

Food Loss and Waste in the Halal Supply Chain: A Systematic Literature Review

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Abstract

Food loss and waste have been a point of discussion since a decade ago. In fact, it has been a highlight recently due to the increasing global food crisis as well as the COVID-19 pandemic. It is found many works of literature define food loss and waste individually and interchangeably. The 2019 report from the Food and Agriculture Organization (FAO) of the United Nations defines food loss as the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retail, food service providers, and consumers. Food loss and waste reflect the complex inefficiencies throughout the food supply chain. The conventional understanding of food loss and waste focuses mainly on disposed of or unused foods. However, understanding what constitutes food loss and waste is rather complex, as it comprises several dimensions. The halal supply chain can be an important instrument in managing loss and waste by adopting a more detailed approach from the traditional supply chain. Therefore, the objective of this study is to provide findings based on the systematic literature review presented by reviewing 20 articles, which are relevant to the study.

Keywords: *Food Loss, Food Waste, Food Supply Chain, Halal*

Introduction

The 2019 report of the Food and Agriculture Organization (FAO) of the United Nations defined food loss as the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retail, food service providers, and consumers. In the same report, food waste is defined as the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services, and consumers (United Nations Economic Commission for Europe, 2020). Food loss and waste are no longer a trivial nuisance, they have become a significant and growing problem associated with a population with rapidly growing food and energy demands, environmental degradation, climate change, price volatility, and production pressures. The causes of food loss and waste in supply chains are varied and occur at various points in the supply chain, from production to consumption (United Nations Economic Commission for Europe, 2020). These include the inability to obtain data on production, prices, requirements, and storage facilities; logistical issues due to freight, and local transportation (including destination storage); last-minute order cancellations; lack of knowledge of market demand, quality requirements production without knowledge of demand and prices; stringent buyer requirements; fluctuations in interest rates that affect the supply of produced commodities and cause severe food losses; “natural overproduction” due to favorable growing conditions; or climate and climate change (Food and Agriculture Organization of the United Nations (FAO), 2019).

Food loss across the food supply chain represents a significant loss of resources invested in food production, transport, and storage. Since resources (land, energy, freshwater, and agricultural inputs) are limited in nature, they should be used efficiently and sustainably. Further negative externalities of food production include environmental toxicity of pesticides, eutrophication, soil erosion, loss of organic matter, and loss of biodiversity. Food consumption accounts for 20 to 30 percent of a product's environmental impact (Alexander et al., 2017). Therefore, the loss of food can have a substantial impact on the environment. Furthermore, economically avoidable food losses are important for reducing hunger and improving food security, not only in developing countries but also in developed countries (Beretta, Stoessel, Baier, & Hellweg, 2013).

The halal food industry is based on the concept of *halalan thayyiban* prescribed in the Quran. The holistic concept contains guidelines for the production and consumption of food according to Islamic law. Not only that, but Islam also teaches some simple dietary etiquette, including refraining from excessive extravagance and doing charity to our neighbors and relatives (Kadirov et al., 2020). However, as reflected in current halal standards, requirements, and practices, *halalan thayyiban's* current approach may overlook some components that should be part of the concept, especially at the waste recycling or waste recovery stage. The implementation of the *halalan thayyiban* concept in halal supply chain management is comprehensive, and the maximum implementation is expected to be a preventive measure to reduce the amount of food loss and waste, and indirectly save the planet from more severe destruction. Therefore, *halalan thayyiban's* approach in this regard needs to be better understood and implemented to reduce food loss and waste in the global food supply chain. This article mainly focuses on solutions to prevent food loss in the supply chain using the *halalan thayyiban* approach.

Literature Review

Food Supply Chains

A food supply chain is defined as the movement of products and services along the value-added chain of food commodities with the aim of achieving better benefits for customers in addition to minimizing costs (Folkerts & Koehorst, 1998). A food supply chain is different from any other type of supply chain because it deals with complex issues such as the perishability of commodities, interactions with many stakeholders, and impacts across industries. The complexities associated with the food supply chain come with concerns about the safety, sustainability, quality and efficiency of the process (Göbel, Langen, Blumenthal, Teitscheid, & Ritter, 2015).

