

Food Losses and Food Waste in the Context of Sustainable Development of the Food Sector*

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Globally, about one third of all food produced is wasted every year. Losses take place along the entire food chain and they need to be analyzed and monitored due to their impact on the development of the food sector. In addition to quantitative losses, irrational use of food contributes to the depletion of natural resources (water and energy) and poses a threat to the environment, constituting a barrier to sustainable development of the food sector. The aim of this study was to establish the causes and effects of food waste throughout the food supply chain and to propose mitigation measures. Identified causes of food waste can be divided into two groups. The first are those that lead to the fact that food cannot be consumed (e.g., inadequate conditions of agricultural production and interruption of the cold chain). In the second, those that cause food cannot be sold (e.g., wrong label and wrong product weight). Most of the identified causes of food waste can be avoided (e.g., by improving the conditions of production, storage, and transportation). However, it is not possible to eliminate all potential errors leading to food waste. It is therefore necessary to consider what action to take to use food as intended. One way to reduce losses and food waste can be re-distributing to charity.

Keywords: food losses and food waste, causes of food losses and food waste, potential ways of reducing the waste of food, sustainable development

Introduction

Sustainable development was first defined as “development that meets the needs of today without endangering the supply of the needs of future generations” in the UN Report (Retrieved from <http://www.un-documents.net/our-common-future.pdf>). A sustainable food system is defined as a system which ensures

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food and nutrition security in a way (economic, social, and environmental) which does not endanger the food and nutrition security of future generations (Vishweshwaraiah, Ambuko, Belik, Huang, & Timmermans, 2014).

Worldwide, about 4.5 trillion tones of food are produced every year, which is nearly twice as much as the amount required to satisfy the food needs of the world. In spite of this, 870 million of the inhabitants of the Earth starve and 2 million are undernourished (accounting for 12.5% of the population) (Food and Agriculture Organization [FAO], 2013). In the era of globalization, in which so many people suffer from hunger and deprivation, in developed countries, food supply exceeds demand. Moreover, consumeristic attitudes have an effect on lifestyles, leading to an increase in nutritionally irrational behaviour. This in turn contributes to the development of non-infectious diseases, such as obesity (500 million people), overweight (1.4 billion people), diabetes, hypertension, etc. (FAO, 2013). About 79 million people (15% of EU citizens) live below the poverty line. Only 20% of them (16 million people) benefit from food aid provided by organizations engaged in the redistribution of food (Retrieved from <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+TA+P7-TA-2012-0014+0+DOC+PDF+V0//EN>). To support initiatives associated with the fight against hunger, it is essential to promote a sustainable food system that prevents food losses and the waste of food (Retrieved from <https://sustainabledevelopment.un.org/rio20>).

Food losses and food waste are defined as a decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption (Vishweshwaraiah et al., 2014). According to the terminology adopted by the Polish Working Group on Efficient Use of Food, set up by the Federation of Polish Food Banks, losses are defined as a decrease in edible food mass due to mismanagement, errors, and irregularities in processes, such as agricultural production, harvesting, processing, transport, or marketing. The term food waste refers to poor management practices in the area of catering and in households (Wrzosek, Kołozyn-Krajewska, & Krajewski, 2012).

The Impact of Food Waste on Sustainable Development of the Food Chain

The food chain is a structured process consisting of a number of mutually dependent food management processes whose main objective is to ensure a flow of food, adequate in terms of quantity and quality, which is needed to feed the population. An essential aim of this chain is to guarantee the stability of supplies and to make sure that the offered foodstuffs are safe to eat. In a sustainable food chain, priority is given to its environmental aspect, understood as a reduction of its adverse impact on the quality of air, soil, and water, while also focusing on minimizing the use of natural resources and reducing noise. A sustainable food chain can also be defined as a cycle of economically rational processes designed to preserve the potential of the environment. Economic objectives are understood as a balance between demand and supply, stabilization and maintenance of an appropriate level of food prices, as well as maintenance of jobs (Sznajder, 2008).

