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Innovation Activities to Reduce Food Losses and Food Waste in the Slovak Republic

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Due to its dependence on natural resources and weather conditions, agriculture is widely acknowledged as one of the most vulnerable sectors when talking about climate change. Lower yields and productivity, droughts, and water shortages have had an impact on food security globally. The food system using agrochemicals, cattle breeding, processing storage, transportation, and trade contributes even more to global emissions. Incorporating sustainability in the production of diverse and healthy food as a systematic approach to the concept of food security is challenging for the future capacity reduction of ecological systems due to the degradation of natural resources and the rise in social and economic inequality. Regenerative agricultural production that ensures long-term food security and nutrition, as well as processing and trade are therefore essential currently to secure the cooperation of social and economic systems. The main goal of the presented scientific paper is to point out the serious challenge of today related to environmental food losses and food waste in the world and the Slovak Republic in particular.

Keywords: causes of food waste, environmental impacts, reducing food losses, economic inequality, short supply chains.

Introduction

There are many reasons for the urgency of addressing the problem of food loss and food waste. About one-third of food produced for human consumption is lost or wasted (Campoy-Muñoz et al., 2021). The world generates 0.74 kilograms of waste per capita per day, yet national waste generation installments fluctuate widely from 0.11 to 4.54 kilograms per capita per day (Kaza et al., 2018). There are

690 million chronically malnourished people in the world (FAO, 2020). Despite this fact, globally increasing volumes of food continue to be lost or wasted throughout the food chain. Due to the crisis associated with the COVID-19 pandemic and the resulting economic recession, according to the WFP estimate, another 130 million people will be affected by acute hunger, especially in Sub-Saharan Africa

and the Middle East (Khorsandi, 2020). The impact of the pandemic and armed conflict has strongly affected the disruption of food supply chain management, access to food and the impact on food security, which has greatly influenced consumer behavior and consumer decisions (Woesrtell, 2020; Ibn-Mohammed et al., 2021; Rejeb et al., 2020). Changing lifestyles, reduced household income, and job insecurity, along with changes in time availability have forced individuals to cope with changes in behavior (Hassen et al., 2021; OECD, 2020), and subsequently, it also affected the amount of food thrown away, including the handling of food in households related to the generation of food waste (Kamble et al., 2021; Vanapalli et al., 2021). Agricultural policies, the food chain and consumption are areas that are interconnected and are reflected in the following political approaches: policies guiding agricultural development, investments, supporting various actors of the food system, regulation of food chains, fiscal policies, market regulations, food self-sufficiency (food security) and consumer protection, social safety nets, sustainable development policies, and environmental protection policies. In general, some policy measures can be oriented towards the first stages of the food chain, such as the development of good production practices, food preparation, and hygiene, which contribute to the reduction of food losses. In terms of storage and preservation solutions, technologies need to be developed on a smaller scale with lower costs so that smallholder farmers can access them. Along with this, they must improve the means of transport from producers to retail buyers, so it is necessary for them to have cooling facilities (Durán-Sandoval et al., 2023).

Everyone and everything involved in the production, distribution, or consumption of food is included in a food system. The sustainability of food systems is perceived or interpreted differently by many authors. According to Von Braun et al. (2021) a sustainable food system ensures that the economic, social, cultural, and environmental basics necessary to ensure food security and nutrition for future generations are maintained while simultaneously contributing to food security and nutrition for all. This dynamic process of achieving food security and healthy diets contributes to well-informed consumers and considers the variety and complexity of interactions between food producers, processors, and distributors, considering trends and shocks, such as climate change, economic globalization, or conflict causing significant disruption of the food system (WFP, 2022). Multiple actors with their interconnected value-adding activities

play a role in organizing food systems and making them more sustainable and more equitable at different levels (Graeub et al., 2016; Bronson and Knezevic, 2016). In addition, production, aggregation, processing, distribution, consumption, and disposal (loss or waste) of agriculturally produced food products are included in food systems together. All this together with the forestry, fishing, and food industries, as well as the broader economic, social, and natural environments are embedded. This means that a concept of a sustainable circular economy as an all-encompassing systems frame that includes food systems should be taken into consideration.

