



A Systems Approach to Food Waste Prevention in Food Service Operations: An Integrative Review

Boineelo Pearl Lefadola*
Department of Consumer and Food Sciences
University of Pretoria
Pretoria, South Africa
Email: nkelepb@ub.ac.bw

Annemarie Viljoen
Department of Consumer and Food Sciences
University of Pretoria
Pretoria, South Africa
Email: annemarie.viljoen@up.ac.za

Gerrie Elizabeth du Rand
Department of Consumer and Food Sciences
University of Pretoria
Pretoria, South Africa
Email: gerrie.durand@up.ac.za

Corresponding author*

Abstract

The magnitude and complexity of the global food waste problem is attracting increased attention worldwide. Given the magnitude of the problem of food waste and its associated impacts, food waste prevention and reduction practices are gaining greater attention than ever before. Prevention of food waste is important economically, environmentally and socially. In addition to that, prevention of food waste may contribute to the achievement of the third target of Sustainable Development Goal 12 (target 12.3) which calls for halving per capita global food waste at the retail and consumer level, and reducing food losses along production and supply chains by 2030 (Food and Agricultural Organisation, 2018). Given the undisputed importance of food waste prevention, the current study reviewed the literature in order to identify current practices applied in food service operations to prevent and reduce food waste. The study applied an integrative review methodological approach following the guidelines of Whittemore and Knafl (2005). A total of 36 articles were reviewed and this included 25 empirical articles and 11 organizational guides. A thematic analysis approach was employed to identify patterns and themes from the literature. The analysis revealed a total of 56 food waste prevention and reduction strategies in the inputs subsystem, the subsystems that transform inputs into outputs, the outputs, controls, management, feedback, memory as well as environmental factors of the food service system. Further research is required to develop formal and validated tools that follow a holistic approach which can assist in the prevention of food waste throughout all stages of the food service system.

Keywords: food waste, food waste prevention, food waste management, food service operations, integrative review

Introduction

The concept of food waste is seemingly straightforward, yet it is underpinned by considerable complexity and there is little universal consensus regarding its definition (Thyberg and Tonjes, 2016). A variety of terminologies and phrases have been used when discussing 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; Irish Environmental Protection Agency, 2014). Thi et al. (2015) further point out that the



definition and usage of food loss and waste terms is 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 interchangeably (Thi et al., 2015). Recently, the (High Level Panel of Experts on Food Security and Nutrition, 2014) coined another food wastage terminology – "food quality loss or waste". For the purpose of this study, the term food waste is adopted and it is defined as any edible portion of food that is discarded at some point along the food service system as part of the processes and activities in the food service operation.

The issue of food waste has gained increasing attention worldwide with growing concern around economic, environmental and social impacts associated with food waste (Goonan et al., 2014). From an economical perspective, the literature clearly indicates that food waste carries significant economic losses (Buzby and Hyman, 2012; Nahman et al., 2012; Nahman and de Lange, 2013; Quested et al., 2013; Whitehair et al., 2013). Reducing food waste benefits foodservice operators in gaining economic benefits in two ways; efficient use of limited resources hence saving costs embedded within resources, as well as reducing costs linked to food production and disposal of food waste (Papargyropoulou et al., 2014). Secondly, food waste is associated with significant environmental impacts which are dependent on food waste management practices adopted (Thyberg and Tonjes, 2016). Prevention is the most favourable option and disposal is the least favourable. However there is still a significant portion of food waste – (90 percent of wasted food) that ends up at the landfills which impacts the environment negatively (Thi et al., 2015). In landfills, food waste converts to methane, a greenhouse emission that hugely contributes towards global warming (Papargyropoulou et al., 2014, de Lange and Nahman, 2015, Scholz et al., 2015). Approximately 20 percent of the global greenhouse gas emissions are associated with the food supply chain (Kallbekken and Sælen, 2013). The current study therefore adopts a food waste prevention approach as the most favourable option that has less adverse impacts on the environment. From a social perspective, discarding edible food while millions of people around the world go hungry each day is socially unethical (Oelofse and Nahman, 2013).

Despite the importance of food waste prevention, the volume of food waste generated continues to grow. It is shown that at least 1.3 billion tonnes of food per year is wasted globally (Gustavsson et al., 2011). Several scholars have studied food waste in food service operations over years. The results of their studies indicate that food service operations are among large generators of food waste (Goonan et al., 2014). Food service operators like other role players in the food supply chain are compelled to prevent or reduce food waste. In addition to that, prevention of food waste may contribute to achievement of the third target of Sustainable Development Goal 12 (target 12.3) which calls for cutting in half per capita global food waste at the retail and consumer level, and reducing food losses along production and supply chains by 2030 (FAO, 2018). Given the undisputed importance of food waste prevention, the current study reviewed the literature in order to identify current practices applied in food service operations to prevent and reduce food waste.

Theoretical Perspectives

The study acknowledges the assumptions of Ludwig von Bertalanffy's systems theory (Von Bertalanffy, 1968). The literature defines the systems theory as a management approach that views an organisation holistically, made up of a set of interdependent and interrelated parts that work together to achieve a common goal (Goonan et al., 2015). The current study applied the systems approach by considering food waste prevention practices on the entire food service system and critically scrutinizing application of these practices at each of the subsystems.

The study considers a food service organisation as a system. The food service systems model includes inputs, which are transformed into outputs through operations in the transformation



subsystem (Gregoire, 2017). The functions of control, management and memory impact the transformation process (Goonan et al., 2015). All subsystems interact with the external environmental factors (Goonan et al., 2015). Feedback from any part of the system provides useful information to the managers which can inform them about corrective measures necessary to restore equilibrium (Gregoire, 2017; Payne-Palacio and Theis, 2016).

