

Analyzing logistical challenges to address food waste in the grocery retail sector

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Abstract

This paper examines the causes of food waste in the grocery retail sector and develops a framework for how logistics and supply chain management actions could mitigate this problem. Customer preferences and perceptions for food are analyzed to determine their influence on the structure of food supply chains and their indirect contribution to food waste at grocery store levels. Based on the literature review, our study identifies five main categories that influence food waste: information flow, demand uncertainties and forecast, inefficiencies in the safety stock and inventory management, disruptions of the cold supply chain, and customers' perceptions and preferences for food in stores. We propose solutions to these causes as a possible way to alleviate and minimize food waste in the grocery retail sector. At a managerial level, the findings of this paper can lead to positive changes by creating a more efficient food supply chain structure that minimizes food waste in the grocery retail sector. Additionally, the results can have individual implications at a social level regarding customer preferences for and perceptions of food at grocery stores.

Keywords:

Food waste, grocery retail sector, logistical challenges

1.0 INTRODUCTION

The world's growing population will present challenges to the agricultural sector and the global food supply chain (FSC) in the near future (Food and Agricultural Organization [FAO], 2017, p. X). According to the United Nation's FAO (2017), the rate of advances in the field of agricultural technologies and crop yield will not be able to meet the future demand for food. The 10 billion people that will be living on the Earth by 2050 will require 70–100% more food than the current global food consumption (Godfray et al., 2010, p. 813). One way to answer the growing demand for food will be to grow plants more efficiently and rely more heavily on agricultural technologies. However, we should also identify the stages at which the most food waste occurs and attempt to minimize these losses.

Identifying the sources of food loss is not a straightforward process for a number of reasons. Food is lost during all stages of the FSC: production, packaging, storage, transportation, distribution, and consumption (Parfitt, Barthel, & Macnaughton, 2010, p. 3065). However, it is arduous to calculate the amount of food waste precisely since different stakeholders within the FSC cannot or do not keep track of this waste.

The High-Level Panel of Experts on Food Security and Nutrition (HLPE 2014, pp. 11, 32) calculated that one-third of the food produced worldwide is lost throughout the supply chain, amounting to annual losses of more than US \$1 trillion. In developing countries, 40% of the food losses and waste occur during post-harvest and processing operations, while in industrialized countries, more than 40% of food waste is generated by retailers and consumers (FAO, 2011). Lundqvist, Fraiture, and Molden (2008, p. 4) argued that up to 50% of all food is wasted or lost between the manufacturer and the end consumer. For example, more than half of the food waste in Europe is produced by households, resulting in over 44 million tons of waste, while 5 million tons come from the wholesale and retail sectors (Stenmarck et al., 2016). In 2013, grocery retailer Tesco revealed that around 70% of all bagged salads and half of its baked goods are wasted (Press Association, 2013).

Reducing food losses and waste in the grocery retail sector can be conducive to substantially minimizing food waste in general. Supermarkets can be defined as gatekeepers of the food system (Fox & Vorley, 2004, p. VI). Grocery stores alone do not influence all actors within the food industry; however, they do serve as a medium between consumers and producers.

Cicatiello, Franco, Pancino, Blasti, and Falasconi (2017, p. 273) found that 35% of the food wasted in an Italian grocery store was still edible. The authors revealed that the food waste produced by the store amounted to 70.6 tons (valued at nearly €170,000) in one year, of which 21.4 tons were unrecorded.

This example from Italy depicts two far-reaching issues regarding food waste at grocery stores. The first is that a large amount of food waste is still consumable, amounting to one-third of food waste generated by the grocery store in the study by Cicatiello et al. (2017). The second is that grocery stores do not have indicators of how much food waste is discarded. Thus, retailers do not know the exact causes of food waste and cannot comprehend the significance of the problem. This can become a vicious cycle in which the lack of information leads to underestimation of the magnitude of food waste, thus exacerbating the issue. Filimonau and Gherbin (2017, p. 1184) stated that despite the fact that food waste negatively impacts our society in several ways, most prominently environmentally, economically, and socially, insufficient research has been carried out on the issue of food waste in supermarkets.

Published research on food waste prevention within the supply chain has shown a broad variety of approaches. Some studies have dealt with the description and quantification of food waste in order to provide prevention scenarios (Gruber et al., 2016, p. 4; Xue et al., 2017). Xue et al. (2017, p. 6622) distinguished between approaches using “direct measurement or approximation based on first-hand data” (weighing, garbage collection, surveys, diaries, records, and observations) and “indirect measurement or calculation derived from secondary data” (modeling, food balance, use of proxy data, and use of literature data). Lebersorger and Schneider (2014, p. 1912) stated that the data on food loss in the retail sector found in the literature often provide only rough estimations on a national basis. Detailed data, if available, focus only on a limited number of outlets or on individual food product groups.

Given these issues, we developed the following set of research questions in order to contribute to the above-mentioned gap:

1. What are the logistical and SCM problems that need to be addressed in order to diminish food waste and loss in the grocery retail sector?
2. What solutions have been proposed to alleviate these challenges?

