

Causes of Food Waste in a University Food Service Operation: An Investigation Based on the Systems Theory

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Abstract

The study applied the systems theory to investigate causes of food waste generation in the University food service operation. A qualitative, case study design was adopted. One-on-one interviews with food service managers and supervisors, focus group discussions with back-of-house and front-of-house food service personnel, participant observation and document analysis were used to explore causes of food waste at different points of the University food service. The data collected were analysed with a qualitative data analysis software; ATLAS.ti. Thematic analysis was conducted to generate common themes. The findings illustrated that different activities in the functional subsystem of the food service system had an influence on food waste. The study contributes to the literature as causes of food waste were investigated from the systems theoretical perspective. This represents an important first step towards an improved understanding of the causes of food waste within the university food service setting. Unlike previous studies, a holistic view of the causes of food waste in different parts of the functional subsystem of the University food service were explored. An understanding of food waste from this perspective is useful in proposing strategies that adequately address food waste in the entire functional subsystem.

Keywords: food waste, University food service operation, qualitative study, thematic analysis, systems theory

Introduction

Food waste has gained increasing attention worldwide because of its environmental, social, and economic impact (Goonan et al., 2014). Its severity is exemplified by the fact that the United Nations has set an agenda through the Sustainable Development Goals (SDGs) that directly links with food waste, such as SDG 2 (zero hunger), SDG 12 (sustainable consumption and production) and SDG 13 (climate action). According to the Food and Agricultural Organisation (2023), it is estimated that global food production must increase by 60% by 2050 to meet the demands of the increasing population, yet 30% of the food produced is wasted. In terms of unit tons, Gustavsson et al. (2011) indicated that 1.3 billion tons of food per year was wasted globally. This is equivalent to one-third of the total food produced for human consumption (Gustavsson et al., 2011). Other studies (Lundqvist et al., 2008) have suggested that as much as half of the food intended for human consumption is lost or wasted before and after it reaches the consumer.

As the largest contributor to food waste during consumption, household food waste has been extensively researched. However, the food service sector also generates considerable amounts of food waste. Research indicates that in all 28 European Union countries, the food service sector generates a total of 11 million tons of food waste (Food Use for Social Innovation

by Optimizing Waste Prevention Strategies (FUSIONS), 2016). In the United States, 16 million tons of food waste is generated by full-service restaurants, institutional food services and limited-service restaurants (Rethink Food Waste [ReFED], 2017). This translates to an equivalence of 25% of the total food supply chain food waste (ReFED, 2017). According to Betz et al. (2015), in Switzerland, the food service industry was the third largest source of food waste (18%) after households and the food industry. Kranert et al. (2012) evaluated the amount of food loss and waste along the food supply chain (FSC) in Germany. They found that the food service industry was the second largest source of approximately 1.9 million tons of food waste, representing 17% of the total FSC food waste (Hennchen, 2019). In the UK, the food service sector accounted for 29.6% of food wasted in the entire food supply chain of which the largest contributors are restaurants, pubs, education, and healthcare food services (The Waste and Resources Action Programme [WRAP], 2013). In Finland, the food service sector wastes about 75 – 85 million kilogram of food per year, which represents 20% of all food handled and prepared (Silvennoinen et al., 2015). In this study, the largest contributors of food waste were day-care centers, workplaces, and student canteens (Silvennoinen et al., 2015). In university food service settings, it has been found that these institutions around the world generate a significant amount of food waste. The magnitude of food waste in the university food sector is discussed under the literature review section below.

Given the magnitude of the problem of food waste and its associated impact, food waste prevention strategies are garnering more support than ever in both policy and academic debates (Thyberg & Tonjes, 2016 cited in Painter et al., 2016). Critical to preventing food waste or at least its reduction, is an understanding of the causes of food waste. This area has been under researched. Understanding the causes of food waste can provide insights into relevant interventions for food waste reduction and prevention. In this regard, the prevention of food waste will contribute to the environmental, social, and economic sustainability. Within this context, this study aimed to investigate the causes of food waste generation at different phases of the university food service system. It is worth noting that, to date, research on causes of food waste in the food service sector has focused primarily on plate waste (Boruhan & Ozbiltekin-Pala, 2021; Falasconi et al., 2015; Freedman & Brochado, 2010; Qian et al., 2021; Saccare et al., 2014; Schwartz et al., 2015; Smith & Cunningham-Sabo, 2014; Thiagarajah & Getty, 2013; Thorsen et al., 2015). What is notably missing is the understanding of other categories of food waste that occur at different stages in the food service system. Therefore, this study focused on causes of food waste in different stages of the functional subsystem of the university food service operation.

Literature review

The literature review is divided into two sections. The first section explains the concept of food waste; the second discusses the magnitude of food waste in university food services.

The definition of food waste

Various forms of waste can be generated by food service operations; however, food waste is gaining increasing attention (Christ & Burritt, 2017). The concept of food waste is seemingly straightforward, yet it is underpinned by considerable complexity, with little universal consensus regarding its definition (Thyberg & Tonjes, 2016). A variety of terminology and phrases have been used to discuss the subject of food loss and waste. Sometimes, different terminologies are used for the same meaning, while at times the same terms are used for different meanings (Food and Agricultural Organisation, 2014). Thi et al. (2015) further pointed out that the definitions and usage of food loss and waste terms are often content-specific and dependent on the author's opinion. Multiple terms, including 'food loss', 'food

waste’ and ‘food loss and waste’ have been used synonymously (Thi et al., 2015). Different studies (Betz et al., 2015; Charlebois et al., 2015; Goonan et al., 2014; Sonnino & McWilliam, 2011), which focused on food waste in the food service sector, have used the term food waste and food loss interchangeably. However, according to Filimonau and De Coteau (2019), the key difference between food loss and food waste is that food loss is characterised by largely unintentional occurrence, whereas food waste arises due to both unintentional and intentional human actions and operational deficiencies. In this paper, the term food waste was adopted and defined as the edible parts of food intended for human consumption that are lost or discarded at some point in the food service system (Figure 1). Causes of procurement waste, preparation, and production waste, holding and distribution waste and service waste were explored.