From a systems viewpoint food waste is conceptualised as an undesirable output resulting from a set of interrelated practices in different sub-systems of the food service system. The systems model considers inputs to have an impact on the system. A faulty input can cause waste at subsequent points of the food service system (Sushil, 1990). The knowledge and skills of food service workers, the state of ingredients, information used, equipment and time may contribute to food waste prevention or reduction. The operations or transformation sub-system is a critical stage at which the quantifiable food waste can be generated as a result of poor practices put in place during the transformation of inputs into outputs. However, some practices at this stage can help prevent or reduce food waste.

Controls of a foodservice system are external legal documents and internal plans that guide how the organisation operates (Gregoire, 2017; Payne-Palacio and Theis, 2016). External controls consist of local, national and international laws and regulations as well as contracts with outside companies. Internal controls include plans consisting of goals and objectives of the operation, standards, policies and procedures (Gregoire, 2017). In the context of the current study, effective plans, well designed contracts and laws and regulations that considers alleviating food waste are an important part of a food service system that seeks to prevent food waste.

The systems approach also has a focus on the memory; all records of past performance of the food service system's operations (Payne-Palacio and Theis, 2016). This is an important element of the study as analysis of past records may provide the manager with useful information that can be used in making plans and avoiding repetition of past errors including food waste generation trends as well as which food waste prevention measures work best. In the same manner, feedback is considered as a critical component of this study. Gregoire (2017) describes feedback as information received from the internal and external environment on how systems worked or failed. This can inform management on what needs to be changed (Payne-Palacio and Theis, 2016) in particular with regards to systems that impact food waste generation. In the systems approach, management integrates and coordinate resources to achieve intended goals of the food service organisation (Payne-Palacio and Theis, 2016). The current study takes the perspective that an effective and efficient management system may be an important element in the prevention of food waste.

Methodological Approach of the Study

The study applied an integrative review methodological approach following the guidelines described by Whittemore and Knafl (2005). An integrative review method is an approach that allows incorporation of data from a variety of literature sources when little empirical research has been done in an area (Carey et al., 2011). Limited empirical research has been done in the area of food waste prevention practices in the food service sector. As such the researcher used organizational guides and cases on best practices in addition to the limited scientific research available. The approach was suitable for the current study as it allowed for identification and integration of concepts and themes which led to theory building (Nicholson et al., 2017). The review method as executed in the study is illustrated in figure 1 and explained below.