These questions are answered by developing a conceptual framework based on an analysis of the relevant literature. The initial point of this analysis is an extensive literature review examining papers on the different logistical and SCM causes of food waste in the grocery retail sector. The literature review is based on secondary sources such as textbooks, journal articles, reports, and statistics. The first step was a keyword search in the Science Direct and Scopus databases as well as the library catalogue of the Staats- und Universitätsbibliothek Bremen (Germany). Four different pairs of keywords were used during the search: “food waste” in combination with “grocery store,” “grocery retail,” or “logistics causes.” To identify specific papers, the search was narrowed down to literature from 2000 to the present in order to exclude information that might be outdated and to reflect a current picture of the grocery retail sector. The second step was to examine the title, abstract, or keyword list for the keywords searched. If any of the keywords were found in these locations, the third step was identifying the relevance of the article. Articles were judged on their relevance by scanning the title and (if needed) reading the abstract and skimming the text. Additional literature was gathered by examining the references in the relevant papers. Overall, our content analysis returned 18 papers that met the criteria (Appendix).

2.0 FOOD WASTE AS A GENERAL PROBLEM IN THE RETAIL SECTOR

Katajajuuri, Silvennoinen, Hartikainen, Heikkilä, and Reinikainen (2014, p. 322) studied food waste in a Finnish food chain and concluded that the retail sector is responsible for 65–75 million kg of food waste per year out of the 335–460 million kg of food produced per year in Finland. The authors further mentioned that Finnish retail chains were not willing to provide information on the exact amount of food waste produced. Because of that fact, the authors were only able to establish an estimate on the amount of food waste.

The problem of food waste in the retail sector is not exclusive to specific countries such as Finland. A report by the European Union’s FUSIONS Project stated that 55% of the 88 million tons of food waste in 2012 was produced by households within the EU, and 5 to 6 % of the total food waste resulted from the wholesale and retail sectors (see Stenmarck et al., 2016, p. 4). Thus the food waste of these two sectors represents an amount of €143 billion.

In 2013, one of the largest food retailers in the world, Tesco, generated more than 56,000 tons of food waste in the United Kingdom (UK) alone (Swaffield, Evans, & Welch, 2018, p. 43). Swaffield et al. (2018, p. 50) demonstrated that a later audit of Tesco’s food waste showed an

increase to nearly 60,000 tons. Overall it seems that supermarket chains are aware of the problem but so far, their efforts in regards to reduction of food waste were not successful.

Teller, Holweg, Reiner, and Kotzab (2018, p. 981) used root cause analysis to determine that the main cause of food waste in the grocery retail sector is customers' behavior, specifically fluctuating demand, inefficient store management, in-store operations, and replenishment policies. In order for grocery stores to operate efficiently and minimize food waste, they need to comprehend the significance of the problem and then identify and classify the causes of food waste.

Various factors lead to food waste, for instance, not supplying the right product or the right amount of it to the distribution channel. Based on their study of German food companies, Raak et al. (2016, p. 1) concluded that overproduction may be directly connected to consumers' preferences, and products that are still edible but suboptimal are shunned by customers. Although they have a significant effect on food waste, consumers' preferences are not the sole reason for this phenomenon. Mena, Terry, Williams, and Ellram (2014) studied the main causes of food waste across 15 food networks in the UK and concluded that some of the main causes of waste of meat products in the retail sector were weather changes, forecasting accuracy, promotions, stock rotation policies, quality control (discoloration), and temperature control during storage and supply. Similarly, their study found that some of the main causes of fruits and vegetables waste in the retail sector were temperature management during transportation and in stores, product handling in stores (display and back of store), and stock management.

The problem of food waste in the grocery retail sector is not only related to the improper transportation and handling of the products but also to not meeting demands precisely. A project by the Nordic Council of Ministers (as cited in Stenmarck, Jörgen Hanssen, Silvennoinen, Katajajuuri, & Werge, 2011, pp. 3–5) found out that one reason for food waste generation at grocery stores is the unstable demand for food products. This unstable demand leads to imperfect forecasting; the resulting gap between actual and estimated sales creates a substantial amount of food waste. The authors stated that the main challenge for grocery stores is selling food products that have reached a suboptimal condition.

In light of this, Holweg, Teller, and Kotzab (2016, p. 635) demonstrated that food products are negatively influenced by the problem of unsellability because of their short shelf life. Papargyropoulou, Lozano, Steinberger, Wright, and Ujang (2014, p. 108) developed a food

waste hierarchy (prevention, prepare to reuse, recycle, recovery, disposal) that aims to minimize food surplus and food waste. The term food surplus refers to food produced beyond human needs, which is approximately 2,000 kcal per person per day (Papargyropoulou et al., 2014, p. 112). The food surplus that is needed to cope with unexpected losses and provide food security should be 30%, but the authors of the article estimated that in some high-income countries, retailers provide food surpluses of over 1,000 kcal per person per day, or 50%.

