Follow up on food waste quantification in Swedish public catering

Uppföljning av matavfall i offentliga storkök i Sverige

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Degree project/Independent project • 30 credits
Swedish University of Agricultural Sciences, SLU
Department of Molecular Sciences
Sustainable Food Systems
Molecular Sciences, 2021:47
Uppsala, 2022

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Credits: 30 credits
Level: Second cycle, A2E
Course title: Master thesis in Food science
Course code: EX0875
Programme/education: Sustainable Food Systems
Course coordinating dept: Molecular Sciences
Place of publication: Uppsala
Year of publication: 2022
Title of Series: Molecular Sciences
Part number: 2021:47

Keywords: Sustainable development, Public catering, Food waste measurement, Plate waste, Food waste in schools

Swedish University of Agricultural Sciences
Department of Molecular Science

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Abstract

One-third of all food production is wasted according to international estimations. United Nations have set an aim to reduce food waste by halving the amount by 2030 as food waste is responsible for creating much of the negative impacts on the environment. Food waste reduction is seen as one of the critical elements to achieving a sustainable food system under the EU food strategy.

This study compiles food waste data from a large number of food serving places in Sweden. The information was collected from 822 kitchen units that recorded 609 tons of food waste from serving 7,683,650 meal portions served in Swedish public catering including Elderly care, Hospitals, Preschools, Primary schools, Secondary schools, and places that was a mixture of these categories. The data was recorded by the municipalities themselves and was then collected and compiled for the present study. The average waste per portion (in gram) throughout 2013 to 2020 were 122 g, 110 g, 65 g, 64 g, 96 g, and 51 g respectively in all sectors of catering units aggregated. In all sectors, the trend of food waste generation was declining to indicate that measures to reduce food waste are successful and contribute to a sustainable food system.

Keywords: Sustainable development, Public catering, Food waste measurement, Plate waste, Food waste in schools

Table of contents

1. Introduction

According to the UN Environment Programme (UNEP, 2021), in 2019, 931 million tons of food waste were generated worldwide, mainly from households, food services, and retails, and the contribution is 61%, 26%, 13%, respectively. Reducing food waste gives assorted achievements for humankind and the planet, including food security improvement, addressing climate change, saving money, and reducing pressures on land and management systems (UNEP, 2021).

During the last few years, environmental issues related to food waste have increased in the Swedish public foodservice sector. The reason for this is partly related to the daily serving of approximately three million portions in the sector and to a large amount of waste that occurs (Eriksson et al., 2018). Elander (2016) reported that the Swedish public foodservice sector generates 70,000 tons of food waste every year, including schools, preschools, elderly care homes, hospitals, and prisons. The Swedish public foodservice sector is partially being operated and managed by 290 municipalities. The Swedish municipalities are generally responsible for schools, preschools, and care homes, but hospitals and prisons are not within the authority of the municipalities. So, taking a close look at the municipalities' data on food waste is noteworthy for getting an integrated image of the food waste situation in the Swedish public foodservice sector. Based on a quantitative case study in 30 kitchen units in one municipality carried out during three months, Eriksson et al. (2017) concluded that 23 % of the mass of food served, or 75 grams per food portion, is thrown away; Of these, 64% was serving waste, while 33% was plate waste; There was a high amount of waste in elderly care homes, followed by schools with 79 g/portion and preschools with 51 g/portion. According to a recent study in Swedish hospitals, there was a noticeable amount of food waste throughout their functions. The plate waste was 42 %, serving waste 36 %, and kitchen waste 22 % (Eriksson et al., 2020).

The United Nations defined the Sustainable Development Goals (SDG) in 2015 with a comprised target on food waste reduction (12.3) which states "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (UN 2015).

To meet SDG 12.3, it is necessary to find specific policies and strategies for food waste reduction and to follow the direction both on canteen, national and global level.

1.1 Aim of the study

The aim of the study is to follow up on food waste generation in Swedish public catering.

1.2 The rationale of the study

Sustainable food production and consumption of food are among the most critical aspects of maintaining a global sustainable food system. In Sweden, a fairly large amount of food is wasted in the public catering sector. There are different types of adverse impacts of food waste on the environment, economy, and health. As a result of this, it has become essential to investigate various strategies for food waste reduction and the development on a national scale to track the development in relation to global food waste reduction goals, to see if further actions are needed and where the focus should be held.

