering that during the measurement period, results were evaluated daily and quantities as well as recipes were revised to follow consumption data, the method seems to have provided tools for continuous adjustment of the production.

In table 2, the recipes with the ten highest and ten lowest weighed waste costs can be seen. Calculation of the different data categories was executed using complete recipe cost sheets and weighed waste data. As the table shows, there is a strong connection between wasted masses and cost. However, quantity of waste per recipe was not necessarily a direct indicator of waste cost, as in several cases, similar daily waste masses had considerably differing daily total cost sums. Thus, it was found that the cost per kg waste did not correlate with the total waste cost for each of the extreme examples. This result suggests that estimates of food waste

costs need to rely on integrative approaches to support more effective resource management strategies in the future.

As the table also shows, some types of recipes tended to produce systematically higher or lower than average waste quantities. The highest waste quantities measured came from non-blended soups as well as from combined meals (a mixture of proteins, vegetables and carbohydrates). Lowest waste quantities were seen on blended soups and meals with reusable safety waste.

Average waste quantities on the other hand were associated mostly with meals composed of separately served components such as meat, carbohydrates and different sorts of vegetables; as well as from other easy to portion dishes such as pancakes, meatballs with pasta or fish sticks with rice.

Table 2. Top ten and bottom ten recipes with regards to their waste costs

Top 10 and bottom 10 recipes (Highest/lowest waste values measured)	Waste per day (kg)	Total produced food per day (kg)	Cost of meal (SEK)	Cost per port. (SEK)	Waste in %	Cost of waste (SEK)	Cost per kg waste (SEK)
Jambalaya, rice	11.6	23.5	428	5.0	49%	211	18
Fish soup	9.2	18.1	397	4.7	51%	201	22
Mac ´n´ cheese	10.8	22.3	337	3.9	48%	163	15
Bean soup with ham	10.6	21.4	306	3.6	49%	151	14
Chili con carne, rice	9.6	22.9	317	3.7	42%	133	14
Chicken in mangochutney, rice	8.9	23.6	340	4.0	38%	128	14
Grilled sausage with cheese, rice	8.4	18.7	271	3.2	45%	121	14
Fish in red curry sauce, rice	8.9	23.4	301	3.5	38%	114	13
Swedish hash	12.9	21.1	156	1.8	61%	96	7
Lentil soup	9.8	17.1	129	1.5	57%	74	8
Lasagne	3.1	23.9	471	5.5	13%	60	20
Jerusalem artichoke soup	2.5	18.1	437	5.1	14%	59	24
Asparagus soup	2.4	18.4	458	5.4	13%	59	25
Mashed turnips, roast pork	3.3	22.2	393	4.6	15%	58	18
Chicken curry, rice	3.1	21.2	316	3.7	14%	45	15
Chicken in rich sauce, rice (35 port.)	2.6	11.6	154	4.4	22%	34	13
Salsify soup	2.6	21.1	217	2.6	12%	26	10
Tomato soup	2.6	19.1	171	2.0	14%	23	9
Pumpkin soup	2.9	22.6	172	2.0	13%	22	8
Cauliflower soup	2.7	19.5	150	1.8	14%	20	8

A collection of data was compiled regarding cost and waste calculations for the average quantities of non-lunch meal components and salad, consumed by guests at Kevinge Kindergarten. The estimates were based on weekly product purchase invoices, combined with peel waste statistics from the nutritional calculation program Dietist XP.

A greater part of the food wastage mass from even this component of the consumed foods was recorded by measurement. At the same time, based on the comparative calculations from salad waste and some of the collected and thus measured peel waste, a daily average of 2.2 kg waste was estimated to occur in this component. Comparisons with records of the municipal organic waste collection statistics exposed that a minor part of the food waste was never measured in the kitchen, as it got disposed of by teachers in the food waste bin directly instead. In addition, a certain remaining part of this waste category was not recorded at all, as it was discarded in mixed household waste containers. Calculating total quantities of waste indirectly from purchase data at a later stage revealed that an estimated quantity of unsorted waste was thrown out in non-food waste containers. This result stands in line with SMED´s (2011) report informing of underestimation of food wastage from large scale units due to missed opportunities to sort and collect parts of food waste as organic food waste and discarding it in mixed municipal waste instead (SMED, 2011).

Because of some combined effects, the chosen category definitions proved to be somewhat faulty in retrospect, leading to a certain double registration of waste from the complementary food items to the lunch meal. The waste collection method also led to registering some of the unavoidable peel waste as food waste on some occasions. Thus, evaluation of results from this study will address the need for separating categories more strictly for a higher level of accuracy. In the future, it will be important to include all solid lunch components such as salad or sandwiches in the lunch meal cost calculations as well, the same as separating and measuring peel and kitchen waste as an own category notoriously.