There is a lot of literature on food loss management that highlights the potential role of social responsibility in problem-solving and paves the way for a promising area of research that combines management studies and interdisciplinary efforts (Scholz et al., 2014). Initiatives for corporate social responsibility (CSR) are intricate phenomena that may even have unintended or detrimental effects (Ferraro et al., 2015). Despite the seriousness of these phenomena, there is a lack of knowledge about the organizational conditions that allow the development of effective social responsibility initiatives related to food losses (Rose and Chilvers, 2018). For addressing this issue, farmer market organizations provide particularly intriguing research. Despite previous studies on food losses, the focus in these areas is mainly on consumer behavior (Redman and Redman, 2014). In addition, farmer market organizations will be crucial in their territorial contexts, which can use their inter-organizational relationships, institutional role, and ability to network with businesses, government bodies, and charities to increase the impact of CSR initiatives. Social responsibility initiatives related to food loss can only be effective if they also have an impact on consumer perception and behavior, which are crucial to addressing this problem, especially in developed countries (Moseley, 2017; Redman and Redman, 2014).

Food waste prevention across the food supply chain has been addressed by the European Union (EU) as the top priority to reduce farm-to-fork impacts (Albizzati et al., 2022). In the European Green Deal, the “farm to table” strategy contains comprehensive solutions to the challenges related to the sustainability of food systems, recognizing the inextricable link between the health of people, the health of societies, and the health of the planet. It is a central element of the European Commission's

agenda for achieving the goals of the United Nations in the field of sustainable development (Fanzo and Davis, 2021). Nowadays, people are paying more attention than ever to the protection of the environment, health, social sphere, and ethical issues, and what is significant, they are looking for value in food (EC, 2020, 381 final). In the EU, the availability of food for residents is being investigated. It follows from the published results that about 33 million people every other day cannot afford quality food, and food aid is an absolute necessity for part of the population in many Member States (Eurostat, EUSILC, 2018). Experience suggests that the problem of food insecurity and unaffordability worsens during an economic downturn. Therefore, there is a need to focus efforts on changing food consumption patterns and reducing food waste, following the fact that about 20% of produced food becomes waste (Stenmarck et al., 2016).

In other words, the production and socio-economic conditions of developing countries must be directed so that they produce more of their food (Medved'ová et al., 2022). Given that the current industrial food system is a major driver of climate change and social inequalities, a transformation toward sustainable, resilient and productive food systems is urgently needed (Haack et al., 2020; Voge et al., 2023). The most pressing environmental issues currently facing Slovakia are climate change, waste management, air quality, and the preservation of species habitats and species, particularly in forest, meadow, and wetland ecosystems (Ministry of the Environment of the Slovak Republic, 2019). The main objective of the presented scientific work is to point out the serious challenge connected with food losses and wastage in the world nowadays and especially in the Slovak Republic. The partial objectives of the research include food losses and trends in the development of technologies and innovative approaches, legislation on the use of waste to produce alternative forms of energy in the Slovak Republic, the potential of biogas and bioenergy in the world, and the links between the impact of climate change on natural resources and the agri-food sector. Food loss and food waste are serious problems that have received increasing attention in recent years. Food losses and food waste have serious economic, environmental, and social impacts. The goals of the scientific paper are identical to the goals of the VEGA 1/0802/18 project and correspond directly to the Agenda for Sustainable Development until 2030. The main goal of the presented scientific paper is to point out the serious challenge of today related to

food losses and food waste in the world and the Slovak Republic in particular. Sub-objectives include food losses and trends in the development of technologies and innovative approaches, legislation to use waste to produce alternative types of energy in the Slovak Republic, the potential of biogas and bioenergy in the world, and the interrelations of the impact of climate change on natural resources and agri-food sector.

Materials and Methods

The methodological procedure of processing the research task was focused on the phases, namely review phase, empirical phase, and analytical phase. To fulfill the set goals, five research objects were chosen, and the research was carried out in agricultural enterprises, food processing enterprises, retail and distribution, common catering establishments, and Slovak households.