2. Background

2.1 Definition, nature, and the impact of food waste

The issue of food waste has gotten immense attention lately and strategies for including it in sustainability policies are being recommended (Ikizoğlu and Koçak, 2020). According to United Nations Environment Programme (UNEP), the notion of food waste generally refers to the food completing the food supply chain up to the final product, of good quality and fit for consumption but still does not necessarily get consumed (Ravandi and Jovanovic, 2019).

The nuisance of food has gotten increasing attention in the last couple of years, and a clear connection has been found between the food waste issue and the measure of sustainability dimensions including environmental, economic, and social aspects (Elnakib et al., 2021). The food waste phenomenon has also been associated with the waste of natural resources and financial resources (Definition of food loss and waste, 2021). The food waste issue is also involved with social aspects as the food waste phenomenon has particular implications for maintaining food security for the society (García-Herrero et al., 2019). Different sustainable challenges are associated with food waste within the food catering and services industries (Martindale and Schiebel, 2017).

Food waste has different categories and dimensions, including direct food waste and indirect food waste (Molina-Besch, 2020). Each category of food waste has specific implications and complications on the environment and economy (Janssen et al., 2017).

2.2 The impact of food waste on the environment

Food waste has a significant impact on the environment, contributing to the emission of various greenhouse gases into the atmosphere. When foods are thrown out to the environment, they often go to the landfills leading to different types of environmental pollution (Jain, 2016). Furthermore, food waste represents a massive amount of freshwater waste and groundwater resources. Reducing the different types of food waste also connects with the deterioration of the overall environment

(Jalali and Saremi, 2020). Increased food production equals increased inputs of fossil fuel leading to additional emissions. Moreover, a considerable amount of land is required to produce the extra food. Whereas, if there is wasted these resources were used meaninglessly (Tao et al., 2021). If individuals stop throwing food away, the environment will save the equivalent of 17 million tons of carbon dioxide from being released into the atmosphere. (Toma et al., 2017). The impacts of food waste need to be correctly recognized to find a sustainable and effective solution regarding the issue (Alba et al., 2019).

2.3 Establishing a common framework for food waste quantification and reasons for food waste in the food supply chain

Food waste quantification methodologies are essential to finding sustainable solutions to reducing food waste, including the healthcare and catering service industries. Previous studies have found that far from all the kitchens within the sector have quantification in place and that a majority of the study objects had perceived the quantification measurement inclusion as optional. The regions with the central quantification measurement often have the following waste categories serving wastage, plate wastages, preparation wastages, safety margin wastages, and rejection waste while delivering (Corrado et al., 2019). Some of the organizations in the catering industry have been found to have included the special diets in the wastage records as well. As far as hospitality organizations are concerned, many companies have recorded the number of customers served to supplement the recorded data on food waste (De Lange and Nahman, 2015). The most important figure used to communicate the quantification of the food waste was the absolute mass followed by associating the mass of the waste to the number of the guests or associating it to the total amount of mass of the food served or the total mass of the food prepared. Most of the organizations in the food services and catering industries have been found to quantify food waste to identify the causes and to monitor the progress by the entire organization or even to inform the guests about the advancement in the waste production practices (Garrone et al., 2014).

In most of the organizations in the food supply chain, the quantitative food waste measurement mechanism is used to measure and quantify the amount of food wastage. The quantity of food wastage is generally caused by the deployment of improper harvesting methods, packaging, storing, transporting, and inappropriate traditional customs practised in the services and catering industries. There might be food wastage when harvesting and threshing the products (Jereme et al., 2018). Cereals and legumes are considered non-perishable items; the mature grains should

only be harvested to prevent the deterioration of the immature grains rich in active enzymes and terms of high moisture content (Swedish National Food Agency, 2021). Higher quantities of fruits and vegetables can also get damaged because of improper harvesting practices. So, it becomes crucial to consider the food wastage incidents at the time of harvesting and threshing of the food grains and other items. Food wastage can also occur at the time of packaging and storage of the food items (Kamaruddin et al., 2020).

Because of the rough handling of the fruits and vegetables at the time of harvesting and sorting, the physical damage of the items can lead to quantitative food loss. Besides, food wastage can also continue in the post-harvest stage, which happens at the time of packaging. Food waste can also take place at the time of following the traditional customs and procedures. Inappropriate traditional customs can substantially cause food waste stages in the services and catering industries (Nonomura, 2020). People often buy grains and vegetables in bulk but have little idea about the storing necessities of those items. Self-reported questionnaires are also used to quantify and measure the food waste incidents in the food and catering industries. The use of food waste diaries can also be observed (Watanabe, 2020). Food wastage can occur due to faulty procedures of premarketing, preservation, and the overall cooking mechanisms. So, it is clear that the different types of quantification strategies of food waste have different implications and potential impacts on the effective and efficient reduction of food waste in the catering and services industry.

