Identification and modelling of risk factors for food waste generation in school and pre-school catering units

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ABSTRACT

Public sector food service is a major contributor to food waste generation in Sweden, with schools, pre-schools, elderly care homes, hospitals etc., producing approximately 70,000 tons of food waste each year. Sweden has appropriate infrastructure for handling food waste in place, recycling nutrients and energy, but there is still great potential to move upwards in the waste hierarchy and prevent waste. An important step in designing waste reduction measures is to identify and quantify the importance of different risk factors, in order to start by solving the problems with the greatest potential benefit and the lowest cost. This study sought to identify and quantify risk factors for food waste generation in public sector canteens by correlation analyses and statistical modelling. The empirical material comprised food waste quantification data for 177 kitchens in the Swedish municipalities of Falun, Malmö, Sala, Uppsala and Örebro, supplemented with quantifiable information about the kitchens obtained using a questionnaire. According to the findings, plate waste in schools and pre-schools increases with children's age. Schools with older children could potentially reduce plate waste by introducing more structured lunch breaks. Plate waste also increases with dining hall capacity, potentially due to rising stress and noise levels. Both plate waste and serving waste increase with greater overproduction, as indicated by calculated portion size, and could be reduced by schools and pre-schools estimating their daily number of diners and their diners' food intake more accurately. As serving waste was significantly higher in satellite units (which bring in cooked food), due to lack of cooling and storage possibilities, than in production units (which cook, serve and sometimes deliver hot food), satellite units in particular would benefit from more accurate quantification of the food required on a daily basis. These findings were confirmed by multiple linear regression models, which explained >85% of the variation in plate, serving and total waste per portion. When used for quantification after changing the value of different factors, these models confirmed that the main factors influencing serving waste and total waste per portion were type of kitchen and rate of overproduction, while plate waste was mainly influenced by children's age and factors indicating a stressful dining environment.

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1. Introduction

Public sector food service is a major contributor to food waste generation in Sweden. According to the Swedish Environmental Protection Agency (SEPA), public food service, including schools, pre-schools, elderly care homes, hospitals etc., generates approximately 70,000 tonnes of food waste per year, which is roughly the same amount as for all other food services such as hotels and restaurants together (SEPA, 2016). Private households waste most food, 717,000 tonnes (SEPA, 2016), which can be explained by the much larger amount of food served in households compared with public catering units. Among all public facilities investigated by SEPA (2016), schools and pre-schools generated most of the total waste (67%), followed by elderly care homes (24%).

Landfilling of organic waste is banned in Sweden (Ministry of the Environment and Energy, 2001) and food waste is mainly managed through incineration (62%) and anaerobic digestion and composting (38%) (SEPA, 2017). In a global perspective, this can be considered fairly advanced waste management, but even the biological recovery options (digestion and composting) are still far from the waste reduction rates stated as the top priority in the EU Waste Framework Directive (EC, 2008). The environmental benefits of producing biogas are also much lower than the potential benefits of preventing waste or using it for higher priority valorisation options (e.g. reuse), thereby substituting for more resource-demanding products and services (Eriksson et al., 2015; Eriksson & Spångberg, 2017).

Only a few academic studies have examined the food waste generated in public serving units. Eriksson et al. (2017) quantified the food waste from 30 public kitchen units in the Swedish municipality Sala with regard to plate waste and serving waste and found that elderly care homes had the highest waste per portion (90 g), followed by schools (79 g) and pre-schools (51 g). In general, 23% of the food served in Sala's public kitchens was wasted, with 64% being serving waste and 33% plate waste. Production units (facilities which produce food in their own kitchens) had significantly lower waste than satellite units (facilities that receive food produced in another facility and often have few possibilities for cooling and storage of food leftovers). Pre-schools had significantly lower waste than schools. Overall, however, there was great variation between kitchens of the same type (Eriksson et al., 2017).

In a study quantifying the food waste in an American primary school based on a short measurement period of five days, Byker et al. (2014) concluded that portion size, noise levels, time available for food consumption and children's age were possible factors determining food waste in schools. Some other attempts to identify the drivers of food waste in educational establishments have been made, most of which have relied on surveys and have aimed at ensuring that pupils receive sufficient nutrients via their school lunch, rather than at reducing waste. Kinasz et al. (2015) developed a checklist for the prevention of food waste based on the votes of experts, but also concluded that more research is needed to identify the factors controlling food waste generation. In addition to factors concerning management in the service sector, they suggested dining ambiance and knowledge about the diners as potential factors influencing food waste in public facilities. Whitehair et al. (2013) examined whether food waste in universities was reduced when students received information about food waste and found that a reduction of 15% could be achieved. However, only 40% of the students approached agreed to participate in that study and let their trays be weighed. Kuo and Shih (2016) suggest that gender differences might be a factor influencing plate waste, as they found that female plate waste in universities was significantly higher than male plate waste. A significant decrease in plate waste was also found in a study where trays were removed from a university dining hall (Thiagarajah and Getty, 2013).