The surveys were carried out in Slovak businesses, households, catering establishments, and retail establishments in the period from September 2019 to August 2020. The schedule for fulfilling the research objectives was divided into four stages: stage 1 – collection of materials and their processing to learn about the current situation in the world in Slovakia; stage 2 – establishing contacts, collecting background data and databases, creating questionnaires and pilot testing; stage 3 – research implementation, data processing, and evaluation, and data analysis; and stage 4 – evaluation of data, their processing, and suggestions for improving the current situation. Filling out questionnaires was carried out in two forms, i.e., electronically and by personal inquiry. Respondents were approached via email, social networks, or personal inquiry, while the respondents filled in and then sent back the questionnaires. In the case of personal inquiries with the manager, it was an interview, where their answers were recorded in the questionnaire. The total number of evaluated questionnaires was as follows: 45 in agricultural enterprises, 42 in food processing enterprises, 442 in communal catering facilities, 2068 in Slovak households. We subjected the database of the obtained data to an internal consistency reliability test, which guarantees that all components of the measuring instrument measure the same variables. Based on the test results, we found that the value of Cronbach's alpha reached 0.84, which means that the internal consistency of the database is optimal for conducting further tests and interpreting general conclusions.

Results and Discussion

Key areas that need to be focused on to reduce food losses, and food waste in the Slovak Republic

Among the key areas that need to be focused on to reduce food loss, waste, and food waste in the Slovak Republic are quantification of food loss, waste, and food waste, harmonization of food legislation, a more responsible approach to all, and food donation.

Quantification of food losses and food waste. The Plan for preventing food waste in the Slovak Republic states that there is currently no harmonized and reliable method for measuring the amount of spoiled food in the Slovak Republic or the EU; therefore, it is difficult to assess the extent, origin and trends of the impact (Tkáč et al., 2022). It follows that without quantification of food losses, food waste, and the place of origin of their origin in the Slovak Republic, it is not possible to identify the main causes of food waste and propose measures for their elimination, or minimization. Furthermore, it is necessary to define the method of obtaining information on the amount and type of wasted food from individual subjects in the food chain and to involve as many subjects of the food chain as possible due to the relevance of the results.

Harmonization of food legislation. In this context, the following activities are mainly involved: food labeling, food safety rules, food standards, and subsidy policy supporting food production. In these contexts, it is desirable to mention the case of the Food Code (Codex Alimentarius) for food labeling, when, based on the initiative of New Zealand, its actors proceeded to revise the general procedures for labeling the date of food packaging (Kelly, 2018). Among the frequently discussed topics in the Slovak Republic is also the topic of the correct understanding of food labeling by final consumers. We often witness discussions pointing to the fact that consumers do not know the differences between terms in food labeling, which can result in the creation of food waste. For this reason, we also included this question in the research. This fact was not confirmed by the research, as Slovak respondents are aware of the differences in product labeling “Minimum shelf life” and “Use by”. Only 160 respondents gave the wrong characteristic. As many as 1677 respondents (81%) said that they consumed durable products even after the expiry of the minimum durability period. 391 respondents (19%) no longer consume such products, which we consider to be a high proportion that significantly contributes to food waste.

A more responsible approach for all. Even though the EU is a strong economic player in the world, it remains behind its strategic goal “Europe 2020”, according to which 20 million people suffer from the risk of poverty and social exclusion. Only 8.2 million people receive enough help, so after 2008, they are already out of the poverty zone. According to Eurostat, as many as 872 thousand people living in Slovakia in 2018 were exposed to poverty (Poór et al., 2021).

Donating food waste. According to the generally accepted hierarchy of waste management, reducing the amount of food waste is considered first, followed by donation and reuse, recycling, and recovery. The last option is waste disposal. After reducing the amount of food waste, there is a suggestion that edible food will be redistributed gradually to people, animals, and, in the last case, to industry. A reasonable way to reduce the amount of wasted edible food and at the same time effectively use it is to donate food to people who need it. Usually, this food goes to people in need, through various charity facilities, or is directly donated to food banks, which later redistributes it. Donating food is the second most preferred option to avoid food waste. There is a strong history and culture of food donation in some EU member states. At the level of various EU policy areas, there are still several obstacles to donating food, e.g., insufficiently clear existing legal provisions, missing legal standards or decrees, which are used partially or not at all in practice (Eriksson et al., 2020). Overcoming these obstacles would contribute to aligning EU policies to facilitate food donation.

