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Mapping of food waste quantification methodologies in the food services of Swedish municipalities

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ABSTRACT

Since food waste valorisation measures, like energy recovery, have limited possibilities to fully recover the resources invested in food production, there is a need to prevent food waste. Prevention is most important at the end of the value chain, where most sub-processes have already taken place, like in catering facilities. In Sweden, the public catering sector serves a large number of meals through municipal organisations, including schools, preschools and elderly care homes. Many of these organisations quantify food waste, but since Sweden has 290 municipalities with a high degree of independence, the possible variation is significant. This study therefore investigated how food waste is quantified, in order to help formulate a national standard for food waste quantification.

Mapping of food waste quantification practices was conducted using a questionnaire and follow-up telephone calls, achieving a response rate of 93%. Of the 290 Swedish municipalities, 55% replied that they quantify food waste on central level. The most common practice at present is to quantify plate- and serving waste from school lunches during two weeks per year, and to compile waste data in spreadsheets and compare the values against the number of plates used, giving a result in grams per portion served. There are many similarities between municipalities, so there is great potential to implement a common standard that many municipalities already fulfil. This is important in order to gain acceptance and fast implementation, thereby speeding up the process of establishing a benchmark for food waste in the Swedish public sector catering sector.

1. Introduction

Waste, loss or spoilage of food is an efficiency issue that has attracted increasing attention from the media, researchers, politicians, companies and the general public in recent years. Although food waste seems to be a simple problem, with the solution “to just stop throwing it away”, it is much more complex than would appear at first glance. The complexity of the food waste issue also links it to the three pillars of sustainable development (Lipinski, 2015): economic, social and environmental. This does not mean that reduced food waste automatically results in sustainable development e.g. if the waste reducing measures is more recourse demanding then the savings they achieve (Eriksson et al., 2016a), but reducing unnecessary food waste has the potential to make an important contribution and also has high symbolic value. Food waste can be associated with a substantial waste of money (FAO, 2013) and natural resources (Steinfeldt et al., 2006; Garnett, 2011; Scholz et al., 2015), but also has moral implications in relation to food security (Stuart, 2009; FAO, 2012). The political will to work on food waste reduction can be seen as rational and positive, since there are few good arguments for continuing to waste food. This has resulted in several goals on waste reduction among companies (Tesco et al., 2014), states (Rutten et al., 2013) and international organisations (UN, 2016). As pointed out by Godfray et al. (2010) and Garnett (2011), reducing food waste is not the only way to make the food supply chain more environmentally sustainable, but it has the added potential to save money and improve food security. Reducing food waste is also less controversial than e.g. reducing meat consumption or increasing productivity by extending the use of genetically modified organisms.

Food is wasted for a large number of reasons and by different actors in the food supply chain, which makes it difficult to find a ‘quick fix’ to reduce food waste once and for all. Food can also be wasted as a consequence of measures to increase economic profit or preserve public health, which are often a higher priority. In many countries the food waste in itself creates a problem if it is landfilled or left in illegal dumping sites. In other countries, Sweden included, landfilling of organic waste is prohibited (Ministry of the Environment and Energy, 2001) and surplus food is considered a resource that can be used for biogas production or for feeding people in need (Eriksson et al., 2015;

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Eriksson and Spångberg, 2017). It is therefore not the wasted food that should be the main concern, but the wasteful behaviour that results in unnecessary food production.

In the Swedish public food service sector, environmental issues related to food waste have been an increasing concern during recent years. This is partly due to the approximately three million portions served every day in this sector and the substantial amount of food waste generated. According to the Swedish Environmental Protection Agency (SEPA, 2016), 70,000 tons of food waste are generated every year in the Swedish public food service sector, including schools, pre-schools, elderly care homes, hospitals and prisons, which corresponds to 7 kg capita^{-1} y^{-1}. This is much lower than the corresponding estimate for Swedish households (74 kg capita^{-1} y^{-1}), but households serve a much larger volume of food so comparisons in absolute numbers give a limited view of the problem. It is even likely that the public food service sector has a similar level of waste as households in relation to mass of food served. According to a recent study by Eriksson et al. (2017a), relative waste in the 30 kitchens in the Swedish municipality of Sala amounts to 75 g per portion served or 23% of mass of food served. Other studies of relative waste levels in similar types of food services indicate what could be considered the normal level, although these studies have different scopes and refer to different times and geographical locations. For example, two schools in Stockholm investigated by Engström and Carlsson-Kanyama (2004) wasted 18% and 15% of delivered mass, which corresponded to 115 and 46 g per portion served, while two kitchens in the education and business sectors in Switzerland investigated by Betz et al. (2015) wasted 10.7% and 7.7%, corresponding to 91 and 86 g per portion served.

Food waste generated by the Swedish public food service sector is normally sorted and treated as part of the organic waste stream, together with organic waste from restaurants and households. In Sweden, municipalities have a monopoly on household-like waste, which includes waste from professional kitchens, and therefore the possibilities for individual kitchens to use other treatment methods are extremely limited. Swedish municipalities normally use one of three methods for waste disposal: i) anaerobic digestion for biogas production, ii) composting or iii) incineration for production of district heat and electricity. Therefore the waste is properly handled and nutrients and/or energy are recovered. Thus the waste management of Swedish municipalities can be considered appropriate and resource-efficient in a global perspective. However, the energy recovery options used are not those most highly prioritised in the European Union (EU) waste hierarchy (EC, 2008). In terms of food waste valorisation, Eriksson and Spångberg (2017) report that the potential to reduce greenhouse gas emissions increases significantly by going from energy recovery options to re-use options where surplus food is still used for human consumption. Waste prevention through source reduction can reduce the environmental impact even further (Gentil et al., 2011; Bernstad Saraiva Schott and Andersson, 2015; Eriksson et al., 2016a).