2.4 The relationship between food waste quantification and food waste reduction in the catering and services industry

Proper food waste quantification has an integrated relationship with waste reduction in the catering and services industry. Specific methods and strategies are being applied to quantify food waste in the professional catering units in various countries. Different smart scales and dedicated software have been designed to simplify food waste quantification. The ultimate rationale of such innovation is to reduce food waste in catering services (Malefors et al., 2021). The ultimate purpose of innovating specific scales to simplify the food waste reduction is to effectively manage meal production more effectively based on the previous outcomes (Papargyropoulou et al., 2019). The food services and catering industries have also been found to effectively apply different quantification measurements by innovating specific scales and software to quantify food waste. The quantification of food waste can also be performed in various ways. But it is essential to mention that quantifying food waste does not necessarily guarantee food waste reduction

(Ranji, 2020). Different factors have been identified for food waste quantification so that effective methods of reducing food waste can be inaugurated and implemented. It has been found that the initial mass of waste per guest served in the catering industry is one of the most significant factors in the case of waste reduction (Spring and Biddulph, 2020). The completeness of quantification has also been found to be significant in terms of reducing food waste. Many catering services have applied the automated quantification method to reduce the amount of food wastages (Eriksson et al., 2019). The automatic quantification tool is the primary technique used in the automated food waste quantification methodology. These automated quantification tools have been found to have a higher level of initial waste and have more potential for reducing food waste. As a matter of fact, dealing with food waste reduction is not the ultimate focus. Rather, the ultimate focus must be on behavior resulting in excessive food production. But a handful of countries have successfully been able to apply the energy recovery options in the waste reduction hierarchy. As far as the food waste valorization is concerned, it has been reported that the ultimate potential in reducing the greenhouse gas emissions can substantially increase if the energy recovery options are removed to the re-use options where the surplus food is used for human consumption. Waste prevention through reducing the source waste can significantly reduce the environmental impact of food waste of various kinds (Eriksson et al., 2012).

2.5 The importance of quantification methods

Different quantification methods have different implications on food reduction initiatives in various industries. It has been found that redesigning the portion sizes can significantly increase the potential of reducing the amount of food waste in the catering industry (Eriksson et al., 2020). A portion is the specific amount of food the customer selects to eat at once in a restaurant or at home. If the portion sizes are redesigned in alignment with the specific requirements of the number of customers, there is a possibility that such a quantification method can help reduce the amount of food waste in the catering industry (Steen et al., 2018). As far as the services and the catering organisations are concerned, many companies have started recording the number of customers served to supplement the listed data on food waste (Eriksson et al., 2020). The most significant figure used to deal with the quantification amount of the food waste was considered the absolute mass followed by associating the mass of the waste to the amount of the guests or linking it to the total amount of mass of the food served or the total mass of the food made.

Most of the organisations in the food services and catering industries have been found to measure the food waste in order to effectively recognize the causes behind waste and to monitor the advancements by the entire organisation or even to inform the guests about the perceived improvement in the waste production practises. The

application of nudging procedures with small plates and information signs has also been influential in the effective contribution method. Different catering companies have also modified the service styles and the design of the menu to reduce the amount of food waste generated by the restaurant guests (Elimelech et al., 2018). Many companies are reported to have applied the employee participatory approach to reduce overproduction by maintaining better alignment with the quantity of the meals produced. So, the quantification method can have an integrated relationship with the sustainable method of reducing food waste in the catering industry. Without correctly identifying the exact problem in the case of the food waste chronicle, it becomes quite challenging to solve the problem (Brancoli et al., 2019). Besides, accurate food quantification is an essential part of evaluating the impact of any waste-reducing steps taken in the procedure of continuous improvement and advertisement.

2.6 Food catering and services in a global and Swedish perspective

The global catering services market has been estimated to reach more than 600 billion dollars by the end of 2027. Besides, it has also been estimated that the global market for catering services amid the covid-19 pandemic was almost 500 billion dollars in the year 2020 (Markets, 2021). The products used in the global catering services industry generally include cooking, refrigeration and handling activities, warehousing, and sanitation activities. The estimated CAGR (compound annual growth rate) has been estimated at around 3% over the period, which is also a sign of the great potential of the industry (Michalec et al., 2018).