Causes and origin of food waste in Slovakia

The globalization of markets, the high demands of consumers for the diversity of the food supply, and the growing demand for products originating from distant countries are the cause of lengthening supplier-customer relations (Niu and Jiang, 2023). Changes in consumer habits and fast-paced lifestyles are affecting the food chain and are the reason for increasing food waste and food loss. If we were to compare food waste data from 25 years ago, we would easily conclude that the amount of food waste has increased sharply (Pércsi et al., 2023).

What is the cause of such waste and food losses? The reasons why food waste is created have many explanations. It is important to mention that food waste occurs in agriculture, during production, in catering

establishments, food distribution, on the way to final consumers, and in their households.

Food waste in agricultural enterprises

The basic question we investigated was knowledge about the occurrence of food losses within society. Up to 73% of companies stated that they had food losses and only 20% said that food losses did not occur in their company, while some companies could not comment on this issue (7%). Food losses represent a huge environmental and economic cost to societies.

Based on the obtained data, cereals have the largest share of food losses in agricultural enterprises (29%). The situation is also critical when animals die (22%). Animal deaths are a frequent cause of food losses in primary production.

Oil crops account for up to 17% of the total food losses in agricultural enterprises (Fig. 1). Food losses occur before and during harvesting.

The reasons for the occurrence of food waste on the part of households as food consumers are relatively well known; however, in the questionnaire survey, we were interested in the main causes of food losses as well as their percentage share. Respondents stated that approximately 10% of all food losses were mainly losses caused by insufficient hygiene and losses caused by transport. Interestingly, losses caused by spoilage or damage represented the largest percentage, more than 50%, but in

the survey, they were not among the main causes of food losses (Fig. 2).

Based on research carried out in restaurants and catering facilities (restaurants and canteens), the causes of food waste and food waste were identified, which are:

- not picking up lunch;
- insufficient hygiene when eating;
- excessive portion sizes;
- improperly prepared food, inedible leftovers;
- purchasing many raw materials and expiration dates;
- improper storage;
- preparing more portions than were consumed;
- government measures related to the Covid-19 pandemic.

The food quality and the served portion size are among the most common reasons for food waste in communal dining facilities. Not picking up lunch also has a significant share, with up to 19% of establishments reporting this fact. Incorrect planning and inappropriate storage of raw materials accounted for 14% of food waste. Most of the listed reasons for food waste have relatively easy solutions, but especially better planning. It requires a responsible approach from all parties involved. Catering service providers should consider the size of the food offered and, in case of non-consumption, pack the food for the customer. There is a relatively high representation of low-quality processed food, resulting from the cooks' insufficient gastronomic skills.

Fig. 1. Crops where the food loss situation is most critical (source: own research)