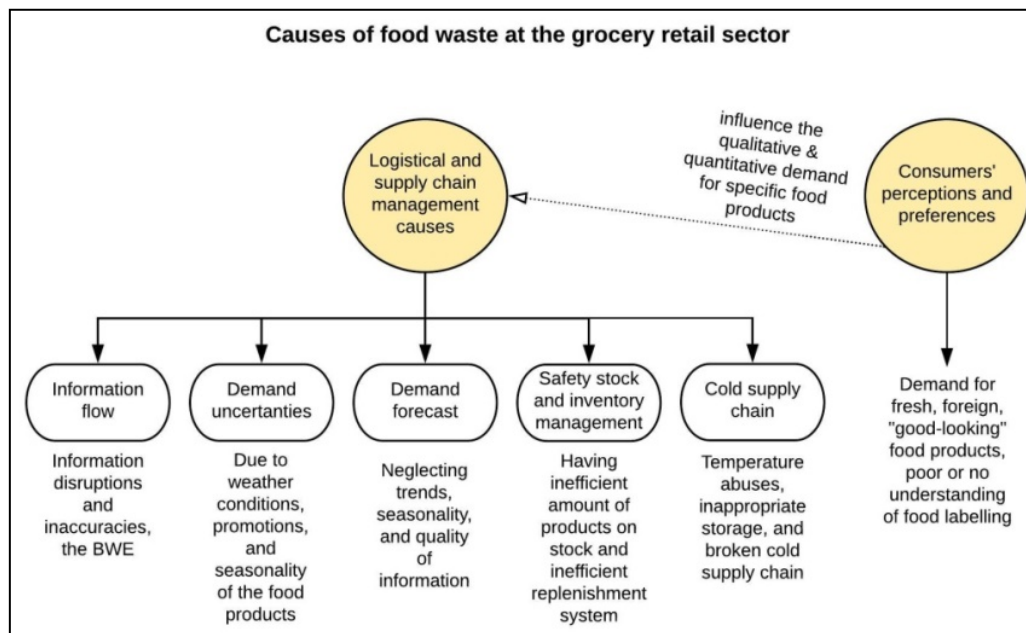
Technological advancements can be used as a starting point to mitigate the problem of food waste in grocery stores. Technology has become essential for improvements in supply chain logistics management by enabling operations such as product traceability, security, and food waste reduction (Tanner, 2016, n.p.). Technology can also be used for managing the inventory age of perishable goods (Haijema & Minner, 2019, p. 316). Kummur et al. (2012, p. 477) determined that one-quarter of the food produced (in terms of kcals) is lost along the FSC, and more than 20% of water and fertilizer use accounts for food production. In their study, the authors estimated that half of all food losses can be avoided through improvements in the SCM; if this was achieved, one billion extra people could be provided with food.

3.0 LOGISTICS AND SUPPLY CHAIN-RELATED CAUSES OF FOOD WASTE IN THE GROCERY RETAIL SECTOR

3.1 Introduction

Figure 1 classifies and summarizes the causes identified as contributors to food waste in the grocery retail sector. It also shows the connection between customers' preferences for food and how these influence the ways in which operations within the FSC are designed and managed.

Figure 1. Summary of the causes of food waste at the grocery retail sector.



Eighteen literature sources were identified as relevant to this research. Based on the contents of these 18 sources, five main causes of food waste in the grocery retail sector were established. The first four categories depict logistical and SCM flaws that result in food waste, while the fifth category explains the impact of customers' choices. Analyzing customers' food preferences and perceptions is necessary because these influences how the FSC is organized, indirectly contributing to food waste.

3.2 Information flow

3.2.1 Information disruptions and inaccuracies

The most common reason for food waste at the grocery store level is that the expiration date of the product has passed (Hanssen, Meiler, Svanes, & Schakenda, 2012, p. 350). This usually results from overstocking that does not reflect the actual demand for the product. Inaccurate predictions about demand results in products staying on the shelves longer and eventually being discounted or wasted.

Another cause of food waste at the grocery store level that is interrelated with information flow and expiration dates is when food products are delivered later than planned. In this case, the window of time in which these products are of optimal quality is decreased, and they reach the

grocery stores closer to their expiration date than was planned. A possible cause of this may be when the wholesaler delays the delivery of products so late to retailers that the time window to sell these products is very short. The worst-case scenario hereby would be that the delivery delay is so tremendous that delivered products will be directly disposed (Jenkin et al., 2017, p. 24).

3.2.2 The bullwhip effect

Mena, Adenso-Diaz, and Yurt (2011) stressed that insufficient communication between the various actors in the FSC can result in food waste. This is clearly demonstrated by the bullwhip effect (BWE), which is characterized by overproduction by producers and overstocking by retailers due to inefficient communication between these actors (Mena et al., 2011, p. 654; Taylor, 2006, p. 163).

An example of this is when food products are close to their best before or expiry date, resulting in the grocery store manager discounting the product. According to the law of demand, when the price of a product decreases, the demand increases and consumers buy more of that good/food product (Mankiw, Taylor, Wagner, & Herrmann, 2012, pp. 80–84). The store manager then decides to place a larger order for that particular product but does not provide information to the wholesaler that the product in question is on sale. The wholesaler overstocks that product based on the increased demand from the grocery store manager. Logically, the producer of the good wants to make sure that he or she will be able to satisfy the increased demand downstream in the supply chain and in turn produces more of the food product, which may not sell and thus result in food waste. This example depicts how information distortions along the supply chain lead to excessive inventory, lost revenue, overproduction, etc. (Lee, Padmanabhan, & Whang, 1997, p. 93).