The global catering services market is being boosted as different corporate offices use catering as a talent attraction and retention strategy (Conrad et al., 2018). Besides, the growing and dynamic technology adoption improves the overall customer experience and reduces the delivery time while waiting for the food is augmenting the entire market growth to a great extent. Sweden's restaurants, services, and catering have reported a market worth more than 150 billion Swedish kronor in 2020 In Sweden, more than 105 thousand persons are employed in the food services and catering industries (Topic: Restaurant industry in Sweden, 2021).

2.7 Some previous quantification studies

Experts and organisations have conducted many quantification studies. In table 1, here are some examples of previous food waste quantification studies.

Table 1:Previous quantification studies

Sector	Period	Country	Waste/portion (g)	Source
Hospitals	2013-2019	Sweden	111	Eriksson et al., (2020)
University	2-3 days	China	73.7	Wu et al., (2019)
Schools	12 days	Italy	151	Lagorio et al., (2018)
Hotel	63 days	Slovenia	15.2	Juvan et al., (2017)
Preschools	2 weeks	Sweden	145	Hansson (2016)

3. Material and methods

3.1 Data collection

In this study, the quantitative method was used. The primary data were collected from different public caterings by the municipalities themselves and used in this quantification study.

3.2 Details of data

Food waste data were collected from elderly cares, hospitals, preschools, primary schools, upper secondary schools, as well as mixed sectors (combined and other types of sectors)

In this study, the process definitions identified by Eriksson (2018) (Figure 1) and definitions for the different waste processes defined by the Swedish National Food Agency (Livsmedelsverket, 2019) (Table: 2) were used.

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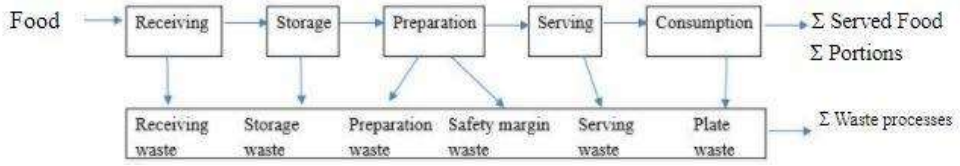

Figure 1. Different waste generation processes inside a kitchen. During the various stages of the kitchen operation, food is prepared and wasted.

Table 2: Definitions used in the food waste quantification process (Livsmedelsverket, 2019; Malefors et al., 2019)

Term	Definition
Waste process	
Receiving waste	Waste that occurs from goods delivered to the kitchen, but never stored or used. Also known as reclamation waste in other sectors, such as retail.
Storage waste	Stored goods that become waste for whatever reason.
Preparation waste	Waste from the preparation and/or trimming of food, such as peel, bones, and fat.
Safety margin waste	Waste from food produced which did not leave the kitchen for consumption and was not saved for another meal.
Serving waste	Food served that did not reach the plates of guests.
Plate waste	All waste from the plates of guests. May contain napkins and/or bones.
Waste	Sum of mass from the different food-waste processes. Used for calculation of key performance indicators (KPIs) for food-waste quantification baselines.
Served food	The amount of food that left the kitchen intended for consumption.
Portions	The recorded number of portions served for a given meal. One portion is defined as the amount one person eats per meal.
Meal	Breakfast, lunch, dinner, or snack, depending on when the food is served
Kitchen type	
Production unit	A kitchen that prepares all meals from raw materials.
Satellite kitchen	Kitchen that can prepare some meals, but relies on deliveries from a production unit, especially for food that needs to be cooked
KPI	Key performance indicator
Waste/portion (g)	Waste (kg) divided by the number of portions × 1000.
Waste (%)	Waste (kg) divided by served food (kg) × 100.

Table 3: Summary of quantified data representing the public catering sector

Sector	Quantification days (n)	Units (n)	Waste (tons)	Food served (tons)	Portions
Elderly care	678	20	6	17	58819
Hospital	2234	22	197	0	966116
Mixed	264	13	3	24	74722
Preschool	7240	352	34	70	467156
Primary school	15993	368	280	788	4912453
Upper secondary school	1954	47	89	190	1204384
Total	**28,363**	**822**	**609**	**1,089**	**7,683,650**

In the study, six different sectors of Swedish public catering were considered: elderly care, hospital, mixed (different type of activities), preschool, primary

school, and upper secondary school. Total quantification days were 28,363 days, the lowest was 264 days in mixed activities, and the highest days were 15,993 days in primary school. Total units were 822. The total waste amount was 609 tons, the lowest waste amount was from elderly care, 6 tons, and the highest was in primary school with 280 tons. A total of 1,089-ton food was served in the entire study and approximately 7.6 million portions according to table 3.