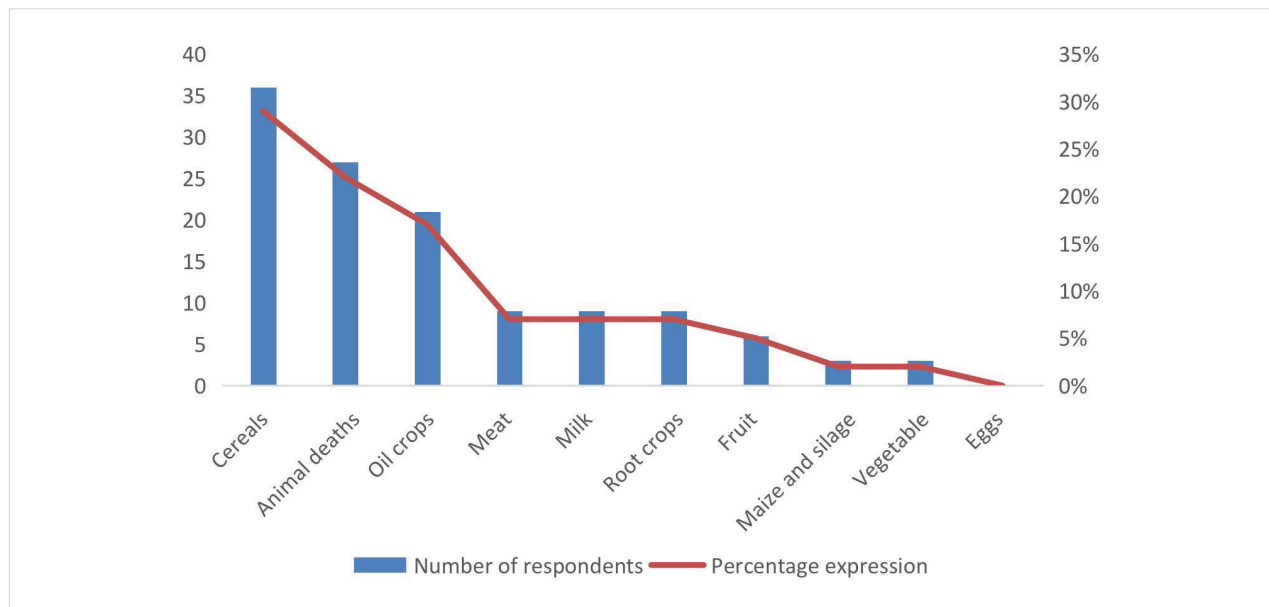


Fig. 2. The main causes of food losses and their percentage (source: own research)

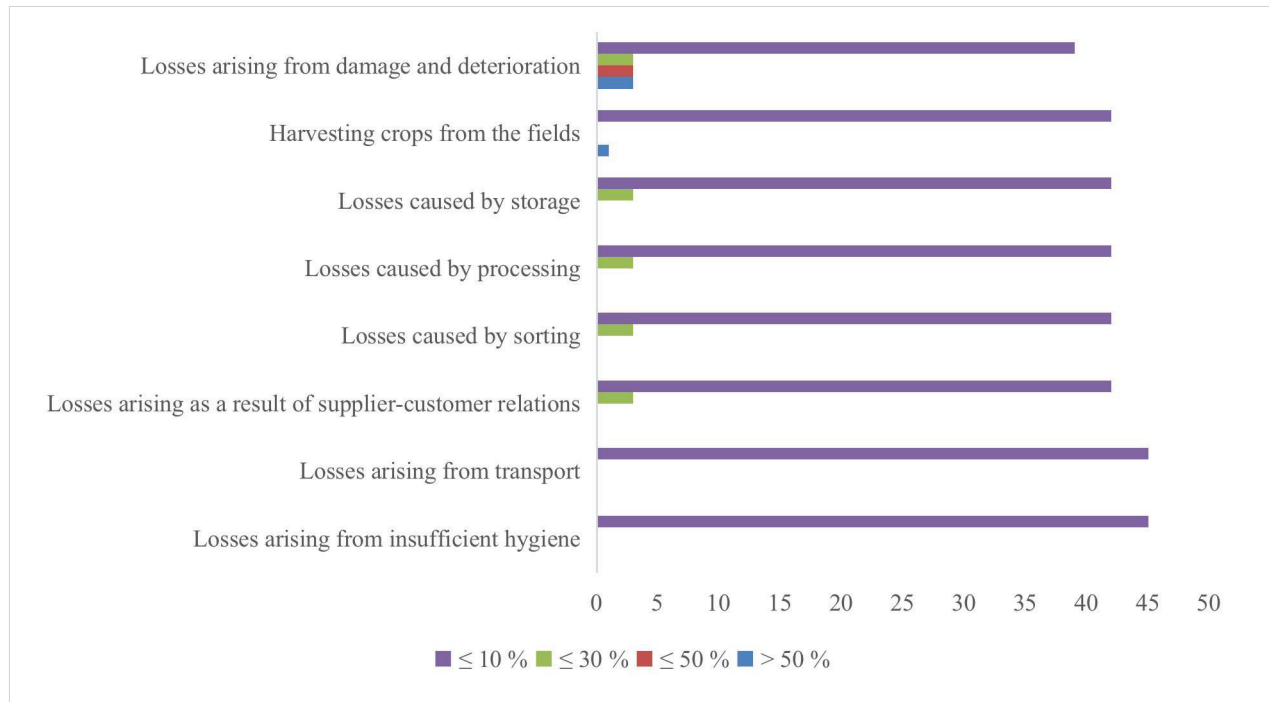
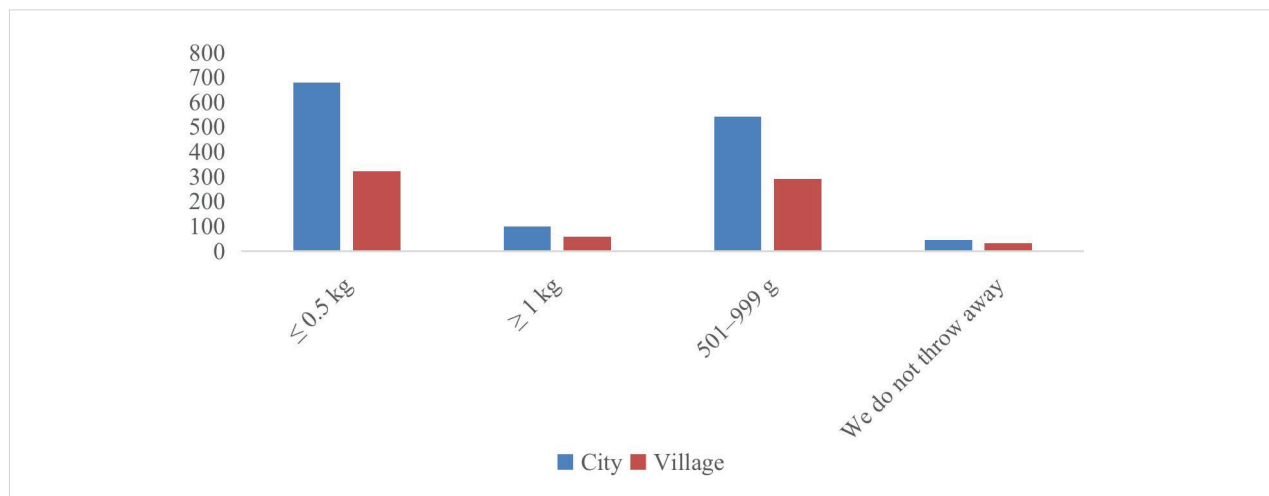