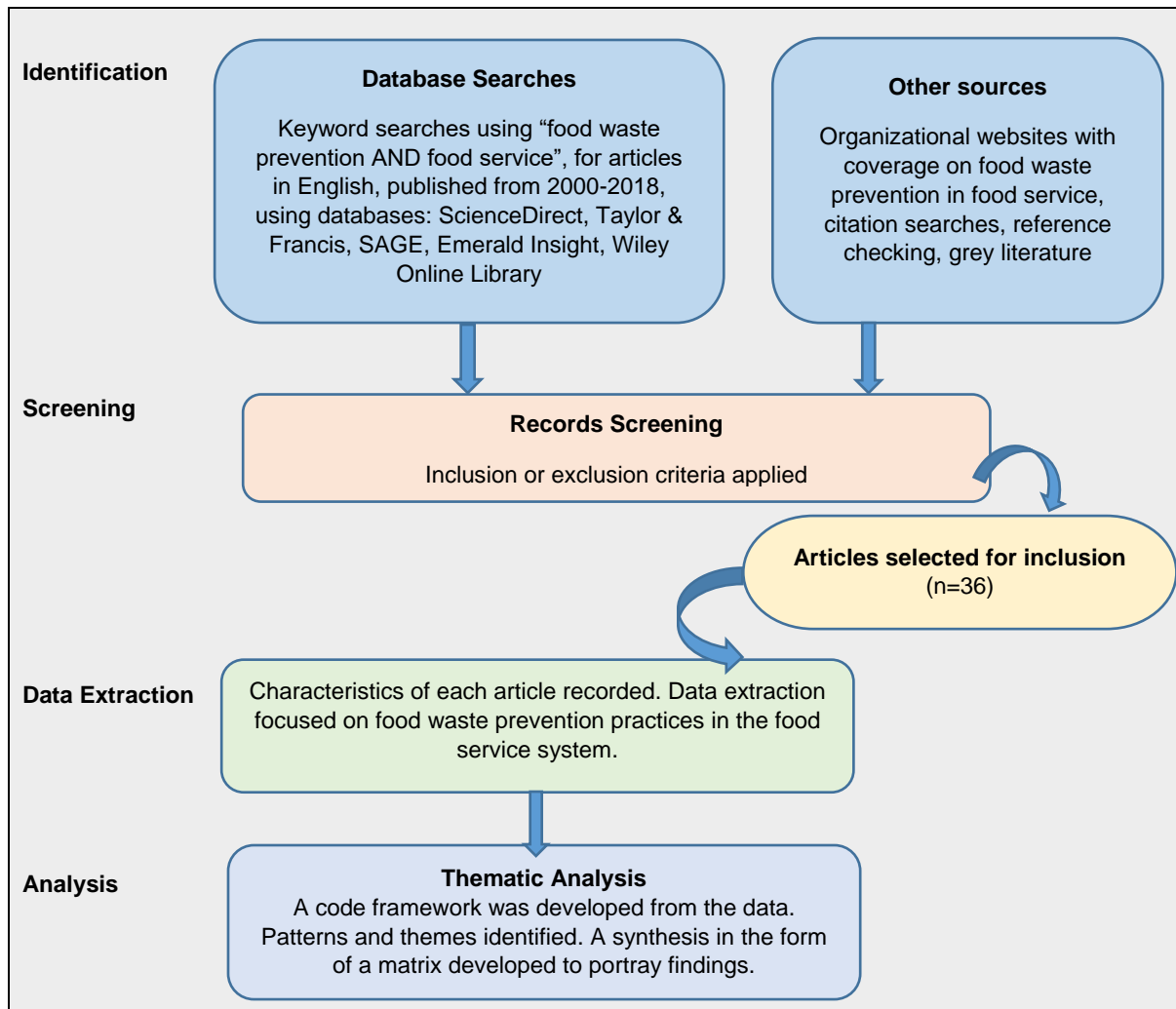


Figure 1: Steps Followed in Conducting the Integrative Review

Identification

Searches of databases were performed using a combination of terms and different Boolean operators. Such combinations as: “food waste generation AND food service”, “food waste prevention AND food service”, “food waste management AND food service”, “food waste reduction and food service” were used. The terms restaurant, kitchens, catering operations, canteens and hospitality sector were used synonymously with food service. Specificity of the searches was further enhanced by using keyword filters: NOT supermarkets, NOT households, NOT agricultural production, NOT postharvest handling and storage, NOT processing and packaging, NOT solid waste. ScienceDirect, Taylor & Francis, SAGE, Emerald Insight, Wiley Online Library and Google Scholar were searched. Additionally, citation searches, reference tracking on identified articles and web based searching were conducted to identify grey literature (Carey et al., 2011; Nicholson et al., 2017).

Screening

Articles with coverage on food waste reduction and prevention in the food service sector were retained for further evaluation. A framework for inclusion and exclusion (Table 1) was developed and applied to screen retained articles. The final sample (n = 36) included 25 empirical articles and 11 organizational guides. Reviewers recorded all decisions made during the screening process and there was no disagreement between reviewers regarding eligibility of articles selected.



Table 1: Inclusion or Exclusion Criteria

<i>Inclusion Criteria</i>	<i>Exclusion Criteria</i>
Original publication in English Published between year 2000 and 2018 Focus on food service operations	Written in languages other than English Published before year 2000 Focus on supermarkets, retail, households, agricultural production, food processing and packaging.
Covering food waste prevention practices or strategies in food service settings.	Articles did not cover any food waste prevention practices that are relevant to the food service operations.

Data Extraction

Using data extraction procedures outlined by Whittemore and Knafel (2005), a matrix was developed to record summary of characteristics of each article including: period of study, country, topic, purpose of the study, study design, and study site or setting. Another matrix was developed to record identified themes on food waste prevention practices. The practices were categorized according to the subsystems of the systems model of food service organizations.

Data Analysis

Thematic analysis was used to identify the prominent themes that describe current food waste prevention practices applied in food service settings. The study adopted the approach suggested by Braun and Clarke (2006) for analysis. A code framework was developed using the extracted data from each article in order to outline patterns. Retained articles were read at least three times in order to analyse and synthesise themes, patterns, and variations within the articles. Data matrices were used to categorically display coded data from each article and were iteratively compared.

Findings and Discussions

Food Waste Prevention Practices

The following section provides a review of food waste prevention approaches that are currently being implemented in the food service sector. The review follows a systems approach within the food service system.

Table 2: Food Waste Prevention Practices in Food Service Operations

Systems Component	Food Waste Prevention Practices or Strategies	Relevant Research Evidence
Inputs	Pre-booking system that however allows for an advanced cancellation before preparation time.	Beretta et al. (2013), Ferreira et al. (2013), Irish Environmental Protection Agency (2014), Marais et al. (2017), Marthinsen et al. (2012), Ofei et al. (2014), Painter et al. (2016), Papargyropoulou et al. (2016) Derqui et al. (2016), Marthinsen et al. (2012)
	Use of advanced demand planning software.	Betz et al. (2015), Derqui et al. (2016), Heikkila et al. (2016), International Tourism Partnership (2014), LeanPath (2016), Marthinsen et al. (2012), Pirani and Arafat (2016), United States Environmental Protection Agency (2014)
	Flexible menu planning that allows use of food approaching its expiration date, excess ingredients and utilisation of leftovers.	Scotland Resource Efficient (2014), Strotmann et al. (2017), Thyberg and Tonjes (2016)
	Design a lean menu: reducing the number of menu options which will result in simplified production planning and lower food waste.	Betz et al. (2015), Charlebois et al. (2015), Derqui et al. (2016), Ferreira et al. (2013), Heikkila et al. (2016), Priefer et al. (2016), Scotland Resource Efficient (2014), Strotmann et al. (2017), Thyberg and
	Trained and experienced employees.	