3.3 Description and calculation of waste per portion

The key performance indicators' waste per portion' were determined on a sector level and on an individual kitchen basis. Since kitchens and their food waste quantification process are not perfect all the time and since kitchens focus their quantification efforts on different processes, a criterion system was developed to filter the data. The reason for having this filter was to eliminate missing values and to compare data from different kitchens. The most obvious reason for doing this is evident from Table 2, which shows that catering rarely quantified the amount of food served. Therefore, calculation on the raw data material would render unfair and unrealistic results and not be comparable.

The filter only proceeded with a calculation of the key performance indicator waste per portion if the kitchen had quantified portions and the waste processes' plate waste', 'serving waste' for the indicator' waste per portion (g)' and with the additional parameter 'amount of food served' When any of these ingoing parameters for calculation of the indicator was missing, the quantification for a given day was excluded.

Waste per portion is calculated as described by Equation 1:

$$Waste\ per\ portion\ (WPP) = \frac{\sum Waste\ process}{\sum Number\ of\ portions} \qquad 1$$

The data from the organisations were used to calculate the "Waste per portion" for each segment, according to Equation (1).

3.4 Data analysis

The study had been performed based on the primary data analysis, and the data collection had been done by taking the responses from the municipalities. The data spans from 2013 to 2020 and the present time compared to observe the performance of the Swedish public catering service in applying the waste reduction policies of the government.

Microsoft Excel has been used to collect, analyse and compare data. Descriptive statistics on 'waste per portion' were compiled on a kitchen level. The waste was

divided between the waste processes and displayed as stacked bar plots, which highlighted how the waste processes were dispersed in each segment to determine which waste process was most dominant in each segment. This was accomplished by aggregating data at the quantification day level. Calculations were also done in order to understand the trend over time, with the 'waste per portion' indication accompanied by a 95% confidence interval and aggregated yearly for the Swedish public catering organisations who provided data.

4. Results

For research, organisations from different industries have been selected to measure the amount of food waste. Six categories of institutions have been considered for collecting data and analysing them. The categories considered in the study include elderly care, hospitals, mixed institutions, preschool institutions, primary school institutions, and upper secondary schools.

As far as the elderly care institutions are concerned, the Waste per Portion (WPP) median for 2013 was 77 g, where the lower value was 55 g, and the upper value was 155 g. The number of observations was 10. The Waste per Portion (WPP) median for 2014 was 107 g, where the lower value was 42 g, and the upper value was 161 g. The number of observations was 9. The WPP median for 2015 was 85 g, where the lower value was 67 g, and the upper value was 96 g. The number of observations was 67. The WPP median for 2016 was 107 g, where the lower value was 92 g, and the upper value was 95 g. The number of observations was 92. The WPP median for 2017 was 101g, where the lower value was 98 g, and the upper value was 109 g. The number of observations was 98. The WPP median for 2018 was 98 g, where the lower value was 88 g, and the upper value was 109 g. The number of observations was 11. The WPP median for 2020 was 125 g, where the lower value was 106 g, and the upper value was 141 g. The number of observations was 28. The hotspots in terms of WPP were in 2018, where the WPP median was the most among all the observations recorded. The lowest median among the observed years was 2013.