According to the FAO report from 2011, about one-third of all food produced and marketed worldwide ends up uneaten by people. This high percentage of losses is mostly attributable to mechanical damage, supply and demand mismatch, and ineffective use of purchased food by members of households (FAO, 2011). According to Eurostat and national data, it is estimated that about 89 million tones of food waste were produced in the EU-27 countries in 2006 (179 kg per person). Based on data from 2006, it is predicted that in 2013, food waste will grow in the EU-27 countries to about 100 million tons (data from 2013 are not yet available) (Puigarnau, 2014). There is an upward trend in the level of food losses, which may reach about 126 million tons by 2020 (Retrieved from <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+TA+P7->

TA-2012-0014+0+DOC+PDF+V0//EN). The structure of the sources of food waste produced in EU-27 countries is as follows (Retrieved from http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf):

- households—42%;
- production and processing—39%;
- food services—14%;
- retail and wholesale—5%.

Due to such a large scale of this phenomenon, it needs to be discussed at the European Parliament so that preventive measures can be developed to reduce the waste of food. The documents drawn up for this purpose include the Resolution entitled “How to avoid food waste: Strategies for a more efficient food chain in the EU”, which argues that specific measures must be taken to minimize the waste of food, to ensure the exchange of information and practices by all member states, and to promote cross-sectoral cooperation in the food chain “from farm to fork” (Retrieved from <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+TA+P7-TA-2012-0014+0+DOC+PDF+V0//EN>). A reduction in the amount of food waste can result in a decrease in demand, because less food will be needed to achieve the same aim (Puigarnau, 2014).

Global and local activities taken with the aim of reducing the waste of food and fighting hunger culminated by Fan and Polman’s report (2014), they strongly emphasized that the fight with hunger was being fought on a continuous basis and that its real effects were already visible. Therefore, one can expect that the problem of hunger in the world will be completely eliminated in the next 20 years. A 10-year framework on sustainable consumption and production was also adopted at the summit. It states that support for the development of “green economy” is needed to minimize poverty. In addition, investment in such a model of the economy may contribute to global economic growth and protection of the environment. However, this aim can only be achieved by ensuring positive relationships and involvement of state authorities, business partners, and entire societies (Fan & Polman, 2014).

The overarching objectives of the environmental policy of the European Union stem from the general declaration of the Rio de Janeiro Conference. It formulates 27 principles and conditions that countries should follow to implement the idea of eco-development (Hadryjańska, 2008). The Sustainable Development Strategy of the European Union (EU SDS) provides for continuous improvement of the quality of life of citizens by communities organized in accordance with the principle of sustainable development which manages and uses resources in an efficient way and makes the most of the economical potential associated with ecological and social innovations, ensuring prosperity, environmental protection, and social cohesion. The progress made in achieving sustainable development is measured as an integral part of the EU SDS, while Eurostat is tasked with drawing up a biannual monitoring report on the basis of the EU’s set of sustainable development indicators (Retrieved from <http://ec.europa.eu/eurostat/documents/3217494/5760249/KS-02-13-237-EN.PDF>).

Food losses and food waste have an impact on the food system and its balance in three dimensions (Vishweshwaraiah et al., 2014):

- economic dimension—causing economic losses and reducing the return on investment;
- social dimension—hindering social development and progress;
- environmental dimension—due to the waste of resources used to produce food that is never eaten and due to greenhouse gas emissions from landfills where food waste is dumped.

Given the scale of the cumulative effects of food production and consumption, food waste can be seen as the main cause of the overexploitation of resources and global environmental problems (Puigarnau, 2014).