In order to reduce food wastage, it is necessary to understand the exact problem to be solved (e.g. Steen et al., 2018). According to Eriksson (2012, 2015), detailed quantification is an essential first step in this process. Moreover, accurate food quantification is needed in order to evaluate the effect of any food-reducing measures taken. Despite this, a recent survey showed that only about 50% of Swedish schools measure food waste for at least one week per semester (School Food Sweden, 2013). Another survey showed that a majority of Swedish municipalities have conducted projects in school canteens with the aim of reducing food waste (Stockholm Consumer Cooperative Society, 2015). However, similar efforts are rare in elderly care homes, even though food waste is higher in elderly care homes than in schools (Eriksson et al., 2017a). Moreover, waste quantification studies are often short and include limited material, so it is difficult to compare different studies and to generalise based on the results obtained for one municipality in one case study (e.g. Eriksson et al., 2017a,b). Several previous studies have sought to quantify the waste from the catering sector, but using short measuring periods in a rather small number of catering units, e.g. two days in three hospitals in the UK (Sonnino and McWilliam, 2011), two days in four kitchens in Sweden (Engström and Carlsson-Kanyama, 2004), five days in two kitchens in Switzerland (Betz et al., 2015), 471 school meals during one month in Portugal (Martins et al., 2014), five days in a kitchen in the USA (Byker et al., 2014), 28 days in one hospital in the UK (Barton et al., 2000), one week in 55 kitchens in Finland (Katajajuuri et al., 2014) and three months in 27 kitchens in one municipality in Sweden (Eriksson et al., 2016b, 2016c, 2017a). A short quantification time may produce results that are inconclusive or difficult to interpret, e.g. it makes the results highly dependent on the dishes served during the quantification period, since different dishes can be expected to produce different levels of waste and different composition of waste. An example of this is chicken drumsticks, which result in a high level of unavoidable plate waste due to the bones, and should not be compared with bone-free chicken fillets, where the bones have been removed from the meat during processing.

In the present study, the main focus was on municipal catering in Sweden, mainly for pre-schools, schools and elderly care homes. There are variations across Sweden, but school meals typically include lunch and sometimes breakfast and snacks (typically with fruit and sandwiches), while a majority of preschools serve breakfast, lunch and snacks. At elderly care homes, all meals are usually provided. Under Swedish law, lunches must be served free in compulsory schooling (Swedish Parliament, 2010). At preschool, parents pay a fee for their children, but there is no extra charge for the meals. In elderly care homes, the residents pay a fee for their meals, which varies across the country. Public meals vary depending on where they are served but, taking school meals as an example, a typical school lunch in Sweden often consists of a choice of one or more cooked dishes comprising a warm component, typically fish, meat or poultry or a vegetarian alternative, served with a carbohydrate-rich component, usually pasta, potatoes or rice. Additional components of the meal are cooked vegetables and/or a salad buffet, milk or water to drink and crispbread with spread (National Food Agency, 2013). The food is usually served as a buffet in a self-service system, which means that schoolchildren typically determine which of the available options end up on their plate.

Since many of the public services are organised on municipal level in Sweden, these organisations have extensive power to act on political will. This should be positive for food waste reduction, since the same public organisation is responsible for purchasing and preparing food, for the buildings and teaching/care/nursing staff in schools/preschools/hospitals/elderly care homes and for waste collection and management. Many of these functions can be outsourced to private companies, but the public body is always responsible for funding them through the taxation system and therefore has a powerful position. However, if the problem of food waste is not apparent or acknowledged, it is difficult for any organisation to act. Therefore many Swedish municipalities have started to quantify food waste during recent years. However, since these quantifications are often communicated through internal or external webpages and/or newspaper articles, it is difficult to get a good picture of how the sector is progressing. Another problem is the lack of a common standard for quantifying and reporting food waste, which makes results from different organisations difficult to compare. The Food Loss and Waste Accounting and Reporting Standard (World Reasource Institute, 2016) can be used to specify a reasonable trade-off between resources used for waste quantification and relevance, completeness, consistency, transparency or accuracy. Eriksson et al. (2018) extended existing quantification methodology by demonstrating how different datasets can be compared and designed in a common framework. However, there have been no suggestions to date on the categories that should actually be recorded if all Swedish municipalities were to quantify waste in the same way. This problem is highlighted by Suhonjic (2017), who found that even though many Swedish schools quantify food waste, they have no benchmark to compare with and therefore do not know whether they need to improve

Table 1
Content validity index (CVI = relevance) and clarity ratings given by the expert panel for the questionnaire used in data collection.

	Term	Definition	Result	Recommendation[a]
Relevance	I-CVI	Item-level content validity index. Proportion of experts rating content validity as 3 or 4 for each individual item.	0.75 (2 items)–1.0 (16 items)	1.0
	S-CVI-Ave	Scale-level content validity index, average I-CVI value.	0.97	0.9
	S-CVI-UA	Scale-level content validity index, proportion of universal agreement.	0.89	0.8
Clarity	I-CI	Item-level clarity index. Proportion of experts rating clarity as 3 or 4 for each individual item.	0.75 (3 items)–1.0 (15 items)	1.0
	S-CI-Ave	Scale-level clarity index, average I-CI value.	0.96	0.9
	S-CI-UA	Scale-level clarity index, proportion of universal agreement.	0.83	0.8

[a] Based on Polit and Beck (2006) and Lövestam et al. (2014).

or are already better than the rest. In order to create an acceptable benchmark, there is a need for a common standard that is simple enough for all municipal catering units to follow and that is based on current quantification practices.