Scholars have illustrated the food supply chain concerning globally relevant stages which include (i) farm production, (ii) handling and storage, (iii) processing, (iv) distribution, and (v) consumption. Inefficiencies in the food supply chain, leading to food loss and waste generation take place across all food supply chain stages. It is also possible that the reason for food loss and waste at a particular stage might be concealed in another stage. The globally acknowledged approaches to food loss and waste reduction are expected to address inefficiencies of the entire food supply chain (Chauhan, Dhir, Akram, & Salo, 2021).

The length of the food supply chain and the importance of each stage depend largely on geographic location. Previous research has claimed that the early stages of the food supply chain are responsible for the greatest amount of food loss and waste (Gustavsson, Cederberg, Otterdijk, & Meybeck, 2011). The causes of food loss and waste in developing countries are often related to poor harvesting techniques and a lack of storage, packaging and transport infrastructure (Gustavsson, Cederberg, Sonesson, & Emanuelsson, 2013). The fact that most developing countries score very low on the Hunger Index, with about 800 million people suffering from chronic hunger (Food and Agriculture Organization of the United Nations (FAO), 2013), highlights the need to focus on food loss and waste in the early stages of the food supply chain, from the farm until the distribution stage.

The conventional understanding of food loss and waste focuses mainly on disposed of or unused food. However, understanding what constitutes food loss and waste is rather complex, as it comprises several dimensions. Moreover, each dimension has numerous economic, social, and environmental implications (Irani, et al., 2018).

Food Loss and Waste in Halalan Thayyiban Perspective

There is no literature found that discussed the Islamic perspective of food loss and waste in a comprehensive way. However, the following discussion illustrates the relationship between food loss and waste which undermine the very foundations of food and nutrition security. In fact, it affects all four components of sustainable food security i.e. availability, access, utilization, and stability. Therefore, reducing the amount of food lost or wasted around the world is now considered essential to improving food security (Berjan, Capone, Debs, & Bilali, 2018).

Transitioning to sustainable food consumption and production means systematically addressing consumer demand and production supply factors by promoting smarter, more efficient and

appropriate food production and consumption patterns. Curbing the amount of food loss and waste is a tangible starting point. Food loss and waste, directly and indirectly, affect food security and the sustainability of food systems. Wasting food is unsustainable, economically negative, environmentally wrong, and morally unacceptable. (Berjan, Capone, Debs, & Bilali, 2018)

Food quality standards in the Islamic perspective are based on the concept of *halal* and *thayyiban*. There are several factors that determine good quality foods. No doubt that it depends on its nature, how it is processed and how it is obtained. Therefore, the concept of *halal* and *thayyiban* is not just about slaughtering or the material itself, it covers all aspects, including the safety and quality of food as well as the necessities of hygienic along and sanitation requirements which encompass the holistic standards of good and wholesome (*thayyib*) as well as lawful (halal) by Allah SWT (Arif & Ahmad, 2011).

The Holy Quran says:

“It is He Who has brought into being gardens, the cultivated and the wild, and date-palms, and fields with produce of all kinds, and olives and pomegranates, similar (in kind) and variegated. Eat of their fruit in season, but give (the poor) their due on harvest day. And do not waste, for God does not love the wasteful.” (Al-An’am 6:141).

From this verse, we comprehend that food is a primary source of waste. However, Allah SWT teaches the Muslims how to avoid waste by sharing our food with the poor, especially on the same day it is harvested. Waste is also a problem that arises from having too much (Abdelhamid, 2021). Similarly, Allah SWT addresses this problem of excess in the Quran:

“O you who believe! Do not make unlawful the wholesome things which God has made lawful for you, but commit no excess for God does not love those given to excess.” (Al-Maidah 5:87).