Fig. 3. Wasting of fruit in Slovakian households (source: own research)

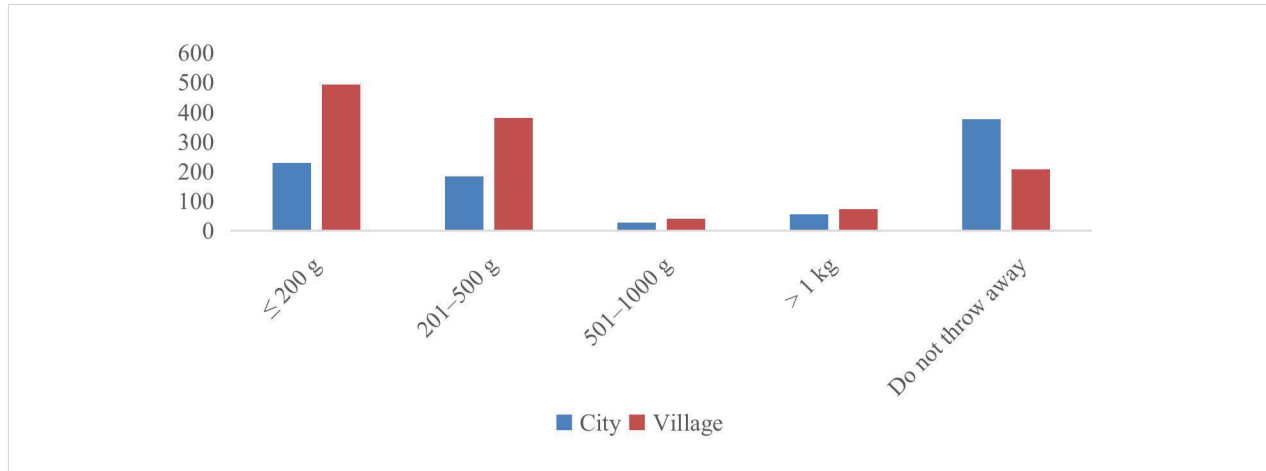


The results of the research also confirm that the minimization of food losses and waste represents one of the concrete possibilities for increasing the sustainability of food systems regarding food and nutrition security. The greatest attention should be paid to Slovak households, as they produce the largest amount of waste. They waste fruit and vegetables (42%), bread and pastries (40%), meat and milk (19%) and dairy products like yogurt (14%). The following graphs also point to this fact.