	Tonjes (2016), United States Environmental Protection Agency (2014) Charlebois et al. (2015), Creedon et al. (2010)
Implement a regular cleaning and maintenance programme for all equipment.	
Transformation	
Procurement	
Continuous supplier evaluation	Charlebois et al. (2015)
Development and adherence to food specifications.	Charlebois et al. (2015)
Sourcing ingredients locally.	Creedon et al. (2010), Derqui et al. (2016), Pirani and Arafat (2014)
Purchase perishable food with sufficiently long expiry date.	Betz et al. (2015), Creedon et al. (2010)
Enhancement of order interval and no stock buying.	Heikkila et al. (2016), Creedon et al. (2010)
Ordering suitable amounts of food.	Derqui et al. (2016), Heikkila et al. (2016), Halloran et al. (2014), Irish Environmental Protection Agency (2014)
Package considerations: Optimizing food packaging size and design to ensure complete utilisation by the operation avoid residual container waste.	Heikkila et al. (2016), ReFED (2016)
Receiving	
Checking deliveries to ensure that they are from contaminants, meet specifications and that packaging is undamaged.	Charlebois et al. (2015), Creedon et al. (2010), Pirani and Arafat (2014)
Perishables and frozen food promptly transferred to storage areas immediately after delivery.	Engström and Carlsson-Kanyama (2004)
Label and date all products upon delivery.	Creedon et al. (2010)
Storage, Inventory Control and Issuing	
Application of the First-In-First-Out (FIFO) approach.	Betz et al. (2015), Charlebois et al. (2015), Creedon et al. (2010), Derqui et al. (2016), International Tourism Partnership (2014), Irish Environmental Protection Agency (2014), Marthinsen et al. (2012), Pirani and Arafat (2014), United States Environmental Protection Agency (2014)
Ensure proper storage of all food.	Betz et al. (2015), Beretta et al. (2013), Creedon et al. (2010), International Tourism Partnership (2014), Marthinsen et al. (2012), Pirani and Arafat (2014), United States Environmental Protection Agency (2014)
High compliance with stock rotation e.g. rotating perishable stock at every delivery.	Creedon et al. (2010), Goonan et al. (2014), Pirani and Arafat (2014)
Periodic control of date of expiry and monitoring inventory levels.	Betz et al. (2015), Derqui et al. (2016), United States Environmental Protection Agency (2014)
Adequate storage space.	Engström and Carlsson-Kanyama (2004)
Maintain the appropriate storage temperature.	Creedon et al. (2010)
Ensure that the refrigerator and freezing equipment are operating at the required temperature.	Creedon et al. (2010)
Controlled food issuance	Kinasz et al. (2015)
Preparation and Production	
Avoid over-trimming during preparation.	Pirani and Arafat (2014), Creedon et al. (2010), LeanPath (2016)
The use of pre-prepared ingredients.	Creedon et al. (2010), Derqui et al. (2016), Goonan et al. (2014), International Tourism Partnership (2014)
Use of good quality ingredients.	LeanPath (2016)
Reducing the number of menu options	Heikkila et al. (2016)
Batch cooking	



	Improved food preparation techniques.	Creedon et al. (2010), LeanPath (2016), Marais et al. (2017), Marthinsen et al. (2012), United States Environmental Protection Agency (2014) Papargyropoulou et al. (2016)
	Distribution Regulation and maintenance of food temperature during holding. Logistic improvements: improved transportation that reduces food damage and improved food packaging.	Betz et al. (2015), Creedon et al. (2010) Thyberg & Tonjes (2016)
	Service Accurate order taking and food ordering Use of smaller containers for buffet service or control amount of food put on serving areas. Changing from buffet to a la carte service.	Creedon et al. (2010) Betz et al. (2015), Creedon et al. (2010), Irish Environmental Protection Agency (2014), LeanPath (2016) Halloran et al. (2014), Papargyropoulou et al. (2016), Pirani and Arafat (2016), Pirani and Arafat (2014) Betz et al. (2015), Heikkila et al. (2016), Ofei et al. (2015) Betz et al. (2015), Derqui et al. (2016), Irish Environmental Protection Agency (2014) Ferreira et al. (2013), Heikkila et al. (2016), Ofei et al. (2014) Heikkila et al. (2016), Silvennoinen et al. (2015) LeanPath (2016), United States Environmental Protection Agency (2014) Kinasz et al. (2015)
	Attractive presentation of meals.	
	Reducing the range and amount of food offered towards the end of service time.	
	Use standardised portioning equipment	
	Sufficiently long meal times	
	Reduce use of rarely eaten garnishes.	
	Monitor food holding temperature	
Controls	Meal auditing	Charlebois et al. (2015), Goonan et al. (2014)
	Stock monitoring and rotation policies.	Goonan et al. (2014), Marthinsen et al. (2012), Priefer et al. (2016), ReFED (2016)
	Food safety plans and regulations.	Creedon et al. (2010), Goonan et al. (2014), Papargyropoulou et al. (2016), Priefer et al. (2016)
	Portioning guidelines Standardised recipes Food purchasing policies	Goonan et al. (2014) Goonan et al. (2014) United States Environmental Protection Agency (2014)
	Just-in-Time (JIT) system	Derqui et al. (2016), Ofei et al. (2015), United States Environmental Protection Agency (2014)
Management	Effective communication between personnel across different units, suppliers, customers and other relevant stakeholders.	Goonan et al. (2014), Heikkila et al. (2016), Irish Environmental Protection Agency (2014), Ofei et al. (2014), Ofei et al. (2015), Papargyropoulou et al. (2016), Strotmann et al. (2017)
	Effective management and control of kitchen activities.	Heikkila et al. (2016)
Outputs	Management and re-use of leftovers	Betz et al. (2015), Engström and Carlsson-Kanyama (2004), LeanPath (2016), Ofei et al. (2015), United States Environmental Protection Agency (2014)
Memory	Accurate forecasting e.g. through use of automated forecasting system	Goonan et al. (2014), International Tourism Partnership (2014), Papargyropoulou et al. (2016), Priefer et al. (2016), Silvennoinen et al. (2015)
	Utilising computer generated recipes	Marais et al. (2017), Pirani and Arafat (2016)
	Long term analysis of meals	Betz et al. (2015), Derqui et al. (2016), Ferreira et al. (2013), Irish Environmental



