Waste Management 97 (2019) 97–104

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Food waste case study and monitoring developing in Finnish food services

Kirsi Silvennoinen *, Sampsa Nisonen, Oona Pietiläinen

Natural Resource Institute Finland, Maarintie 6, FI-02150 Espoo, Finland[1]

ARTICLE INFO

Article history:
Received 22 April 2019
Revised 18 July 2019
Accepted 20 July 2019

Keywords:
Food waste
Food services
Restaurants and catering sector
Buffet line waste
Monitoring system

ABSTRACT

For enhancing food waste weighing measurements we established a platform (*Restaurant Forum* RF) for different kinds of food service businesses. Our aim was to explore food waste data, but also to develop a monitoring system by increasing our knowledge about the relevant processes and possible internal barriers. We studied food waste generation and origin in the outlets and how to avoid overproduction of food and buffet line waste. During 2016–2017, a number of outlets (n = 51) conducted food waste measurements over a period of two weeks. The businesses that participated included schools, day-care centres and work place and student canteens, which present sectors that mainly serve a lunch buffet. According to our results, 17.5% of all prepared food ended up as waste, which can be further divided into kitchen waste (2.2%), serving waste (11.3%) and customer leftovers (3.9%). On average, 449 g of food was prepared per portion and 78 g of this ended up as waste. We also studied the mechanisms of waste generation, best practices for decreasing food waste, how staff experienced weighing measurements and how measurement systems can be utilized in food service business management.

1. Introduction

Food waste (FW) minimization is an important part of the sustainable food system providing food for a future growing population and maintaining the viability of natural systems (Willet et al., 2019; Foley et al., 2011). Approximately one third of all the food produced never gets eaten and ends up as waste (FAO, 2011). This has substantial negative environmental effects, as greenhouse gases have been emitted and resources used for production, processing and transportation of that food (FAO, 2013). FW is generated in all stages in the food supply chain (e.g. Canali et al., 2017) and the later the phase of the food supply chain where food is wasted, the bigger the negative impacts are for the environment, the economy and society. The food service sector is part of the late phase with households and these phases have been estimated to produce a significant share of FW (e.g. Stenmarck et al., 2016; Buzby and Hyman, 2013). In addition a growing urban population, tourism and food service business (Knorr et al., 2018; Satterthwaite et al., 2010; Eurostat, 2018) would potentially increase food services and FW amounts in future and on the other hand they have the potential to develop redistribution to keep edible food in the food system (Knorr et al., 2018). The food service industry is also a significant employer (Eurostat, 2018) and with regard to FW, waste management and other sustainability issues, its economic and social competence will increase. In Finland this sector serves a great number of everyday lunches. Especially large in this regard are communal-based food services, as all school pupils get their lunch at canteens free of charge (FNEB, 2014). Additionally, a great number of citizens eat their lunch at workplace restaurants or student canteens (Vikstedt et al., 2012a, 2012b).

Even though research data on FW in the Nordic and other countries is available (e.g. Stenmarck et al., 2016) there is notably weak data on the amounts and quality of FW in the food service sector. Instead of the quite uniform amount of waste from households, food services (food service sector) differ largely in terms of the business idea and size (e.g. HORECA register 2016). FW research has been carried out in school canteens and by examining customer plate leftovers, however, estimations of total FW amounts and the complete food service sector are rare. In general FW data has been found to have several weaknesses, e.g. the studies have been conducted mainly in a few western countries and they are often based on secondary data sources (Xue et al., 2017).

In this study we will present a case study from the Finnish food service sector, discuss its origin, drivers and monitoring methods.

* Corresponding author at: Natural Resources Institute Finland (Luke), Maarintie 6, FI-02150 Espoo, Finland.
E-mail addresses: kirsi.silvennoinen@luke.fi (K. Silvennoinen), sampsa.nisonen@luke.fi (S. Nisonen), oona.pietilainen@luke.fi (O. Pietiläinen).

[1] https://www.luke.fi/en/.

https://doi.org/10.1016/j.wasman.2019.07.028
0956-053X/

The importance of FW research in the food service sector in Finland is based on sector's large size, growth potential and significance in the Finnish food and economic system (OSF, 2018; Mara, 2018). One third of the population eats every day in canteens and work or student restaurants (Vikstedt et al., 2011). An earlier study conducted in Finland (Silvennoinen et al., 2015) found about 20% of food produced was wasted in the services.

Several studies have been carried out in other countries, e.g. in Sweden, where food waste quantification was performed in 30 communal food service outlets for three months (Eriksson et al., 2017). Other studies were performed in Switzerland in two outlets for 5 days (Betz et al., 2015), in the United States in three schools for 5–8 days (Wilkie et al., 2015) and in Britain in 39 schools for three weeks (WRAP, 2011). Some studies covering the food service sector have quantified FW from one origin only, e.g. customer leftovers (Soares Pinto et al., 2018; Derqui et al., 2018; Boschini, 2018; Liz Martins et al., 2014) or the kitchen and serving (Falasconi et al., 2015). European FW project FUSIONS has estimated FW in food service sector to be about 10.5 million tonnes and about 21 kg/pp/year (Stenmarck et al., 2016).