Inefficient management of raw materials and food products renders a given food lot unfit for human consumption despite human labour involved in its production, irreversible loss of natural resources used up in its production, unnecessary costs, and ineffective financial expenditure. The food chain is divided into two stages. As a result, losses relate either to a raw material or a final product. It thus becomes obvious that the later a given foodstuff is wasted, the higher is its unit cost and expenditure involved in its production and production-support activities, given their cumulative effect along the multi-stage food chain. The waste of food in the final stages of the food chain also has a more negative environmental impact due to emissions of greenhouse gases (including carbon dioxide, methane, etc.), the use of drinking water, or the farming of land which could have been used for other purposes (FAO, 2013). Estimates show that the food system in developed countries, throughout the supply chain (from agricultural production, through to processing, distribution, households, and waste), is responsible for 15%-28% of all greenhouse gas emissions (Garnett, 2011).

One of the indicators of the negative environmental impact of food waste is the total amount of uneaten food compared with the amount of water used to produce it. It is estimated that the amount of water wasted when food is discarded without being eaten amounts to about 250 km³ worldwide every year. Raw materials with the highest water demand throughout the entire food chain include: cereals, fruit, meat, milk, and vegetables (FAO, 2013). The annual amount of irreversibly lost food per inhabitant as well as the amount of water used up during its production, has been found to be the highest in North and West Africa and Central Asia (92 m³/per person/annually). In comparison, uneaten food in European countries amounts to about 26 m³/per person/annually (FAO, 2013). Another factor which makes it possible to compare the environmental impact of particular foodstuffs is the analysis of their carbon footprint, understood as total gases emitted to the atmosphere throughout the product life cycle "from farm to fork", expressed as carbon dioxide equivalent (CO_{2e}). In the multi-stage food chain, where gas emissions and carbon footprint mostly relate to gas emissions that take place during the cultivation and transportation of raw materials, processing operations, delivery of food to places of its distribution, maintenance of the continuity of the cold chain, cooking, or disposal of post-consumer waste and packaging materials, the food industry is characterized by a particularly large share in greenhouse gas emissions. Analyzing the level of CO_{2e} emissions per every 100 kcal of specific food (raw materials or products), one can see that it is particularly high for food of animal origin. In the case of beef, CO₂ emissions amount to about 1,431 gram CO_{2e}/100 kcal. In the case of tomatoes or potatoes, they amount to 46 grams of CO_{2e}/100 kcal and 52 CO_{2e}/100 kcal, respectively (Konieczny, Mroczek, & Kucharska, 2013).

The last stage which poses a real threat to the environment is the process of storage of unconsumed food. In 2007, landfills with food waste covered an area of 1.4 trillion hectares globally. This area is equal to about 28% of the entire area of arable land worldwide. The countries which use the largest areas of land for the production, processing, and storage of food waste include, Russia, Canada, the United States, China, Brazil, and Australia. The food industry that covers the largest percentage of land is the production and processing of meat and milk (jointly), followed by the production and processing of cereals and eggs (FAO, 2013).

Another aspect of the losses caused by non-consumption of food is the financial losses incurred as a result. Globally, these losses amount to about \$750 trillion annually. Geographically, these losses are the highest in Asia (48%). The products which account for the highest percentage of financial losses include, vegetables, meat, fruit, cereal, and milk (FAO, 2013).

The aim of this study was to establish the causes and effects of food waste throughout the food supply chain and to propose mitigation measures.

Causes and Effect of Food Losses and Food Waste in the Food Sector

Food losses and food waste can only be reduced, if their causes are identified. All entities-participants of the food chain are responsible for the waste of food and therefore they should undertake joint initiatives to reduce it. It should be pointed out that the waste of food occurring at one stage (e.g., retail sale and households) can be caused by an error made in a previous activity or process, e.g., incorrect harvesting can shorten shelf-life.

Table 1 shows the causes and effects of the waste of food for each stage of the food supply chain. Identified causes of food waste can be divided into two groups. The first are those that lead to the fact that food cannot be consumed. In the second, those that cause food cannot be sold, although it does not create any health hazard and can be ingested.