3.3 Demand uncertainties and demand forecast

Taylor and Fearn (2009, p. 381) estimated that uncertainties regarding demand can be explained by factors such as changes in weather conditions or seasonality, but most demand uncertainties are the result of promotions at grocery stores. Moreover, customers' preferences for food products can change over time, for example, by demanding new products or bigger packages of existing food products. These changes represent a significant challenge and require sustainable information systems among the actors in the FSC to earlier detect and minimize

demand uncertainties. Furthermore, if these changes are not accounted for or the demand forecast is not updated accordingly, this can lead to food waste in the grocery retail sector.

Highly perishable goods have a short shelf life, and their incorrect forecast leads to food waste (Mena et al., 2014, p. 151). Retail managers choose the appropriate forecasting technique for the stores they manage based on the data available (Bozarth & Handfield, 2016, p. 270). It is important to take these specific characteristics into account when forecasting the demand for food products. Mena et al. (2014, p. 152) discussed how promotions are planned in advance and linked to events such as Christmas. The authors mentioned that in order for promotions to be successful, a good forecast is needed. If the additional products are not sold, they are either discounted or end up being wasted.

3.4 Safety stock and inventory management

Food waste is a major challenge at the retailer stage because food products have a low profit margin overall and stores have high operating and handling costs (Teller et al., 2018, p. 982). Some high-end retailers may be unwilling to sell fresh produce that is of a lower quality for two reasons. First, this leads to lower profit margins, and second, selling discounted products does not match with the image of a high-end grocer (Lee & Tongarlak, 2017, p. 945). In order to avoid selling suboptimal products, retailers tend to overstock because they assume that customers are more likely to buy from fully stocked displays (Gunders, 2012, p. 10). Unfortunately, by doing so, products are damaged by both staff and customers because of the accumulated weight on the bottom, resulting in food waste.

If store managers order too many products, they run the risk of overstocking, which increases storage time and reduces products' remaining shelf life, ultimately leading to food waste. Lee and Tongarlak (2017, p. 944) stated that grocery stores produce food waste because retailers stock up inventory in order to deal with demand uncertainties. Grocers usually replenish their inventories with new and fresh products before selling out of old ones because they want to provide a high level of service and satisfy customers' demands (Ferguson & Koenigsberg, 2009, p. 306). Chabada, Damgaard, Dreyer, Hvolby, and Dikovska-Popovska (2014, pp. 1–2) stated that when retailers have promotions for perishable products, they set stock levels high so they can prevent stock outs and deal with demand unpredictability. This high inventory and safety stock levels of products with a fixed shelf life results in food waste. To conclude, over-

ordering, suboptimal inventory rotation, and stocking too much inventory are some of the logistical causes that contribute to food waste at the retail level.

3.5 Cold chain management¹

3.5.1 Improper temperature storage

There are numerous factors across the cold food chain that affect products' quality. Fresh food is extremely sensitive to external conditions. The period during which food remains edible depends on temperature, humidity, and other factors that influence the speed of food spoilage (Hammond et al., 2015, p. 758). Food spoilage is mostly caused by microorganisms such as bacteria and fungi, which spread at a rapid rate and make food inedible (Hammond et al., 2015, p. 758). Temperatures that are too low cause freezing or damage the food, while temperatures that are too high increase the rate of microbial activity (Badia-Melis et al., 2018, p. 171). Mismanagement of temperature requirements can occur at any stage in the FSC, including in the grocery retail sector.

In light of this, a study on the temperature of fresh fish, minced meat, and different vacuumed or ready-to-eat products in Finnish grocery stores found that 50% of the food products were not kept at their specific temperature range (Lundén et al., 2014, p. 109). Significant temperature violations in retail freezers were reported in Spain, especially for products located on the top shelf during summertime. These temperature mismanagements result in an estimated shelf-life reduction of 40% for smoked salmon and 57% for cooked chicken breasts. (Zubeldia, Nieto Jiménez, Valenzuela Claros, Mariscal Andrés, & Martin-Olmedo, 2016, p. 614).

Exposing perishable products to unexpected temperature changes throughout the cold food chain leads to loss of food quality and endangers the safety of the transported food (Ndraha et al., 2018, p. 13). Food waste results from not adhering to the requirements for properly refrigerating and handling food products across the FSC, which is crucial for maintaining food freshness for as long as possible. Perishable products that have undergone temperature abuse experience loss in quality; as a result, customers are not willing to buy them, and this leads to food waste. Even when food products are handled according to their temperature requirements

¹Cold chain management refers to an undisrupted temperature-controlled transportation and storage system between suppliers upstream of the supply chain and consumers (Ndraha, Hsiao, Vlajic, Yang, & Lin, 2018, p. 20).

at the grocery stores, it is fundamental that the cold chain has not been disrupted before the products reach the retailer. The preservation of the freshness and quality of food products is directly correlated to their exposure to optimal temperatures and humidity for that particular food group (Taoukis et al., 2016, pp. 285–309). The value of international trade in food has significantly increased and the travel distance between production and consumption of food has also extensively grown between 1980 and 2000 (Halweil, 2002, p. 6). Ndraha et al. (2018, p. 17) showed that because of the internationalization of FSCs, the likelihood of food waste increases with the length of the supply chain.