		Protection Agency (2014), Marais et al. (2017), Painter et al. (2016), Pirani and Arafat (2016), Priefer et al. (2016), United States Environmental Protection Agency (2014)
Feedback	Food waste tracking and analytics	Burton et al. (2016), Creedon et al. (2010), LeanPath (2016), Ofei et al. (2015), Ofei et al. (2014), Pirani and Arafat (2014), Priefer et al. (2016), ReFED (2016), Silvennoinen et al. (2015), United States Environmental Protection Agency (2014)
Environmental Factors	Taxes and fees on waste treatment	Priefer et al. (2016), Thyberg and Tonjes (2016)
	Legislation to ban landfilling of organics	Thyberg and Tonjes (2016)

Food Waste Prevention in the Inputs Subsystem

The literature indicates that a number of elements within the inputs subsystem can assist in food waste prevention. Trained or skilled staff are key in the prevention of food waste more especially production waste, as they reduce the risk of spoilage and the need to re-produce food items (Papargyropoulou et al., 2016). The literature also clearly indicates that flexible menu planning that allows use of food approaching its expiration date, excess ingredients and utilisation of leftovers (Betz et al., 2015; Derqui et al., 2016; Heikkila et al., 2016; LeanPath, 2016; Marthinsen et al., 2012; Pirani and Arafat, 2016; Pirani and Arafat, 2014; United States Environmental Protection Agency, 2014). Additionally Thyberg and Tonjes (2016) argue that a simple lean menu with fewer options result in simplified production and lower food waste.

A pre-booking system that allows for cancellation before preparation time, marginally reduces food wastage through an almost accurate estimation of the would-be taken meals (Marais et al., 2017; Painter et al., 2016). Further to that there are several software packages available for advanced demand planning in the food service sector which allows for accurate prediction of demand and thus significantly contributes to food waste prevention (Derqui et al., 2016). In addition to that the literature indicates that implementation of a regular cleaning and maintenance programme for all equipment plays a role in food waste prevention (Charlebois et al., 2015; Creedon et al., 2010). Regular cleaning and maintenance of equipment extends the life of compressors, and hence avoids food spoilage that may otherwise be caused by equipment breakdowns (Creedon et al., 2010).

Food Waste Prevention in the Transformations Subsystem

A number of food waste prevention approaches are put in place in the transformation subsystem of food service operations. This sub-section discusses food waste prevention approaches at different stages of the transformation subsystem.

Procurement

Various approaches have been applied to prevent and reduce food waste at the procurement stage of the food service system. One of the strategies is continuous supplier evaluation in which suppliers are regularly appraised for such aspects as product quality, timely delivery and ability to supply the required volume, all of which directly influence food waste prevention in the food service operation (Charlebois et al., 2015). Additionally, food service operations establish specific standards or food specifications that suppliers have to abide to, failure of which food can be rejected upon delivery in order to avoid food waste generated by the supplier (Charlebois et al., 2015). The literature (Creedon et al., 2010; Derqui et al., 2016; Pirani and Arafat, 2014) further indicates that sourcing ingredients locally ensures that the food service operation receives freshest ingredients hence reducing the risk of spoilage. Careful consideration also needs to be made regarding the food packaging. A suitably sized and designed package ensures complete utilization of the food product and avoids residual container waste (Heikkila et al., 2016). While not all food is available in suitable sizes, food



service operators have leverage to make specifications in terms of the packaging design and size required in order to minimize food wastage as a result of spoilage of leftover or unused ingredients.

Other commonly applied food waste prevention practices include avoiding overstocking and ordering suitable amounts of food for a given period (Derqui et al., 2016; Heikkila et al., 2016; Halloran et al., 2014; Irish Environmental Protection Agency, 2014). As a way of avoiding overstocking, food service operators establish a system that allows them to record what is in stock and what needs to be ordered, and the ingredients that are moving slowly plus their expiry dates, as the ingredients are used the stock quantity is reduced and the quantity of what needs to be ordered is altered appropriately (Creedon et al., 2010). Additionally, prevention of food waste at the procurement stage entails purchasing perishable food with sufficiently long expiry dates in order to avoid food spoilage before the food can be used (Betz et al., 2015).

Receiving

The most common strategy applied at the receiving point to minimize food waste is checking deliveries to ensure that food is free from contaminants, it meets specifications, not expired and that the packaging is not damaged (Charlebois et al., 2015; Pirani and Arafat, 2014). Any food product that does not meet the standards is immediately returned to the supplier in order to avoid food waste on the part of the food service operator. Upon delivery, all food products are labelled using an easily understandable food labelling system; the label should clearly indicate the expiration dates, date of receipt or delivery, product name and storage instructions (Creedon et al., 2010). This information will enable food service workers to optimize inventory control hence minimize food spoilage. Once food is delivered and labelled it is promptly transferred to the storage areas. This is especially critical with perishables and frozen food which are put in refrigerators and freezers within the shortest period possible, which prevents food spoilage through maintenance of the appropriate temperature (Engström and Carlsson-Kanyama, 2004).

Storage, Inventory Control and Issuing

A number of strategies have been implemented during storage, inventory control and issuing to prevent food waste in the food service system. Adequate storage space is an important aspect of food waste prevention that allows food service workers to store food appropriately as well as enables arrangement of food in a manner that allows easy access to food products (Engström and Carlsson-Kanyama, 2004). This helps minimize food wastage that may occur due to spillages, breakages and spoilage. Furthermore, Betz et al. (2015) and Beretta et al. (2013) underline the optimisation of storage conditions and proper storage of food as per the storage requirements as amongst the recommended initiatives to reduce food waste. Moreover, Creedon et al. (2010) mention the importance of maintaining the appropriate storage temperature and ensuring that storage equipment are operating at the required temperature as this prevents food spoilage that may occur due to microbial growth. Storage waste could also be minimized by another approach commonly applied to prevent food waste at this stage, is the First-In-First-Out approach and high compliance with stock rotation, in order to ensure that food is used within its expiration date (Betz et al., 2015; Charlebois et al., 2015; Creedon et al., 2010; Derqui et al., 2016; Marthinsen et al., 2012; Pirani and Arafat, 2016; United States Environmental Protection Agency, 2014). Periodic control of expiry dates and adaptation of menus to use food which is close to its expiry date is highly recommended for food waste prevention (Betz et al., 2015; Derqui et al., 2016; United States Environmental Protection Agency, 2014). To prevent food waste during process of issuing stock the storage clerk should comply with the foodstuff quantities ordered by the kitchen staff and use as stated on the production recipe (Kinasz et al., 2015).