The causes of the waste of food which make it unfit for consumptions, include in particular: natural disasters, inadequate conditions of agricultural production, storage, exposure, interruption of the cold chain, equipment failures, damage to unit packaging, and the so-called plate losses. Another important aspect is the lack of knowledge on how to maintain the conditions which are necessary to retain the nutrient quality of food, for example, losses at the stage of the distribution of food occur due to improper loading and unloading (e.g., overloading of vehicles) and errors during commercial operations (e.g., failure to observe appropriate temperature conditions). One of the most essential causes of food waste in retail trade is the expiry of the use-by date. Losses in large-area commercial facilities are caused by commercial standards which make it necessary to maintain "full shelves" in the sales zone. It should also be mentioned that the storage of excessive quantities of goods may increase the incidence of mechanical damage to food sold in bulk or in fragile packages. According to studies carried out in 2008, losses taking place in trade in the USA are estimated at 10%. In the opinion of researchers, these losses were mainly caused by the storage of goods in large quantities (Buzby, Hyman, Stewart, & Wellsal, 2011). Other American data confirm that over 10% of food intended for sale is discarded. In the case of supermarkets, the level of losses within a given product range can be extremely varied, ranging from 0.6% to 63% (Griffin, Sobal, & Lyson, 2009). In contrast, studies carried out in developed countries have shown that commerce is responsible for about 5% of food losses (Eriksson, Strid, & Hansson, 2012). As demonstrated by the research conducted by Wrzosek, Bilska, Kołożyn-Krajewska, Krajewski, and Kondraszuk (2014) in 117 commercial retail establishments in Poland, the most frequent cause of the waste of milk and dairy products in retail trade is the expiry of the use-by date (78%), followed by mechanical damage to the packaging (22%) (Wrzosek et al., 2014).

The following factors are thought to be lead to food losses and food waste, if they are not noticed and eliminated sufficiently in advance: buying-in prices which are too low, market collapse, overproduction and order overestimation, non-conformity with commercial standards (size, colour, shape, etc.), incorrect labelling, wrong product mass, mechanical damage to outer packaging, short expiry dates, and items missing from commercial sets.

Overproduction at the stage of primary production is caused by fear of unforeseen events (e.g., bad weather, insect pests, natural disasters, etc.), leading to decisions on increasing the scale of agricultural production, just in case. Due to such excessive production, the consumer purpose of thus harvested crops is ultimately changed to a manufacturing one, e.g., animal feed is ultimately used as biofuel (Parfitt, Barthel, & Macnaughton, 2010). Overproduction at the processing stage may be caused by incorrectly estimated demand, resulting in excessive stocks of finished products and potential losses. To prevent this, processes should be implemented to monitor and analyze the market and estimate the demand. In addition, processes should be developed to ensure coordination and collaboration among particular sectors of the food supply chain.