The longer the FSC is, the higher the chances for a product to be mishandled. Moreover, product quality diminishes when different perishable products are transported in the same truck or container without taking into account their different temperature requirements.

Across the studies, it was noticeable that grocery retailers often do not strictly follow the temperature requirements for perishable products and disregard the positioning of products in stores. Ultimately, this results in losses for some of the most vulnerable groups of food products, poultry and pork. The main reason for such practices is that employees at the stores do not have sufficient knowledge or have not undergone training on how perishable products should be stored and handled to maintain the cold food chain.

3.5.2 Storage

Before food products reach the grocery store, it must be ensured that they have not been exposed to conditions that can endanger their safety or diminish their quality. Otherwise, these products will have a suboptimal shelf life, which means that they must either be discounted or wasted. During transportation, temperature is the most important factor that affects the food shelf life. For this reason, disruptions in the cold food chain can result in excessive ripening, weight loss, color and texture changes, softening, bruising, or physical degradation (Jedermann, Ruiz-Garcia, & Lang, 2009, p. 145). If products experience such changes, they will fail to meet consumers' expectations and will not sell.

Adequate storage before products reach grocery stores and during transportation is crucial for their quality since improper storage conditions negatively affect a food's remaining shelf life. Accurately handling and storing food products at grocery stores is essential since handling costs at stores represent 38% of the operational logistical costs in the retail supply chain (Broekmeulen, van Donselaar, Fransoo, and van Woensel, 2004, pp. 5–8; van Zelst, van

Donselaar, van Woensel, Broekmeulen, & Fransoo, 2009, p. 621). A study by Saghir and Jönson (2001, p. 22) found that 75% of handling time occurs at the grocery store. These studies show the significance and importance of how food products are handled and stored at grocery stores. The personnel that are responsible for unloading food products from the trucks, storing them, and placing them on the shelves at supermarkets need to have the required skills and knowledge of how to execute these operations efficiently and correctly to maintain food quality and shelf life.

Another interesting fact is that 21% of food waste is due to spoilage, with fresh food and vegetables accounting for approximately half of spoiled foods (Myers, 2016, n.p.). Potential spoilage of fruits and vegetables can occur during storage due to high temperatures or moisture.

3.6 Customers' preferences and their influence on retail operations and food waste

Consumers play an important role in how the FSC is designed and managed. Their perception of optimal and edible goods significantly contributes to food waste, and their food choices and preferences have evolved over time. Customers demand seasonal food throughout the year, which presents some challenges for logistics and supply chain operations. This change is fairly recent; children raised in the 1970s and 1980s ate frozen vegetables during the winter months (McCluskey, 2015, p. 2).

Nowadays, consumers do not want to feed their children or themselves food products that are highly processed (McCluskey, 2015, p. 2). Grocery stores need to provide fresh fruits and vegetables throughout the year because of consumers' preferences, which makes transport distances of food significantly longer. For example, in 2015, more than 3 billion kg of fruits and vegetables remained unharvested by grocers in the U.S. because they failed to meet customers' expectations (DeLoatch, 2017, n.p.). Customers tend to not buy products that are bruised, blemished, or misshapen, even if they still taste and smell good. Moreover, high-end grocery stores do not sell fruits and vegetables that are bruised or blemished because this practice does not correspond with many stores' marketing policies.

Poor understanding of the terms *best before* and *use by* is another issue that is directly correlated to food waste. A study conducted by the European Commission (n.d.) concluded that 10% of the 88 million tons of food waste accumulated in Europe is caused by date marking. The best before date indicates that food remains at its best quality prior to that date, which does