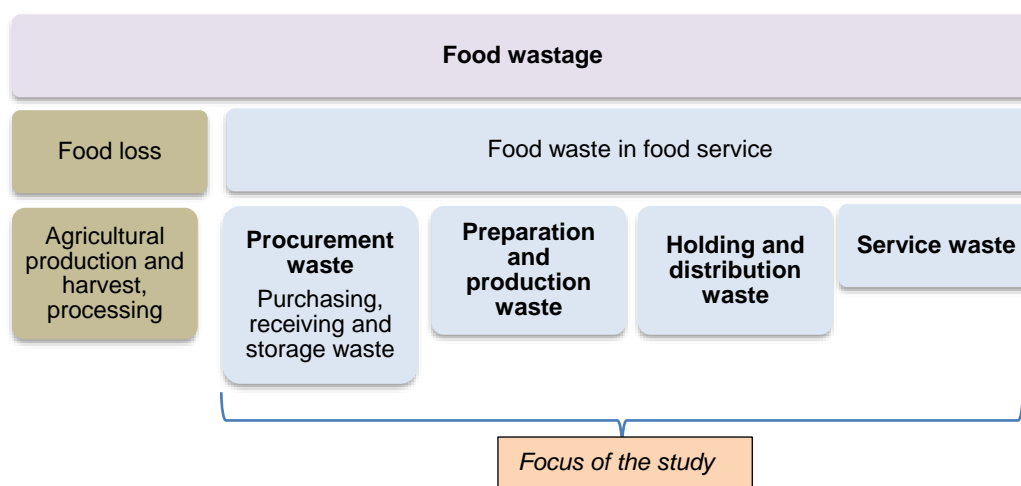


Figure 1: Food waste along the food service system

The magnitude of food waste in the university food service sector

The university food service sector may possibly make up a large source of food waste given the large number of students enrolled each year. Considering that a significant amount of food is produced each day for students who consume several meals per day at university food service units, addressing food waste in universities appears to be an important issue. Empirical research shows trends of appreciable food waste at institutions of higher education across the world. Several studies have documented food waste in the context of universities in the United States of America. A study undertaken at four different campus dining facilities at the University of Missouri in Columbia, found that of the 1000 kg food reaching the dining facilities, 56 kg was lost as kitchen food waste of which 41 kg was edible and 15 kg inedible (Costello et al., 2016). The high proportion of the edible food waste generated was a major concern. An empirical study by Whitehair et al. (2013) estimated that a total amount of 1.5 tonnes of edible food waste was generated during a six-week study at an American university dining facility, servicing 540 students living in residence halls. In another study, Babich and Smith (2010) estimated that an average of 30 g of food was disposed of per meal in an American university setting. Thiagarajah and Getty (2013) compared the amount of plate waste generated using a tray versus a tray-less delivery system in a university dining hall. They found that 125 g of solid food per person was wasted when using the tray system versus 100 g per person with the tray-less system.

In Canada, a study undertaken by Rajan et al. (2018) at the University of Northern British Columbia indicated that kitchen food waste made up the second largest component (32%) of total food waste generated by the University food service facility. Specifically, the study estimated that 29.4 kg of kitchen food waste was generated per day and in a period of a week, a total of 205 kg was produced. Rajan et al. (2018) further showed that starchy grain-

based food waste was the single largest proportion (56%) of kitchen food waste. Another study in Canada by Gillard (2017) assessed and quantified food waste at the University of Saskatchewan. It was found that kitchen waste accounted for most of the food waste generated by the University cafeteria, with 59% being kitchen waste, 36% plate waste and 5% non-edible food waste.

In Portugal, a baseline visual waste observation at the University of Lisbon established that a third of plated meals ended up being discarded (Pinto et al., 2018). The study estimated that plate waste amounting to 76.5 g per student per day was generated prior to the implementation of an educational campaign. Thereafter, it was reduced to 64.67 g (Pinto et al., 2018). Another study, conducted by Ferreira et al. (2013) in a different Portuguese university setting, estimated that each patron generated an average of 200 g of plate waste per meal. This is considerably higher compared to the study conducted by Pinto et al. (2018). Wong (2011), cited in Betz et al. (2015) estimated that 9.65% of the food reaching a certain German university canteen ends up being discarded. A study carried out in Turkey, at the Çurukova University's dining halls, indicated that about 10.7% of the served food gets wasted (Ozcicek-Dolekoglu & Var, 2019). In China, a study revealed that the average plate waste generated by Beijing university students was 73.7 g/capita/meal, with staples and vegetables contributing the most (Wu et al., 2019). In a study conducted by Abdelaal et al. (2019), food waste generation at four food outlets of a university campus in Qatar was estimated at 329.5 kg/day or 80 t/year.

In the context of South Africa, two empirical studies have been conducted to establish the magnitude of food waste generated at Rhodes University and Stellenbosch University. A study conducted by Painter et al. (2016) reported that an estimation of 555 g of food waste per student was generated on a daily basis at Rhodes University, which translated to about 450 tonnes of food waste per year. This estimation indicated that food waste generated at Rhodes University is strikingly higher than an average amount of food waste generated by most universities. For instance, at Kansas State University the average amount of food waste generated per student is 170 g (Whitehair et al., 2013), 73.7 g/capita/meal at universities in Beijing (Wu et al., 2019), and 200 g/capita/meal at a Portuguese university (Ferreira et al., 2013). On the other hand, the results of the study undertaken by Marais et al. (2017) indicated that 26.7% of food was discarded at Stellenbosch University residential food service units. This was a much higher percentage of food wasted, compared to 9.65% in a German university canteen (Betz et al., 2015). Given the magnitude of the food waste problem and its associated impact, this study investigated the causes of food waste. Understanding the causes of food waste can provide insights into relevant interventions for food waste reduction and prevention.

Methods

This study used a qualitative case study design. The study was conducted in one of the largest universities in South Africa, which has just over 53 000 registered students with 16 685 undergraduates and 36 467 postgraduates. Data was collected at a purposively sampled residential food service unit. The sampled food service operation is the largest of all operations in the university, servicing a population of approximately 900 students residing at six of the residence halls. It is also a central production kitchen that produces and distributes meals to four satellite residential cafeterias. Given the magnitude of the cafeteria, access was made to a large group of food service personnel to be interviewed and a focus group to be held.

Data were primarily gathered through semi structured interviews with the general manager and supervisors responsible for procurement, production, distribution, and service. The interview guides were structured according to the processes of the food service operation including general management functions, purchasing, receiving, storage, preparation and production, distribution and serving. Three focus group discussions with the front-of-house

and back-of-house food service personnel at the research site were conducted. Personnel at management level were excluded from these focus groups to avoid power dynamics that may have inhibited the discussions but promoted conversation and communication (Stewart & Shamdasani, 2014). In addition, participatory observations were undertaken. This approach offered the opportunity to understand context related practices and to gather rich data without being intrusive or disturbing the participant's normal routine. To complete the data collection, existing documents including menus, meal statistics, financial records and daily reports which reported on food waste occurrences as well as stock movement records were examined.