Preparation and Production

Food waste at the preparation and production stage is minimized by avoiding over-trimming of ingredients especially bulk meats and whole vegetables (Pirani and Arafat, 2014; Creedon et al., 2010; LeanPath, 2016). Where food trimmings occur, food service operators may use such trimmings to produce other food items like stock in order to curb food waste. (Derqui et al., 2016; Goonan et al., 2014) highlight the use of pre-prepared ingredients as an important strategy that significantly eliminate food waste due to trimmings. However, this approach shifts responsibility of food waste generation further up the food chain thus need to be applied with caution. A study by Heikkila et al. (2016) elucidate that the use of good quality ingredients in food production is important in minimising generation of kitchen waste. Good quality ingredients produce good quality meals that are suitable for human consumption and reduces the chances for discarding food. According to Papargyropoulou et al. (2016) another strategy that has the potential to reduce food wastage is improving preparation techniques for the commonly wasted food products.

Other strategies for food waste prevention include reduction of menu options which result in simplified production planning hence lower food waste (Marais et al., 2017). Preparation of food to order, or batch cooking in which food especially those that need a short preparation time are prepared as needed during serving time which allows for greater accuracy and reduces the likelihood of overproduction (Creedon et al., 2010; LeanPath, 2016; Marais et al., 2017; Marthinsen et al., 2012).

Distribution

Hot and cold holding of food is a critical process in the distribution phase of a food service system. Maintenance of a proper temperature during holding of food contributes to food waste prevention as it preserves the safety of food and avoids food spoilage (Betz et al., 2015; Creedon et al., 2010; Engström and Carlsson-Kanyama, 2004). In a decentralized delivery-service system, there is need for improved logistics such that transportation and packaging used reduces food damage when food is ferried from a central kitchen to satellite kitchens (Thyberg and Tonjes, 2016).

Service

During service, accurate order taking and food ordering appear to contribute towards preventing food waste (Creedon et al., 2010). Front of the office staff who provide customers with clear descriptions of meal items and accurately take orders from customers as well as accurately communicate orders with kitchen staff, minimize order errors hence reduce the risk of food waste generation. In addition to this, appropriately using standardized serving tools has a role in preventing food waste (Kinasz et al., 2015). This strategy increases accuracy in portion control thereby reducing food waste (Heikkila et al., 2016; Ofei et al., 2014). Research (Pirani and Arafat, 2014) further indicates that food service operators who changed their service from buffet to a la carte service experienced a noticeable decrease in food waste. Buffet service is associated with overproduction of food that ends up not served as compared to the a la carte service (Papargyropoulou et al., 2016). To minimize food waste in a buffet service, smaller containers are used and a limited amount of food is put on the serving area (Betz et al., 2015).

Research (Heikkila et al., 2016; Silvennoinen et al., 2015) illustrates that sufficiently long meal times reduce food waste as this strategy ensures sufficient time for patrons to order, eat and possibly finish the produced food. Along the same lines, reducing the range and amount of food offered towards the end of service time plays a critical role in food waste prevention (Betz et al., 2015; Derqui et al., 2016, Irish Environmental Protection Agency, 2014). Another strategy applied to prevent food waste in the food service operation is to regularly monitor and control the temperature of food throughout service by ensuring that the bain-marie, salad buffets, holding cabinets and others are at the appropriate temperature (Kinasz et al., 2015). According to Betz et al. (2015), Heikkila et al. (2016) and Ofei et al. (2014), attractive meal



presentation has a role in curbing service waste. Notwithstanding this, (LeanPath, 2016) suggest that the use of garnishes that are rarely eaten should be reduced in order to diminish food waste. Creative food presentation can be achieved with creative plating of food of different colors and artistic plating of sauces that do not lend themselves in food waste generation (LeanPath, 2016).

Food Waste Prevention in the Outputs Subsystem

With regard to the outputs of the food service system, good management and re-use of leftovers play a role in food waste prevention (Betz et al., 2015, Engström and Carlsson-Kanyama, 2004). In an event where food is left, blast chilling or rapid cooling is applied under controlled time and temperature in order to avoid multiplication of micro-organisms and avoid food wastage and the food is appropriately stored for later use (Betz et al., 2015).

Food Waste Prevention in the Controls Subsystem

A number of controls, policies and plans applied throughout the food service system have been identified to have a positive impact on food waste reduction and prevention. Meal auditing as a control measure assist in minimization of food waste (Goonan et al., 2014). This is an approach that uses a meal quality checklist to inspect a meal and identify areas to improve and if such areas are not improved may contribute to generation of food waste. Other control systems that have been applied to prevent food waste include stock monitoring and rotation polies which minimise the risk of food spoilage during storage (Goonan et al., 2014; Marthinsen et al., 2012; Priefer et al., 2016; (ReFED), 2016). Adherence to food safety plans and regulations is critical in food waste prevention as it reduces the risk of discarding food due to failure to observe food safety requirements (Papargyropoulou et al., 2016, Priefer et al., 2016). Further to that, Goonan et al. (2014) show that the use of standardised recipes reduce the amount of food wasted during food preparation and production as it minimises production errors. Additionally, the use of portioning guidelines increases accuracy in portion control hence prevents service waste (Goonan et al., 2014). Research (Derqui et al., 2016, Ofei et al., 2014, United States Environmental Protection Agency, 2014) shows that the application of Just-in-Time (JIT) systems such as the use of Just-in-Time purchasing software to avoid unnecessary purchasing, and the Just-in-Time delivery system which ensures that suppliers deliver ingredients to the production kitchen flexibly when needed achieve either a reduction in inventory or zero inventory and consequently a reduction in food waste.