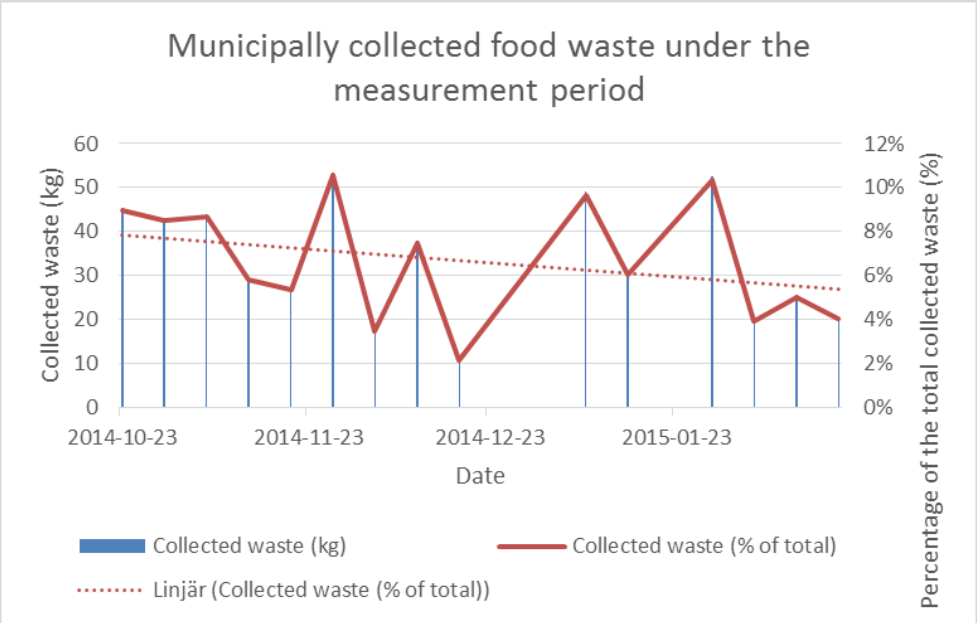

Figure 3. Statistics over collected food waste from Kevinge Kindergarten by Danderyd Municipality

Figure 3 shows a descending trend in the total collected organic food waste by the municipality in line with results from the measured food waste masses, from an average of 40 kg collected waste per week to an average of 28 kg in the end of the measurement period. In total, 396 kg food waste was measured in Kevinge Kindergarten, while the total collected organic food waste from the same unit amounted to 495 kg during the measurement period. Calculating with a weekly average of 31 kg, food waste from Kevinge Kindergarden (K.K.) could be estimated to amount to 1300 kg per year.

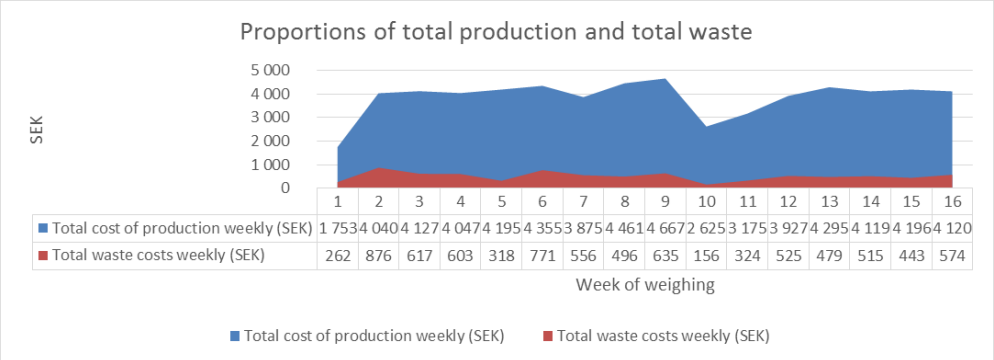

Figure 4. Proportions of total production costs and total waste costs at Kevinge Kindergarten

As seen in figure 4, the proportion of waste costs from the total production costs can be followed through the measurement period. With the help of the tested measurement method, a database could be generated that informs of the total production and waste costs of measured restaurant in detail, on the long run.

To estimate the quantity of unrecorded waste, the difference between measured waste and recorded i.e. municipally collected organic food waste was calculated. The differential amount was 137 kg: 28 % of the total collected organic waste mass. After comparing the resulting amount of unrecorded waste to the estimated total waste (based on total measured and estimated waste quantities from weekly consumption data), an additional category was identified as unsorted waste with an estimated mass of 21 kg, i.e. 4 % of the collected waste. Though a complete mass measurement would supply the most reliable database, the tested method seems to be applicable for collecting data from catering units regarding unsorted food waste as well with a more flexible approach, which could be useful towards building better grounds for food waste research. Thus, this type of a method could serve as a platform that could prove applicable for collecting data from schools, kindergartens and other large scale units for calculating total waste masses and costs on a macro level – to establish the kind of database that is missing today (SMED, 2011).

Adding the calculated average waste cost values to the total sum of food waste at a facility provides more detailed information about waste costs for the total production than relying on estimates from merely waste mass measurement data, as seen in previous research (Mattison, 2015). After compensating for missing values using the developed cost calculations, a total waste mass and total waste costs could be estimated with a higher level of detail than by other methods. In this case, a waste cost of 21 SEK per kg could be established.

It appeared from results that there is a strong connection between wasted masses and cost. However, quantity of waste per recipe was not necessarily a direct indicator of waste cost, as in some cases, a high waste mass costed considerably less than other similar measured quantities. The reason to this is a great variation in price per ingredient, as well as effects from processing. Thus, it was found that the cost per kg waste did not correlate with the total waste cost for each of the extreme examples of waste cost per meal.

Kevinge School

Data collection in Kevinge school consisted of measurement of waste masses, without calculating raw material costs in this case. Just as at Kevinge Kindergarten, food waste measurement data was collected here following lunch meals and registered in an Excel data-sheet. As table 3 illustrates, under 7 weeks, 733 kg food waste was measured in total, with a weekly average of 105 kg. The average measured daily value of the total waste per category was the following: 8.5 kg from plate scrapings, 11.4 kg from canteen waste, 4.3 kg from safety waste, 4 kg from preparation waste and 3.3 kg from peel waste. Daily measurement was done only for plate scrapings, canteen waste and peel waste, as waste in all the other categories did only occur occasionally from production. Storage waste was weighed at just one occasion.