In this study we established a platform for food service businesses *(Restaurant Forum* RF) to help them to conduct a high quality FW weighing study for outlets with a buffet line, which includes estimates about the amount, origin and type of FW. As previous research has shown that serving waste is the most significant FW category in outlets with a buffet line (Silvennoinen et al., 2015) and because approximately half of portions are served from buffet lines, we limited our study to those outlets. We also organized a workshop to find out from stakeholders how measurement procedures should be developed, what are the most important barriers to decreasing FW and to hear the opinion of food service professionals on the problems in measuring FW.

Our aim was to explore FW data, its variation and measurement method and discuss what kind of monitoring process would be optimal for Finnish food service system. We also wanted to get up-to-date information about FW amounts in the sector and acquire new knowledge about origins of FW, the composition of serving waste and to get a sense of the diversity within the sector.

2. Methodology

2.1. Platform

Participants in the weighing study were taken from among the *Restaurant forum* (RF) plaform members. The platform was established to contact companies and promote co-operation with them. Invitations were sent by e-mail and The Finnish Hospitality Association MaRa informed their member companies about the possibility to participate by publishing notifications in their magazines. The platform had a web page with information about FW, previous studies and instructions for registration (/www.luke.fi/ravintolafoorumi/). Altogether 44 companies registered for the platform and 11 companies wanted to conduct the measurement period. All companies were located in Southern Finland and they represented a mix of various kinds of buffet restaurants.

These food service companies were approached by email and phone to confirm participation in the study and to deal with the details. First, the participants were directed to familiarize themselves with the weighing instructions and result forms. If the participants had any questions about the weighing procedure, the researchers were available by both email and phone to clarify and explain the details. In the end a total of 51 food service outlets from 11 companies were accepted on the study, representing four food service subsectors: schools (N = 26), day-care centres (N = 13), vocational schools (N = 5) and workplace and student canteens (N = 7). The outlets belonged to 11 companies from different areas of Southern Finland. The outlets were all part of the subsectors, which use a buffet line to serve food. These have been shown by previous research to be significant producers of FW (Silvennoinen et al., 2015). A workshop was held in Helsinki on 6th February 2017 to complement the quantitative weighing study with a more qualitative outlook from people working in the food service sector. Different kinds of companies and experts were invited to share their experience about food waste and related topics. Invited food service companies sent representatives, who were in charge of reducing FW in their respective companies. Additionally, representatives from the Finnish Hospitality Association and the Finnish Food Safety Authority were present. The participants (n = 21) had group discussions about i) current FW generation and how to decrease it, ii) the best monitoring methods and iii) how to develop *Restaurant Forum.* The discussions were moderated by the researchers and the main points were written down for further analysis.

2.2. Measuring waste, cooked food and number of customers

Most of the outlets used the waste registration forms we provided for them, but some wanted to use their own forms that they were familiar with. The forms had the same input fields and they provided identical information. The participants reported the amount of food prepared, kitchen waste, serving waste, customer leftovers and the number of customers for each day. In addition schools and day-care centres reported the composition of serving waste in a categorial level, e.g. main dish (meat, fish or vegetarian), sidedishes, bread, dessert. The typical duration of a weighing study was two weeks and the total number of weighing days in all outlets was 482. The data provided by participants was analyzed and if there were any missing records, the participants were contacted to complete the data. If they couldn't provide the missing data, these incomplete records were ignored. For example three outlets were completely left out of the results, because the quality of data was lacking. An exception was made for day-care centers, for which data was accepted even though the amount of kitchen waste was not reported at all. In these outlets food was prepared in central kitchens, making it difficult to allocate produced kitchen waste to each separate outlet. We estimated the kitchen waste in day-care centers using previous research (Silvennoinen et al., 2015) in order to fill the gap in data. The separation of waste categories used in this study is presented in Table 1.

The data from weighing studies was analysed by summing up prepared food, kitchen waste, serving waste, customer leftovers and the number of customers. Based on the data sample, we calculated the following indicators: food waste percentage and food waste per customer. Food waste percentage describes the percentage of food that is wasted relative to the amount that is produced. Food waste percentage for the whole sample is equal to the weighted average of food waste percentages of single outlets, weights being the amounts of prepared food. The indicator calculations were also made separately for each subsector and FW origin. The calculation for the food waste percentage for the whole sample is

$$W\% = \frac{\sum_{i=1}^{N} W_i}{\sum_{i=1}^{N} P_i} = \frac{\sum_{i=1}^{N} P_i * W\%_i}{\sum_{i=1}^{N} P_i} \quad (1)$$

where $W\%$ is the food waste percentage for the whole sample, N is the sample size, W_i is the amount of food waste generated at outlet i, P_i is the amount of food produced at outlet i and $W\%_i$ is the food waste percentage at outlet i.

Food waste per customer describes the amount of food that was wasted per customer on average. Food waste per customer for the

Table 1
Sorting and definition of kitchen waste, serving waste and customer leftovers.

Type of waste/origin of waste	Kitchen waste	Serving waste	Customer leftovers
FW originally edible solid	Spoiled products, incorrectly prepared food, expired date products	Overproduction, food left from buffet	Food leftovers left by clients on plate
FW originally edible liquid	Milk, other drinks, broths	Milk, sour milk	Milk, sour milk
FW non edible	Non-edible parts of vegetables, coffee grounds and bones	Non-edible parts of vegetables, bones	Vegetable peelings, bones

whole sample is equal to the weighted average of the indicator values for single outlets, weights being the amounts of customers. This indicator was calculated separately for each subsector. The calculation for the food waste per customer for the whole sample is

$$\frac{W}{c} = \frac{\sum_{i=1}^{N} W_i}{\sum_{i=1}^{N} C_i} = \frac{\sum_{i=1}^{N} C_i * \frac{W}{c_i}}{\sum_{i=1}^{N} C_i}, \quad (2)$$

where W/c is the food waste per customer for the whole sample, N is the sample size, W_i is the amount of food waste generated at outlet i, C_i is the number of customers at outlet i and W/c_i is the food waste per customer at outlet i.