The main objective of this study was to map current practices regarding food waste quantification in all Swedish municipalities, as a first step in creating a detailed standard for food waste quantification and reporting in Swedish public sector food services. Using the knowledge obtained, an additional objective was to devise a preliminary, practically feasible food waste quantification standard for food services. The overall aim was help create a more sustainable food supply chain where public food services can contribute more efficiently by reducing food waste.

2. Materials and methods

2.1. Pilot study

The data collection procedure used for all municipalities in Sweden was developed during a pilot study in the 15 municipalities in the county of Dalarna in Sweden. The managers of the food service organisation in each of those 15 municipalities were approached by telephone and surveyed about their current actions regarding food waste quantification and food waste. The survey took the form of semi-structured interviews seeking answers to a number of fixed questions, but also allowing the respondents to share their own experiences and reflections. Depending on the answers, the pilot municipalities were divided into three distinct groups that: i) Quantify food waste on municipal level (even if only individual kitchens participate), ii) contain individual kitchens that quantify food waste on their own initiative, outside the control of the food service manager, and iii) do not quantify food waste at all (to the knowledge of the food service manager). During the interviews, it was clear that only municipalities belonging to the first group, with a central waste quantification scheme, had any informative answers to the questions.

2.2. Questionnaire

The questionnaire used for all municipalities in Sweden was developed in a multistep process. Based on the data developed in the pilot study, the first step in this process was to design an online questionnaire. In a second step, the questionnaire was validated. The first phase of the validation process involved discussions with representatives of the National Food Agency in Sweden and the union and branch organisation for food service managers (Kost & Näring [Eng. Food & Nutrition, author's translation]). The second phase consisted of testing content validity, i.e. relevance, using recommendations by Polit and Beck (2006). The clarity of the questionnaire was also tested, using an approach developed by Lövestam et al. (2014). A panel of consisting of four experts within the field of food waste in the public sector was given detailed information on how to perform the validation and asked to rate (independently of each other) the questionnaire items for relevance (content validity) and clarity. In order to avoid a neutral midpoint, a scale of 1–4 was used (1 = not relevant/unclear to 4 = relevant/clear), where 3 and 4 meant that the questionnaire item was considered valid. The ordinal scale of 1–4 was thereby dichotomized as relevant/clear (items rated 3 or 4) and not relevant/unclear (items rated 1 or 2) when computing the index (Polit and Beck, 2006). A content validity index (CVI) was calculated for each item (I-CVI) and the entire questionnaire (S-CVI) where a perfect score is 1. This entails that if all raters gave an item a rating of 3 or 4, the I-CVI was 1 for that item. The S-CVI may be calculated as both universal agreement (UA), i.e. proportion of items that received a 3 or 4 by all experts, and average agreement (Ave), i.e. the average of the I-CVIs for all items on the scale, and both of these scores are presented. The same procedures were used for calculating an index for clarity (Lövestam et al., 2014). The definitions of the different validity terms, the ratings obtained and the recommendations made by Polit and Beck (2006) and Lövestam et al. (2014) are presented in Table 1, where range is shown for the item-level indices and both average agreement and universal agreement are shown for the scale-level indices.

The validity and clarity were good for the individual items, with most reaching the recommended value of 1.0. The validity and clarity were excellent for the whole questionnaire, as all criteria were met. Based on these results, it was concluded that no further changes were needed to the questionnaire and thus only one round of expert review was necessary. In other words, the questionnaire used in the expert review was also used in actual data collection. The final validated questionnaire covered items such as background information, how, where and for how long food waste has been measured, what is included in the measurements, and how results are presented. Some question items were open-ended, but for most items a nominal scale was provided. The participants were also given the chance to add additional information in free text if they wished.

2.3. Data collection

The final validated online questionnaire was distributed by email to one contact person in each of Sweden's 290 municipalities, and was later followed up by an email reminder to contact persons at municipalities that had not responded. The municipalities that still did not reply to the questionnaire were then approached by telephone and asked if they could answer the questionnaire orally. Since some preferred to answer the questionnaire in writing, a third reminder with the questionnaire was sent to these organisations. Three of the municipalities that did not reply to the email questionnaire had already participated in the pilot study or in previous studies by Eriksson et al. (2016c, 2017a) and Malefors et al. (2017). These organisations were

not approached by telephone, since the majority of their replies were already known.

A total of 274 replies were collected, but this did not represent the actual number of municipalities in Sweden, since some organisations cooperated and therefore gave just one reply for several municipalities and some organisations replied several times, either by mistake or because they had several sub-organisations dealing with food services. A common structure in the latter was to have two separate organisations, one for elderly care and one for childcare and schools. The data were therefore normalised so that each municipality was represented by one answer, i.e. the answers were either divided or aggregated in order to give one answer per municipality. This means that the answers represent the actions of at least one of the sub-organisations in an organisation, but not necessarily all. The normalised replies gave a response rate of 93%, since 270 out of 290 organisations were ultimately included in the study. No municipality declined to participate, but two municipalities replied that the position of catering manager was vacant and therefore there was no-one who could complete the questionnaire. The remaining 18 municipalities could not be reached, even though a minimum of 10 attempts were made by telephone in addition to the two by e-mail. To count as an attempt, the call had to be made during office hours and receive no answer (automatic or manual), so the real number of telephone calls in some cases exceeded the 10 official attempts. Since it was time-consuming to reach almost all municipalities, it took almost a year to complete the data collection, which means that some municipalities could have changed their routines during the data collection phase and this might not have been captured in the study. The number of replies to the questionnaire in relation to the number of reminders needed is illustrated in Fig. 1.