A study done by Sadati (2018) revealed the culture of Iranian households is heavily dominated by luxury-oriented behaviors. Correspondingly, Iranian families perform extravagant ceremonies that often involve wasting large amounts of food. The findings suggest that despite rising food prices, processing, preservation, and packaging, food purchases are still higher than necessary (Sadati, 2018). Furthermore, Rastegary (2015) stated that consumerism is the main cause of food waste in Iran (Rastegary, 2015).

Excess production is a problem every farmer tries to cope with in several ways. Neighborhood sharing has been and remains a common practice among small family farms and businesses. In Islam, Allah requires that Muslims share a part of every harvest with the poor in our neighborhoods. But, unfortunately, the practices of industrialized commercial farming lead to the worst forms of food waste due to excess (Abdelhamid, 2021). As a result, food waste has emerged as one of the most relevant areas of the current unsustainability (Diaz-Ruiz, Costa-Font, López-i-Gelats, & Gil, 2018)

Many acres may ripen their produce all at once, and workers often cannot physically harvest fast enough to avoid food spoilage. Sometimes entire fields of produce lay rotting in the sun. Next, the

harvested and packaged products are distributed in bulk to wholesale produce markets. This is far more produce than can be distributed to grocery stores and restaurants without avoiding another massive food loss due to spoilage (Abdelhamid, 2021).

Therefore, Islamic values could be helpful in this regard since any kind of waste is condemned in Islamic culture. These values reject all types of waste in any circumstances. Yasini (2019) argues that living an extravagant life is a sign of ungratefulness to the bounty of Allah SWT, which contradicts the fundamental principles of Islam (Yasini, 2019). Moreover, the findings of Aktas et al. (2018) have indicated that Ramadan as an Islamic ritual can have a positive impact on consumer behavior with regard to food waste. Therefore, it is recommended that Islamic values be further investigated for the proper management of food loss and waste (Sadati, 2018).

Methodology

Research Design

This study applies a systematic literature review (SLR) with the purpose to summarise existing studies in this field. There are various articles and papers concerned with food loss and food waste. This approach using SLR was aimed to answer five formulated research questions at the start of this study. These research questions guided the researchers to refine several articles written on food loss and waste focusing on the supply chain aspect. The authors believe that by adopting SLR, this study will provide quality discussion because it uses a systematic methodology in reviewing the literature to present results in a transparent, objective, and reproducible way (Rhoades, 2011). This study is better suited to use SLR due to its pattern as a qualitative study to analyse the literature for a well-documented search and a clearly defined evaluation procedure (Tranfield, Denyer, & Smart, 2003). A review of the literature is based on the following sources: ScienceDirect, Springer, and Scopus.

Figure 1: Research Planning and Process

	Process	Criteria			Description
		ScienceDirect	Springer	Scopus	
Identification	Literature Research in the digital database				Keywords: Food loss Food waste Supply chain halal
Screening	Database Result Record	448	154	260	Keywords: Food loss Food waste Supply chain halal
Eligibility	Analysis by titles, abstract introduction, and conclusion	116	137	78	Social sciences study

Inclusion and Exclusion Criteria

This study is guided by the following questions:

- Q1. What is the difference between food loss and food waste in the food supply chain?
- Q2. What are the causes and impacts of food loss and waste in the food supply chain?
- Q3. How does the adoption of the concept of halalan thayyiban plays a role as a preventive measure in reducing food loss and waste?

Table 1: Inclusion and Exclusion

Inclusion	Exclusion
This study covers the publication period between 2013 to 2022	Publication before 2013
Focus on social sciences field of study	Thesis, book, posters, and editorials
Sources are derived from articles, journals, conferences, and proceedings.	Non-English study
Articles relevant to the research questions	Duplication in publication

Analysis

In this study, the authors analyzed the 20 screened articles and aim to answer three research questions determining the objectives of this study.