Because previous research has shown serving waste to be the most significant FW origin, the composition of serving food waste was analyzed by calculating two additional indicators: share of each food type of all serving waste and share of each food type of produced food of the same type.

3. Results

3.1. Food waste percentages

Aggregating the results from all 51 outlets, 17.5% of all prepared food ended up as waste. The key statistics of the sample for FW percentage are presented in Table 2. There is great variation in the FW percentage values across the sample: weighted average is 17.5 and standard deviation is 5.9. Analysis of the sample indicates that it is not normally distributed.

Further, food waste percentage can be divided by origin into kitchen waste (2.2%), serving waste (11.3%) and customer leftovers (3.9%) as seen in Fig. 1. The differences between subsectors, which had been observed in previous research, are seen in the results of this study as well. Serving waste is still the most significant origin of FW for all subsectors. The relative order of kitchen waste and customer leftovers depends on the subsector. Day-care centres have the highest percentage of FW (20.3%). It must be taken into account, that the percentage of kitchen waste for day-care centres (4.7%) was estimated using previous research, which means that there is uncertainty related to the total percentage of food waste as well. Even if the true value of kitchen waste percentage were much lower, the percentage of serving waste is nonetheless the highest for day-care centres (12.6%). Vocational schools have the lowest percentage of FW (14.7%) even though the share of customer leftovers is the highest among the subsectors (5.5%). This result is easy to understand as the serving waste percentage for vocational schools (7.0%) is much lower compared to other subsectors (11.6–12.6%) (Fig. 1).

3.2. Food waste per customer

On average, 449 g of food was prepared per portion and 78 g of this ended up as waste. The results for eaten food and food waste per portion are presented in Fig. 2, separately for each subsector. The first observation to make here is that the more food is prepared, the more food waste there is as well. On the other hand the differences in effectiveness between subsectors can be seen here as well. For example day-care centres produced almost the same amount of FW per portion as workplace and student canteens, even though they produce 214 g less food per portion on average. Again, vocational schools prepared almost the same amount of food as day-care centres, but they produced 33 g less FW per portion.

3.3. Composition of FW in schools and day-care centres

Data on the composition of FW was available only for serving waste (e.g. overproduction Table 1) in schools and day-care centres, as it was not compulsory to submit this data. Looking at Fig. 3, it can be seen that a very large part of the serving waste in schools and day-care centres consists of meat based main dishes, followed by fruit and vegetables and side dishes. These numbers mainly reflect the composition of food served; the more a type of food is served the more of it ends up as serving waste as well. We get a better understanding of the composition of serving waste, if we look at what percentage of each food type produced ends up as serving waste. These numbers, also presented in Fig. 3, reflect how efficiently each type of food is used instead of just how much of it was prepared. Now the differences between food types are much smaller, but we can see that fruit and vegetable produce a bit more waste, while desserts produce the least.

3.4. Workshop results: members' opinion on food waste and its measurement

A workshop was organized for restaurant forum members to discuss food waste origins, best practice to reduce it and food waste measurement. The key results are presented in Table 3. The most crucial reason for FW generation was seen to be the difficulties in predicting the amount of food that should be prepared each day. The participants stated that the buffet must always look attractive and that it would look incomplete and not worth the

Table 2
Key statistics of the sample for FW percentage, which is an indicator that is comparable between outlets. All values are percentage points.

	N	Weighted average	Standard deviation	Median	Min	Max
All	51	17.5	5.9	18.4	6.4	33.8
Schools	26	17.4	4.4	16.9	8.5	26.5
Day-care centres	13	20.8	4.9	20.9	15.1	33.8
Workplace and student canteens	7	17.0	8.8	15.7	6.4	31.6
Vocational schools	5	14.7	3.2	15.0	12.2	20.5

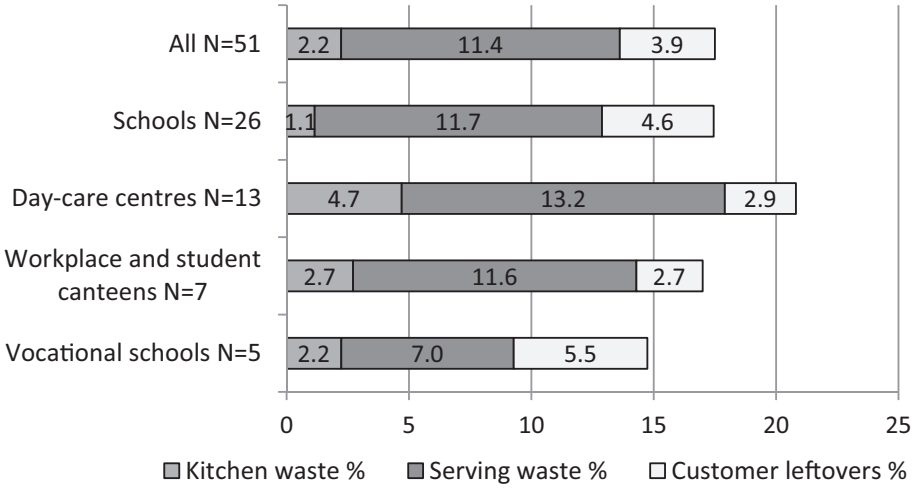

Fig. 1. Food waste percentages in each subsector. Food waste is divided into three components by origin: kitchen waste, serving waste and customer leftovers. Kitchen waste in day-care centers was estimated using previous research.