2.4. Data analysis

The answers were analysed in order to produce descriptive statistics on the food waste quantification routines in each organisation. General statistical information about municipalities was obtained from Statistics Sweden, the national statistics agency. In order to search for geographical patterns in the data, some key figures (i.e. the number of food waste quantification days per year and number of years of quantification) were displayed on maps using the software QGIS 2.18. Some parameters were related to each other in order to produce more complex key figures. One key figure for activity was the rate of inclusion of catering units, which was calculated as the percentage of catering units in a municipality that quantified food waste in relation to the total number of catering units in that municipality. The other activity measure was the estimated number of data points collected, which was the product of number of years, number of days per year, number of meals per day, number of categories per meal and number of catering units.

2.5. Development of a food waste quantification standard

The answers from the municipalities were used to devise a food waste quantification standard. This was based on the tree structure developed by Eriksson et al. (2018) and corresponded to the minimum level of quantification that should be acceptable to a majority of Swedish municipalities. Since the tree structure already describes how food waste quantification in food services can be broadened, this study only focused on the base where all other quantification schemes can overlap, in order to produce comparable key figures.

3. Results

3.1. Current practice in food waste quantification

Of the 290 municipalities in Sweden, 55% replied that they quantify food waste on central level, 21% replied that some of their kitchens quantify food waste on their own initiative, 17% replied that they do not quantify food waste and 7% did not reply at all. Since the Swedish municipalities can differ greatly in terms of population size, the different answers were weighted by the population represented (Table 2). The results showed that the 55% of municipalities quantifying food waste on central level had a greater number of larger organisations than the other municipalities and therefore represented 61% of all inhabitants in Sweden. The average number of inhabitants in the municipalities that reported quantifying food waste on central or individual level was 35,000–38,000, whereas the average number of inhabitants in the municipalities not quantifying food waste was only 17,000.

Of the municipalities quantifying food waste on central level or in individual kitchens, all quantified the food waste from the lunch serving. In additional, food waste from dinner was recorded by 12% of the municipalities, food waste breakfast by 7% and food waste from snacks by 6%. This reflected the fact that most municipalities focus their quantifications on schools (98%), which often only serve lunch, and pre-schools (44%). However, 31% of the municipalities also quantified food waste in elderly care homes, but all municipalities that quantified food waste from breakfast or dinner also quantified waste from lunch.

The most common categories of waste included in quantification were plate waste (91%), serving waste (70%), safety margin (26%), storage (11%) and rejections at delivery (11%). Other categories were only quantified to a smaller extent and special diet food waste was only quantified separately by three municipalities. The food waste data were normally complemented with information on the number of guests, which was quantified by counting the number of plates used (65%) or meals sold (11%) or estimated from the number of portions ordered (34%). Some municipalities also kept records on the mass of food prepared (26%) and/or served (25%), in order to generate a figure for

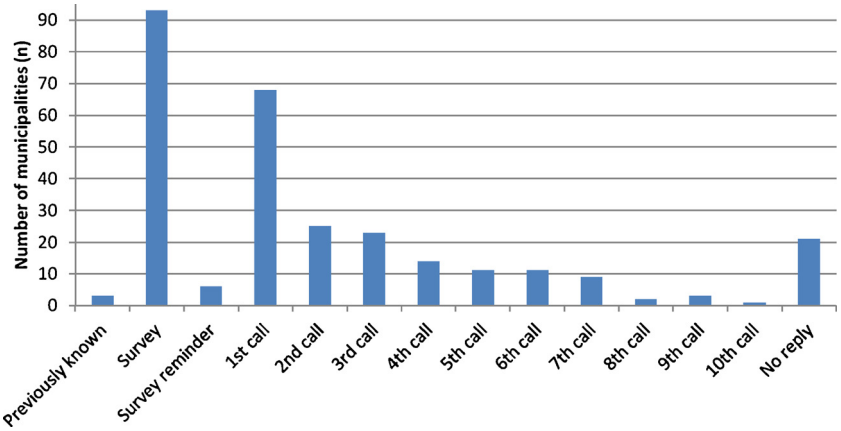

Fig. 1. Number of replies by municipalities to the questionnaire in relation to the number of attempts/reminders needed to obtain a reply. The municipalities that needed more than 10 telephone reminders did not reply to the questionnaire.

Table 2
Population-weighted responses of different municipalities in Sweden regarding their food waste quantification efforts.

Answer	Number of replies (n)	Share of replies (% of total, n = 290)	Total number of inhabitants in the municipality (million inhabitants)	Share of inhabitants in the municipality (%)	Average number of inhabitants in the municipality (n)
Yes, food waste is quantified on central level	159	55	6.0	61	37,510
Partly, food waste is quantified in individual kitchens	63	22	2.4	24	38,110
No, food waste is not quantified	48	17	0.8	8	17,178
No answer	20	7	0.7	7	34,983