A food supply chain is defined as the movement of products and services along the value-added chain of food commodities with the aim of achieving better benefits for customers in addition to minimizing costs (Folkerts & Koehorst, 1998). A food supply chain is different from any other type of supply chain because it deals with complex issues such as the perishability of commodities, interactions with many stakeholders, and impacts across industries. The complexities associated with the food supply chain come with concerns about the safety, sustainability, quality, and efficiency of the process (Göbel, Langen, Blumenthal, Teitscheid, & Ritter, 2015).

Scholars have illustrated the food supply chain concerning globally relevant stages which include (i) farm production, (ii) handling and storage, (iii) processing, (iv) distribution, and (v) consumption. Inefficiencies in the food supply chain, leading to food loss and waste generation take place across all food supply chain stages. It is also possible that the reason for food loss and waste at a particular stage might be concealed in another stage. The globally acknowledged

approaches to food loss and waste reduction are expected to address inefficiencies of the entire food supply chain (Chauhan, Dhir, Akram, & Salo, 2021).

The length of the food supply chain and the importance of each stage depend largely on geographic location. Previous research has claimed that the early stages of the food supply chain are responsible for the greatest amount of food loss and waste (Gustavsson, Cederberg, Otterdijk, & Meybeck, 2011). The causes of food loss and waste in developing countries are often related to poor harvesting techniques and a lack of storage, packaging, and transport infrastructure (Gustavsson, Cederberg, Sonesson, & Emanuelsson, 2013). The fact that most developing countries score very low on the Hunger Index, with about 800 million people suffering from chronic hunger (Food and Agriculture Organization of the United Nations (FAO), 2013), highlights the need to focus on food loss and waste in the early stages of the food supply chain, from the farm until the distribution stage.

The conventional understanding of food loss and waste focuses mainly on disposed of or unused food. However, understanding what constitutes food loss and waste is rather complex, as it comprises several dimensions. Moreover, each dimension has numerous economic, social, and environmental implications (Irani et al., 2018).

Food Loss versus Food Waste

Studies in food loss and waste research use the terms “food loss”, “food waste”, “food loss and waste”, and “post-harvest losses” interchangeably. However, they may or may not have explored the same aspects of the problem as these terms can be used to express very different concepts. A major problem arises when these terms are translated into another language, especially from the author's native language into English for international publication. Ishangulyyev, Kim, and Lee (2019) have proposed a comprehensive framework of food loss and waste definitions. The framework aims to explain the definition of food loss and food waste as well as their relation in the food supply chain. The framework is extracted from various definitions from some research published by some institutions as follows.

Table 2: Definitions of Food Loss and Food Waste

Concepts	Definitions
Food Loss (by FAO, 2019)	Decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retail, food service providers, and consumers
Food Waste (by FAO, 2019)	Decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services, and consumers

Food Waste (by FUSIONS EU)	Any food and its inedible parts, removed from the food supply chain to be disposed of (including composted, crops plowed in or not harvested, anaerobic digestion, bioenergy production, incineration, co-generation, disposal to sewer, landfill or discarded to sea) or recovered
Food Loss (by High-Level Panel of Experts)	A decrease, at all stages of the food supply chain prior to the consumer level, in the mass of food that was originally intended for human consumption, regardless of the cause
Food Waste (by High-Level Panel of Experts)	Food appropriate for human consumption being discarded or left to spoil at the consumer level, regardless of the cause
Food Loss and Waste (by United States Department of Agriculture)	Food waste is a subcomponent of food loss and occurs when edible food goes unconsumed. The food which is still edible at the time of discard is considered food waste

These definitions give a clear boundary both for food loss and food waste in the food supply chain stages. These losses can be attributed to climatic and environmental factors such as weather damage and poor agricultural farming practices or damaged crop yields. These losses are also due to inefficiencies in the food supply chain, such as poor logistics and infrastructure, lack of technology, knowledge, skills, and management capabilities of supply chain participants, and lack of market access (Colbert, 2017). On the other hand, food waste refers to waste that occurs at the end of the food chain. This food waste is usually due to food spoilage, but can also be due to other reasons, such as oversupply, depending on the market conditions, or individual consumer eating and shopping habits (Luo, Olsen, & Liu, 2021).