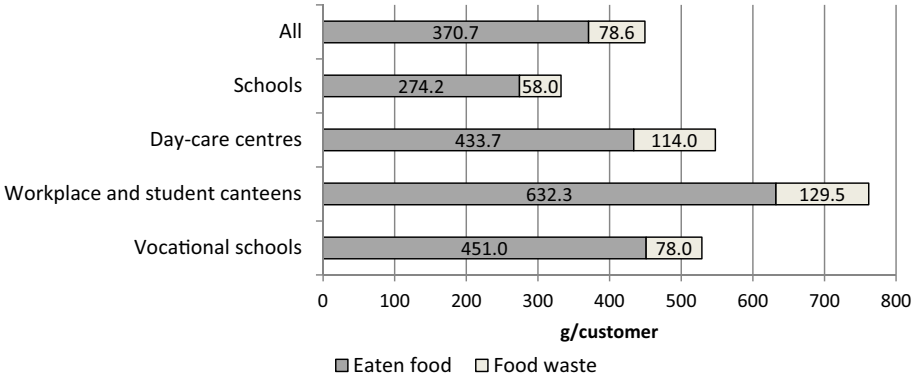

Fig. 2. Eaten food and food waste (originally edible) in grams per customer. Results for each subsector.

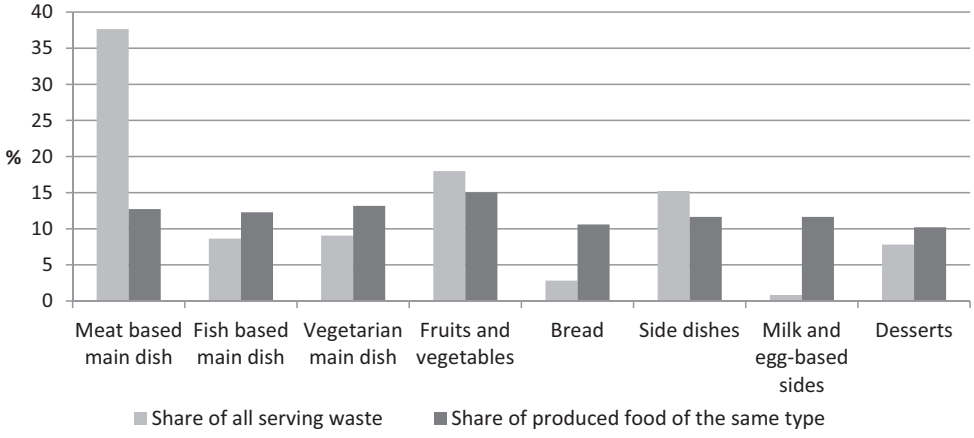

Fig. 3. Serving waste composition in schools and day-care centres. Meat-based main dishes make up the most significant portion of serving waste by far. Second series shows the percentage of prepared food that ends up as serving waste, which reflects how efficiently that type of food is used.

client's money if food was allowed to run out on the buffet, so the restaurants tend to minimize that risk and overproduce. Related to prediction, the choice of recipes can greatly affect the amount of FW. Poorly liked recipes can lead to more customer leftovers and insufficient knowledge of the recipes makes it more difficult to produce the right amount of portions of the right size. There are also problems with attitude and awareness: negligence, ignorance or apparent hurry on part of the kitchen staff will lead to FW that could be avoided.

One of the best practices discussed was to tackle the problem of overproduction and improve planning. Data on past days should be used to produce the correct amount of portions of the right size.

Table 3
Key findings and recommendations from food waste workshop.

Reasons for food waste	Best practices	Measuring food waste
Difficulties in prediction and overproduction	Improve planning, measure food waste	Easy to use tools are crucial
Acceptability of recipes, portion size	Improve work management and direction	Measurement results should be used more in planning and for increasing awareness
Problems with attitude and awareness	Increase training, education and orientation to change attitudes	Strong commitment is required, especially for long term measurements

FW measurements would help in reducing FW by identifying the problematic sections of the process. A centralized ordering system and a standardized set of recipes would make it easier to produce the correct amount of food. The menu should be planned based on experience in what foods are well-liked. Additionally, work control and direction could be improved. There should be a check in for ingredients when they arrive and the ingredient cycle should be planned to avoid unnecessasy spoilage. Cooperation with wholesale companies could be increased as well. However, none of these actions will work in practice without the motivation to perform them well. Thus orientation and discussion were seen as important tools in increasing awareness and changing attitudes to make staff care about the FW problem.

As FW measurements are crucial for reducing FW, the topic was discussed in more detail to find out what makes them difficult to take and what could ease these difficulties. First of all, easy to use measurement and result registration tools were seen as essential for successful measurements. Because FW measurements are usually a new task that is added on top of existing ones, they should be as easy to do as possible. If the kitchen is busy, measurements are typically dropped in favour of more essential tasks. The measurement results should also be used more visibly in the kitchen to maintain the motivation to perform them. Measuring just for its own sake does not make any sense to kitchen staff. There is a possibility that motivating is sensitizing the staff to report less FW, but there is also the same possibility if they ignore and neglect the measurements. We also see the possibility that someone alters the FW records as secondary to the positive effect motivating usually has on personnel. Overall a strong commitment to measuring is required from the staff, as it does not offer any direct reward for completed work. Long term measurements require an especially strong commitment, and to succeed motivation has to be kept high through feedback and measurements have to be integrated into the routine as a normal part of the job.