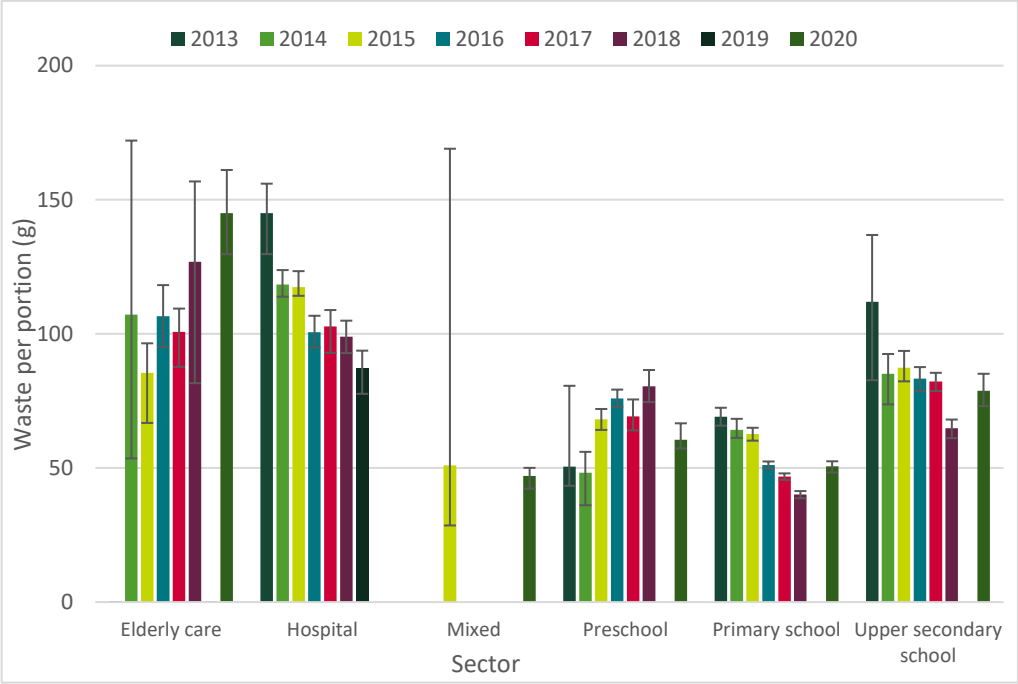

Figure 2: Median WPP for the elderly care, Hospital, Mixed, Preschool, Primary school and Upper Secondary School categories.

From figure 2, it is pretty clear that the values of 2014, 2015, 2016, 2017, and 2018 have no significant differences in terms of the WPP median recorded. But there is a significant difference between the values of 2020 and 2015, 2016, 2017. From figure 2, it is also evident that the highest WPP median value recorded for the elderly care category was in 2020.

There are specific data collection gaps for the elderly care data. The WPP median values of 2013 and 2019 could not be obtained because of specific issues. On the contrary, the lowest WPP media value recorded for the elderly care category was 2015.

As far as the hospitals are concerned, the Waste per Portion (WPP) medians for 2013-2019 were 145 g, 118 g, 117 g, 101 g, 103 g, 99 g, and 87 g, respectively. In 2013, the lower value was 130 g, and the upper value was 156 g. In 2014, the lower value was 113 g, and the upper value was 123 g. In 2015, the lower value was 114 g, and the upper value was 123 g. In 2016, the lower value was 95 g, and the upper value was 107 g. In 2017, the lower value was 93 g, and the upper value was 109 g. In 2018, the lower value was 93 g, and the upper value was 105 g. In 2019, the lower value was 78 g, and the upper value was 94 g. The number of observations for 2013-2019 was 48, 224, 180, 194, 129, 115, and 35. The hotspots in terms of WPP were in 2013, where the WPP median was the most among all the observations recorded. The highest observations recorded were in 2014, and the lowest amount of incidents observed was in 2019. The highest median among the observed years was 2018 and the lowest was 2019.

From figure 2, it is pretty clear that there are no significant differences in terms of the WPP value in 2016, 2017, and 2018. Considerable differences have been found between the values of 2013 and 2019. The highest WPP median value recorded for the elderly care category was in 2013 and the lowest in 2019.

Considering the elderly care sector and hospital sector, no significant differences have been found between the values 2020 and 2013. But significant differences have been found between the values of 2015 in these two sectors. In 2018, no significant differences were found in the data observed.

The Waste per Portion (WPP) is concerned with the mixed institutions. In 2015 it was 51 g, the highest and lowest value was 169 g and 29 g, respectively.

As far as the preschool institutions are concerned, the Waste per Portion (WPP) medians for 2013-2018 and 2020 were 50 g, 48 g, 68 g, 76 g, 69 g, 80 g, and 61 g, respectively. The data for 2019 was not available. In 2013, the lower value was 43 g, and the upper value was 81 g. In 2014, the lower value was 40 g, and the upper value was 60 g. In 2015, the lower value was 64 g, and the upper value was 72 g. In 2016, the lower value was 73 g, and the upper value was 79 g. In 2017, the lower value was 64 g, and the upper value was 76 g. In 2018, the lower value was 75 g, and the upper value was 87 g. In 2020, the lower value was 57 g, and the upper value was 67 g. The number of observations for 2013-2018 was 43, 78, 1070, 1623, 988, and 474. The number of observations for 2020 was 635. The hotspots in terms of WPP were found in 2018, where the WPP median was the most among all the observations recorded. The highest observations recorded were in 2016, and the lowest amount of incidents observed was in 2014. The highest median among the observed years was 2018, and the lowest was in 2014.

From figure 2, it is pretty clear that there is no significant difference between 2013, 2014 as well as among 2015, 2016, 2017, 2018. But there are significant differences between the values of 2013, 2014 and 2015, 2016, 2017, 2018. It has been found that there are no significant differences between the values of 2015 and the data of mixed institutions and preschool institutions in 2015.