The results of the research confirm that in the Slovak countryside, older age groups show more respect for bread, as the minimum amount of bread ends up in waste. If bread is not consumed even in one household, it is a good practice to offer it to neighbors who raise poultry or other farm animals. This is also an example of good practice on how to minimize household waste.

The research recommends better integration of food chains and food systems into strategies for food

Fig. 4. Wasting of bread and pastries in Slovakian households



self-sufficiency, food security, and nutrition shortly. Reducing food losses and waste must be systematically considered and evaluated as a potential means to increase the efficiency of agricultural and food systems or the sustainability of food security and nutrition. The direct and indirect causes of food loss and waste in each food system, as well as in the food chain, should be analyzed at critical points to determine which phase or link in the chain is the most worthwhile to invest in.

For an effective solution to the discussed issue, it is important to carry out the following three inclusive and participatory activities: firstly, to improve data collection and dissemination of knowledge on food loss and waste; secondly, to create effective strategies that would lead to the reduction of food loss and waste at the required levels; and, thirdly, to take effective steps to reduce food loss and waste.

Regarding data collection, it is necessary to determine the definition of the term food loss and waste, as well as the scope and scope of what will be related to data collection. In addition, the obtained data must be reliable, to be able to be shared with other interested participants. It is also important to exchange positive practical examples and experiences related to food losses and waste in all phases of the food chain.

To create effective strategies that would lead to the reduction of food loss and waste at the required levels, an inclusive process must be organized at the state level, but also at the regional level, through which critical places, causes of food losses, and waste at different levels would be determined. It is necessary to propose potential solutions and methods of intervention. This requires

determining those actors who will directly and individually or collectively implement such solutions, evaluating the costs associated with them, as well as determining the potential benefits and the recipients of these benefits. The coordination of policies and strategies also need to be improved here. At the same time, it requires the identification of barriers (including systemic ones), and how these barriers will be removed (e.g., through building infrastructure, and technologies, changing the organization in food systems and food chain systems, building capacities, policies, and institutions, etc.).

What concerns the third pillar, it is necessary, especially in developing countries, but also in less developed ones, not excluding Slovakia, to invest in infrastructure and public goods to reduce food losses and waste, to ensure sustainable food systems, such as warehouses and processing capacities, reliable energy sources, transport, appropriate technologies, better accessibility and connections with food producers and consumer markets. In developing countries, this is mainly the role of the state, but even here it can be private projects, but also multi-donor activities (PPP projects). In developed countries, state support and interventions in development programs, solutions to crises, or pandemics are equally desirable and, in some cases, even necessary. Due to the strongly developed business activities in this direction, private initiatives are more prevalent, and PPP projects are still rather exceptional in this sector. PPP projects and multi-donor activities can significantly help in minimizing food losses and, in our conditions, especially food waste. It is necessary to implement adequate legislative approaches, including regulations, incentives, and support

for the private sector (wholesale, retail, restaurants, and other catering facilities), and for consumers to take convincing measures to address their unsustainable eating habits. This legislative framework will also have to ensure that the private sector reacts more effectively to the negative externalities of its activities, such as excessive or one-sided loading of natural resources.

In the effort to reduce food waste, guiding consumer behavior plays an important role. This primarily concerns direct communication and raising awareness of the importance of reducing food loss and waste. Emphasizing social responsibility also plays a significant role in these contexts. It is also necessary to present various technical alternatives to consumers, such as more economical and purposeful ways of packaging food. For example, fresh sliced bread should also be offered in smaller packages (250 or 500 grams). In cases where the customer buys a whole loaf of bread, or even half of it, with a smaller number of family members, they do not have time to consume it in time if it retains its freshness and consumability, so the bread often ends up in the waste.

Another good practice that we adopted from abroad is the possibility to take away unconsumed food in packages (doggy bags) from restaurant facilities. They do not end up in food waste and can be consumed later at home, but they can also be fed to pets.