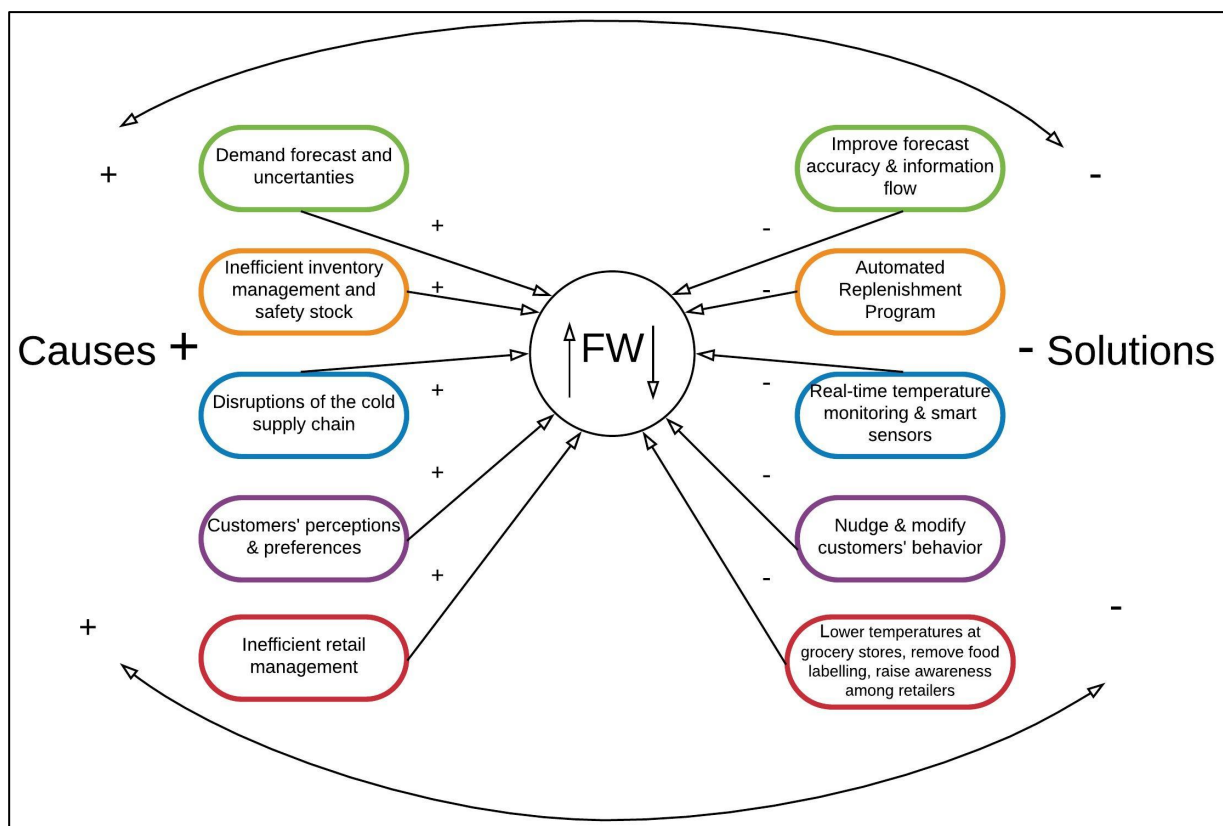
not mean that the food is unsafe to be consumed after that point; the product may not taste as expected but will still be consumable (Huen, 2017, n.p.). In contrast, the use by date indicates after which point food products should not be eaten due to a safety risk. A study among more than 4000 consumers indicated that less than half of them correctly understood the meaning of the best before date (NFWI, 2016, p. 4). Following this study, Tesco announced that it would remove best before labeling from 70 fruit and vegetable products in an attempt to reduce food waste since these two food groups are among the most wasted (Morrison, 2018, n.p.). Having identified the major causes of food waste at the retail store level, the next section presents potential mitigating solutions to minimize the food waste problem at this supply chain stage.

4.0 MITIGATING SOLUTIONS

4.1 A general framework

Figure 2 represents the interaction between the causes of food waste and how they could be addressed by the proposed mitigating solutions.

Figure 2. Causes of and solutions to food waste (FW).



The solutions, which are illustrated on the right-hand side, are situated directly opposite of the causes they aim to mitigate. The main point of such allocation is to show a potential causal link between causes and solutions. Since the causes contribute to food waste generation, the plus signs depict the resulting increase in food waste while the minus signs next to the solutions indicate the expected decrease in food waste at grocery stores.

4.2 Improving forecast accuracy

The literature demonstrated that one of the main reasons for food waste at grocery stores is insufficient and inaccurate demand forecasting. Fruits and vegetables naturally grow in cycles and ripen during a particular time of the year. Meat products require between 42 days and 36 months before being ready for consumption (Mena et al., 2014, pp. 150–151). Cheese takes a couple of weeks to three years to ripen, with most types of cheeses requiring two years to ripen (Mirafzali, Thompson, & Tallua, 2014, p. 148). Between production, harvesting, and processing times, forecasting and planning are crucial factors for keeping supply and demand in equilibrium, especially when such activities may take months or years. A possible way to improve forecast accuracy is to implement collaborative schemes such as efficient consumer response or collaborative planning, forecasting, and replenishment (Mena et al., 2014, p. 152).

By understanding customers' demands and preferences and taking into account food product promotions and seasonality, grocery stores can significantly improve their forecasting models (Walters, 2015, n.p.). In this way, the BWE, unnecessary inventory, and excess production can be prevented. Improvements in information sharing throughout the FSC can swiftly satisfy demand changes and avoid disruptions. Additionally, the possibility of generating food waste at the grocery store is also reduced.

4.3 Implementing automatic replenishment programs

Shelf availability is considered a key performance indicator at grocery stores (Mena et al., 2014, p. 153). As mentioned earlier, grocery stores maintain high levels of safety stocks because they fear dwindling revenues due to a loss of customers.