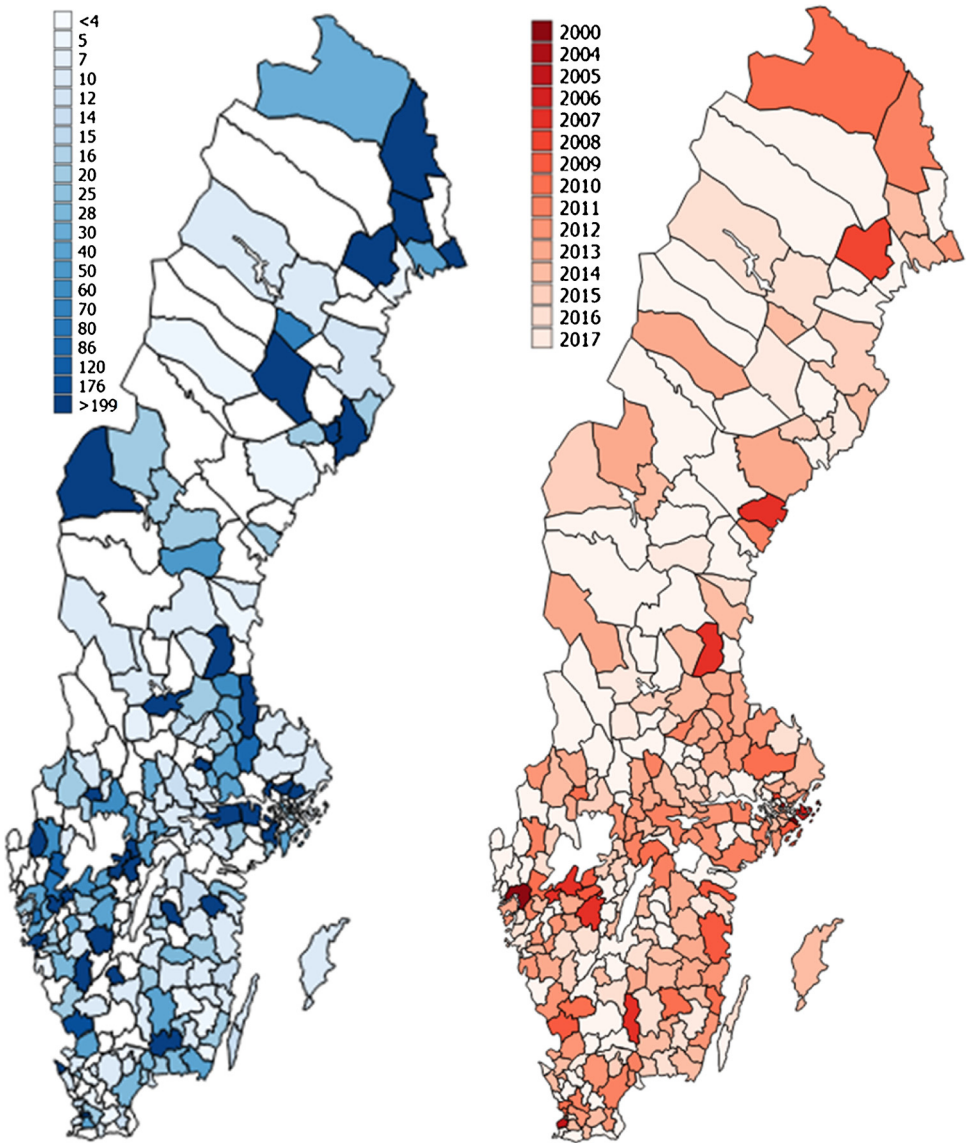

Fig. 2. Geographical representation of Swedish municipalities colour-coded in terms of (left) number of food waste quantification days per year (right) and the starting year for the quantification (right).

waste in relation to prepared/served mass. However, the most common key figure used to express food waste quantification was mass of waste in relation to number of guests (62%), in absolute mass (43%) or in mass of waste in relation to mass served (28%). Some municipalities used more than one key figure and therefore also recorded more than one reference base.

Municipalities often took the initiative (55%) to develop a food waste quantification routine, but it was also common to have political goals for this (41%). However, the free text comments revealed that a common development was for the municipality to first take the initiative and then make this initiative into a political goal. Other reasons for quantifying food waste were to identify causes (44%), to monitor progress by individual kitchens (29%) and/or by the whole municipality (20%), to communicate progress to the guests (25%), to complement food waste reducing campaigns (10%) or to communicate food waste data to the media (4%). Most municipalities communicated food waste data to kitchen staff (75%), politicians (55%), guests (49%), managers in schools and care units (46%), executive directors within

the municipal organisation (35%), head chefs (27%), teachers and nursing staff (27%), the media (8%) and/or parents of children and relatives of the elderly (5%). However, many municipalities appeared to conduct the quantification for one reason, but then use the results to communicate to more groups than initially intended. For example, 4% of municipalities reported quantifying food waste with the intention of communicating the results to the media, but 8% of municipalities replied that they actually communicate the data to the media.

The tools used to record the food waste data were most commonly spreadsheet software (74%) or handwritten lists (32%). However, 15% of the municipalities used both handwritten lists and spreadsheets, indicating that many staff first write on paper and then enter the data into a common spreadsheet. Only a few (10%) of the municipalities used more advanced tools for data collection, such as a shared database or an external waste quantification tool. Even fewer (2%) consulted an IT department or external agency to design and conduct data collection. The simplicity of the systems used may reflect the fact that only 17% of the municipalities archived the waste data in a central location and 12% archived the waste data in the individual kitchens. However, a common reason to archive the data in individual kitchens might be that they consist of handwritten lists which would require extra work to digitalise, since 50% of the municipalities archiving in individual kitchens used only handwritten lists to record food waste.

There were clear differences in the amount of data collected in each municipality and in the length of period for which the quantification routine had been running. The municipality that started quantifying food waste first (according to the answers) began in 2000, but only 17 municipalities started food waste quantifications before 2010. The start year peak was 2014, when 36 municipalities started to quantify food waste. The number of days per year on which food was quantified ranged from five to continuous recording (ranging from approximately 200 to 365 days per year depending on how many days the catering unit was closed), with an average of 53 quantification days per year. A geographical plot of the number of quantified years showed a few dark spots representing the pioneers in terms of food waste quantification, with weak clusters in the regions close to Gothenburg and Stockholm where more than one municipality started quantification early (Fig. 2). Some other municipalities also started early, but according to the geographical analysis their initiative did not spread to neighbouring municipalities. Analysis of the number of quantification days per year also showed a pattern of isolated initiatives rather than regional collaboration with spread of knowledge from one municipality to its neighbours (Fig. 2).