The Food Use for Social Innovation by Optimizing Waste Prevention Strategies EU (FUSIONS EU) project has defined food waste as “any food and its inedible parts, removed from the food supply chain to be disposed of (including composted, crops plowed in or not harvested, anaerobic digestion, bioenergy production, co-generation, incineration, disposal to sewer, landfill, or discarded to sea) or recovered” (Östergren et al., 2014).

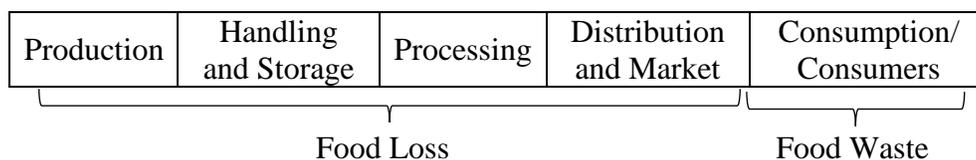
High Level Panel of Experts (HLPE)¹ defined food loss as, “a decrease, at all stages of the FSC prior to the consumer level, in the mass of food that was originally intended for human

¹ The High-Level Panel of Experts on Food Security and Nutrition (HLPE) was established in 2010 as the science-policy interface of the UN Committee on World Food Security (CFS). The HLPE aims to improve the robustness
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consumption, regardless of the cause”, and they defined food waste as “food appropriate for human consumption being discarded or left to spoil at consumer level, regardless of the cause” (High Level Panel of Experts on Food Security and Nutrition (HLPE), 2014). The United States Department of Agriculture (USDA) defined food loss and waste as, “food waste is a subcomponent of food loss and occurs when an edible food goes unconsumed. The food which is still edible at the time of discard is considered as food waste” (Buzby, Wells, & Hyman, 2014).

The above definitions are all similar when expressing a decrease in the quantity or quality of food intended for human consumption. However, they differed in how they viewed external causes and defined the link between food waste and food loss. According to the FAO definition, food loss occurs in the first three stages of the food supply chain, and food waste refers to waste that occurs in the final stages of the food supply chain. According to this definition, food waste is related to the behavior of retailers and consumers. In FUSIONS EU definition, all losses and waste are related to food waste; there is no term for food loss. The HLPE defines food loss as the reduction in the first four stages of the food supply chain, while food waste refers only to the reduction in the last stage of the food supply chain. The USDA interprets food waste as a subset of food loss, which is the reduction of food throughout the food supply chain.

Figure 2: The framework of food loss and waste in the supply chain stages



Food loss refers to the reduction in the weight of edible food in the first three stages of the food supply chain. Food waste is food that was originally produced or processed for human consumption but not consumed by humans. Food waste includes food that is edible when thrown and food that spoils before disposal. Food waste essentially refers to waste that occurs during the distribution, marketing, and consumption stages. However, for the purpose of this paper, both food loss and waste will be measured.

Food loss and waste are the natural result of various errors throughout the food supply chain to feed the entire world’s population (Colbert, 2017). Around 815 million people, mostly living in developing countries, are malnourished and hungry (12.9% of the total population) (United Nations, n.d. If food loss and waste were reduced by 50%, an additional one billion people could be fed (Ishangulyyev, Kim, & Lee, 2019). As food demand increases, serious concerns about an adequate and sustainable global food supply exist. Soils, oceans, forests, biodiversity, and

of policy making by providing independent, evidence-based analysis and advice at the request of CFS (Scaling Up Nutrition UN, 2017).

freshwater could all be at serious risk if the same levels of food loss and waste continue (United Nations, n.d.).