One approach that can modify such situations is the use of automatic replenishment programs (ARPs). ARPs increase the information shared between FSC actors to create transparency so that replenishment decisions can be synchronized and managed more efficiently (Kiil, Dreyer, Hvolby, & Chabada, 2018, p. 107). ARPs can be connected to efficient consumer response

systems or can be used to assist the process of replenishment. ARPs suggest order quantities for each item in the store. These suggestions are based on information from stores, such as point of sale, waste data, review periods, or batch sizes, and can be accepted or declined by the retail manager (Kiil et al., 2018, p. 107). This process results in greater transparency, allowing the wholesaler to use this information to calculate an assessment for future orders. The study by Kiil et al. (2018) concluded that ARPs can prolong shelf life between 51 and 110 days and can reduce food waste by 20%.

4.4 Real-time temperature monitoring and smart sensors

Today's supermarkets offer products which are delivered to and presented in the store at different temperature levels. Typically these products are moved in mixed-temperature transport means which represents a challenge because a failure in the temperature management can reduce foods' quality, shorten the remaining shelf life and contribute to food waste. Thus, retailers cannot be sure, that the products have been under the correct or optimal temperature requirements during transportation (Smith and Sparks, 2014, p. 180). Real-time- product monitoring during transport offers a possibility to solve this issue by collecting via wireless sensor networks permanently information regarding ambient temperature and humidity during transportation (see Tsang et al. 2018, p. 84). By this food products can reach a retail store with maximum shelf life and with no quality loss caused by temperature abuses during transportation. Hsiao and Chang (2016) present time-temperature indicators (TTI) as another possibility to avoid losses in food quality within the cold chain. TTIs are smart labels that record temperature of a product along the cold chain and indicate with a color-scale any incidents that happened while transport.

4.5 Lowering temperatures at grocery stores and removing best before dates

Another way to reduce food waste is to lower the temperature at grocery stores. Since one of the main causes of food waste in the retail sector is the expiration date, this issue can be alleviated by prolonging the shelf life of products through reducing the temperature at the store (Eriksson, Strid, & Hansson, 2016, p. 73). According to Eriksson et al. (2016, p. 74), there is a campaign in Sweden that aims to "reduce storage temperatures from 8°C to 4-5°C in the whole FSC." This campaign by the Stockholm Consumer Cooperative Society found that store representatives welcomed this idea, but the study was inconclusive on the costs associated with reducing the temperature and the effect this had on food waste. Through an analysis of three years of data, Eriksson et al. (2016, p. 76) found that the shelf life of meat products (which are

usually stored at 4°C) can be prolonged by around 30% when stored at 2°C. Furthermore, adjusting the temperature from 8°C to 4°C can result in a 44% longer shelf life for food products. This study highlights the possibilities for food waste reduction at grocery stores by decreasing the temperatures in the cheese, dairy, deli, and meat departments.

Removing best before information from some products can have a monumental impact on how much food a store wastes. A recent example is Tesco, which was the first supermarket to remove best before dates from more than 70 fruits and vegetables lines (Blake, 2018, n.p.). Some of the products that are no longer labeled are apples, lemons, and potatoes. By removing the best before label, it is up to the customer to decide if the product is fresh to consume or not.

4.6 Modifying customers' behaviors

Last but not least, retailers can start to offer blemished and imperfect produce. An example for this would be curvy carrots, bananas that have brown spots, or pears that are slightly blemished. These products are currently considered unsellable in grocery stores and end up wasted (Holweg *et al.*, 2016, p. 635). In 2008, the European Commission removed precise requirements for the appearance, weight, and size of 26 types of fruits and vegetables (Waterfield, 2008, n.p.). With this action, curvy carrots and cucumbers, imperfect eggplants, and other ugly produce could be sold at grocery stores. However, retailers are often unwilling to sell ugly or imperfect produce in their stores because of a fear of negative customer reactions (Hermsdorf, Rombach, & Bitsch, 2017, p. 2532). Customers need to change their perceptions and preferences for food and stop expecting full shelves at stores. Throwing away perfectly edible food products at grocery stores is unethical and a waste of resources.

The nudge theory offers one method for influencing customers' behaviors and decision-making practices without direct instructions or enforcement (Thaler & Sunstein, 2008, pp. 1–14). A possible way to encourage people to start buying food that is not visually appealing is by providing them with information about the product in stores. For example, stores may present information about the distances food products have travelled from the producers to the stores and how many resources (such as liters of water or units of energy) were used to do so. This seemingly insignificant information could have an immense impact on customers' behavior.

5.0 CONCLUSION

The main purpose of this work was to identify logistical and SCM-related causes of food waste in the grocery retail sector as well as to find potential mitigating solutions to minimize and/or avoid food waste. Based on our content analysis, we identified the following major causes of food waste: a) disruptions to and inaccuracies in information flow causing quality loss, overstocking, and delayed deliveries; b) the BWE, which leads to overproduction and excessive food waste; c) inaccurate demand forecasts and ignoring food specifications, such as seasonality; d) inadequate cold chain management resulting in products reaching grocery shelves in suboptimal condition; and e) customers demanding food products that are out of season.