Using Braun and Clarke's (2012) guidelines, thematic analysis was electronically conducted using the ATLAS.ti software to analyse the qualitative data. The first step of the qualitative data analysis involved organising and preparing the data for analysis. The researcher used ATLAS.ti to upload raw data in the form of text, audio, and photographs, and transcribed the data. During this phase, the researcher studied the data repeatedly and actively read the transcripts to gain a general sense of the meaning of the entire body of data (Braun & Clarke, 2012). The transcripts were read at least twice before coding. As the data was reflected on, general ideas emerged, including impressions of the overall depth, credibility, and tone of the participants (Creswell, 2014). Coding was performed inductively, after which the codes were merged into themes to represent the causes of food waste in the university food service system.

Findings and discussions

The findings are organized according to the functional subsystem of the food service operation. Themes relating to each heading are presented and then discussed in relation to the existing literature.

Purchasing

Several practices during procurement contributed to food wastage. During the interviews, participants highlighted that procurement of unpopular food items caused food waste. This is a similar finding to the previous research conducted by Charlebois et al. (2015), who mentioned that expansive inventories with unpopular food items that were not consumed before expiry, resulted in food waste. In this study, unpopular items, such as *Halaal* foods, were often not consumed before the expiry date, causing storage waste. "... we used to order the *Halaal* foods, and it wasn't very popular. It ended up not being consumed and resulted in waste".

Overstocking was also identified as a contributing factor of food waste generation, though to a lesser extent. For example, during the study period, such items as peppermint crisps, pecan nuts, caramel treats, brisket rolls, knotted rolls and vegetable style strips were overstocked, and some reached the expiry date before use. Contrary to previous studies (Martin-Rios et al., 2018; Thyberg & Tonjes, 2016), food waste generated because of overstocking was generally low at the case University food service unit. This may be attributed to the multiple stock control measures put in place, such as the use of the computerised stock management system, stock monitoring through recording stock movement as well as recording inactive food items. Notwithstanding this, it was observed that when overstocked ingredients were about to expire, the production unit was informed and planned the menu around such ingredients. Even though this prevented food waste at the storage point, sometimes it created food waste at the production and service points because of overproduction of food that was reaching the expiry date.

Receiving

Failure to check quality against specifications and to identify poor quality, damaged or spoiled food products at the time of delivery, led to receiving food that ended up being discarded

instead of rejected and returned to the supplier. This was mostly the case with fresh produce, including fruit and vegetables. Charlebois et al. (2015) reported a similar issue, that if receivers failed to identify poor quality at the time of delivery the food service outlet ended up assuming the waste instead of returning the food supplies to the suppliers. The following quotation indicates the cause of food waste at the receiving point: "... there are specifications, but I think at the point of receiving the specifications are not always followed or checked".

This shows that the availability of quality controls, such as food specifications alone is not enough to reduce food waste, but correct interpretation and strict adherence to specifications is important in reducing food waste. It was further observed that some perishable food items received were not immediately transferred to the storage areas. Even though food wastage was not immediately observed because of mishandling food products during the receiving process, it may lead to food spoilage and ultimately food wastage in subsequent stages of the functional subsystem (Charlebois et al., 2015).

Storage, inventory control and issuing

The major issue that emerged during the study was the improper storage of food supplies, which led to food deterioration, resulting in food waste during storage. Similarly, previous studies (Betz et al., 2015; Filimonau & De Coteau, 2019; Thyberg & Tonjes, 2016) indicated that food items which were not stored properly, spoiled leading to food wastage. The participants pointed out the tendency to overproduce food, which was sometimes stored for a longer time than appropriate, resulting in spoilage, hence food waste generation. It was also observed that some leftover foods were stored uncovered and exposed to extremes of temperature, hence spoilage. Still at the storage stage, some participants highlighted failure to store food at the correct refrigerator and freezer temperatures as a possible driver to food waste. This was a rare but high impact issue that resulted in a considerable amount of food waste. It was commented that: "... we had such a high waste when the meat was kept in the fridge at an incorrect temperature for two days, so that's when we lost 18 pans of beef stew".

Food waste generation, due to incorrect refrigerator or freezer temperature in food service operations, has not been indicated as a problem in previous literature. The literature frequently cites maintaining the refrigerator at too high a temperature being a major concern, causing food waste at household level (Van Geffen et al., 2020; Van Holsteijn & Kemna, 2018). In this study, this was an unusual occurrence, given that the University food service unit implemented a food safety programme (*control*) that required regular monitoring and recording of the refrigerator and freezer temperatures. A possible explanation for the incorrect temperature of cold storage could be mechanical failure of the refrigerators and freezers. It is, therefore, important to ensure regular maintenance of such equipment.

Moreover, some participants indicated that failure to follow inventory and stock rotation methods, such as FIFO (First-In/First-Out) led to the use of food products without consideration of production dates and expiry dates. Ingredients were returned to storage areas without consideration of inventory management methods, such that stock was used randomly, hence older stock being wasted. The same challenge was faced with issuing of cook-chilled or cook-frozen menu items as narrated by one of the participants below: "... we do experience food waste like today we have wastage of cooked rice. You know what they do; they keep food for too long instead of using the first in, first out principle".

This mostly happened with cooked food that was produced in bulk. In this case, freshly produced food ended up being served first and older stock being wasted. This finding agrees with that of Charlebois et al. (2015), Filimonau and De Coteau (2019) and Halloran et al. (2014), who stated that failure of staff to adhere to stock rotation principles, such as FIFO, contributed to food waste. Furthermore, failure to date mark food during storage was identified

as a reason for food waste. This made it difficult for food service workers to make decisions on which food products to use at a certain time, which led to the deterioration of older stock and hence waste. Failure to control pests in the storage areas was cited as one of the causes of food waste in the food service system. Supporting this observation, it was noted: "... we had a rat and the destruction that the rat caused was incredible, that flour, oh it was disastrous".

Along the same lines, failure to strictly adhere to food storage requirements was found as a culprit in attracting pests and insects. In support of this, one of the participants commented that: "... I think in some way the policy of removing stock from boxes is not applied 100% because some products are still stored in boxes like macaroni".

In this study, participants highlighted rats and cockroaches as the most prevalent pests and insects found in the food service unit. These pests and insects contaminated food items with their droppings and possible bodily secretions. They also consumed some food items. Rats damaged food containers and packaging, leading to spillages and allowing for contamination, hence food wastage. However, this was not a common problem at the case University food service unit as pest control and fumigation were performed on a regular basis. Failure to weigh food during the process of issuing was identified as a contributing factor to food waste. This led to the failure to track food waste nor account for it. In relation to this, participants noted that:

Yesterday I explained to one of the workers that he has to weigh what the stock clerks are issued. 23 kg of steak was issued and the yield after cooking should be 20kg but instead we had 17kg which means 3kg was wasted and could not be accounted for.

