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Review paper

Food loss and waste: a global problem

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ABSTRACT

The world produces an enormous amount of food to sustain its population, yet a substantial portion of it goes to waste or is lost throughout the supply chain. Food loss refers to the reduction in the quantity or quality of food throughout the production, post-harvest, and processing stages, primarily in developing countries with inadequate infrastructure and storage facilities. It is estimated that up to one-third of all food produced globally is lost before it even reaches consumers. Food waste occurs mainly in developed countries, primarily at the consumer and retail levels. It refers to the discarding of edible food that is still fit for consumption.

Addressing food waste and food loss requires a multifaceted approach involving governments, businesses, communities, and individuals. By tackling food waste and food loss on a global scale, we can work towards achieving food security, reducing environmental degradation, and fostering a more equitable and sustainable future for all.

1. Introduction

Providing a sufficient amount of safe food with defined desirable quality parameters is a crucial responsibility of every producer, but also a basic human right guaranteed by the Universal Declaration of Human Rights in 1948 (Article 25) (*Beuchelt et al.*, 2022). The attitude of people towards food has changed over time. Today's consumers are more aware and informed about food safety and quality, and they expect the food they consume to be safe, nutritious, and of high quality. This has led to a growing demand for food products that meet specific quality parameters, such as minimally processed foods, organic food, non-GMO foods, and food with reduced content of sugar, salt, unhealthy fats, etc (*Alcorta et al.*, 2021). However, in parallel with modern trends in the food industry, significant increases in the food losses and food waste, as well as risk of food spoilage in the food chain are now being seen. These questions are becoming even more significant as the global population continues to increase. According to the United Nations' "World Population Prospects 2019" report (*UN*, 2019), the global population is projected to reach 9.7 billion by 2050 and 10.9 billion by 2100.

By minimizing these risks we can better meet the increasing global food demand and ensure a more sustainable future for all.

2. Food losses and waste in the world

In the 21st century, food loss, with its consequent losses, is of great influence for economic, ecological and sociological aspects (*Seberini*, 2020). In addition to direct material damage, a significant loss

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is also reflected in lost work, used water, energy, land, and other resources that enter the food production chain (*Lipinski et al.*, 2013). Food loss occurs at all stages of food production starting from primary stage (field or farm), through processing, storage and transportation to end-users, excluding retail stores (*Vågsholm et al*., 2020). Inefficient farming practices, storage and transportation losses, and inadequate infrastructure contribute to significant food losses even before food reaches consumers.

In contrast to food loss at the producer and market interface, food wastage is linked to the reduction of its quantity due to specific decrees and activities within retail systems, food service providers and from consumers themselves. In developed countries, consumers often discard edible food due to various factors, such as purchasing excess quantities, improper storage, confusion over expiration dates, or aesthetic preferences for visually appealing produce. It is necessary to recognize that food wastage comprises rejected safe and nutritious foods (*FAO*, 2011).

Estimating the exact amount of food wasted globally, or in specific countries, is challenging due to the lack of comprehensive data and variations in measurement methodologies. According to the Food and Agriculture Organization (*FAO*, 2011) of the United Nations, it is estimated that approximately one-third of all food produced for human consumption is lost or wasted globally each year in the first decade of the 21st century. This amounts to about 1.3 billion metric tons of food, or approximately $1 trillion in economic losses. However, food losses and waste varies across regions and countries due to various factors, such as, the level of economic development, cultural practices, infrastructure and food supply chain management practices. Generally, higher levels of food waste are observed in more economically developed countries, while in developing nations, food losses often occur at earlier stages of the supply chain (during production, storage, and transportation).

The United States is one of the countries with significant food waste. It is estimated that around 30–40% of the food supply is wasted, amounting to approximately 63 million tons of food annually with an estimated value of around $161 billion (*FDA*, 2023). In the UK, it is estimated that around 9.5 million tons of food is wasted annually, with households accounting for the majority of the waste. Australia wastes around 7.3 million tons of food each year, with consumers and households contributing to about 34% of the total food waste. China is the world's largest producer and consumer of food, and food waste is a growing concern. While specific figures are challenging to ascertain, it is estimated that China wastes around 17–18 million tons of food annually (it is important to note that these figures are approximate and may vary based on different data sources and reporting methods).

In Europe, the economic costs of food waste and loss are also substantial. Is considered that Europe is responsible for 22% of food waste on the global level (*Searchinger et al*., 2014). According to a study by the European Commission, food waste in the EU alone costs around €143 billion per year. This includes the costs of producing, processing, and transporting food that is ultimately wasted, as well as the environmental and social costs of food waste. It is an interesting fact that the level of food wastage in Europe is quite uniform in the countries with high-, middle- and lower middle-income (*UNEP*, 2021).

Serbia still does not have a dedicated national food waste study, nor comprehensive data on food waste. However, according to estimates (*NALED*, 2019), about 247 thousand tons of edible food are wasted in Serbia annually, about 30–40 kg per capita, the estimated value of which is about €240 million.