Statistical approaches examining the drivers of food waste in school kitchens have shown that plate waste increases when sixth graders purchase food outside the dining hall, referred to as competitive food items (Marlette et al., 2005). A study by Niaki et al. (2017) found that children's age is an important factor influencing food waste behaviour in schools which should be taken into account when examining the drivers of plate waste in school kitchens. According to that study, children attending pre-school had significantly higher plate waste than children in higher school years. However, the authors point out that the youngest participants in the study had lunch two hours earlier than the oldest participants. Differences in lunch break procedures should therefore be examined as a factor coupled to food waste behaviour (Niaki et al., 2017). For example, food waste has been shown to decrease by about 10% when primary school children in school years 1 to 3 have their break before eating lunch (Getlinger et al., 1996).

In WRAP (2011), three interventions (improving familiarity and appreciation of school meals; improving the dining experience; children ordering their meals in advance to cooking them) were tested in 39 schools and led to a 4% waste reduction, although this reduction was not statistically significant. Barr et al. (2015) introduced the LEAN philosophy (a systematic method including the elimination of waste within manufacturing) to reduce overproduction, and thereby food waste, in school canteens in Sweden, but was unable to demonstrate any reduction in food waste due to insufficient waste quantification. This highlights the importance of a systematic approach to evaluating food waste reduction measures. An important step is therefore to describe the problem by quantifying waste, but also to correlate this waste to factors that can be improved. Multiple linear regression models have previously been used to quantify risk factors for waste generation in supermarkets (Eriksson et al., 2014) and to simulate the effect of waste-reducing measures (Eriksson et al., 2016a), but this approach has not previously been applied to public sector food services.

The Food and Agricultural Organization FAO (2013) estimates that 1.3 Gtonnes of edible food are lost or wasted along the food supply chain each year, which answers to one third of all food that is intended for human consumption. The consumption stage contributes with 37% to the total carbon footprint generated along the food supply chain, due to food wastage of 3.3 Gtonnes CO_2 equivalents. Annually, the production and post-handling of food that is later wasted together require around 30% of the world's agricultural area. The blue water footprint caused by agricultural products for food waste answers to 250 km^3 of groundwater and surface resources. (FAO, 2013)

Although the agricultural stage has the biggest impact on the environment among all stages in the food supply chain, food consumption has a huge impact on the environment through the energy used for production, packaging, transportation and cooking among others (Schott and Cánovas, 2015). By preventing 1 kg of food waste, up to 29 kg of emitted CO_2 could be saved, depending on the type of food wasted (Eriksson et al., 2015). In addition to decreased greenhouse gas emissions, a 50% reduction in food wastage in developed countries is estimated to result in lowering the global water footprint by 59 Gm^3 according to calculations by Munesue et al. (2014). Furthermore, over 60 million people could be nourished as a result of a 50% reduction. Food waste prevention would save natural resources and diminish negative effects on the environment caused by agricultural economy (Munesue et al., 2014). Knowledge about the implications of food waste and its prevention should be an "urgent priority" according to Thyberg and Tonjes (2015).

This study therefore examined factors influencing food waste in schools and pre-schools, with the objective of identifying and analysing these factors. Another objective was to investigate and model the influence of factors that were significantly related to food waste, in order to create a base for effective measures to reduce food waste in schools and pre-schools.

2. Materials and methods

Risk factors potentially influencing food waste generation were identified from the literature (Section 2.1). Quantitative data that could function as indicators for different potential risk factors were collected, as were food waste data (Sections 2.3 and 2.4). The correlation between food waste and risk factors was then tested for each factor individually. Lastly, the factors were modelled together, in order to calculate their collective impact on food waste generation. The research approach was highly influenced by a previous study conducted by Steen (2017), but with additional analysis and material in order to expand the results.

2.1. Identification and selection of risk factors

Possible risk factors identified from the literature are summarised in Table 1. Although food waste is likely to be influenced by factors such as attitudes and opinions, such factors were excluded from the study due to the associated difficulties in quantification and generalisation. However, for some factors that are difficult to quantify, such as stress, secondary factors such as time available for eating were used as an indicator of how stress was