The activity in terms of data collection varied between the municipalities. The proportion of catering units quantifying food waste in relation to the total number of catering units ranged from 0% to 100%, with an average of 61% (Fig. 3). The potential number of data points collected ranged from 0 to 1,008,000, with an average of 18,249 per municipality (for the municipalities that provided enough data for this key figure to be calculated) (Fig. 3). As can be seen from the diagram, the two key figures for activity gave rather different pictures. The relative activity for each municipality (i.e. the number of catering units quantifying food waste divided by the total number of catering units) showed a few clear clusters of municipalities where several neighbouring municipalities had the same high activity. These clusters were mainly around the three major cities in Sweden (Stockholm, Gothenburg and Malmö), but there were also three quite distinct clusters (in Västmanland/Dalarna, Västergötaland and Småland). These clusters of high relative activity to some extent overlapped with the clusters of estimated number of data points collected (Fig. 3). Again, there were few very active municipalities and many of them fell within one of the six clusters of relative activity mentioned above. However, there were also a few very active municipalities in terms of data collection that had a low relative activity, meaning that there are some kitchens in these municipalities with high ambitions to quantify, but that this ambition is not shared by all kitchens in these municipalities.

3.2. Suggestions for a national quantification standard

The Swedish municipalities have engaged differently in food waste quantification, but there are clearly similarities between the different organisations. This study found that the municipalities quantifying food waste often used the same methodologies, but applied them differently. The findings from the survey indicate that use of similar quantification methodology would be feasible for Swedish municipalities, but that municipalities should be able to adopt this standard methodology stepwise to achieve slow systematic implementation rather than poor acceptance due to high initial thresholds.

Based on the results obtained in this study, a minimum level of quantification could form the basis of a waste quantification standard. We found that the Swedish municipalities have very different ambitions regarding data collection. Therefore we suggest a standard methodology comprising five levels (1–5), where each new level adds on the previous level in order to increase data coverage and enable continuous improvements. The base level (Level 1) should involve quantification of plate waste and serving waste during the lunch meal on at least 10 days per year (i.e. one working week per semester) (Table 3). This is already fulfilled by 114 of the 290 Swedish municipalities (representing 2619 catering units) and is close to being fulfilled by many others, so it should be readily acceptable to municipalities. This is a quite low level of data collection, so it should be seen as a starting point to get all municipalities involved, but is probably not sufficient for comparisons or to facilitate food waste reduction. However, if the wasted mass were related to the number of portions served, the data would be sufficient for comparison. This second level (Level 2) in the suggested quantification standard is already fulfilled by 79 of the Swedish municipalities (representing 1820 catering units).

According to the survey results, one critical factor for quantification is the quantification period. However, increasing the quantification time from two weeks to two months per year would significantly improve the robustness of the data and this is therefore suggested as Level 3 of the quantification standard. This is already fulfilled by 21 municipalities (including 608 catering units), indicating that there is potential for improvement for the majority. However, proper data collection is important and therefore we added Level 4, which requires food waste quantification for at least 200 days per year (which represents continuous quantification for schools since the school year is approximately 200 days long). This level is currently only fulfilled by five municipalities, representing a total of 67 catering units. Since it is likely that these municipalities only collect data from the most interested catering units, an important improvement would be to include all catering units in quantification. Level 5 therefore requires at least 90% of the catering units in each municipality to be included in food waste quantification. Only one municipality, running 34 catering units, currently fulfils this criterion.

Suggesting that all public catering units quantify plate waste and serving waste together with the number of meals served at lunch every day is somewhat ambitious, since only one municipality does so to date. However if the public sector is to achieve significant waste reduction, proper information will be required, and the fact that one municipality has achieved Level 5 indicates that it is not impossible to achieve. Some other municipalities would only need to improve their quantification slightly in order to reach Level 5 in our suggested standard.

Since the different levels in the suggested quantification standard mainly differ in terms of quantification time and degree of inclusion, waste data could easily be presented using the tree structure developed by Eriksson et al. (2018). This is done in Fig. 4 for a simple system where a catering unit provides food for a canteen, but could be extended by adding subcategories to the categories depicted.

The benefit of the tree structure is the flexibility to add quantification of sub-categories over time. Therefore kitchens are given the opportunity to focus their quantification efforts on the points where they generate the most useful data, which is probably the points where