Additionally, failure to accurately measure ingredients when issuing, contributed to food waste. For instance, during observation more bread flour than the recipe required was issued and the flour that remained after preparation was discarded instead of returning it to storage. Inaccuracy in the measurement of ingredients also led to the production of poor-quality menu items that were discarded as production or service waste. Food waste because of these factors has not been documented in previous literature.

Production

The findings of the study indicated that overproduction was one of the leading causes of food waste in the University food service system. The themes that emerged from the study regarding food waste caused by overproduction of food, informed the development of the food waste framework presented in Figure 2. In cases where food was overproduced, leftovers remained at the service point. From the leftovers, food suitable for later use was stored; that which was not suitable for later use, such as reheated leftovers, were discarded leading to service waste. Of the surplus food stored, some lost quality and/or was spoiled, which resulted in storage waste. Leftovers, which were of a good quality, were sold, thus preventing food waste. As indicated in this discussion, overproduction led to food waste at the service and storage points, which demonstrated the interdependency nature of the food service system.

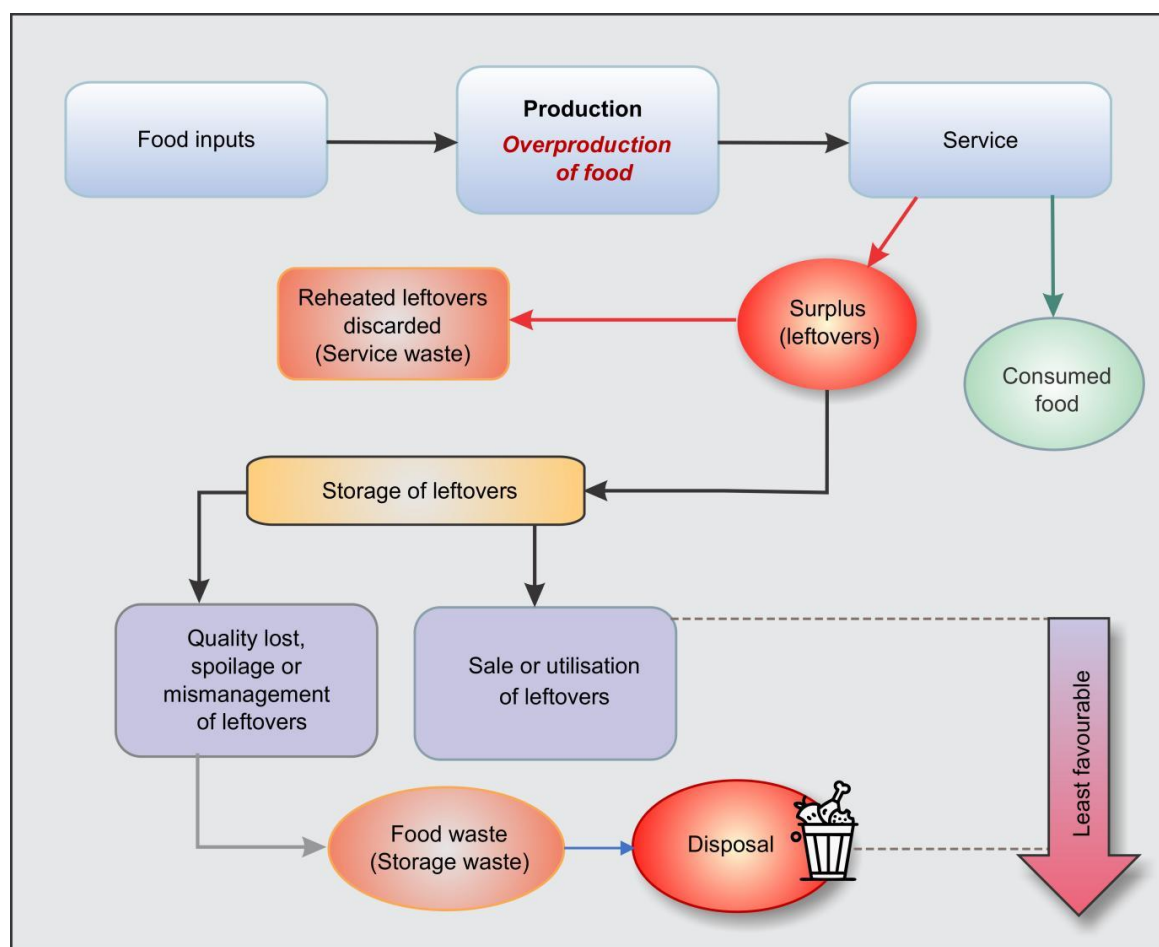


Figure 2: Overproduction and food waste framework

A common view amongst participants was that overproduction was a result of inaccurate forecasting. This finding was also reported by Goonan et al. (2014). Challenges of the forecasting system that exacerbated the overproduction problem, included the booking system that allowed students to cancel bookings a few hours before production when preparation was already completed. Additionally, less consideration was given to the quantities for the less costly dishes, such as starchy food and vegetables. Historical records, such as past customer counts, meal statistics, or sales records that could be used as the basis for forecasting, were not always applied when planning to produce starchy foods. As such, it was observed that pans of starchy foods, such as rice and maize meal porridge, were discarded in large quantities. The following comments illustrate the intensity of the problem of overproduction:

The other thing that has a lot of waste is maize-meal porridge. Porridge ...eish... (whistling). We throw a lot of porridge into rubbish bins. For example; they (chefs or cooks) cooked porridge for staff meals over the weekend, they did not eat that porridge leaving [two-three] (2-3) pans of porridge, additionally, they cooked about [six] (6) more pans of porridge for students for supper, about [four] (4) of them remained, we discarded a lot of porridge last week so much that my heart hurt as if the maize meal was mine.

Another participant commented:

Yesterday production workers cooked [eight -ten] (8 to 10) pans of rice in the morning and held them in the heated cabinets, some rice was eaten at lunch and a lot of pans were still left. At supper (booked) it was rice again and potatoes, the production staff cooked more rice and held it in the heated cabinets. The students ate potatoes because they prefer potatoes, the potatoes got finished and rice was leftover, we took back about [seven -to ten] (7-10) pans of rice.

This suggests that overproduction of food can be attributed to the failure to consider the number of meals produced or leftovers, prior to producing more of that menu item. Additionally, students' preferences were overlooked when estimating the quantities of menu items to be prepared. As indicated in the previous comment, students preferred potatoes over rice. However, more rice than needed was produced resulting in approximately seven to ten (7-10) pans of left-over rice. This implies that food waste resulted where menus were planned without considering students' preferences and needs. A similar finding was reported by Marais et al. (2017) who indicated that students attributed food wastage at Stellenbosch University to failure of the catering facility to consider their preferences of food items and meal sizes.