4. Discussion

FW is generated in all stages of the food system in Finland, totaling about 450 M kg of FW in a year, of which the food service sector generates a significant portion (Katajajuuri et al., 2014). Because the sample of this study is not representative of the food service sector in Finland, the results cannot be used to calculate good estimates for the national level of FW produced by the sector. However, to get a sense of the scale of the FW problem, a simple exercise can be done to roughly illustrate the level of FW produced by the subsectors investigated in this study. There are statistics for the number of portions prepared annually in each subsector (Horeca register, 2015), which can be used in this exercise. First, we multiply the number of portions by portion size and the FW percentage separately for each subsector. Second, we sum them up to reach a result of about 25 million kg in a year. We can conclude that tens of millions kilograms of FW are produced annually in the Finnish food service sector.

For schools we can also illustrate the scale of the economic losses caused by FW. According to a report by the Finnish National Agency for Education the mean price for a school lunch in Finland in 2013 was 2.8 € (Manninen et al., 2013). This price includes food resource costs, transport costs and production costs, i.e. wages for kitchen staff. Now multiplying the price of a school lunch by the number of portions served annually and the FW percentage a result of about 70 million € is reached. As school lunches are relatively cheap compared to most other food service sector outlets, we can easily assume that the annual economic losses for the whole sector are measured in hundreds of millions of euros.

Finland, among other EU member states, has committed to decrease the amount of FW by 50% by 2030 (European Commision, 2015), which means that the food service sector has to take action as well: both businesses and customers can affect FW and resource efficiency. We discuss here how the results of this study could be used to develop means and solutions for minimizing FW in Finland.

4.1. Amount, origin and decreasing of FW

Kitchen waste, from storing, preparing and cooking, forms a relatively small proportion (1–5%) of food produced, depending on whether or not food is ordered from a central kitchen, which affects the amount of food prepared locally. Participants saw that the amount of kitchen waste could be decreased by improving ingredient check-in and stock turnover, by following recipes carefully and by utilizing all materials creatively. A centralised ordering system and co-operation with wholesale companies could assist in stock management, e.g. by avoiding too big packages, using raw materials efficiently for different menu combinations and using ready-to-use packaged solutions for vegetables, which can decrease waste if the right amount is ordered.

Serving waste, that is food left from the buffet line and over produced food prepared but never served, is the most significant contributor to FW generation (7–13% of prepared food). Serving FW is generated when an outlet has difficulties in estimating the number of customers and how much food they are going to eat. The most critical question for how to decrease FW in food services is how to prepare the right amount of food so that there is just enough for the last customer. According to the workshop results the solutions are connected to managing and planning, which could be supported by measuring waste amounts.

There are a number of obstacles in the way of proper planning and predicting the right amount of food to prepare. The workshop participants saw that sometimes there is lack of real will to reduce food waste, which can be due to incompetence, negligence or apparent hurry. Personnel could lack willingness and knowledge to take the risk that food could run out during the lunch hour. The lack of experienced personnel, e.g. a large number of extra workers, could contribute to the problem. Feelings of being rushed and stress can also cause a situation where it is more convenient to overproduce food instead of cooking in stages as needed. The answer could be to change attitudes and increase awareness by orientation and discussions. Also changing the attitudes of the customers is needed, so they would not mind a dish running out in the buffet. If customers understood and accepted that sometimes this

can happen because the restaurant is trying to minimize the amount of food waste, the staff would not need to overproduce food to keep the customers happy. Menu planning based on past food consumption records would help to estimate the amount of food needed and to choose meals that are preferred by customers. This effect can be further magnified by having a standardized set of recipes so that each menu cycle will increase knowledge about consumption and sale amounts. Also, estimating the monetary losses caused by food waste can help to concretize the problem and increase motivation to reduce FW.

In schools and day-care centres the exact number of pupils is known, but not all will eat every day. Excursions, exam dates and illnesses cause additional uncertainty. This could be avoided by increasing communication between school management and kitchen personnel. *Customer leftovers* (food left over from plates) constituted 3–6% of food produced and in this study they are considered to be part of the meal taken from buffet line by customers themselves. Food service businesses are interested in plate waste as it is connected to costs and resource efficiency. Some schools have measured plate waste as a part of the campaign and for educational purposes (e.g. Yle news, 2013).

Whenever and wherever possible, the companies seek to reuse and serve overproduced food in the next days. However, the lack of proper storage in the form of freezers and fridges may make it difficult. Some companies donate overproduced food to charities, which collect the food after lunch hours.

4.2. Comparison with previous FW studies

In this study, food waste was 17.5% of all food prepared, and food waste per portion was 78 g. The results were compared to results from the previous Finnish food waste study from 2012 (Silvennoinen et al., 2015). It must be noted that the comparison is only indicative of the change in the amount of food waste produced in the food service sector in Finland, because the research methods were not identical in these two studies and because the samples are not representative of the sector. Nonetheless the current total food waste percentage was lower compared to the earlier study. The amount of customer leftovers, in particular, was smaller in the outlets participating in this study on average. In schools the food waste percentage was almost unchanged, but there was a slight decline in the food waste percentage of the other subsectors.