As far as the primary school institutions are concerned, the Waste per Portion (WPP) medians for 2013-2018 and 2020 were 64 g, 69 g, 64 g, 63 g, 51 g, 47 g, and 40 g, respectively. The data for 2019 was not available. In 2013, the lower value was 55 g, and the upper value was 76 g. In 2013, the lower value was 66 g, and the upper value was 72 g. In 2014, the lower value was 60 g, and the upper value was 67 g. In 2015, the lower value was 60 g, and the upper value was 65 g. In 2016, the lower value was 50 g, and the upper value was 52 g. In 2017, the lower value was 46 g, and the upper value was 48 g. In 2018, the lower value was 39 g, and the upper value was 41 g. In 2020, the lower value was 48 g, and the upper value was 53 g. The number of observations for 2013-2018 were 92, 947, 878, 1751, 2938, 2597, 1861, and 1269. The hotspots in terms of WPP were in 2013, the highest median among the observed years was 2013, and the lowest was in 2018.

From Figure 2, it is pretty clear that for the primary schools, there are no significant differences among the values of 2013, 2014, 2015 also no significant differences were found among 2016, 2017 and 2018.

As far as the upper secondary school institutions are concerned, the Waste per Portion (WPP) medians for 2013-2018, and 2020 were 79 g, 112 g, 85 g, 87 g, 83 g, 82 g, 65 g, and 79 g respectively. The data for 2019 was not available. In 2013, the lower value was 83 g, and the upper value was 137 g. In 2014, the lower value was 78 g, and the upper value was 96 g. In 2015, the lower value was 82 g, and the upper value was 94 g. In 2016, the lower value was 79 g, and the upper value was 88 g. In 2017, the lower value was 79 g, and the upper was 85 g. In 2018, the lower value was 61 g, and the upper value was 68 g. In 2020, the lower value was 73 g, and the upper value was 85 g. The number of observations for 2013-2018 was 4, 60, 63, 245, 377, 332, 272, and 162. The hotspots in terms of WPP were in 2013, where the WPP median was the most among all the observations recorded. The highest observations recorded were in 2016, and the lowest amount of incidents observed was in 2013. The highest median among the observed years was 2013, and the lowest was in 2016.

From figure 2, it is pretty clear that there are no significant differences between 2013, 2014, 2015, 2016, 2017 and 2020 only 2018 is exceptional for a lower value.

From the overall description, a summary of quantification is illustrated in Figure 3.

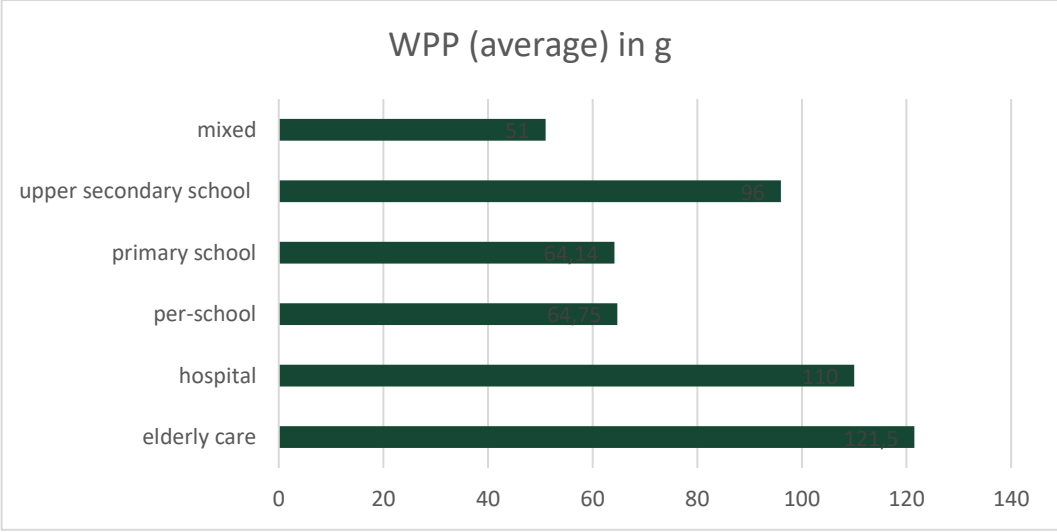

Figure 3: The average of different means of waste per portion between 2013 and 2020.

The average of varying means Wastes Per Portion (in gram) throughout 2013 to 2020 are 121.5 g, 110 g, 65 g, 64 g, 96 g, 51 g respectively in elderly care, hospital, preschool, primary school, upper secondary school, and mixed settings.