Table 1

Analyzes of Causes and Effect at Food Losses and Food Waste in the Food Chain

	Stage	Cause of losses and waste	Effect
FOOD LOSSES	Primary production in preservation	Too low purchase price; Market collapse; Non-compliance with marketing standards (size, color, shape, etc.); Overproduction; Mechanical failure of the raw material.	Product is suitable for consumption, but there are problems with their sale.
		Natural disasters; Inadequate conditions of agricultural production; Inadequate storage condition.	Product is not suitable for sale and consumption.
	Transportation of raw materials	Mechanical failure of the raw material.	Product is suitable for consumption, but there are problems with their sale.
		Inadequate transport conditions; Interruption of the cold chain.	Product is not suitable for sale and consumption.
	Processing	Damage of packing units in the packaging process.	Product is not suitable for sale and consumption.
		Market collapse; Overproduction; Wrong label; Wrong product weight; Errors during production processes and storage; Equipment failures; Interruption of the cold chain.	Product is suitable for consumption, but there are problems with their sale.
		Mechanical damage of packaging;	Product is suitable for consumption, but there are problems with their sale.
	Transportation product	Damage of packing units in the packaging process; Interruption of the cold chain.	Product is not suitable for sale and consumption.
		Mechanical damage of packaging; Short shelf life; Overestimation the order; Non-compliance with marketing standards (size, color, shape, etc.).	Product is suitable for consumption, but there are problems with their sale.
	Wholesale and distribution centers	Damage of packing units in the packaging process; Excess of products shelf life; Inadequate storage and exposure conditions.	Product is not suitable for sale and consumption.
		Mechanical damage of packaging; Decompleting of commercial kits; Short shelf life; Overestimation the order; Non-compliance with marketing standards (size, color, shape, etc.).	Product is suitable for consumption, but there are problems with their sale.
	Retail	Damage of packing units in the packaging process; Inadequate storage and exposure conditions; Excess of products shelf life.	Product is not suitable for sale and consumption.
Overestimation the order; Keeping too large inventory; Short shelf life.		Food is suitable for consumption, but there are problems with proper use of sales.	
FOOD WASTE	Food services	Inadequate production conditions; Inadequate storage conditions; Production errors; Post-consumer losses.	Food is dangerous and is not suitable for consumption.
		An excessive amount of food purchased; Short shelf life.	Food is suitable for consumption, but is lost due to a lack of willingness or ability to consummate.
	Households	Inadequate storage conditions; Excess of products shelf life; Manufacturing errors; Post-consumer losses.	Food is dangerous and is not suitable for consumption.

Source: Own study.

The processes which contribute to losses even though they do not involve any health hazards include: restrictive requirements concerning the shape, colour, and the size of raw materials. In the current system, products are either defined as “marketable” (suitable for sale in supermarkets) or as having no market value (they are usually left unharvested in the field). In addition, large quantities of raw materials can go to waste when their buying-in prices are too low and there is no economic sense to harvest them. Some errors (e.g., incorrect product labelling) that occur during the processing stage make products unsellable, although they do not create any health hazards.

One of major causes of the waste of food is associated with the fact that households buy more than they need. Improper storage of purchased food, non-consumption of incorrectly cooked dishes (resulting in inadequate sensory quality of food), and preparation of excessive quantities of dishes in households are mentioned by Papargyropoulou, Lozano, Steinberger, and Wright (2014) as essential causes of the waste of food in households.

The structure of food products wasted in households is slightly different in particular countries, for example, in Great Britain, the most often wasted foodstuffs include: vegetables and fruit (27%); beverages (17%); bakery products (11%); ready meals (10%); dairy products (10%); and meat (7%) (Questa, Ingle, & Parry, 2013). In contrast, the most often wasted foodstuffs in the USA in 2008 included: meat, fish, and poultry (34%); vegetables (20%); cereals (15%); and milk products (17%) (Buzby & Hyman, 2012).

The causes of food waste in the sector of food services are similar to those occurring in households. According to Halloran, Jesper, Kornum, Bucatariu, and Magid (2014), food waste in commercial kitchens can be reduced by serving measured meals, instead of serving them on a buffet basis. Katajajuuri, Silvennoinen, Hartikainen, and Heikkilä (2014) pointed out that in restaurants where meals are cooked to order, leftovers have a larger share in overall food waste than in self-service restaurants (7% and 4%, respectively). Garrone, Melacini, and Perego (2014) argued that food surpluses in this sector are mainly caused by overproduction caused by incorrect estimation of the demand. Theoretically, catering establishments can transfer unsold food to charitable organizations. In practice, however, it is quite difficult due to high costs of transport and relatively small quantities of meals collected from each restaurant. In addition, any such meals must be delivered to those in need in a very short time (Halloran et al., 2014; Garrone et al., 2014).

Potential Ways of Reducing Food Losses and Food Waste

One of the concepts which may contribute to reducing food losses is the corporate social responsibility (CSR). According to the European Commission’s definition from 2001, CSR is a “concept whereby companies integrate social and environmental concerns in their business operations and in their interactions with their stakeholders on a voluntary basis” (Retrieved from <http://www.eea.europa.eu/policy-documents/com-2001-366-final-green>).