The daily average total food waste per portion was 55 grams, with an average of 18 grams coming from plate waste and 37 grams from all other categories. Compared to results from previous research, where an average of 30 grams per portion for plate scrapings in Swedish school canteens has been registered, the result of 18 grams per portion was rather good. It could be observed that halving this component of the food waste as suggested target by previous research was in very close reach for this school canteen. A contributing factor observed was the availability of the food waste information for the pupils and teachers near the dishing facilities, during the measurement period, as well as periodically before this study.

While the quantities of plate scrapings were near the suggested target quantity, 15 grams per portion, the wastage from the canteen showed somewhat higher values than optimal. Comparison to results from previous research can prove to be hard nonetheless, considering the varying category descriptions and evaluation methods that are prevalent in this young research area. Some studies have published waste percentage of lunch meals, while the mass of the served lunch meal was not defined. Other studies have created categories to examine relative quantities of lunch components; however no combined values were calculated those could be applicable to other studies based on other category divisions (Mattison, 2015.) As there is still a lack of clear definitions and frameworks for operational targets in national policy, the evaluation of results will need to become more defined in this area towards uniform and more accurate evaluation possibilities in the future.

Wastage in the large-scale kitchens in this study seemed to be distributed throughout the whole restaurant. This result agrees with observations made in Mattison`s comparison study stating that evaluation of wastage needs to cover data from the whole unit for it to be reliable (Mattison, 2015).

Table 3. Total measured waste at Kevinge School per category as well as average daily values per category and values for guest/day (i.e. waste in gram/portion)

	Plate scrapings kg	Canteen/ bar waste kg	Safety waste kg	Preparation waste kg	Peel waste kg	Storage waste kg	Total waste kg	Weekly average kg	Daily average kg
Total waste per category	**239**	**358**	**23**	**17**	**91**	**5**	**733**	**105**	**21**
Average of total values/category	**8.5**	**11.4**	**4.3**	**4**	**3.3**				
Average of category values guest/day (gram)	**18**	**27**	**2**	**1**	**7**		**55**		

Inapplicable data

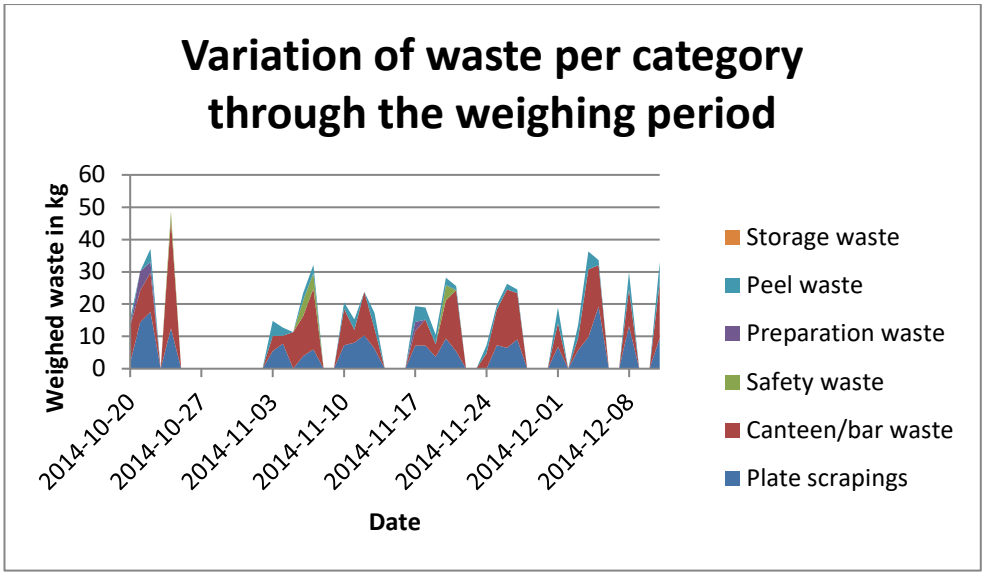

Figure 5. Variation of the weighed food waste at Kevinge School per category over time

Figure 5 illustrates that there appeared to be a great variation in daily waste quantities in this unit as well, similarly to regarding the proportions between the different categories. This result then stands in line with the earlier result at Kevinge Kindergarten´s production kitchen that following up each production day is crucial towards identifying the reasons to wastage and developing strategies towards minimizing or minimizing waste.