Efforts to reduce food loss and waste must first distinguish where they occur. The FAO provides information on the moments in the supply chain when food products become food loss and waste: (1) crops mature on plantation, field, or orchard; (2) animals on-farm (field, pens, sty, sheds, and coop) ready for slaughter; (3) milk that is drawn from the udder; (4) pond cultured fish; and (5) when wild fish are caught. The supply chain ends at the point where the food product is consumed, discarded, or removed from the chain for human consumption. Therefore, food that was originally produced for human consumption but removed from the supply chain is considered food loss and waste, even if it can later be used as bioenergy or animal feed (Food and Agriculture Organization of the United Nations (FAO), 2013).

The United Nations FAO and World Resources Institute (WRI) report on global food loss and waste highlights the huge disparities in per capita food loss and waste across economies (Gustavsson, Cederberg, Otterdijk, & Meybeck, 2011). About 56% of total food loss and waste occurs in developed countries, while the other 44% occurs in developing countries. However, the generated food loss and waste are different at each stage. These differences can be observed between developed and developing countries. Food loss is relatively high in developing countries, while the proportion of food waste in developed countries is higher (Ishangulyyev, Kim, & Lee, 2019).

In developing regions, 29% of food loss and waste is generated in the first two stages (production, handling, and storage) (Colbert, 2017). However, in developed countries, the incidence of food loss in the production phase is lower than in developing regions, but food loss in developed countries occurs due to the excessive loss of embedded resources (Leib & Gunders, 2013). In both regions, the production stage is the most resource-intensive stage. For this reason, food sustainability models (Environmental Protection Agency's Food Recovery Hierarchy) emphasize reducing excess food produced during the production stage (United States Environmental Protection Agency, n.d.). Food waste at the consumption stage in developing regions has been significantly reduced due to limited household income and poverty. Households in developing countries purchase fewer groceries and tend to buy food daily. (Gustavsson, Cederberg, Otterdijk, & Meybeck, 2011). For example, in the European Union and North America, consumer food loss and waste per capita range between 95 and 115 kg, while total food loss and waste per capita in developing regions (Sub-Saharan Africa (SSA) and South-East Asia (SEA)) are between 6 and 11 kg (United Nations, n.d.).

The occurrence of food waste at the last stages of the food supply chain is generally considered more harmful because more resources are required to move the food from one stage to another. In developed countries, a large portion of food loss and waste occurs at the final stages of the food

supply chain. Targeting food waste interventions at the consumption stage may result in a significant reduction in wastage and decrease the environmental impacts of food waste (Gustavsson, Cederberg, Otterdijk, & Meybeck, 2011).

The United Nations Economic Commission for Europe (UNECE), in “*Code of Good Practice for Reducing Food Loss in Handling Fruit and Vegetables*” (2020), has also identified preventive measures to reduce food loss, especially when handling fruits and vegetables, which are perishable at all stages of the food supply chain (from harvest to retail) before they reach consumers. The Code consists of three distinct chapters focusing on the three main parts of the fruit and vegetable supply chain, namely producers, traders, and retailers (United Nations Economic Commission for Europe (UNECE), 2020).

Aramyan et al. (2021) believe that investing in different types of innovation holds great potential for reducing and preventing food loss and waste in supply chains. Such innovations may take the form of new technologies (such as new smart refrigerators and freezers that display the content and the expiry date of certain food items, improved storage environment, better packaging, advanced software tools for better production planning, precision farming tools such as drones that provide accurate information about harvested crops and minimize losses, or crop framing sensors that provide accurate real-time information about crop health, moisture levels, and soil nutrition), new services (such as redistribution of excess food), marketing and branding (such as advertising "volatile" products to be included in the supermarkets' assortments) (Aramyan, et al., 2021). These innovations are highly needed as food loss and waste are one of the most relevant examples of inefficient use of resources in the food supply chain.