Food Waste Prevention in the Management Subsystem

According to Heikkila et al. (2016), an effective management system has a significant influence on food waste reduction and prevention. Research (Goonan et al., 2014, Heikkila et al., 2016) illustrates that communication, which is a part of the management subsystem, has an influence on food waste creation. Effective communication with customers, suppliers, all levels of food service staff and food service staff is necessary for reduction of food waste throughout the food service system (Heikkila et al., 2016, Ofei et al., 2014, Ofei et al., 2015, Papargyropoulou et al., 2016, Strotmann et al., 2017). For example, communication between the stock clerk and production team about products that will soon be expiring, or about stock levels of different ingredients, informs the production personnel to alter the menu and thus will prevent storage waste (Heikkila et al., 2016). Additionally, effective management and control of kitchen activities such as how various practicalities like maintaining and correcting recipes, deciding on the amount of food to be prepared, menu planning and inventories are dealt with plays a role in food waste prevention (Heikkila et al., 2016).

Food Waste Prevention in the Memory Subsystem

Accurate forecasting is particularly important in food waste prevention. In order to achieve this, food service operators use automated forecasting systems which enable them to accurately predict the number of patrons to serve thus avoiding food surplus (Papargyropoulou et al., 2016). Another strategy is utilising computer generated recipes where the measurements are adjusted to the actual number of consumers which can improve accuracy of meal production



(Marais et al., 2017, Pirani and Arafat, 2016). Further to that, long term analysis of meals is essential as it informs adjustment of orders and thus reduce frequently uneaten or wasted food (Betz et al., 2015, Derqui et al., 2016, Ferreira et al., 2013, Marais et al., 2017, Painter et al., 2016, Pirani and Arafat, 2016, Priefer et al., 2016).

Food Waste Prevention in the Feedback Subsystem

Food waste tracking and analytics is an important strategy in minimisation of food waste generation (Burton et al., 2016). A study conducted by Burton et al. (2016) indicates that food waste tracking makes food service staff aware of the amount of food waste generated and allows them to come up with corrective actions that can minimise wastage. According to Ofei et al. (2014), recent advances in technological innovations such as computerized weighing scale with scanners and digital cameras enables food service staff to easily capture food waste data for routine monitoring hence food waste reduction.

Environmental Factors Contributing to Food Waste Prevention

Food waste can be prevented by policies, laws and regulations made by external regulatory bodies which affect practices within food service operations. According to Thyberg and Tonjes (2016) policies can be enacted to reduce food waste, for example, a legislation to ban landfilling of food waste can be introduced. Additionally, monetary incentives, such as taxes and fees on waste treatment can be sanctioned or mandated higher costs for waste disposal can also encourage food waste reduction (Thyberg and Tonjes, 2016).

Conclusions

Food service operators have increasingly become more aware of the need to prevent and reduce food waste both for environmental, social and economic reasons. The key strength of this review is its focus on a holistic approach to food waste prevention that considers application of food waste preventative measures at all stages of the food service system. Previous studies have generally considered food waste reduction strategies, but failed to consider all stages of a food service system. To this end, we have provided a review of food waste prevention and reduction strategies with consideration to the inputs, the subsystems that transform inputs into outputs, the outputs, controls, management, feedback, memory as well as environmental factors of the food service system. The review adds to the evidence base and could inform food service personnel at different levels of feasible strategies they can adopt to prevent or reduce food waste.

Further research can use the strategies presented in this study to develop formal and validated tools that can assist in the prevention of food waste in the food service sector. It is important to test the extent to which each of the strategies contribute towards food waste prevention and assess the relative importance, cost effectiveness and feasibility of each strategy which will inform development of a working food waste prevention tool. Finally, it is important for further research to contextualise the reviewed food waste prevention strategies given the varying nature of food service operations and develop context specific and targeted interventions.

References

- Beretta, C., Stoessel, F., Baier, U. & Hellweg, S. (2013). Quantifying food losses and the potential for reduction in Switzerland. *Waste Management*, 33, 764-73.
- 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.



Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3, 77-101.

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, 428-438.

Buzby, J. C. & Hyman, J. (2012). Total and per capita value of food loss in the United States. *Food Policy*, 37, 561-570.

Carey, W., Philippon, D. J. & Cummings, G. G. (2011). Coaching models for leadership development: An integrative review. *Journal of Leadership Studies*, 5, 51-69.

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, 278-291.

Creedon, M., Cunningham, D. & Hogan, J. (2010). Less Food Waste More Profit. Cork: Ireland.

de Lange, W. & Nahman, A. (2015). Costs of food waste in South Africa: Incorporating inedible food waste. *Waste management*, 40, 167-172.

Derqui, B., Fayos, T. & Fernandez, V. (2016). Towards a More Sustainable Food Supply Chain: Opening up Invisible Waste in Food Service. *Sustainability*, 8, 693.

Engström, R. & Carlsson-Kanyama, A. (2004). Food losses in food service institutions Examples from Sweden. *Food Policy*, 29, 203-213.