Other participants indicated that when food was overproduced, leftovers were stored for later use but after a certain period, certain food items lost quality and had to be discarded. Talking about this issue a participant said: "... what happens is that there could be food prepared and then it was not served in time, within 3 or 4 days then we have to throw it out. We can't serve that".

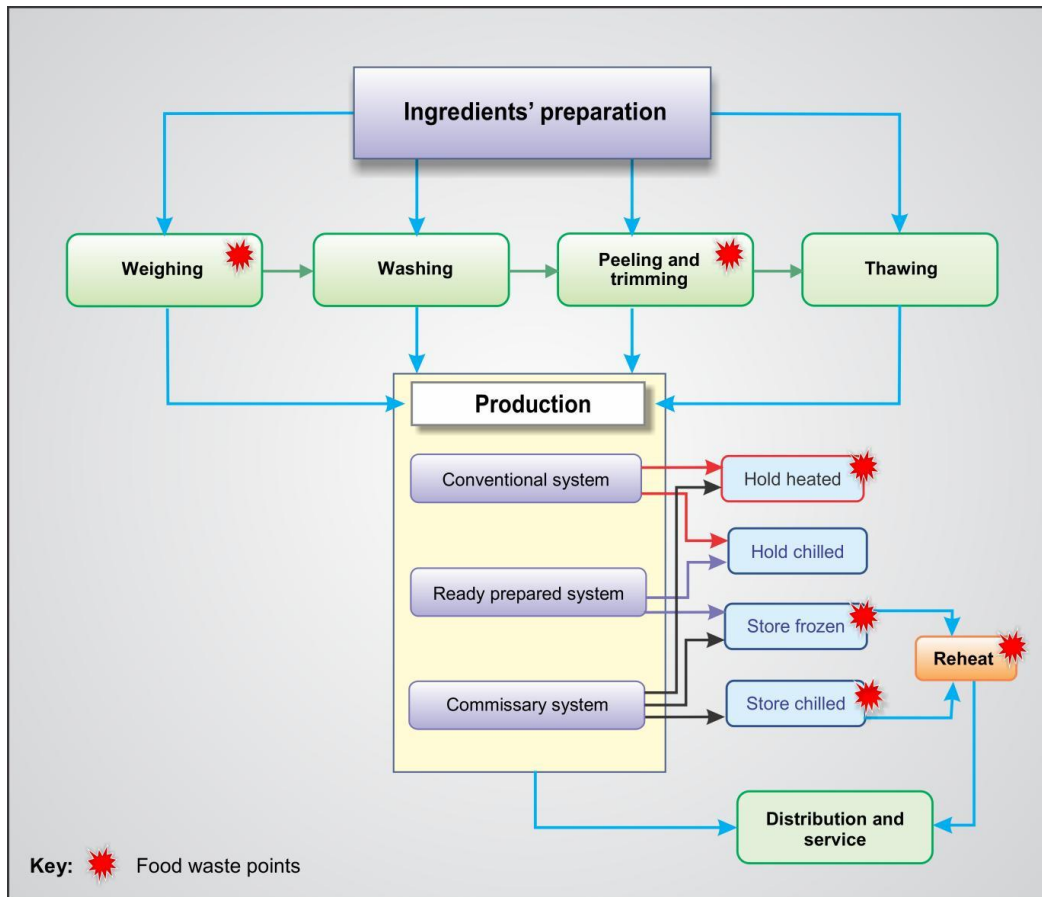
Comparing the findings with those of other studies confirms that overproduction of food is the leading cause of food waste in food service units (Burton et al., 2016; Goonan et al., 2014; Heikkilä et al., 2016; Kasavan et al., 2019; Prescott et al., 2019). In accordance with the present findings, previous studies have demonstrated that overproduction resulted from inaccurate forecasting (Garrone et al., 2014; Goonan et al., 2014; Silvennoinen et al., 2015). Food production mistakes such as burning and overcooking of food items, because of improper temperature control and failure to adhere to the prescribed cooking times, also influenced production waste. Food waste records indicated that 14 of the 70 portions (20 %) of pork cordon bleu were wasted because of burning on one cooking occasion. Previous literature failed to clearly discuss burnt or overcooked food as a contributor to food waste.

The study further demonstrated that the causes of food waste generation are dependent on the food production system applied by the food service unit. The case University food service unit applied a combination of food production systems; conventional, ready prepared and commissary food service systems. Figure 3 below indicates points at which food waste was generated in the food production system of the University food service unit.

Incorrect measuring or weighing of ingredients contributed to food waste. This involved weighing more ingredients than needed, which ended up being discarded instead of being returned to storage. In some cases, the inaccurate measuring of ingredients led to the production of poor-quality menu items, which resulted in service waste. During the preparation of food, the ingredients (*inputs*), which were less processed and required peeling, trimming, and cutting, contributed to unavoidable food waste. This is supported by the findings of other studies (Papargyropoulou et al., 2016; Pirani & Arafat, 2014), which linked minimally processed ingredients requiring preparation and cooking from scratch, with food waste generation at the preparation and production level. Additionally, cutting more ingredients than required, which were not stored for later use, led to food waste. A possible explanation for this might be that there were multiple differences in perceptions, attitudes, and habits of food service workers regarding food waste. While some were proactive around issues of food waste

and finding ways to curb waste, some were less concerned and not actively involved in its prevention.

Figure 3: Points of food waste generation in the food production system



Holding, distribution and service

Certain practices undertaken during hot holding, contributed to food waste. The findings revealed that forgetfulness by food service workers and lack of communication caused food waste during hot holding. This shows the interrelations between hot holding, inputs (human resources) and linking processes (communication) and their impact on food waste generation. For example, wastage of a batch of roasted chicken was observed when one of the food service workers forgot the chicken in the holding cabinet and failed to communicate to staff members responsible for service about this at the end of his shift. This chicken was found at the end of service and could not be saved for later use as it had previously been reheated.

Another factor that contributed to food waste during hot holding, was keeping food for too long in the heated cabinets. From a quality perspective, this practice led to overcooking of food and quality loss such as drying and loss of colour. This is illustrated by the comments below:

The food that is cooked is kept in the heated cabinets the whole day and it's very hot in there, from there it will be steamed again and put back in the heated cabinets. Like the rice from yesterday was put in the heated cabinets for lunch, and it was left there for supper, so it's like it is cooked a lot of times, from the heated cabinets it is kept in the bain-maries. It becomes overcooked and loses quality.