Discussion of Findings

Population growth, changing dietary habits, and the scarcity of depleting natural resources add to the urgency of food loss and waste reduction and further exacerbate the pressures on the global food value chain. Mitigating food loss and waste would reduce the needed land, water use, and greenhouse gas emissions to produce that food, thereby reducing ecological pressures to ensure future food security. Despite being in the global discussion and agenda, the food loss and waste situation have not witnessed major improvements, and experts do not expect this trend to curb unless further actions both upstream and downstream are taken (Al-Khateeb, Hussain, Lange, Almutari, & Schneider, 2021). Food losses arise at all stages of the food supply chain due to different problems, including food degradation, mechanical damage, storage, sorting, processing, and transportation, or due to statutory and private quality standards (Silvestri, Facchini, Mossa, & Mummolo, 2022).

From the analysis of the causes of food loss and waste which differ from stage to stage, it was found that practices that lead to food loss and waste often take effect across various levels of the

food supply chain. Thus, quality standards and requirements of the later stages of the food supply chain cause a downshifting of food waste along the food supply chain towards the earlier stages. For instance, the food waste found at the farmers' level is caused by standards requested by the retail industry. Furthermore, the understanding of quality, which is responsible for rejecting food, is based on regulations and international standards and not on issues of nutritional value or enjoyment. This understanding affects, for example, the choice of varieties in plant and livestock production at the farmers' level resulting in reduced biodiversity. It becomes clear that the complex system of the food supply chain with different actors and actions relate to each other even in creating food waste.

The present study also found that, economically, avoidable food losses have a direct and negative impact on the farmer and consumer incomes. In fact, food loss and waste represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses (Lipinski, Hanson, Waite, Searchinger, & Lomax, 2013) as food losses during harvest and in storage translate into lost income for farmers and into higher food prices for consumers. Food loss and waste imply that consumers are paying a higher price for food due to inefficiency and/or inequity in the food system. The environmental impacts of food production mean that minimizing food waste is a high priority that could mitigate the negative effects of land-use change and agricultural CO₂ emissions through efficient management of the food supply chain (Di Terlizzi, Otterdijk, Dragotta, Pink, & Bilali, 2016). Additionally, reducing waste across the whole food system will increase the amount of food available for human consumption, thereby improving the efficiency of the food system.

According to literature reviews, the present study finds that there are several proposals for reusing or valorizing agri-food industrial waste like by-products for human consumption, food ingredients, energy, and fuel, or other industrial applications, which can contribute to food loss and waste reduction while providing economic benefits at the same time (Silvestri, Facchini, Mossa, & Mummolo, 2022). Hence, in realizing strategies for food loss and waste reduction, the concept of *halalan thayyiban* needs to be implemented into a sustainable halal supply chain management, especially in the agri-food industry. Halal supply chain management is expected to help reduce food loss and waste through proper food handling and food safety. The Internet of Things (IoT) should also be utilized to support and improve halal supply chain management efficiencies to make this possible. IoT lets each aspect of the food industry access essential data related to the supply and management of production, thereby reducing the amount of waste created (EnMass Energy, 2020).

Papargyropoulou et al., (2014) specifically analyzed food loss and waste management in the defined "Food Waste Hierarchy" model, which aims to identify different options available to plan a set of prioritized actions classified by environmental impact (Papargyropoulou, Lozano, Steinberger, Wright, & Ujang, 2014). The main actions suggested are based on the:

- Food loss and waste **prevention** (i.e., reducing at the source; optimizing processes; adapting production to needs);
- Food loss and waste **recovery** (i.e., redistributing food to people who need and/or want it);
- Food loss and waste **recycling** (i.e., feeding animals; using scraps for industrial production, energy, or compost).

Technological innovations at the processing stage facilitate the development of food reuse strategies. In most cases, these technologies involve transforming fresh food loss and waste, such as fruits and vegetables, into other products like snacks, soups, fruit juices, etc., thereby creating value from waste or low-value products (Cicculloa, Caglianoa, Bartezzaghia, & Peregoa, 2021). Many strategies aim to limit the surplus in food production, identifying the target products to commercialize in the specific market, and adopting advanced tools such as forecasting, monitoring, and grouping. Chemicals (such as active packaging) and mechanical preservation (such as storage and transport systems) can improve product quality while extending product shelf life at the same time (Silvestri, Facchini, Mossa, & Mummolo, 2022).