The building of a socially responsible business model is not directly taken into account in sustainable development indicators, either. CSR indicators indirectly pertain to several thematic areas associated with sustainable development. Successful development of the idea of CSR should lead to social and economic development, promoting social involvement and sustainable consumption and production. CSR is also associated with other EU initiatives within the framework of Agenda 2020 (Jodkowska, 2011). It can thus be said that unjustified waste of food that takes place at any stage of the food chain, resulting in its non-consumption, can be attributed to the lack of corporate social responsibility.

It can be said that there are few causes, such as natural disasters, which inevitably lead to the waste of food. Nearly all other causes can be significantly reduced. Figure 1 shows activities which may help to reduce the losses and waste of food. Most of the actions identified aim to take such measures that will help prevent losses in the future. Improved conditions of agricultural production, storage, and transportation can ensure proper quality of raw materials. In retail, trade can be prevented by the expiry of the use-by date, among other things, by using the FIFO principle (first in—first out), or by estimating the size of an order or delivery in a more precise way.

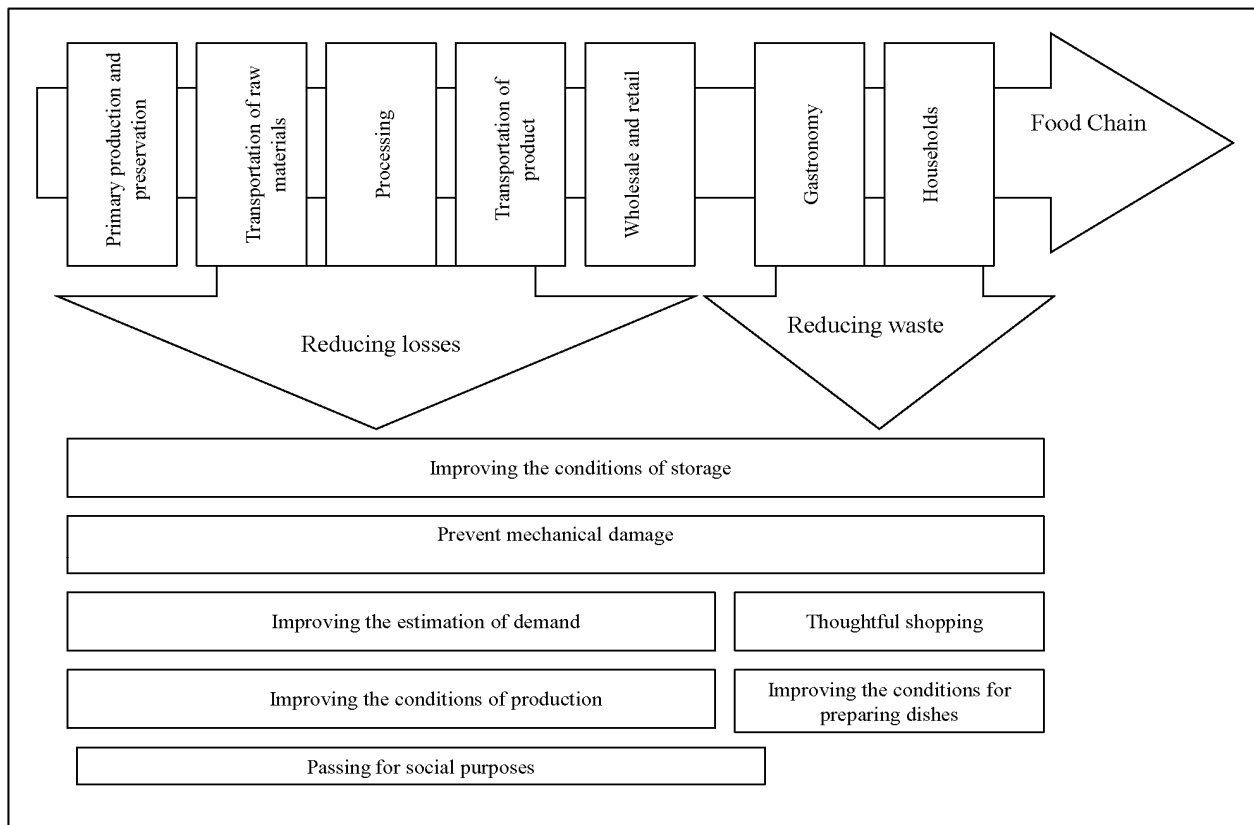


Figure 1. Types of food losses and food waste reduction. Source: Own study.

The second type of action is to prevent wasting food through its rational management. Food which is not suitable for sale can be eliminated by developing procedures for ensuring rational use of products withdrawn from sale. Products with incorrect label can be transferred to charitable organizations where these errors can be rectified, so that they can be used in soup kitchens for those in need. Parfitt et al. (2010) argued that the recovered food surpluses should be transferred to public benefit organizations engaged in redistributing food to those in need. The food redistributed to those in need may not create any health hazards, but it may have shorter expiry dates.

To tackle the problem of large quantities of waste in mass-scale logistical processes, the concept of ecologically oriented logistics has been proposed, followed by a concept of reverse logistics in the next stage (Prahinski & Kocabasoglu, 2006). The reverse logistics has its origin in a place where traditional logistics ends and it is connected with the added value produced in a reversed directions as compared to the flow of initial logistical processes. The reverse logistics relating to food products is characterized by a reversed direction of