... yesterday at supper, a pan of vegetables was left in the heated cabinets for long and it changed colour to brown, we couldn't serve it and we had a shortage, the supervisor had to come with an alternative plan and prepared vegetables for supper service.

Under the ready prepared and commissary food production systems, food was stored frozen or chilled. Food wastage was experienced when the frozen or chilled food was stored and lost quality before consumption. Poor reheating practices when using the cook-chill and cook-freeze system also contributed to food waste. Chilled or frozen food items were reheated in bulk and the food that remained after service had to be discarded since food could only be reheated once for safety reasons. The study revealed that both the centralised and decentralised delivery-service systems applied at the University food service systems, contributed to food waste. In the centralised system, it was found that food waste was generated mostly at the service point. The food waste generated resulted mainly from poor portion control and the rejection of food by customers, due to perceived poor food quality. Where meals were produced at the central kitchen then distributed to remote sites (commissary food service system), a decentralised delivery-service system was applied. In this system, food waste occurred due to changes to the forecasted numbers of consumers. The bookings for meals or cancellation of these by students were allowed until 0400 hours on the day of service. However, remote kitchens were required to order meals a day in advance from the central kitchen. This meant that meals ordered by remote kitchens could not be cancelled as the central kitchen would have already prepared the food. In cases where the number of meals ordered was higher than the actual number of students served, food waste was generated. This corroborates the findings of a previous study by Ofei et al. (2014), which showed that a non-flexible requirement of placing meal orders at the central kitchen three (3) days in advance and declining the request for cancellations based on changes in the actual number of patients at the wards, caused food waste.

In agreement with studies conducted by Papargyropoulou et al. (2016) and Rajan et al. (2018), it was found that the type of service style used by the food service unit had an influence on food waste generation. For example, the buffet and traditional cafeteria service styles produced a considerable amount of waste. With the buffet service, overproduction of food that ended up unserved was a main challenge. A similar finding was made by Papargyropoulou et al. (2016). With regards to the traditional cafeteria service style, customers had an opportunity to request for an adjustment of food portions in line with their preferences. While this might have reduced plate waste, it contributed to food waste generation at the service point. Food that was planned for service but was left over, resulted in waste when not properly managed.

The study further found that portioning practices contributed to food waste in two ways, inaccurate portioning, and limited flexibility in portion size servings. With regards to inaccurate portioning, it was observed that despite the presence of portioning guidelines and standardised portion sizes (*controls*), front-of-house staff often served more food than prescribed. Inconsistencies of the amount of food served, were also observed. This is demonstrated in the comments below: "I think the portioning at service contributes to our waste because we over-serve and if you over-serve your yield is inaccurate." "Portions differ with different individuals, we all portion differently". These findings are consistent with that of Goonan et al. (2014), Heikkilä et al. (2016), Kasavan et al. (2019) and Pinto et al. (2018), who highlighted oversized portions and inconsistencies as common causes of food waste during service. Serving more food than the prescribed portion sizes may be due to attitudes and perceptions of food service workers about the portion sizes. The possible perception may be that the standardised portion sizes were too small to satisfy students. Servers often remarked that the White students as well as the female population were generally satisfied with small portion sizes, whereas Black students, and most males preferred larger portions. As such, they

often served Black students and males with larger portions than specified. This possibly indicates the contribution of cultural differences and demographic factors on food waste generation. A possible explanation for the inconsistencies in portioning may be the lack of common understanding of standardised portion sizes among food service workers responsible for serving. Additionally, poor portion control was observed specifically with starches, vegetables, and sauces. Whereas portions of meat products were carefully counted from production to service, the same was not done for starches, vegetables, and sauces. As such, a lot of starches, vegetables and sauces produced the bulk of the serving waste. These findings are in accordance with a study by Betz et al. (2015), who found that the largest area of food waste in two non-commercial food service establishments in Switzerland, was the serving losses of the starch and vegetable accompaniments. A possible explanation for this is that the wasted food products had little monetary value compared to meat products, thus wasting them cost the food service unit less. This may indicate that the University food service unit placed more emphasis on financial implications of food waste rather than environmental and social implications. These findings underscore the need for food service operators to develop interventions or strategies to help food service workers understand the effect of food waste on social and environmental implications (Muposhi & Musavengane, 2023).

Theoretical and managerial implications

This study offers three main contributions to theory and practice. First, the study is the first to look at food waste in the university food service holistically, from a systems' perspective. The understanding of food waste from this lens is useful in developing strategies that adequately address food waste in the entire food service system. Second, the themes that emerged from the investigation regarding food waste caused by the overproduction of food, informed the development of the overproduction and food waste framework. The framework disentangles how overproduction of food causes food waste in different stages of the food service system. Third, the study further developed a framework that indicates hotspots of food waste generation in the production phase of the food service system which can inform food service operators of areas to focus on to minimise food waste.

Conclusions

To prevent food waste and achieve more sustainable food systems, it is imperative to understand the causes of food waste from a holistic perspective. The study conducted a comprehensive investigation of the causes of food waste in all areas of the functional subsystem of the University food service. This paper has thus contributed to the limited literature in this context. An understanding of food waste from the systems perspective is useful in developing strategies that adequately address food waste in the entire food service system. Despite its contributions, the study has a few limitations. The study applied a qualitative case study approach focusing on one South African university food service operation, therefore, generalisability is limited and the findings may not apply to other food service operations. Therefore, caution should be taken when applying these findings to other food service operations.

References

- Abdelaal, A. H., McKay, G. & Mackey, H. R. (2019). Food Waste from a University Campus in the Middle East: Drivers, Composition, and Resource Recovery Potential. *Waste Management*, 98, 14-20.
- Babich, R. & Smith, S. (2010). Cradle to Grave: An Analysis of Sustainable Food Systems in a University Setting. *Journal of Culinary Science & Technology*, 8(4), 180-190.

- Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I. D., de Haan, S., Prager, S. D. & Khoury, C. K. (2019). When Food Systems Meet Sustainability—Current Narratives and Implications for Actions. *World Development*, 113, 116-130.
- Betz, A., Buchli, J., Göbel, C. & Müller, C. (2015). Food Waste in the Swiss Food Service Industry – Magnitude and Potential for Reduction. *Waste Management*, 35, 218-226.
- Börühan, G. & Ozbiltekin-Pala, M. (2021). Food Waste Management: An Example from University Refectory. *British Food Journal*, 124(1), 293-313.
- Burton, K., Serrano, E., Cox, H., Budowle, R. & Dulys-Nusbaum, E. (2016). Benefits, Barriers, and Challenges to University-level Food Waste Tracking. *Journal of Hunger & Environmental Nutrition*, 11(3), 428-438.
- Braun, V. & Clarke, V. (2012). *Thematic Analysis*. Washington, DC. American Psychological Association, USA.
- Charlebois, S., Creedy, A. & Von Massow, M. (2015). Back of House - Focused Study on Food Waste in Fine Dining: The Case of Delish Restaurants. *International Journal of Culture, Tourism and Hospitality Research*, 9(3), 278-291.
- Chiffolleau, Y., Millet-Amrani, S., Rossi, A., Rivera-Ferre, M.G. & Merino, P.L. (2019). The Participatory Construction of New Economic Models in Short Food Supply Chains. *Journal of Rural Studies*, 68, 182-190.
- Christ, K.L. & Burritt, R. (2017). Material Flow Cost Accounting for Food Waste in the Restaurant Industry. *British Food Journal*, 1193, 600-612.
- Costello, C., Birisci, E. & McGarvey, R. G. (2016). Food Waste in Campus Dining Operations: Inventory of Pre-and Post-Consumer Mass by Food Category, and Estimation of Embodied Greenhouse Gas Emissions. *Renewable Agriculture and Food Systems*, 31(3), 191-201.
- Creswell, J.W. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*. UK, London: Sage.
- De Vos, A.S., Strydom, H., Fouche, C.B. & Delpont, C.S.L. (2011). *Research at Grass Roots: for the Social Sciences and Human Service Professions*. Pretoria, Hatfield: Van Schaik.
- Falasconi, L., Vittuari, M., Politano, A. & Segrè, A. (2015). Food Waste in School Catering: An Italian Case Study. *Sustainability*, 711, 14745-14760.
- Ferreira, M., Liz Martins, M. & Rocha, A. (2013). Food Waste as an Index of Foodservice Quality. *British Food Journal*, 115(11), 1628-1637.
- Filimonau, V. & De Coteau, A. (2019). Food Waste Management in Hospitality Operations: A Critical Review. *Tourism Management*, 71, 234-245.
- Food and Agricultural Organisation. (2023). *Tackling Food Loss and Waste: A Triple Win Opportunity*. Available at <https://www.fao.org/newsroom/detail/FAO-UNEP-agriculture-environment-food-loss-waste-day-2022/en> [Retrieved 18 February 2023].
- Food and Agricultural Organisation. (2014). *Definitional Framework of Food Loss*. Available at https://www.fao.org/fileadmin/user_upload/save-food/PDF/FLW_Definition_and_Scope_2014.pdf [Retrieved 2 February 2023].
- Food Use for Social Innovation by Optimising Waste Prevention Strategies (FUSIONS). (2016). *Estimates of European Food Waste Levels*. Available at <https://www.eufusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf> [Retrieved 04 December 2022].
- Freedman, M.R. & Brochado, C. (2010). Reducing Portion Size Reduces Food Intake and Plate Waste. *Obesity*, 189, 1864-1866.
- Garrone, P., Melacini, M. & Perego, A. (2014). Opening the Black Box of Food Waste Reduction. *Food Policy*, 46, 129-139.

- Gillard, P. (2017). *Assessing and Quantifying Food Waste on the University of Saskatchewan Campus: Developing a Comprehensive Food-Waste Reduction Plan*. Unpublished doctoral thesis. Saskatoon: University of Saskatchewan. Available at https://sens.usask.ca/documents/msem-projects/P.Gilliard_Final_Report_30-07-17_Rec%2010-31-17.pdf [Retrieved 24 July 2022]
- Goonan, S., Miroso, M. & Spence, H. (2014). Getting a Taste for Food Waste: a Mixed Methods Ethnographic Study into Hospital Food Waste Before Patient Consumption Conducted at Three New Zealand Foodservice Facilities. *Journal of the Academy of Nutrition and Dietetics*, 114(1), 63-71.
- Govindan, K. (2018). Sustainable Consumption and Production in the Food Supply Chain: A Conceptual Framework. *International Journal of Production Economics*, 195, 419-431.
- Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R. & Meybeck, A. (2011). *Global Food Losses and Food Waste*, 1-38. Rome: FAO.
- Halloran, A., Clement, J., Kornum, N., Bucatariu, C. & Magid, J. (2014). Addressing Food Waste Reduction in Denmark. *Food Policy*, 49, 294-301.
- Heikkilä, L., Reinikainen, A., Katajajuuri, J.M., Silvennoinen, K. & Hartikainen, H. (2016). Elements Affecting Food Waste in the Food Service Sector. *Waste Management*, 56, 446-453.
- Hennchen, B. (2019). Knowing The Kitchen: Applying Practice Theory to Issues of Food Waste in the Food Service Sector. *Journal of Cleaner Production*, 225, 675-683.
- High Level Panel of Experts on Food Security and Nutrition. (2017). *Nutrition and Food Systems*. Available at <http://www.fao.org/3/a-i7846e.pdf> [Retrieved 22 March 2022].
- Jorgensen, D.L. (2015). Participant Observation. *Emerging Trends in the Social and Behavioural Sciences: An Interdisciplinary, Searchable, and Linkable Resource*, 1-15.
- Kasavan, S., Mohamed, A.F. & Halim, S.A. (2019). Drivers of Food Waste Generation: Case Study of Island-Based Hotels in Langkawi, Malaysia. *Waste Management*, 91, 72-79.
- Katajajuuri, J. M., Silvennoinen, K., Hartikainen, H., Heikkilä, L. & Reinikainen, A. (2014). Food Waste in the Finnish Food Chain. *Journal of Cleaner Production*, 73, 322-329.
- Kranert, M., Kusch, S., Huang, J. & Fischer, K. (2012). Anaerobic Digestion of Waste. In Karagiannidis, A. (Ed.), *Waste to Energy*. UK, London: Springer.
- Lundqvist, J., De Fraiture, C. & Molden, D. (2008). *Saving Water: From Field to Fork: Curbing Losses and Wastage in the Food Chain*. Available at https://www.siwi.org/wp-content/uploads/2015/09/PB_From_Field_to_Fork_2008.pdf [Retrieved 12 August 2022].
- Marais, M. L., Smit, Y., Koen, N. & Lötze, E. (2017). Are the Attitudes and Practices of Foodservice Managers, Catering Personnel and Students Contributing to Excessive Food Wastage at Stellenbosch University? *South African Journal of Clinical Nutrition*, 30(3), 60-67.
- Martin-Rios, C., Demen-Meier, C., Gössling, S. & Cornuz, C. (2018). Food waste Management Innovations in the Foodservice Industry. *Waste Management*, 79, 196-206.
- Muposhi, A. & Musavengane, R. (2023). Influencing Hotel Guests' Food Waste Reduction Intentions Through Social Marketing and Corporate Social Responsibility Stimuli. *African Journal of Hospitality, Tourism and Leisure*, 12(2), 783-797.
- Ofei, K.T., Holst, M., Rasmussen, H.H. & Mikkelsen, B.E. (2014). How Practice Contributes to Trolley Food Waste: A Qualitative Study Among Staff Involved in Serving Meals to Hospital Patients. *Appetite*, 83, 49-56.