Another potential strategy to reduce food loss and waste in the final stages of the food supply chain is to promote and discount the malformed food products or sell them through secondary markets. The malformed fruits and vegetables are considered substandard. The aesthetic defect does not compromise the taste or health benefits. While many agree that food should be enjoyed, it should also not be taken in excess, always in moderation as prescribed by Islamic dietary. In Islam, everyone is responsible to find a solution if there is any leftover or surplus of food (Puan Norkumala binti Awang, 2019). Nevertheless, good planning in food preparation is of the utmost importance in preventing food wastage. Allah SWT has enjoined man to eat only what he needs in moderate quantities without excess and maintain balance in food consumption. In the Quran, Allah SWT proclaims:

“Eat of the good things We have provided for your sustenance, but commit no excess therein, lest My Wrath should justly descend on you: and those on whom descends My Wrath do perish indeed.” (Taha 20: 81)

This is also evidenced in the hadith narrated by Abu Hurayrah (May Allah be pleased with him) that Allah’s Messenger (Peace be upon him) said, “*When one of you eats, he must lick his fingers (after finishing), for he does not know in which of them lies blessing*” (Sahih al Muslim, Jami Tirmidhi) to show us not to let go of any part of our food. To add to that, Sayyidina Jabir (May Allah be pleased with him) reported that the Prophet (Peace be upon him) said; “*When one of you eats his meal and a morsel falls, he must pick it up and remove the doubtful portion and eat the rest. He must not leave it for the devil.*” (Jami’ Tirmidhi) for “*Verily spendthrifts are brothers of the Shaytaan, and the Shaytaan is to his Lord, ungrateful*” (Al-Isra’ 17:27). Such is the abhorrence and hatred of wastage in the sight of Allah SWT to the extent that he declared the wasters and the spendthrifts as the ‘brothers’ of the Shaytaan who is ever ungrateful to the Lord (Akintola, 2021).

Nutritious and balanced food is needed for survival and wellness; therefore, a balanced diet alone is not sufficient. Human beings need to keep the quantity of food consumed adequately. Such practices should be observed especially during fasting in Ramadan so as to maintain good health. Food intake must be moderate since any excessiveness will harm the body and contribute to the increase of food waste (Puan Norkumala binti Awang, 2019). Balance in all forms of action is the foundation of the Islamic lifestyle whereas overconsumption will only disturb and spoil the balance.

Conclusion

Food loss and waste are key components of the current unsustainability of food systems and further attention should be devoted to them. In a world where almost one billion people are hungry, reducing food loss and waste is critical to creating a world with zero hunger by ensuring sustainable consumption and production patterns. To be environmentally effective, interventions to reduce food loss and waste need to consider where food loss and waste have the greatest impact on the environment – both in terms of food products and the stage of the food supply chain. Reducing food waste is not only necessary to avoid the associated environmental impacts it causes or to solve the problem of global food insecurity, but it is also beneficial for economic sustainability as it helps to increase the overall food supply and reduce food prices.

Both consumer behavior and production practices play crucial roles in the efficiency of the food system. The fact that food loss and waste are produced at all stages of the value chain, their main causes must be identified systematically throughout the whole food supply chain. The concept of *halalan thayyiban* in the halal supply chain management provides significant measures in reducing food loss and waste through proper food handling and preserving food safety. Halal supply chain management implements Islamic values that prevent food loss and waste at every stage of the food supply chain. Indeed, efforts are increasing to prevent and reduce food waste since any kind of waste and extravagance are condemned in Islamic teaching, therefore it is essential to instill Islamic values in the awareness of reducing food waste, especially among Muslims.

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