5. Discussion

There were certain limitations in this study. Some of the yearly data were missing as the factual data could not be found from the data source. Significantly, the data of 2019 was not adequate without hospitals' food waste data.

For the hospitals, primary schools, and upper secondary schools, there was a clear trend to reduce food waste in terms of WPP from 2013 to 2018, but in the year 2020, it increased. This could be related to the covid-19 outbreak, the number of school-going children's presence was uncertain. On the other hand, it remains a reduction trend; it might be for the higher number of hospital patients for covid-19.

Pre-school data shows that between the periods 2013 to 2018, there was a trend of increasing waste per portion, but in 2020, there is an apparent deviation from the previous year. Further research is needed to identify these deviations.

Elderly care (average WPP 122 g) and Hospitals (average WPP 110 g) are the host sport for food waste generation.

Malefors illustrated a baseline for food-waste quantification in the hospitality sector (Malefors et al., 2019). The elderly care sector was 129 g/portion; this study (122 g/portion) is entirely satisfactory with Malefors's study. In this study, it ranges from 77 g to 127 g. In the hospitals, Malefors et al. (2019) found it was 112 g/portion; it is also met with this study (110.0 g). For primary school, this study ranges from 40 g to 69 g/portion. The average value is 64 g/portion; on the other hand, Malefors et al. (2019) determined 59 g/portion that validates this study.

Eriksson et al. (2020) showed that, in Swedish hospitals, the waste per person was 111 g; in similarity to this study (110 g/portion).

Hansson (2016) conducted a food waste quantification study in Swedish preschools; the study was two weeks long and four different units. The WPP had been detected at 145 g; this value is much higher than this study (65 g); It might be due to the different quantification methods.

There are several policy recommendations for waste to be reduced to a substantial extent. Proper menu planning is necessary for hospitals to make it practical to reduce the amount of food waste inwards and other sectors. The application of technology can also be beneficial for the organisation wishing to reduce the amount of food waste. Technologies can be used to find out the optimum amount of food necessary for the patients in hospitals. The inclusion of made-to-order stations can also be effective for hospitals to reduce the amount of food waste

to a great extent. As far as the primary and preschool institutions are concerned, optimal food serving can significantly reduce the amount of food waste. This study concentrates on a larger number of materials for the investigation, and such characteristics have increased the quality of the research results to a great extent. From that perspective, it can be said that the report will provide the opportunity for generalisation in exploring the quantification mechanism of food waste in various sectors.

6. Conclusions

The ultimate purpose of the research was to follow up on food waste among various categories in public catering. Quantification of food waste in different categories like hospitals, preschool institutions, primary school institutions, upper secondary schools etc., were selected so that the conclusive food waste scenario in these categories could be understood. It is unclear how the food reduction policy is going in Sweden; The WPP median values in the observed data were found quite different in different categories and years. The average waste per portion (in gram) throughout 2013 to 2020 were 122 g, 110 g, 65 g, 64 g, 96 g, and 51 g respectively in all sectors of catering units aggregated. In all sectors, the trend of food waste generation was declining

Follow up on the same food service places over a certain period using a standard quantification method is necessary to complete a more meaningful follow-up. It is also a need to understand what is going on in canteens and kitchens that at the moment have made no quantification efforts at all.

Different methods of quantification may produce different results. It is a critical challenge in food waste quantification methodologies in many countries. To quantify food waste globally, a uniform approach is required to indicate that measures to reduce food waste are successful and contribute to a sustainable food system.

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Acknowledgements

Special thanks to the Department of Energy and Technology, SLU, Uppsala. I'm very grateful to my supervisor Christopher Malefors, and I got great motivation from Mattias Eriksson.

Popular science summary

One-third of all food production is wasted according to international estimations. United Nations have set an aim to reduce food waste by halving the amount by 2030 as food waste is responsible for creating much of the negative impacts on the environment. Food waste reduction is seen as one of the critical elements to achieving a sustainable food system under the EU food strategy.

This study compiles food waste data from a large number of food serving places in Sweden. The information was collected from 822 kitchen units that recorded 609 tons of food waste from serving 7,683,650 meal portions served in Swedish public catering including Elderly care, Hospitals, Preschools, Primary schools, Secondary schools, and places that was a mixture of these categories. The data was recorded by the municipalities themselves and was then collected and compiled for the present study. The average waste per portion (in gram) throughout 2013 to 2020 were 122 g, 110 g, 65 g, 64 g, 96 g, and 51 g respectively in all sectors of catering units aggregated. In all sectors, the trend of food waste generation was declining to indicate that measures to reduce food waste are successful and contribute to a sustainable food system.