A study quantifying food waste from public catering services in Sweden found that 23% or 75 g/portion of food served was wasted (Eriksson et al., 2017). In other words the food waste per portion was almost the same as in the present study, but the food waste percentage was clearly higher. In Switzerland Betz et al. (2015) conducted food waste measurements in two kitchens and found that 10.7% and 7.7% of all food delivered was wasted, and the waste per portion was 85 g and 67 g. The amount of food waste per portion is in line with our findings, but percentages are surprisingly low in their study. This can be explained by different calculation methods and using the mass of food delivered, as we used the mass of food prepared.

Even though the overall results were similar to those of Eriksson at al. (2017), the amounts of food waste produced by schools and day-care centres differed. We found that the food waste in schools was 58 g/portion and in day-care centres 114 g/portion, where as Eriksson et al. (2017) found it was 79 g/portion for schools and 51 g/portion for day care centres. The food waste produced in schools is in the same range, but in the day-care centres the amount of waste is more than double in the present study. Also the food waste produced in workplace and student canteens (129.5 g/portion in this study) was lower in Betz et al. (2015) and in Møller and Stensgård (2016). Betz et al. (2015) found that 67 g/portion was wasted in a workplace canteen, and Møller and Stensgård (2016) found that the amount of food waste that included originally inedible parts was 61 g/portion in five workplace canteens. The comparison between studies highlights the diversity of the results. More and more extensive studies with large samples are needed to establish generally accepted average values for FW amounts in different subsectors.

4.3. Developing a monitoring system in food services

4.3.1. Measurement system for estimating FW amounts, origin and trends in food service sector

In Finland, the Ministry of the Environment's The National Waste Plan (ME, 2018) has set detailed targets to halve food waste by making a roadmap for measuring and studying FW, directing finance of the food system for decreasing and providing information about FW and increasing education among children and young people. The Ministry of Agriculture and Forestry has published a Government report on food policy (MAF, 2017) and it sets out the policy objectives and key priorities of the activities for the future food system. The report identifities actions to decrease food waste by enhancing the appreciation of food and through education. It also recommends improving the measuring and monitoring of FW in the food chain. We analysed the results of FW amounts and types, workshop results and interviews to develop some requirements for an ideal FW measurement system and for regular monitoring (Table 4).

The criteria presented in Table 4 are difficult to achieve in practice. The demands for accurate and daily measurements of not only FW amounts sorted to separate origins, but also the amounts of produced food and customers for long periods of time are at odds with random sampling and large sample sizes. It is more feasible to conduct demanding measurement periods with relatively few participants with whom contact has been established beforehand. A large number of random participants would be much more difficult to guide through the measurement period, assuming that such a group has even been successfully persuaded to participate.

In principle it would be optimal for the researchers to perform the measurements themselves, as it would improve accuracy and reliability. In practice, there would not be enough resources and time for researchers to perform the measurements, if the samples were any larger. Study periods should last weeks and when there are multiple outlets around the country, the measurement periods will overlap. Consequently the best option is to guide the personnel to perform the measurements along their other daily tasks. To mitigate the losses in accuracy, measurement equipment and waste registration forms should be easy to use and the measurement process itself should be made as simple as possible.

4.3.2. System for company FW monitoring

A suitable monitoring system will help services to monitor and efficiently utilize data gathered by waste weighings. Management

Table 4
Data collection features for a FW monitoring system.

Requirement for data collection	Rationale according the results
Random sampling	Avoiding sampling biases
A fairly large number of participants from every subsector	There is significant variance within the subsectors and FW amounts, types and origins differ.
Use of scales for weighing instead of estimations	It is impossible to estimate large amounts of different kinds of FW.
Daily measurement for food waste and food produced	FW amounts vary by day and menu.
Measurement period should cover at least a complete week	Measurement period should be long enough to capture the day by day variance in the menu (preferably a menu cycle).

Table 5
Monitoring system qualities to help weighing process and monitoring of FW in food service companies.

Quality	Rationale
Simple and unambiguous form or application. Different languages options.	This is essential for kitchen staff during busy times. Easy to use for personnel.
All staff able to measure FW during the day	Preparation personnel would ideally measure FW amounts that they are responsible for.
Possibility to separate FW by origin and type. Possibility to separate originally edible FW	It is more work to separate waste, but it would help to see the proportions of the most important waste fractions.
Comparable measurement methods in separate outlets	Common method to help management and planning. Makes the comparison of outlets possible and consequentially problematic outlets are easier to identify.
Computer/tablet on-line applications	Handier than paper forms for recording measurements: Application saves data for later analysis and it would visualize amounts easily. Management would have data immediately.
Measurement results should be detailed enough for conclusions and the personnel should be informed about them.	Measurement results should be used to increase awareness in a positive manner and to find new ways to decrease FW.

could also use the system to develop best practices, menu planning and monitor the amounts and trends of FW. We found that essential indicators are i) *percentage of food produced that ends up as waste (FW%)* ii) *food waste per customer*. To get sufficient data for indicators, a measuring system should include data collection about amount food waste by origin: kitchen, serving and customers, amount of food produced and number of customers each day. In addition separate sorting and measurement of edible and inedible FW waste amounts should included. We organized a workshop and collected data about companies' opinions regarding a convenient monitoring system and its qualities (Table 5).