activities when compared to traditional logistical processes, as well as by a specific process. It entails a flow from a very large number of dispersed endpoints (from the sphere of processing or marketing and collective collection points) to entities engaged in making use of consumer goods (market products) which are at risk of being used irrationally or excluded from trade, due to which they return to the logistical network. These specific consumers are also recipients of products withdrawn from distribution or sale or of products returned as defective. Further redistributions processes are usually operated by enterprises engaged in the recovery and recycling activity (Krajewski, Wrzosek, Lipińska, Kołożyn-Krajewska, & Bilska, 2013).

It should take various measures to inform consumers about food waste and possible ways of reducing. According to Beretta, Stoessel, Baier, and Hellweg (2013), households can avoid buying too much food by carefully planning one's purchases. It will also reduce the use of promotions, which often tempt consumers to buy unnecessary items. According to Clement, Kristensen, and Gronhaug (2013), consumers usually make their purchasing decisions on-site, under the influence of different stimuli. In many cases, such unplanned purchases ultimately lead to the waste of food. Consumers can avoid this by drawing up a shopping list, taking into account the type and quantity of specific foodstuffs.

Conclusions

Rational management of food in production, processing, and use processes, supported by logistical processes combining them, contributes to sustainable development of the food sector. The waste of food has been identified as one of major factors hindering the sustainable development of that sector.

As follows from the analysis presented in this paper, some causes of food losses and food waste can be reduced. Therefore, efforts should be undertaken throughout the entire food chain to make sure that the food produced is used in accordance with its intended purpose. This can be done, among other ways, by redistributing food to those in need.

In the area of managing food products, it is essential not to exceed expiry dates and to keep them fit for consumption to minimize food losses. Food beyond its expiry dates can lead to losses in primary production and processing (over-production and market collapse), retail, and wholesale (overestimation of an order).

Other causes which render a raw material/product unmarketable despite not creating any health hazards include: restrictive requirements concerning the shape, color and size of raw materials, and mechanical damage to outer packaging and processing errors (e.g., incorrect weight of a product). Such foodstuffs can likewise be transferred to charitable organizations.

To sum up, the sustainable food system represents and will always represent a major global challenge which can only be overcome when all entities concerned cooperate with one another.

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