Ferreira, M., Liz Martins, M. & Rocha, A. (2013). Food waste as an index of foodservice quality. *British Food Journal*, 115, 1628-1637.

Food and Agricultural Organisation. (2014). Definitional Framework of Food Loss. Rome, Italy.

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 Academic Nutrition & Dietetics*, 114, 63-71.

Goonan, S., Miroso, M. & Spence, H. (2015). Systems-practice framework: An integrated approach for foodservice management. *Nutrition & dietetics*, 72, 81-90.

Gregoire, M. (2017). *Foodservice Organizations: A Managerial and Systems Approach*, Boston, Pearson.

Halloran, A., Clement, J., Kornum, N., Bucatariu, C. & Magid, J. (2014). Addressing food waste reduction in Denmark. *Food Policy*, 49, 294-301.

Heikkila, L., Reinikainen, A., Katajajuuri, J. M., Silvennoinen, K. & Hartikainen, H. (2016). Elements affecting food waste in the food service sector. *Waste Management*, 56, 446-53.

High Level Panel of Experts on Food Security and Nutrition. (2014). Food losses and waste in the context of sustainable food systems.

International Tourism Partnership. (2014). Know How Guide To Reducing And Managing Food Waste In Hotels.



Irish Environmental Protection Agency. (2014). Reducing Food Waste in Irish Healthcare Facilities. Cork Institute of Technology.

Kallbekken, S. & Sælen, H. (2013). 'Nudging' hotel guests to reduce food waste as a win-win environmental measure. *Economics Letters*, 119, 325-327.

Kinasz, T. R., Reis, R. B. & Morais, T. B. (2015). Presentation of a Validated Checklist as a Tool for Assessing, Preventing and Managing Food Waste in Foodservices. *Food and Nutrition Sciences*, 6, 985.

LeanPath. (2016). *20 Waste cutting tips every food service chef should know* [Online]. Available: <http://info.leanpath.com/20-food-waste-cutting-tips-guide> [Accessed 09/09/2017].

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, 60-67.

Marthinsen, J., Sundt, P., Kaysen, O. & Kirkeraag, K. (2012). Prevention of food waste in restaurants, hotels, canteens and catering. Copenhagen: Nordic Council of Ministers.

Nahman, A. & de Lange, W. (2013). Costs of food waste along the value chain: evidence from South Africa. *Waste Management*, 33, 2493-500.

Nahman, A., De Lange, W., Oelofse, S. & Godfrey, L. (2012). The costs of household food waste in South Africa. *Waste Management*, 32, 2147-2153.

Nicholson, C., Morrow, E. M., Hicks, A. & Fitzpatrick, J. (2017). Supportive care for older people with frailty in hospital: An integrative review. *International journal of nursing studies*, 66, 60-71.

Oelofse, S. H. & Nahman, A. (2013). Estimating the magnitude of food waste generated in South Africa. *Waste Management & Research*, 31, 80-86.

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.

Ofei, K. T., Werther, M., Thomsen, J. D., Holst, M., Rasmussen, H. H. & Mikkelsen, B. E. (2015). Reducing food waste in large-scale institutions and hospitals: insights from interviews with danish foodservice professionals. *Journal of Foodservice Business Research*, 18, 502-519.

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., Lozano, R., Steinberger, J. K., Wright, N. & bin Ujang, Z. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production*, 76, 106-115.

Papargyropoulou, E., Wright, N., Lozano, R., Steinberger, J., Padfield, R. & Ujang, Z. (2016). Conceptual framework for the study of food waste generation and prevention in the hospitality sector. *Waste management*, 49, 326-336.



- Payne-Palacio & Theis, M. (2016). *Foodservice Management: Principles and Practices*, Boston, Publisher.
- Pirani, S. I. & Arafat, H. A. (2014). Solid waste management in the hospitality industry: A review. *Journal of environmental management*, 146, 320-336.
- Pirani, S. I. & Arafat, H. A. (2016). Reduction of food waste generation in the hospitality industry. *Journal of Cleaner Production*, 132, 129-145.
- 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.
- Quested, T. E., Marsh, E., Stunell, D. & Parry, A. D. (2013). Spaghetti soup: The complex world of food waste behaviours. *Resources Conservation and Recycling*, 79, 43-51.
- ReFED. (2016). A roadmap to reduce US food waste by 20 Percent. Rockefeller Foundation New York.
- Scholz, K., Eriksson, M. & Strid, I. (2015). Carbon footprint of supermarket food waste. *Resources, Conservation and Recycling*, 94, 56-65.
- Scotland Resource Efficient (2014). Managing Food Waste in the Hospitality and Food Service Industry. *Resource Efficient Scotland: Sterling, UK*.
- 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.
- Strotmann, C., Göbel, C., Friedrich, S., Kreyenschmidt, J., Ritter, G. & Teitscheid, P. (2017). A participatory approach to minimizing food waste in the food industry—A manual for managers. *Sustainability*, 9, 66.
- Sushil, D. (1990). Waste management: a systems perspective. *Industrial Management & Data Systems*, 90, 1-67.
- Thi, N. B., 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, 220-9.
- 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.
- United States Environmental Protection Agency. (2014). Reducing wasted food & packaging: A guide for food services and restaurants.
- Von Bertalanffy, L. (1968). *Organismic psychology and systems theory*, Clark University Press Worcester, MA.
- Whitehair, K. J., Shanklin, C. W. & Brannon, L. A. (2013). Written messages improve edible food waste behaviors in a university dining facility. *Journal of Academic Nutrition & Dietetics*, 113, 63-9.
- Whittemore, R. & Knafl, K. (2005). The integrative review: updated methodology. *Journal of Advanced Nursing*, 52, 546-53.