4.4. Limitations of the study

A large number of food service companies were invited to and registered on the Ravintolafoorumi platform. These companies could then choose to participate in the FW weighing study, which means that they were potentially more interested in FW than companies on average. The participants might have a lower level of food waste compared to companies that were not interested in participating. As a case study with a primary purpose of advancing and exploring FW measurement methods, the number of participants is quite low considering the amount of food service outlets in Finland. This is reflected in the fact that the sample is not normally distributed and it does not represent the food service sector in Finland. The study does not take the effect of seasonal changes (e.g. holidays) and menu cycles into account.

Because the staff of the outlets weighed and recorded the amounts of FW, the quality of data may not be as high as if the researchers had measured FW themselves. It is possible that the staff did not weigh all FW or they might have confused the categories. However, self-reporting makes it possible to obtain a much larger dataset compared to what the researchers could deliver. In practice it was impossible for the researchers to even be physically present for every 482 measurement day of this study.

5. Conclusions

In this study food waste was measured in 51 restaurant outlets which used buffet lines for serving food. These case study outlets included schools, day-care centres and work place and student canteens. In summary 17.5% of food produced ended up as waste and serving waste was found to be the most significant waste category (11.3%). Per customer, 449 g of food was produced and 78 g was wasted. The more food was produced, the more FW was generated as well. A workshop was arranged for food service sector personnel to find solutions for decreasing FW. It was found that the challenges to overcome are long term planning, estimating the number of customers and overproduction of food. Disinterested attitude, carelessness and feelings of being hurried can increase FW. Menu planning and menu size were seen as important factors as well. Reduction of FW requires changes in practices, especially improved managing and guidance, and planning based on past experience are possible solutions to the FW problem. Regular measurements would give important data which could be used to forecast the number of customers and estimate the amounts of food that should be produced. Educating staff would promote the right attitudes toward best practice and encourage them to reduce FW.

According to our results, almost 20% of produced food ends up as waste in this sector, which has significant implications for the society. In Finland food services are a growing business sector and also nutritionally significant, because third of the population uses food services daily. Almost half of all food portions, about 383 million, were prepared in public eateries in year 2015. These outlets commonly use buffet lines, which compounds the importance of reducing FW.

Food service sector has impacts on both environment and economy. In Finland school lunches are free of charge and financed with taxes. If the money lost on FW was reduced, it could be used to, for example, improve food quality. It is important to measure and monitor the amount of FW to find new ways to reduce it and to verify the efficacy of the new methods. Companies can also benefit from measuring their FW. It can help them to better understand how and where FW is generated in their operation. On the other hand the information about FW supplied by the companies makes it possible to monitor FW on national level and to plan policies for reaching the FW reduction targets.

References

Betz, A., Buchli, J., Göbel, C., Müller, C., 2015. Food waste in the Swiss food service industry–Magnitude and potential for reduction. Waste Manage. 35, 218–226.

Buzby, J., Hyman, J., 2013. Total and per capita value of food loss in the United States. Food Policy 37, 561–570.

Boschini, M., Falasconi, L., Giordano, C., Alboni, F., 2018. PrimaryFood waste in school canteens: A reference methodology for large-scale studies. J. Cleaner Prod. 182, 1024–1032.

Canali, M., Amani, P., Aramyan, L., Gheoldus, M., Moates, G., Östergren, K., Silvennoinen, K., Waldron, K., Vittuari, M., 2017. Food waste drivers in Europe, from identification to possible interventions. Sustainability 9 (1), 37. https://doi.org/10.3390/su9010037.

Derqui, B., Fernandez, V., Fayos, T., 2018. Towards more sustainable food systems. Addressing food waste at school canteens. Appetite 129, 1–11.

Eriksson, M., Osowski, C.P., Malefors, C., Björkman, J., Eriksson, E., 2017. Quantification of food waste in public catering services – A case study from a Swedish municipality. Waste Manage. 61, 415–422.

European Commision 2015. Communication from the commission to the European Parliament, the council, the European economic and social committee and the committee of the regions closing the loop - An EU action plan for the Circular Economy. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614 (Accessed 5.7.2019).

EUROSTAT 2018. Accommodation and food service statistics. https://ec.europa.eu/eurostat/statistics-explained/index.php/Accommodation_and_food_service_statistics_-_NACE_Rev._2 (Accessed 5.7.2019).

Falasconi, L., Vittuari, M., Politano, A., Segrè, A., 2015. Food waste in school catering: An Italian case study. Sustainability 7, 14745–14760.

FNEB. Finnish National Board of Education. School meals in Finland; 2014. https://www.oph.fi/download/155535_School_meals_in_finland.pdf (Accessed 5.7.2019).

FAO, 2011. Global food losses and food waste. Rome. http://www.fao.org/3/a-i2697e.pdf (Accessed 5.7.2019).

FAO, 2013. Food wastage footprint: impacts on natural resources. Rome. http://www.fao.org/3/i3347e/i3347e.pdf (Accessed 5.7.2019).

Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnstone, M., Mueller, N.D., O'Connell, C., Ray, D.K., West, P.C., Balzer, C., Bennett, E.M., Carpenter, S.R., Hill, J., Monfreda, C., Polasky, S., Rockström, J., Sheehan, J., Seibert, S., Tilman, D., Zaks, D.P.M., 2011. Solutions for a cultivated planet. Nature 478, 337e342.