Based on these causes, we proposed the following solutions to alleviate and minimize food waste in stores: a) improving the forecast accuracy; b) using software to make replenishment decisions that prolong foods' shelf life, minimizes unnecessary inventory, and diminishes the problem of food waste; c) using temperature control systems that enable real-time food monitoring to detect and avoid food spoilage; d) modifying customer behavior by removing best before labels; and e) lowering temperatures in grocery stores in order to achieve longer shelf life.

As discussed throughout the paper, key actors that play a leading role in reducing food waste in the supply chain are governmental institutions, the retail and wholesale industry, manufacturers, logistical service providers, consumers, media, social institutions, and research institutions (Govindan, 2018, p. 427; Gruber et al., 2016, pp. 17–22.; Priefer et al., 2016, p. 159). For instance, customer behavior can be modified not only by removing best before labels but also through media coverage (e.g., the documentary *Taste the Waste*). Priefer et al. (2016, p. 159) stressed the importance of national, regional, and local regulations, such as mandatory reduction targets.

Future research should explore optimal food packaging features in order to minimize food waste in stores and prolong food shelf life. We also suggest that the approach used in this study be widened to include upstream supply chain levels (e.g., wholesalers and producers) in order to obtain a complete picture of the food waste problem.

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Appendix

Article	Published in	Country	Focus of the paper	Food waste
Kiil et al., (2018)	Journal of Production Planning and Control, 29(2), 2018, pp. 106–116	Norway	Impact of automatic replenishment program (ARP) in grocery stores.	20 % food waste reduction at grocery stores when using ARPs.
Chabada et al., (2014)	Conference paper	Norway	Logistical causes of food waste in a Norwegian cooled distribution chain.	90 % of the food waste in this case study comes from chilled products.
Filimonau and Gherbin, (2017)	Journal of Cleaner Production, 167(2), 2018, pp. 1184-1194	United Kingdom	How managers of big UK grocery retailers confront the issue of food waste at the stores.	-
Cicatiello et al., (2017)	Journal of Resources, Conservation and Recycling, 125, 2017, pp. 273-281	Italy	Analysis of the food waste of an Italian grocery retailer.	35% of the wasted food is still edible.
Katajajuuri et al., (2014)	Journal of Cleaner Production, 73, 2014, pp. 322-329	Finland	Analysis of the food waste in the Finish food chain.	65–75 million kg of food waste results annually from the Finish retail sector.
Holweg et al., (2016)	International Journal of Physical Distribution & Logistics Management, 46(6-7), 2016 pp. 634-658	-	Case study of the instore logistics processes related to unsaleable grocery products	-
Mena et al., (2014)	International Journal of Production Economics, 152, 2014, pp. 144–158	United Kingdom	Dominant causes of food waste across multi-tier networks.	-
Ndraha et al., (2018)	Journal of Food Control, 89, 2018, pp. 12-21	-	Review of temperature mismanagement in the food cold chain	-
Raak et al. (2016)	4 th International SEKI Food Conference Vienna (July 2016)	Germany	Processing-related drivers of food waste and losses based on interviews with 13 German food processing companies.	-
Stenmarck et al. (2011)	Report, 2011, June	Denmark, Finland, Norway, Sweden,	Causes of food waste generation, initiatives to reduce food waste, their obstacles and suggestions for action at grocery and wholesale levels.	Denmark – 40 000-46 000 tons per year. Finland – 65 000-75 000 tons per year (retail and wholesale). Norway – 43 000 tons per year in the retail Sweden – 83 500 tons for the retail sector in 2008.
Stenmarck et al. (2016)	European Union Project, Stockholm March 2016	28 EU Member States	Estimated of food waste in 28 EU Member States in primary production, processing, wholesale, logistics and retail markets, food service and household.	The evaluated 28 EU countries generated 88 million tons of food waste in 2012; retail and wholesale were responsible for 5% of them.
Swaffield et al. (2018)	Geoforum, 89, 2018, pp. 43-51	United Kingdom	The role of retailers in the context of food waste and their motivations o	-

Teller et al. (2018)	Journal of Cleaner Production, 185, June 2018, pp.981-997	-	Root cause analysis of food waste generation among different store formats and food categories.	-
Papargyropoulou et al. 2014	Journal of Cleaner Production, 76, 2014, pp. 106-115	-	Food waste hierarchy for preventing and managing food surplus and avoidable and unavoidable food waste.	-
Kummu et al. (2012)	Science of The Total Environment 438, 2012, pp. 477-489	-	-	One quarter of the produced food (in terms of kcal) is lost within the FSC.
Hajjema and Minner (2019)	International Journal of Production Economics, 290, pp. 316-324	-	Overview and classification of order policies for perishable products and examination of stock-age dependent policies.	-
Parfitt et al. (2010)	Philosophical Transactions of the Royal Society B, 365, 2010, pp. 3065-3081	-	Analysis of the scale of food waste, system efficiencies and challenges associated with changes in consumers' behaviors	-
Smith and Sparks (2014)	In Bourlakis, M., and Weightman, P. (Eds.), Food Supply Chain Management	United Kingdom	Importance, principles and processes of temperature controlled supply chains in the context of shelf life and food security.	-