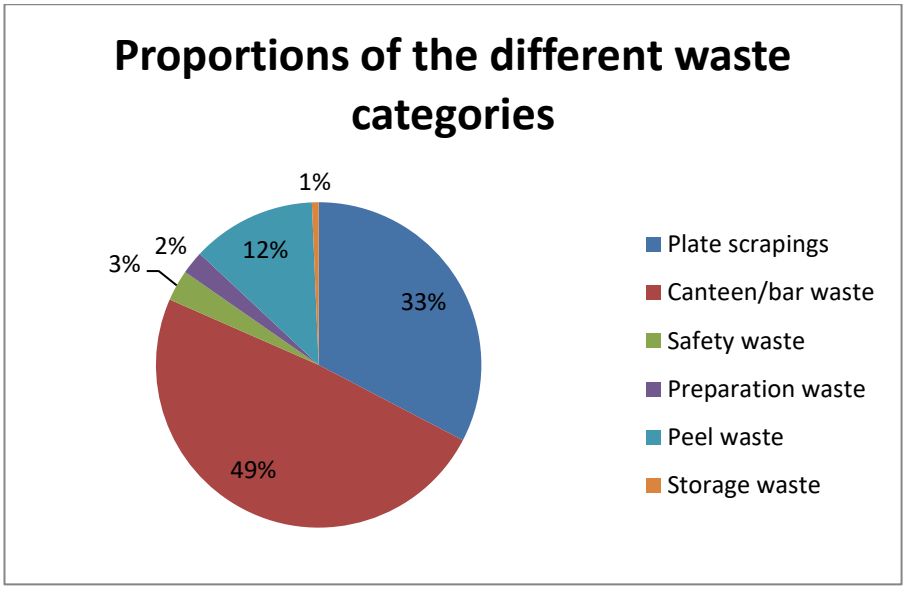

Figure 6. Percentages of the different waste categories

The dominant category from this measurement period was canteen/bar waste, 49 % equivalents of the total food waste, and not plate waste (12 % equivalents) which referred to as the single most important category in other studies. However, unfortunately in these studies, partially differing category divisions were chosen, making comparison of results to this study hard (Mattison, 2015).

Nonetheless, this comparison can support the assumption that canteens may have quite different proportions between categories, due to varying reasons. The assumption is conclusive with previous analysis in this study, which states that reasons to wastage need to be identified in each production unit and considering daily variation. Peel waste proportions were consistent with results from previous studies and estimations (Modin, 2011).

In total, 733 kg food waste was measured in Kevinge School, while the total collected organic food waste from the school amounted to 1182 kg during the measurement period. Calculating with a weekly average of 168 kg, food waste from Kevinge School (K.S.) could be estimated to amount to 7000 kg per year. More exact data could possibly be achieved in further, broader studies by retroactively summing up collected organic waste masses from municipality statistics per unit. Executing an estimation, based on received statistical data from the municipality made it possible to identify the missing waste values of 38 % of the total collected food waste. This component was identified to come from afternoon meals and from the mass of all other unmeasured waste.

Table 4 lists the 12 recipes which proved to produce the highest and the lowest quantities of waste during the measurement period. Some of the same tendencies could be observed at K.S. as at K.K. - i.e. high waste quantities of non-blended soups as well as combined meals (mixed proteins, vegetables and carbohydrates) and low waste quantities on served cream soups (blended soups). However, at K.S. it seemed that fish meals stood out with high waste quantities unlike at K.K. At the same time, finished products such as pancakes, potato pancakes and fish sticks appeared to produce some of the lowest waste masses here. It is necessary to point out that there were missing values of plate scrapings for recipes with two of the lowest waste measures. Nonetheless, when compensated for the missing values by adding the average daily plate scraping value of 8.5 kg to these daily measurement results, these recipes still stayed in the group of recipes with lowest waste values. Such variation would in fact be balanced out on the longer run more effectively, as in cases of longitudinal measurement collection periods statistical variations tend to achieve more even distribution.

Table 4. Recipes with the six highest and six lowest quantities of produced food waste at Kevinge School during the measurement period

Top and bottom six recipes regarding produced waste between 20-10-2014 and 11-12-2014

Alternative 1.	Alternative 2. (Vegetarian)	Plate scrapings kg	Canteen/ bar waste kg	Safety waste kg	Preparation waste kg	Peel waste kg	Storage waste kg	Total waste/day kg
Goulash soup	Beet soup, cream cheese, bread, cheese	12.6	33.5	2.7				48.7
Noodle wok with veggies	Spring rolls, sweet chili sauce	17.6	12.2		3.3	4.1		37.1
Fish fillet with white sauce, poatoes	Zucchini gratin with red lentils, potatoes	9.7	21.1			5.6		36.3
Italian chicken soup, bread, cheesen ham	Broccoli soup, bread, cheese	19.2	12.8			1.6		33.6
Fish sticks, potatoes, remoulade sauce	Vegetarian moussaka with potatoes and aubergines	9.4	17.2			6.6		33.2
Fish sticks, potatoes, dill sauce	Vegetarian patties with sauce and potatoes	6	18.8	4.8		2.6		32.2
Spaghetti bolognese	Vegetarian spaghetti bolognese with quorn	5.5	4.7			4.7		14.8
Potato pancakes, lingonberry jam	Veggie pilaff	5.7	3.8			4.1		13.5
Grilled smoked ham with chili, rice	Spicy bean stew, rice	7.8	2.5			2.5		12.8
Potato and leek soup, egghalves, bread, cheese, ham	Broccoli soup, egg halves, bread, cheese		11.4					11.4
Pancakes, jam	Lentil soup	3.7	3.9			3		10.5
Schnitzel, sauce, potatoes	Vegetarian patties with sauce and potatoes		4.8			2.5		7.3

Discussion

Composition of food waste

Focus of this paper was on waste quantification and on the evaluation of the measurement method tested in this paper.