Horeca register, 2015. Taloustutkimus. https://www.taloustutkimus.fi/tuotteet-ja-palvelut/horeca-rekisteri.html. (Accessed 5.7.2019).

Katajajuuri, J.-M., Silvennoinen, K., Hartikainen, H., Heikkilä, L., Reinikainen, A., 2014. Food waste in the Finnish food chain. J. Cleaner Prod. 73, 322–329.

Knorr, D., Khoo, C.S.H., Augustin, M.A., 2018. Food for an urban planet: challenges and research opportunities. Front Nutr. 4, 73. https://doi.org/10.3389/fnut.2017.00073 (accessed 5.7.2019).

Liz Martins, M., Cunha, L.M., Rodrigues, S.S.P., Rocha, A., 2014. Determination of plate waste in primary school lunches by weighing and visual estimation methods: A validation study. Waste Manage. 34, 8, 1362–1368.

MAF 2017. Ministry of Agriculture and Forestry. Government report on food policy Food203 Finland feeds us and the world. https://mmm.fi/documents/1410837/1923148/lopullinen03032017ruoka2030_en.pdf/d7e44e69-7993-4d47-a5ba-58c393bbac28/lopullinen03032017ruoka2030_en.pdf.pdf (Accessed 5.7.2019).

Manninen M, Wiss K, Saaristo V., Ståhl T., 2013. Kouluruokailu osana terveyden ja hyvinvoinnin edistämistä peruskouluissa 2013. Tutkimuksesta tiiviisti 6, huhtikuu. 2015. Terveyden ja hyvinvoinnin laitos, Helsinki.

Mara 2018. The Finnish Hospitality Association MaRa. Suhdannekatsaus 2/2018. https://www.mara.fi/media/pdf/alan_n_kym_t_2_2018.pdf (Accessed 5.7.2019).

ME 2018. From recycling to a circular economy The National Waste Plan 2030. Ministry of the Environment. http://julkaisut.valtioneuvosto.fi/handle/10024/160889 (Accessed 5.7.2019).

Møller, H., Stensgård, A., 2016. Kartlegging av matavfall I Horeca-netverk – Sodexo, Nordic Choice. https://www.ostfoldforskning.no/media/1702/or1816-kartlegging-av-matsvinn-horeca-nettverk.pdf (Accessed 5.7.2019).

OSF, 2018. Official Statistics of Finland 2018. Structural business and financial statement statistics, e-publication. ISSN=2342-6233. 2017. Helsinki: Statistics Finland (Accessed 5.4.2019).

Satterthwaite, D., McGranahan, G., Tacoli, C., 2010. Urbanization and its implications for food and farming. Philos. Trans. R. Soc. Lond. B Biol. Sci. 365 (1554), 2809–2820.

Silvennoinen, K., Heikkilä, L., Katajajuuri, J.M., Reinikainen, A., 2015. Food waste volume and origin: Case studies in the Finnish food service sector. Waste Manage. 46, 140–145.

Soares Pinto, R., Machado dos Santos Pinto, R., Fochat Silva Melo, F., Santos Campos, S., Marques-dos-Santos Cordovil, C., 2018. A simple awareness campaign to promote food waste reduction in a University canteen. Waste Manage. 76, 28–38.

Stenmarck, Å., Jensen, C., Quested, T., Moates, G., 2016. Estimates of European food waste levels. https://www.eu-fusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf (Accessed 5.7.2019).

Vikstedt, T., Raulio, S., Prättälä, R., 2011. Joukkoruokailutyöryhmä. Julkisten ruokapalveluiden ravitsemuslaatu. Hankintailmoitusrekisteri tarkastelussa (Nutritional quality of institutional catering services. A study using the public procurement register). National Institute for Health and Welfare (THL), Report 18/2011. 57 p. Helsinki 2011.

Vikstedt, T., Raulio, S., Helakorpi, S., Jallinoja, P., Prättälä, R., 2012a. Joukkoruokailutyöryhmä 2012. Työaikainen ruokailu Suomessa 2008−2010. Ruokapalveluiden seurantaraportti 4.

Vikstedt, T., Raulio, S., Puusniekka, R., Prättälä, R., 2012b. Joukkoruokailutyöryhmä 2012. Suomalaisnuorten kouluaikainen ateriointi. Ruokapalveluiden seurantaraportti 5.

Wilkie, A., Graunke, R., Cornejo, C., 2015. Food waste auditing at three Florida schools. Sustainability 7, 1370–1387.

Willet, W. et al., 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet 393, 447–492 (Accessed 5.7.2019) https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31788-4/fulltext.

WRAP, 2011. The Composition of Waste Disposed of by the UK Hospitality Industry. Final report. http://www.wrap.org.uk/sites/files/wrap/The_Composition_of_Waste_Disposed_of_by_the_UK_Hospitality_Industry_FINAL_JULY_2011_GP_EDIT.54efe0c9.11675.pdf (Accessed 5.7.2019).

Xue, L., Liu, G., Parfitt, J., Liu, X., Van Herpen, E., Stenmarck, Å., O'Connor, C., Östergren, K., Cheng, S., 2017. Missing food, missing data? A critical review of global food losses and food waste data. Environ. Sci. Technol. 51 (12), 6618–6633.

Yle news 21.1.2013 https://yle.fi/uutiset/osasto/news/raising_awareness_on_food_waste/6459638 (Accessed 5.7.2019).