- Ozcicek-Dolekoglu, C. & Var, I. (2019). Analysis of Food Waste in University Dining Halls: A Case Study from Turkey. *Feb - Fresenius Environmental Bulletin*, 28, 156-166.
- Painter, K., Thondhlana, G. & Kua, H.W. (2016). Food Waste Generation and Potential Interventions at Rhodes University, South Africa. *Waste Management*, 56, 491-497.
- Papargyropoulou, E., Wright, N., Lozano, R., Steinberger, J., Padfield, R. & Bin Ujang, Z. (2016). Conceptual Framework for the Study of Food Waste Generation and Prevention in the Hospitality Sector. *Waste Management*, 49, 326-336.
- Parfitt, J., Barthel, M. & Macnaughton, S. (2010). Food Waste Within Food Supply Chains: Quantification and Potential for Change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554), 3065-3081.
- Pinto, R.S., Dos Santos Pinto, R.M., Melo, F.F.S., Campos, S.S. & Cordovil, C.M.D. S. (2018). A Simple Awareness Campaign to Promote Food Waste Reduction in a University Canteen. *Waste Management*, 76, 28-38.
- Pirani, S.I. & Arafat, H.A. (2014). Solid Waste Management in the Hospitality Industry: A Review. *Journal of Environmental Management*, 146, 320-336.
- Prescott, M.P., Herritt, C., Bunning, M. & Cunningham-Sabo, L. (2019). Resources, Barriers, and Tradeoffs: A Mixed Methods Analysis of School Pre-Consumer Food Waste. *Journal of the Academy of Nutrition and Dietetics*, 119(8), 1270-1283.
- Priefer, C., Jörissen, J. & Bräutigam, K.R. (2016). Food Waste Prevention in Europe—A Cause-Driven Approach to Identify the Most Relevant Leverage Points for Action. *Resources, Conservation and Recycling*, 109, 155-165.
- Qian, L., Li, F., Cao, B., Wang, L. & Jin, S. (2021). Determinants of Food Waste Generation in Chinese University Canteens: Evidence from 9192 University Students. *Resources, Conservation and Recycling*, 167.
- Rajan, J., Fredeen, A.L., Booth, A.L. & Watson, M. (2018). Measuring Food Waste and Creating Diversion Opportunities at Canada's Green University. *Journal of Hunger & Environmental Nutrition*, 13(4), 573-586.
- Rethink Food Waste (ReFED). 2017. *Foodservice Food Waste Action Guide*. Available at https://www.refed.com/downloads/Foodservice_Guide_Web.pdf [Retrieved 13 July 2021].
- Saccares, S., Scognamiglio, U., Moroni, C., Marani, A., Calcaterra, V., Amendola, M. & Morena, V. (2014). Evaluation Model of Plate Waste to Monitor Food Consumption in Two Different Catering Settings. *Italian Journal of Food Safety*, 3(1669), 107-110.
- Schwartz, M.B., Henderson, K.E., Read, M., Danna, N. & Ickovics, J. R. (2015). New School Meal Regulations Increase Fruit Consumption and do not Increase Total Plate Waste. *Childhood Obesity*, 11(3), 242-247.
- Silvennoinen, K., Heikkilä, L., Katajajuuri, J. M. & Reinikainen, A. (2015). Food Waste Volume and Origin: Case Studies in The Finnish Food Service Sector. *Waste Management*, 46, 140-145.
- Smith, S.L. & Cunningham-Sabo, L. (2014). Food Choice, Plate Waste and Nutrient Intake of Elementary-and Middle-School Students Participating in the US National School Lunch Program. *Public Health Nutrition*, 17(6), 1255-1263.
- Sonnino, R. & McWilliam, S. (2011). Food Waste, Catering Practices and Public Procurement: A Case Study of Hospital Food Systems in Wales. *Food Policy*, 36(6), 823-829.
- Stewart, D. W. & Shamdasani, P. N. (2014). *Focus Groups: Theory and Practice* (Vol. 20). Thousand Oaks, CA: Sage.

- Thi, N.B.D., Kumar, G. & Lin, C.Y. (2015). An Overview of Food Waste Management in Developing Countries: Current Status and Future Perspective. *Journal of Environmental Management*, 157, 220-229.
- Thiagarajah, K. & Getty, V.M. (2013). Impact on Plate Waste of Switching from a Tray to A Trayless Delivery System in a University Dining Hall and Employee Response to The Switch. *Journal of the Academy of Nutrition and Dietetics*, 113(1), 141-145.
- Thorsen, A.V., Lassen, A.D., Andersen, E.W., Christensen, L.M., Biloft-Jensen, A., Andersen, R. & Tetens, I. (2015). Plate Waste and Intake of School Lunch Based on the New Nordic Diet and on Packed Lunches: A Randomised Controlled Trial in 8-to 11-Year-Old Danish Children. *Journal of Nutritional Science*, 4(20).
- Thyberg, K.L. & Tonjes, D.J. (2016). Drivers of Food Waste and their Implications for Sustainable Policy Development. *Resources, Conservation and Recycling*, 106, 110-123.
- Van Geffen, L., Van Herpen, E. & Van Trijp, H. (2020). Household Food Waste — How to Avoid it? An Integrative Review. In *Food Waste Management*. Palgrave Macmillan.
- Van Holsteijn, F. & Kemna, R. (2018). Minimizing Food Waste by Improving Storage Conditions in Household Refrigeration. *Resources, Conservation and Recycling*, 128, 25-31.
- Waste and Resources Action Programme (WRAP). (2013). Overview of Waste in the UK Hospitality and Food Service Sector. Available at <https://wrap.org.uk/sites/default/files/2020-10/WRAP-Overview%20of%20Waste%20in%20the%20UK%20Hospitality%20and%20Food%20Service%20Sector%20FINAL.pdf> [Retrieved 10 June 2021].
- Whitehair, K.J., Shanklin, C.W. & Brannon, L.A. (2013). Written Messages Improve Edible Food Waste Behaviors in a University Dining Facility. *Journal of the Academy of Nutrition and Dietetics*, 113(1), 63-69.
- Wu, Y., Tian, X., Li, X., Yuan, H. & Liu, G. (2019). Characteristics, Influencing Factors, and Environmental Effects of Plate Waste at University Canteens in Beijing, China. *Resources, Conservation and Recycling*, 149:151-159.