Elements of the data collection method applied at Kevinge Kindergarten were:

- Weighed food waste data from K.K. kitchen
- Food waste mass data statistics collected by Danderyd Municipality
- A standardised cost sheet providing an estimate over consumed food and cost for food waste for all items exceeding lunch meals (i.e. recipes)
- Recipes detailing mass and cost data for each meal during collection period (not including complementary food items)
- Observations, notes and comments of personnel during and after production

Elements of the data collection method applied at Kevinge School were:

- Weighed food waste data from K.S. kitchen and canteen
- Food waste mass data statistics collected by Danderyd Municipality
- Observations, notes and comments of personnel during and after production

The total measured waste at Kevinge Kindergarten was 396 kg through 16 weeks, and at Kevinge School 733 kg through 7 weeks. The calculated average waste per portion was 69 grams at K.K., while it was 55 grams at K.S. The difference between weighed and collected waste data was 137 kg (28 % of the collected waste) at K.K., and 449 kg (38 % of the collected waste) at K.S. This constituted the unrecorded portion of the food waste at both locations. At K.K., where a cost analysis was also executed, a third category of unsorted food waste has also been identified and estimated as 4 % of the collected organic waste.

A small part of the measured mass of plate scrapings and canteen/bar waste came from fruit peels and breakfast plate scrapings, due to the mentioned technical challenges for the teachers to separate waste during the daily routines. Even preparation waste from the kitchen was included partially, due to practical reasons. Based on these facts, developing the measurement method further seems necessary in further research, including revision of category descriptions and more detailed instructions for the execution of the measurements, to achieve greater reliability for the tested method. Experience-based cooperative methods can offer a few simple design changes towards making the tested method even more flexible, such as using biodegradable plastic bags for separating waste categories observed at units in other municipalities. Furthermore, better cooperation within school and pre-school organizations would also be crucial to achieve the highest quality data possible in the future.

Evaluation of the measurement method

The measurement method seemed effective towards minimizing food waste at K.K., showing a trend of a visible reduction of the weighed waste and the total collected waste from the beginning till the end of the measurement period. Such a trend was not apparent at K.S. under the data collection period. Considering that day to day evaluation of results was not possible at K.S. in the lack of immediate analysis tools, this result was not unexpected. Due to the higher complexity of the production especially in larger production units and the usual time limitations during the production day, it is suggested that results need to be analysed by automated statistics calculation tools and communicated to staff periodically (e.g. on a weekly basis). This way they can implement changes continuously, even if the time press of the production makes this process somewhat challenging at most units.

Wastage in the large-scale kitchens in this study seemed to be distributed throughout the whole unit. This result confirms the need to widen the scope of measurement in other studies as well, while establishing standard descriptors which can be compared between studies. Consequently, results suggest that further research could verify that effective reduction cannot be limited to only one

area or category, but combined efforts and different strategies need to be developed towards achieving lasting results for minimizing food waste in canteens.

Data depth made multiple aspects of analysis possible at K.K. and gave quite an appropriate detail level of data at K.S. as well. Data from the estimated food consumption sheet at K.K., and municipal waste collection statistics for both units served as control measures for calculating the missing values and unsorted food waste. In comparison with results only from waste mass measurement under short periods of time in previous research, estimates of food waste at a school kitchen could prove much more reliable with this method. The reason is the given possibility to compare results from different sources and conduct complex analyses on different levels based on elements of waste composition data. Longitudinal measurement could support continued research in the future with great reliability, being able to minimize effects of variation in production throughout the year.

Waste cost calculations

As lunch salad bars usually include varied ingredients in Swedish schools, it seemed that mere mass information would not offer much insight into real costs from this component of the waste. Salad bar description is not typically included in meals´ recipes daily. Neither is consumed amounts of bread, milk and any other complements to the lunch meal. Furthermore, in Swedish schools and day-care, some breakfast is occasionally, and an afternoon meal is typically offered to children every day. All the above costs have systematically been omitted from food waste calculations, mostly due to technical difficulties to weigh fluid waste, or due to lack of precious time between meals for data collection. However, it is quite possible to calculate or estimate consumed and wasted quantities on a weekly basis under a longer period – e.g. five/ten weeks – and thus standardise a weekly or daily cost sum for complementary food items. This way much more detailed information can be achieved from each food production unit regarding waste composition and cost. A standard data sheet was developed for Kevinge Kindergarten which could be applied in all kinds of large scale units in the future. The standard data sheet and statistics from collected food waste by the municipality together served as material for estimating unrecorded and unsorted waste in the production units.

A strong connection between wasted masses and cost was seen after analysis of data. However, quantity of waste per recipe was not usable as a direct indicator of waste cost, as high waste mass costs were considerably lower than other similar measured quantities, and vice versa. Therefore, it was found that the cost per kg waste did not correlate with the total waste cost for each of the extreme examples of waste cost per meal. Another finding was that some types of recipes tended to produce systematically higher or lower than average waste quantities. The highest waste quantities measured came from non-blended soups as well as combined meals (made up of proteins, vegetables and carbohydrates) and lowest waste quantities were seen on blended soups and meals with reusable safety waste.

The executed measurements seemed to prove that the choice of categories can have some influence on quantity of missing values from the measurement. For example, a part of preparation waste was not collected in the kitchen as food waste in stressful situations at all, but instead it was thrown out in the household waste containers. On the other hand, enforcing an overly deep detail level of data collection could have caused kitchen staff enough distress to stop measuring altogether.

Designing necessary routines for execution of data collection is very dependent on each production unit´s circumstances. Some universally applicable suggestions can be made based on this case study. Still, it is important that personnel in each kitchen can choose details of participation in some form. Execution of the measurements in both units exemplifies that ascertaining support during start-up is very important, while contact with participating personnel is kept constant to avoid misunderstandings and to minimize some systematic mistakes. The method may also necessitate active guidance services due to different levels of motivation and understanding of usage of the scale and the method in different settings.