Promoting ways to minimize food waste requires close cooperation between the food industry and the business sector, for example, in improving the clarity of the labeling of food use-by dates, including recommendations on how to properly store food. It is desirable to achieve different food packaging alternatives, in terms of their size, so that they meet the needs of customers living in households with different numbers of members, but, for example, also to support a zero-waste approach, that is, that the customer will store the purchased food in their reusable packaging. In this direction, capacity building in the form of education, training, and consulting activities for food producers and all actors along the food chain is also an important means.

Reports on food losses and waste should become an organic part of the Annual Reports of business entities operating in agriculture, the food industry, restaurants, and other catering establishments, organizations dealing with the collection and storage of various types of waste, etc. Entrepreneurs should evaluate the following activities in their reports: a) monitoring of food loss and waste; b) how they approach waste minimization; c) supporting activities

that lead to the reduction of food loss and waste in cooperation with its suppliers and consumers at all levels.

Standardizing products offered to consumers is the main cause of food loss and waste in the modern trade system. In traditional systems, products offered to customers gradually lose their economic and exchange value, including quality. In general, such products are still available, but gradually at lower prices. In modern standardized systems, products are defined as salable or non-salable. They lose their economic value when they have reached the minimum quality at which the product is still salable, as this level still corresponds to the consumables of food. Alternative distribution systems that offer the food of such quality ensure that the consumable food delivered to various target groups is still edible (e.g., Food Bank).

Restructuring the current practice of supermarkets and smaller food establishments in assessing the standards by which agricultural commodities are accepted in terms of size, shape, as well as cosmetic requirements for vegetables, fruits, or animal products). This can be done, for example, with the introduction of tiered prices, which allows customers to choose more affordable foods. Such a procedure has a positive impact on limiting the occurrence of further food losses and waste.

Conclusions

Reducing food losses and waste can lead to greater sustainability of food systems with a positive impact on economic, social, and environmental outcomes. Food losses and waste affect food security in three ways. Firstly, food losses reduce the global and regional self-sufficiency of food and human nutrition. A significant reduction in food losses could lead to a reduction in hunger in the world's most risky regions. Food losses hurt those involved in the harvesting process and post-harvest treatment. In the case of high losses, these will have an impact on primary producers economically, by reducing their income but also by jeopardizing their food security. Secondly, lower food production leads to tighter market relations and thus to rising agricultural commodity prices. Consumer food prices are gradually rising. All this hurts the social situation of the population. Thirdly, the constant effort of producers to produce more and more food to ensure food security for today's 7.9 billion people and for more than 9.6 billion humans in 2050. The greatest depletion of natural resources occurs in countries providing the highest volume of

exports of agricultural commodities. The greatest depletion of natural resources occurs in countries providing the highest volume of exports of agricultural commodities.

The results of this research confirm that the minimization of food losses and waste represents one of the concrete possibilities for increasing the sustainability of food systems regarding food and nutrition security. The different types of policies aimed at reducing food loss and waste include food, agriculture, food security, bioenergy, waste management policies, research and education, social affairs, sustainable consumption, health, dietary guidelines, and others. It is for this reason that an important part of the solution to reducing food losses and food waste can be found in other policies. Slovakia should introduce economic policies and incentives to reduce food losses and waste, through the introduction of waste-free consumption of food, which, if not used in the home, can be used, among other things, for feeding farm animals, by recycling for bioenergy production or composting. The conclusions of our research recommend better integration of food chains and food systems in the strategies of food self-sufficiency, food security, and nutrition, or in the decisions that result from these strategies. Reducing food

loss and waste must be systematically considered and evaluated as a potential means to increase the efficiency of agricultural and food systems and the sustainability of food security and nutrition. The direct and indirect causes of food losses and waste in each food system or food chain pointed to critical points in which phase or link of the chain is the most worthwhile to invest in. For an effective solution to the discussed issue, it is important to carry out the following inclusive and participatory activities: quantification, data collection, and dissemination of knowledge on food loss and waste; creation of effective strategies that would lead to the reduction of food losses and waste at the required levels; and taking effective steps leading to the reduction of food losses and waste, harmonization of food legislation, and a more responsible approach for all. {Gurauskiene, 2006, Eco-design methodology for electrical and electronic equipment industry}

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