Table 1. Annual wastage quantity (kg/capita/year) depending on the country's economic development level (FAO, 2021)

Level of development	Average food waste (kg/capita/year)		
	Household	Food service	Retail
High-income countries	79	26	13
Upper middle-income countries	76	Insufficient data	
Lower middle-income countries	91	Insufficient data	
Low-income countries	Insufficient data		

In Table 1, the average annual quantities of food wastage in countries of different levels of development according to the World Bank research data (*FAO*, 2021) are shown.

Research has shown that in developing countries, due to the lack of modern processing and preservation technologies, as well as adequate storage methods, much more food is lost during the production/processing phase and immediately afterwards. In contrast, in industrialized countries one-third of food spoilage and write-offs occur at the retail or consumer level (*FAO*, 2011). The worrying data is that in the countries with medium and high incomes, food is to a large extent wasted, even if it is still suitable for human consumption, but also due to its increased production in relation to the actual needs of end users.

Despite global progress in the development of human society, access to food remains limited in many regions of the world, which is contributed to by poverty, conflict, climate change, inadequate infrastructure, and unequal distribution of resources. It was estimated in 2020 that from 720 to 811 million people worldwide experienced hunger, which is as much as 161 million people more than the year before (*FAO*, 2021 ; *Tomaszewska et al.*, 2022) and in 2021, between 702 and 828 million were hungry. Hunger affected 46 million more people in 2021 compared to 2020, and a total of 150 million more people since 2019, before the COVID-19 pandemic. Also, an estimated 45 million children under the age of five were suffering from wasting, the deadliest form of malnutrition, while 149 million children (of the same age) had stunted growth and development due to a chronic lack of essential nutrients in their diets. The listed figures highlight the stark contrast between the prevalence of hunger and food waste in the world today.

3. Food spoilage

Food spoilage is a natural, metabolic process that leads to sensory changes in texture, odour, taste, or appearance of food that becomes undesirable or unacceptable for human consumption (*Doyle,* 2007 ; *Nychas and Panagou*, 2011). Irrespective of its origin (vegetable or animal), due to its composition (moisture, proteins, lipids, carbohydrates and other organic and mineral substances) food can be an ideal environment for the development of undesired microbiological, chemical and physical processes that lead to the emergence of unpleasant sensory changes, i.e., spoilage. Numerous factors are involved in the aetiology of food spoilage occurrence. These are, in the first place, activities of microorganisms (primarily, bacteria, yeast and moulds), insects, rodents and other pests, then action of food enzymes themselves, effects of storage temperature, air composition (especially oxygen level), light, air humidity level and other factors. These aforementioned factors rarely act separately, isolated and independent from each other. In most cases, their action is interconnected and simultaneous.

Although microorganisms are the most common causes of the food spoilage process, this process does not always lead to consumer illness, given that pathogenic microorganisms or their toxins need not be present in spoiled food. However, the resulting changes in sensory properties mean that this type of food must not be used further in human diets. The highest percentage of food loss was found in root vegetables (40–50%), fruits and vegetables (35%), fish and seafood (30%), cereals (20%), meat, oilseeds and dairy products (20%) (*FAO*, 2019).

Food spoilage is a major concern of the entire world population, with developing parts of the world particularly affected. At the same time, the research results indicate that there is a global lack of information about this problem, especially in quantifying food loss in relation to the aetiology of the cause, as well as the extent of economic damage that accompanies such loss (*FAO*, 2011). In parallel with these unfamiliarities, there are also no appropriate assumptions about potential costs that could be spent on needed activities aimed at reducing or preventing food loss due to food spoilage.

4. What are ways to minimize waste and food loss?

Regardless of the level of economic development and maturity of the system in the country, it is necessary to strive to reduce food losses to a minimum. Considering the importance of this problem, many countries in the EU have, as part of their national policies in the area of food production, and as an important part of their strategies, raised the issue of reducing food loss and wastage, requesting that by legally binding statutes. However, in most countries, legislation is designed in such a way that food safety is treated separately from the issue of food spoilage. Despite such a prevailing approach, the aforementioned areas cannot be separated or considered individually. The occurrence of diseases

with accompanying health problems, as well as economic losses due to foodborne diseases, are directly related and complementary to economic losses due to food spoilage (*Di Renzo et al.*, 2015).

Looking at the food chain as a whole, based on the many analyses carried out so far, we think that the following approaches (or a combination thereof) could help reduce food losses (*FAO*, 2019 ;*Veskovic Moračanin & Đukuć*, 2022): implementing better post-harvest handling practices (including proper harvesting techniques, efficient transportation, and storage facilities that maintain optimal temperature and humidity levels); improving infrastructure (enabling more efficient transportation of food to markets and storing it in appropriate conditions, thus reducing spoilage and losses along the supply chain); developing efficient and well-coordinated supply chains (establishing effective linkages between farmers, processors, distributors, and retailers to ensure a smooth flow of food products); implementing quality control measures and product standards (ensuring that only high-quality produce enters the market, minimizing potential losses due to rejection or spoilage through inspections, certifications, and adherence to food safety standards throughout the supply chain); educating farmers, processors, retailers, and consumers about proper handling, storage, and utilization of food; and promoting the development and implementation of new technologies and innovations in the food chain. Additionally, government interventions through the implementation of policies and regulations in the food sector can create an enabling environment for stakeholders to prioritize and invest in reducing food losses.

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