Considering that the data collection method was tested only in two quite differing production units, the arbitrary limitations and system boundaries set for these data collection periods need to be revised for better results in future research. Yet, though complete mass measurement would obviously supply the most reliable database, the tested method seemed to be applicable for collecting data from various catering units regarding unsorted food waste as well. Thus, this method could serve as a platform for collecting data from schools, kindergartens and other large scale units for calculating total waste masses and costs on a comparable, macro level, - the kind of information that is missing today.

At K.S., singular missing data points such as missed weighing of a given category on some days made the attempted evaluation of systematic mistakes less reliable in this study. The potential to reveal systematic mistakes however seems to be verified from the example of the data base collected at K.K during a longer period. There are systematic and occasional reasons to waste. With longitudinal studies in the future, it could be possible to reveal systematic reasons and offer suggestions to solve such problems in large scale catering units, while highlighting problems that lack solutions today.

Previous studies´ attempts at assessing food waste quantities in large scale catering assumed that production units´ activities are too diverse to make close examination possible. However, with the right measurement methods and support to personnel, a great number of canteens could execute detailed data collection. It could be established that all kitchens aspire to offer high quality food and good service to their guests. Therefore, seeing the possibility to have a tool to evaluate their own performance and how well they are doing towards their set goals and targets can motivate them to continue longitudinal data collection. But even short term measuring studies can offer insights on how to improve upon the quality of food service in school and kindergarten canteens while minimizing food waste effectively.

The data collection method tested in this study seemed viable when looking at components as well as at the whole usability of the achieved data. In the smaller production unit, K.K. kitchen, it meant practically no extra work to weigh food waste in these settings. Integrating the one additional step before sorting waste did not take much effort at all, and accommodating for the weighing equipment was very easy. In the complex production unit, K.S., some additional efforts were necessary towards completing weighing, and a small part of produced food waste was missing from weighing due to mistakes or other reasons. When there is more than one person responsible for the weighing, potentially more mistakes can be made. However, the longer the data collection period is, the less such mistakes might affect the results. Also, sorting food waste in different containers did pose a problem at both locations on a few occasions, due to a crowded working environment. Missing data points did result from such difficulties, suggesting that developing the logistics of the weighing system further is necessary for getting a well-integrated weighing system in complex units.

Regarding data collection and processing for the cost analyses, it is crucial to develop standardised data sheets with automatic calculation of the statistics from recipes and for the complementary food items as well. In fact, databases of default recipes could serve as a base to flexible registering of the daily data updates. This way, an immediate feedback and evaluation of a production day would also be made possible. Being able to make instant revisions to recipes would not only make execution of data collection easier, but it could be a key towards long term viability of the data collection with this method – not to mention the potential for waste reduction efforts for personnel. This part of the study was very time consuming and it would probably be hard to execute similar data processing in larger studies without automatic data sheets during normal production activities. Such tools would then serve to process data day by day, with a potential to execute quite detailed environmental cost analyses as well. This function would be extremely useful in large scale units.

Standardisation of results from longitudinal studies will be able to provide us with much more accurate pictures about food waste and offer a solid ground for taking measures towards minimizing waste. The repeatability of research with this method appears to be very good, as the measurement method required minimal time and efforts in the examined kitchens - though data depth needed to be adjusted to available resources. This however makes the method promising for evaluating long term efficacy of implemented waste measurement measures in the future in various settings. Naturally, further studies are necessary to test this and other similar methods for evaluating their efficacy, reliability and viability on the long term – this study served merely as a case study for developing and testing a type of a measurement method.

The optimal category depth for short and long term data collection seems to allow registering different categories which tend to be produced daily and can be sorted during the day. Such categories are plate waste, canteen/bar waste and peel waste. However, other categories need also be weighed for a more complete data breadth. Categories which are not typically measurable daily could be standardised through a longer period, after continued measurement. Such categories are storage

waste, safety waste and preparation waste. Further it is suggested that a customisable value reduction (the mass of the container) would be programmed in equipment for each category, thus minimizing the need for a separate category. In smaller production units fewer categories can possibly be sufficient, alternatively combined categories such as in case of K.K.

Regarding correlations between waste categories, possibly more detailed data processing tools are necessary to break down cost data to data points suitable for waste cost analyses both regarding economical costs and environmental costs. Other findings were that observations into different phases of production and consumption suggest multiple reasons of wastage and offer multiple strategies for minimizing waste effectively. Approaches need to accommodate for the fact that such complex production systems can have a variety of challenges those need to be addressed so we can achieve an effective net production, throughout the whole system.

Observations

Regarding made observations, the below – incomplete – collection of possible explanations to variation in food waste stands to show that there is no one simple solution to minimizing waste - except for trying to evaluate results every day and making changes when necessary and possible.

Factors increasing the quantity of waste

- feeling too hungry while portioning food (both the cook and the day-care teacher but also the children)
- tastiness of the dish (both when high and when low)
- highly favoured meal leading to taking too much food on plate
- unfamiliarity of food guests with dish/ingredient, or prior food aversions
- cook is unaware of eating habits of food guests (e.g. preference to select different components as wished)
- too strong/weak spicing (miscalculations)
- low quality ingredients leading to a tasteless or unappetising meal
- food processing miscalculations, such as with cooked pasta absorbing more water while prepared in combi-oven, leading to additional produced quantity
- lower appetite with periods of infections going around between children and teachers
- unreported absence of food guests
- poor choice of recipe or ingredient, possibly based on emotions, or even on interpretations of nutritional guidelines at times; or otherwise not objective/effective decision-making towards tastiness and appeal to children

- The popularity of complex recipes seems to be hard to estimate, as children can tend to consume more carefully of dishes with mixed protein-carbohydrates-vegetables (e.g. jambalaya, Swedish hash, non-mixed i.e. non-creamy soups, macaroni pudding). Thus, the highest amounts of wastage are often associated with this type of dishes, regardless of taste. Also, these dishes are often easier to over-produce due to included extra margins in multiple components, longer cooking times, and thus added water-content.
- Before week endings and on soup/fish days, more safety waste can be generated when saved food is served in addition to the planned meal(s) of the day. This fact may be not visible in mass data if no additional notes are made.