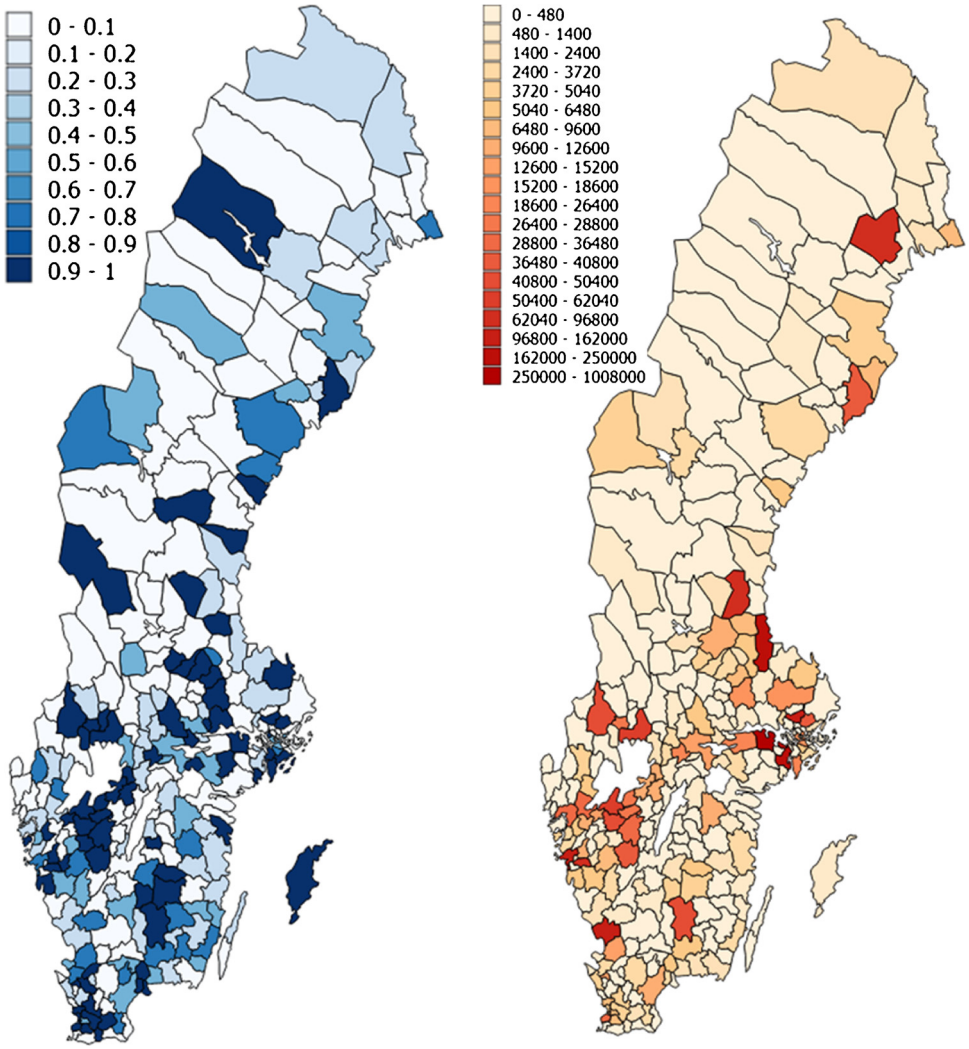

Fig. 3. Geographical representation of Swedish municipalities colour-coded in terms of (left) rate of inclusion of catering units (% of total in municipality) and (right) estimated number of data points collected.

Table 3
Number of Swedish municipalities fulfilling the criteria on each level of the suggested national quantification standard.

Level	Data collection time (days/year)	Quantification of portions served (Y/N)	Includes at least 90% of available catering units (Y/N)	Number of municipalities fulfilling all criteria (n)	Number of catering units represented in municipalities that fulfil the criteria (n)
1	≥10	N	N	114	2619
2	≥10	Y	N	79	1820
3	≥40	Y	N	21	608
4	≥200	Y	N	5	67
5	≥200	y	Y	1	34

they generate the most waste. Since it is possible to individually adjust the data points collected, the framework also handles the challenge that different municipalities have different ambitions on food waste quantification. If every municipality were required to follow the same procedure, the least ambitious organisation would have to set the standard, which means that those with higher ambitions could lose momentum. With a flexible structure, every kitchen can start on different levels of data collection and improve collection over time by adding higher resolution and longer quantification periods, in line with Levels 1–5 of the suggested standard.

4. Discussion

This survey of Swedish municipal food service organisations revealed that a majority are already engaging in some food waste reducing activity and making efforts to quantify their own food waste. While there are variations in quantification period length, the exact categories quantified and the quantification points, there are also clear similarities which are a good foundation for a common quantification standard that can be accepted by all Swedish municipalities. The most common practice at present is to quantify plate waste and serving waste from school lunches during two weeks per year. The waste data are collected in spreadsheets and compared with the number of plates used, with the result presented in grams of waste per portion served. This is quite a

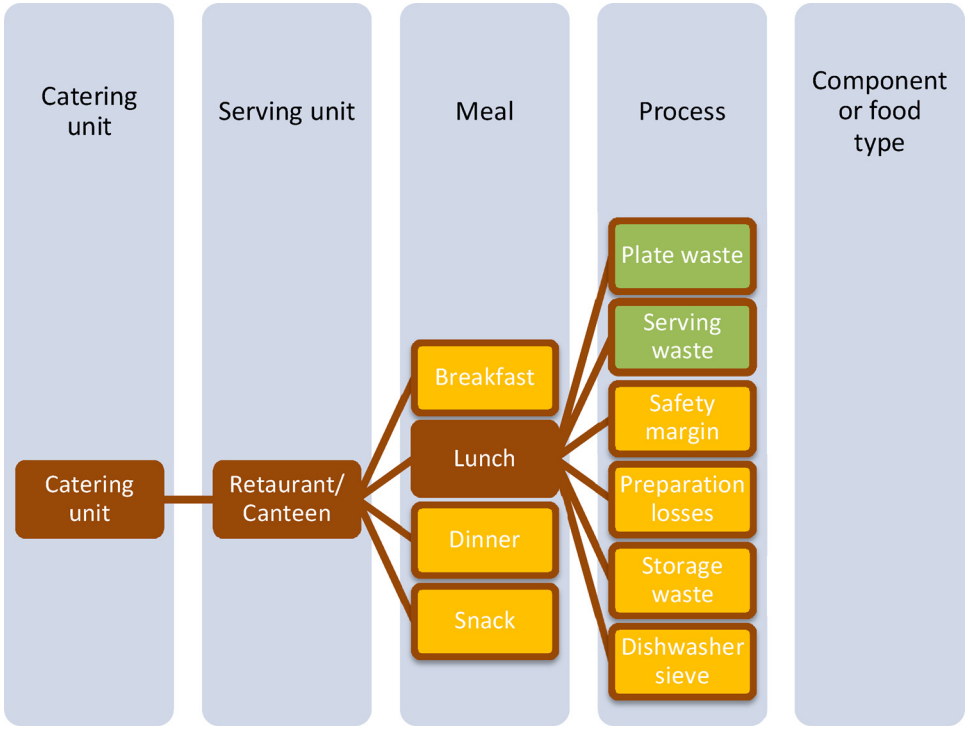

Fig. 4. Tree structure for a suggested minimum level of food waste quantification in Swedish public sector canteens with only one serving unit. The green boxes represent active points of quantification, the orange boxes represent inactive points of quantification and the brown boxes represent structural information included in the observations (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