Factors minimizing waste

- Saving prepared produce by freezing it as soon as possible; alternatively, quick-chilling and serving the overproduced food the next day(s)
- Using updated recipes (identifying quality defects or miscalculations in produced meal and changing ingredients, processing, proportions etc.)
- Choosing types of recipes which have proven to be well-received (while finding ways to keep the nutritional value high)
- Cooking with leftovers
- Preparing food in batches when possible
- Preparing food in separated components to be combined at serving (e.g. cooking fish and sauce separately), thus reusing later is much easier
- Involving guests in planning and in making efforts towards waste reduction as well as trying to achieve constant feedback

Description of the studied kindergarten kitchen´s activities and parameters through a comparison to differing kitchens

At K.K., one kitchen employee is responsible for all activities related to production - from design of menu, ordering, preparing meals, to cleaning up and any other activities in the kitchen. In comparison, larger scale production units (300-5000 produced portions daily) usually are run by a bigger staff, with different roles, responsibilities and competence. At some food catering units, the kitchen utility standard is not sufficient for food production, which is why ready meals are transported there from nearby production kitchens. In such canteens, staff with a lower level of competence is more usual. Also, in some municipalities a central planning of the menus is applied, while in others, the responsibility lies individually on each production unit. Because of the given circumstances, personnel that cooks and prepares the meals has often not much say in revising or replacing recipes in

many kitchens, while they also have necessarily no real knowledge of which ingredients drive costs or waste quantity up per recipe.

In Swedish kindergartens, children´s groups usually eat in their own classrooms. Food is sent out to each group separately, thus most often there is no buffet serving. In schools, the typical catering settings are buffet-serving in a shared canteen. As follows, in kindergartens there normally are no means to separate certain categories of food waste without involving preschool teachers, which would necessitate educating and motivating them about the task. This is not an impossible problem to tackle, nonetheless. Responsibility and action plans need to be shared and distributed throughout the whole of organisation units for achieving great effects.

It seems easier to see satisfaction with meals and thus recipes in smaller production units, especially where only one alternative is served (except for special diets, which even includes vegetarian meals in day-care). In schools, it varies if vegetarian meals are accounted for and designed as special diet or as an alternative for all food guests. There are usually also two to three alternatives planned and served each day here. In kitchens where food from previous production is also served, there are even further different meal choices, which makes it somewhat harder to identify less successful recipes, when no additional information is saved from the given day.

In smaller kitchens, usually there is no quick chill-possibilities, only low-tech methods can be used to save food safely. In school production kitchens, quick-chill equipment is usually available, however storage capacity usually is just as under-dimensioned as in pre-school.

Weighing before waste disposal can typically be quite easily integrated into cleaning up routines, involving almost no extra effort. In school production kitchens, this can be somewhat more problematic, due to the more diversified production system with several work stations and different facilities. This circumstance can define how many categories are followed up constantly in each unit. It is suggested that two to three alternative standard models (category sets) like the tested ones should be further developed for establishing comparable database sets from varying units in the future.

It should be acknowledged that a certain amount of “avoidable waste” is in fact unavoidable. A point to be considered is the fact that large scale catering units are required to produce food to be prepared for needs exceeding ordered quantities each day. This means a given (5-30%) extra production as leftover daily. This fact would make it one of the first priorities in waste reduction attempts to offer strategies for reusing food leftovers, as well as improving storage capacities and educating about safe practice. Also, it is not only the behavioural changes of personnel that need to be addressed but even their working conditions and tools. Towards systematic change the tools are needed so kitchen staff can take part in the task of minimizing food wastage and do what they can and very much wish to achieve: minimize waste, raise food and service quality, and provide food that food guests finish.

Costs of using the tested method include the time necessary for measurement and compilation of cost to waste database, calculations and evaluation of results. Depending on size of production and effectivity of data collection, this cost can vary. Costs for equipment and eventual consulting services could also be added to the total costs, though several solutions can be worked out on different budget levels and measurement scope, with quite varying bottom lines. A follow-up

investigation could evaluate whether it is profitable to buy consulting services and equipment on the financial unit-level as well as regarding the environmental costs, in comparison with self-administered measurement projects.
Revealing which the prioritised areas of action should be would necessitate execution of cause analyses, which also is a topic for further investigations in the future. Nonetheless, one of the findings from this paper show the importance of informing kitchen personnel in large scale production units of the value of measuring food waste in more than one category. Results can often reveal surprising facts and give a much greater understanding of how successful any given production day has been. No measuring leaves personnel feeling like too little can be done towards change, but knowing about mass information at the very least, offers a balancing tool that enables staff towards taking actions.

Furthermore, more research is necessary for evaluating divisions between avoidable and unavoidable waste when considering the variations in production level and complexity at different units. It is important to know how regulations and communicated policies affect motivation and effectivity of kitchen staff for committed work towards waste reduction. It is also necessary that personnel are made aware of which part of the waste can be regarded as being unavoidable and which part could in fact be minimized, through more concrete and understandable guidelines from above. In this line of actions, organising activities could be a useful alternative, where responsibility and ways of action can be spread between personnel, guests and planning. Developing meeting places for staff (courses, workshops, websites etc.) where ideas can be exchanged could be examples for such activities.