basic quantification procedure, probably because the municipalities started on their own initiative, rather than in response to goals set by politicians or managers. In comparison with other professional sectors, the data collection performed in Swedish municipalities is limited and inconclusive. The Swedish retail sector is thoroughly described e.g. in publications by Brancoli et al. (2017), Eriksson et al. (2012, 2014, 2016a, 2017b) and Mattsson et al. (2018), where data were collected daily for several years. The retail sector also has advanced support systems to simplify data collection and the information collected is reviewed in weekly meetings, making it possible to actually reduce the waste. According to the present survey, only a few municipalities in Sweden come close to the quantification efforts that seem to be standard in the retail sector. This lack of quantification effort can explain part of the difference in waste level between retailers, which can have waste levels of 1–2% (Katajajuuri et al., 2014), and public catering units, which normally report waste levels in the range of 10–30% (Engström and Carlsson-Kanyama, 2004; Eriksson et al., 2017a; Malefors et al., 2017).

The survey results as regards methodology used for food waste quantification compared well with findings in previous studies by Engström and Carlsson-Kanyama (2004), Eriksson et al. (2017a, 2018) and Malefors et al. (2017), where lunches in school canteens were assessed for food waste generation during short periods. The focus on plate and serving waste seems to be a sufficient priority, since Eriksson et al. (2017a) report that 87% of food waste in school canteens is found in these two fractions, which means that most food waste can be assumed to be included in quantification.

Previous studies of how Swedish municipalities handle food waste quantification are less robust, since they only include the organisations that responded to a questionnaire, where the response rate was 65% for Stockholm Consumer Cooperative Society (2015) and 54% for Suhonjic (2017). Since the present study managed to include 93% of Swedish municipalities, the results can be considered highly generalisable. This study also included more detail, which yielded useful information on which to base a common quantification standard. However, there were some potential sources of bias in this study, since some municipalities might have several food service organisations but did not distribute the questionnaire to all of them. The questionnaire also has the weakness that it only captures the answers of the respondent and cannot judge if this person actually has appropriate knowledge or is just guessing. However, since the response rate was high, the survey can still be regarded as a very robust mapping of food waste quantification practices in schools, pre-schools and elderly care homes in a whole country.

The suggested quantification standard clearly has potential, since it is based on what the majority are already doing, which should increase acceptance and make it easy to implement the standard. However, the methodology of today is unlikely to be enough for the future, so future policy for public food waste quantification should aim higher in terms of data collection efforts. The standard suggested in this paper has five levels, where many kitchens are already at Level 1 but only one is currently at Level 5. In addition to this five-level standard, catering units could (and probably should) add additional quantification efforts in line with the framework presented in Eriksson et al. (2018) to get comparable figures for benchmarking and tailored waste quantifications targeting specific problems in individual kitchens. However, any quantification standard must be accompanied by sufficient control measures, in order to create incentives to quantify food waste as a first step in the process of waste reduction. For private companies, the economic incentive of not wasting food could be enough to motivate staff, or at least the owners, to reduce food waste, but in the public sector this incentive is lacking. Control measures for the public sector could involve compulsory reporting of food waste quantities to external organisations or political targets with a standard follow-up procedure. There could also be a political goal to contribute to the target of halving per capita global food waste at retail and consumer levels by 2030, as stated in the United Nations sustainable development goals (UN, 2016). Standardised quantification could be a first act in fulfilling this goal.

There is a need for clear incentives and leadership in order to introduce a quantification standard and Swedish municipalities appear to be good candidates for this type of action, partly because some are already quantifying and partly because a number of survey respondents cited a need for a national standard. However, some respondents also expressed a clear unwillingness to pay for any tools or standards, which of course limits the possibility of success. Therefore it is likely that this standard must be funded and managed on national level in order to achieve successful implementation. A national initiative should also

take into account that there are no obvious regional relationships, since food waste quantification practice only appeared to have spread to neighbouring municipalities in a few cases. Therefore personal relationships and networks may play a more important role than geographical distance, as close distance is probably a factor of convenience, but is not the most important factor for collaboration. If all these factors can be handled and a food waste quantification standard can be introduced, the possible benefit is a large reduction in food waste in public sector food services. This can save large sums of taxpayers' money and make a significant contribution to reducing the environmental impact from the food supply chain.

5. Conclusions

This mapping of food waste quantification practices in food services managed by Swedish municipalities provided new insights into quantification practices in schools, pre-schools and elderly care homes. It revealed many similarities in how and why food waste is quantified. The most common practice at present is to quantify plate waste and serving waste from school lunches during two weeks per year. The waste data are compiled in spreadsheets and compared against the number of plates used, in order to present the result in grams per portion served. The many similarities between municipalities provide great potential to introduce a common standard that many municipalities already fulfil, or can fulfil with minor adjustments. This is important in order to gain acceptance and fast implementation and create a benchmark for Swedish public sector food service food waste.

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