Participating and thus attempting to protect the environment by better resource management can serve as a very effective motivator on any level. It could start up unexpected chains of actions towards change. However, this is a process and change could take form in many steps. The aim should be approaching minimal waste, by setting realistic targets towards reaching achievable results. The way to change is through finding both financial, time-sparing and emotional incentives for everyone involved.

It is important to be able to revise and update recipes very easily for minimizing waste, optimising costs and tailoring produced quantities to daily variations in number of guests. Using revised recipes is a simple tool towards working effectively, ascertain nutrition quality and minimize waste. Moreover, it is crucial for being able to plan and order systematically and effectively and collect detailed information about the production with the help of this method. Even organizing and delegating becomes easier when relying on information from analysing recipes.

The potential in using deep data collection methods is that it can make it viable to integrate data collection and evaluation into the everyday activities of food production facilities on the long run. Using such methods, kitchen personnel can revise recipes, minimize costs, achieve flexibility in adapting to variations in daily demands, and invest their free capacity in other areas. That means more effective usage of staff working hours, less pressure from workload and effectivity demands, better general quality of produce output as savings can be used for better quality ingredients.

The tested method showed that planning is essential for efficacy in resource management. It is necessary to plan for preparing meals in smaller, separate batches, to adjust produced quantities, to plan for sparing ingredients and food

components, plan for ways of using leftovers, to free room in freezers for available capacity, and to have safety food to be served when all else fails. Identification of not successful recipes and replacing them is important as well, which necessitates planning, an open mind and objective evaluation of results and feedback each time.

Conclusions

Longitudinal waste data registration with the tested method was feasible in both a school and a pre-school kitchen. Assistance to data collection by consulting proved to be necessary in this study. When complete cost analysis was developed regularly at K.K., the method offered a way to make recipes and production flexible. It generated data for multiple strategies to minimize wastage and cut costs by highlighting hot spots of waste and unreasonably expensive recipes. At the current level of development of the tested measuring method, there were differences is practical usability in smaller and larger production units.

Without cost analysis, the method offered insights into waste composition and production days with extremely high or low waste generation at K.S. In the lack of tools to calculate costs regularly in K.S. and summarize daily waste statistics, waste reduction efforts did not prove to be effective. It is however necessary to define target masses for different categories towards understanding the potential at each unit to minimize waste. As the example of K.S. showed, scrape waste was near target masses, when attempting to near 15 grams per portion – half the precedent amount observed in Swedish school canteens. This fact revealed that focus of efforts to minimize food waste at Kevinge School should predominantly be set on kitchen waste, for achieving greater results.

The possible areas where the tested method could be further evaluated with benefits are towards academic research, in applications for municipal projects aiming at reaching national targets of minimizing food waste in large scale catering units, as well as in developing production at large scale catering units. Further development of the method is needed towards evaluating correlations between waste categories and components. The possibility to use the data grouped into categories for calculating environmental costs is also one potential development area for this and similar methods as well.

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Popular science summary: A method for minimising food waste in school and pre-school canteens

A certain portion of the food served in schools and pre-schools is thrown out daily. Had it been treated differently; this portion could be eaten instead - or maybe the costs could be saved. Planning and preparing the meals is quite complicated in such large quantities, and it can be difficult to minimize wastage without tools that help in identifying the problems leading to excess food. The meals also must fill many requirements, which makes it necessary to work with great margins. However, that costs money that could be better spent. At the same time, this safety net also puts an added burden on the environment.

The purpose of this paper was to develop and test a measurement method for food waste in school and pre-school kitchens that would give kitchen staff a greater control over the process of minimizing food wastage. By using this method, necessary information could also be collected for research purposes that could provide better grounds for national and international environmental actions at the same time.

The method tested in this paper consisted of four possible components: food waste measurement; lunch meal recipe cost calculations; calculation of average costs of and waste from other consumed foods in the canteen; and finally, a comparison of measurement data with municipal food waste collection data.

The method was tested in one pre-school and in one school kitchen in Danderyd Municipality with two different depths of analysis. Food waste was measured under 16 weeks in Kevinge Kindergarten and for 7 weeks in Kevinge School. Measurement results were compared with municipal waste statistics in both locations. Cost and waste cost calculations were also completed at Kevinge Kindergarten, where information could be used to adjust recipes considering found data.

A result from these different approaches seemed to be that the more complex analysis method made the reduction of the wastage possible at the kindergarten. No reduction of waste could be seen in Kevinge School, where the measurement results were not evaluated continually, as no calculations over the results were done parallel to measurement. Nonetheless, measurement data revealed some central problem areas even without cost calculations, pinpointing areas where re-evaluating routines and menu choices would seem necessary, thus establishing a tool for more effective production.

At Kevinge Kindergarten, continuous development of the menu and the balance sheet seemed possible by using the method, leading to minimized waste, optimising recipes, and providing more appreciated dishes at the canteen on the long run. The method gave a greater control over budget and meal planning as well, due to the detailed information about cost and waste components.

One important condition that needs to be filled for the method to work is that support needs to be given during start-up of measurement due to its complexity. Furthermore, the method needs to be completed with automatized calculation statistics to make continuous follow-up possible, to utilise the full potential in this method.