



Analysis of Waste Minimization Challenges to European Food Production Enterprises

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Abstract

Economic growth increases the pressure on environmental issues, thus highlighting the importance of waste minimization processes. The waste management approaches in most European countries have so far been relatively little studied and compared at the micro level. The main objective of the current research is to analyze the challenges of waste minimization in European food industry enterprises and identify good practices in the selected countries. The research used a mixed-method methodology, combining both qualitative and quantitative methods, thus providing an in-depth insight into food enterprises' efforts to reduce their production waste and use their resources more efficiently. The main data collection methods used for the study were secondary data research, discourse analysis, case studies, and focus group interviews. The analysis of the food waste management applications in the European countries' food sub-sectors leads to the conclusion that since the national initiatives and success factors vary between the countries, it is important to invent such national food waste management systems that are economically justified and technically available for all enterprises regardless of their food waste production volumes. It is also necessary to raise awareness of the strategies that food industry employers, employees, and consumers can use to reduce their waste and thus promote a waste minimization culture in Europe.

Keywords:

Food Waste;
Food Sector;
Waste Management;
Circular Economy;
Bioeconomy.

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1- Introduction

In European countries, life quality standards and requirements are based mainly on economic development, which often leads to imbalanced resource management. Consequently, a sustainable environment in Europe requires the proactive involvement of society in changing their habits, awareness, and consumption of resources. The development process is very complicated, and this makes it necessary to use sustainable development strategies for both national, regional, and global issues.

In 1987, *sustainable development* was defined as a process that must be based on three dimensions – economic, social, and environmental [1]. Although both global and national sustainable development goals are aimed at identifying the balance between all these dimensions, businesses are actively seeking solutions on how to comply with the European Union's Green Deal and its rulebook, which promote sustainable investment to reach emission targets and thus address climate change issues in Europe. In this context, waste management activities and their improvement are an important aspect of resource management. In addition, waste management is also one of the main focuses of the Circular Economy Action Plan of the European Union, which is based on the principle of "*less waste, more value*" [2].

In the EU, most of the population lives in urban areas. Moreover, the impact of urbanization is constantly expanding beyond city borders. Therefore, the population has adopted urban lifestyles and uses cultural, educational, and health

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services with growing intensity, which increases the demand for resources and thus results in growing amounts of waste and emissions. According to this, the growing demand for public convenience and quality of life puts more pressure on both urban and non-urban environments. This raises the issue of production waste and waste management processes and how they affect a sustainable environment.

Based on the latest findings of Okayama et al. (2021) [3], Kim et al. (2019) [4], Thyberg & Tonjes (2015) [5], as well as "Recommendations and Guidelines for a Common European Food Waste Policy Framework on Waste Management, Recycling, and Minimization Problems in Food and Beverage Production Industries" [6], the authors conclude that a deeper insight into the food waste management problems at the sub-sectoral business level is necessary and could supplement the previous research works that mainly concentrate on food waste problems at the macro level. The authors' previous research work was devoted to the analysis of waste management practices in selected European countries [7], which helped them to identify the current gaps that should be eliminated to comply with the sustainable development commitments. Therefore, continuing the discourse of the previous study, the authors decided to concentrate their current work on collecting information on European food industry subsectors to prepare a comparative overview of approaches and good practices at the micro level in the United Kingdom, Turkey, Spain, Latvia, and Lithuania. *The aim* of the current research paper is to analyze the challenges of food waste minimization and recycling for the food sector enterprises in selected European countries. *The research object* is the minimization of food waste by European food industry enterprises. *The specific research tasks* are: 1) to present an overview of the waste management applications in European countries and current challenges for food waste minimization; and 2) to analyze the results of focus group interviews with food industry employers and employees, focusing on egg production, vegetable growing and production, and bakery subsectors. The results have highlighted the positive achievements of European countries in food waste minimization and identified some challenges that still exist, for which solutions are suggested in the conclusions part.

2- Literature Review

The Sustainable Development Goals (SDGs) are a collection of 17 global goals designed to be a "blueprint to achieve a better and more sustainable future for all". The SDGs were set in 2015 by the United Nations General Assembly and intended to be achieved by the year 2030. The SDGs have been accepted by 193 countries and thus call on all nations to combine economic prosperity, social inclusion, and environmental sustainability. Up to seven of the Sustainable Development Goals (Goals 6, 7, 11, 12, 13, 14, 15) directly relate to challenges in the environmental dimension, thus identifying it as one of the most influenced and endangered aspects. Furthermore, Goal 12 focuses on the processes that occur in the production area, thus in particular focusing on three aspects – waste management, energy savings, and resource usage minimization. In the global context, it is important to emphasize that in the achievement of this goal, the European Union leadership is critical, not only because Europe needs to achieve the goals for its own benefit, but also because the 2030 Agenda is a global affirmation of the core values of the EU, which promotes peace and wellbeing. In the authors' opinion, environmental sustainability is one of the central aspects that benefits human health and quality of life. However, a high standard of living is closely linked to an increasing variety of products and consumption, which generate more waste and thus create a burden to the ecosystem.

During the last decade the academic interest and scientific output in different food waste management issues has more than doubled [8]. Although food waste is a widely spread problem that attracts the growing interest of researchers, academia and the public, there is neither a single and over-embracing definition of food waste nor a precise explanation of its causes and consequences [9]. Most of the international organizations, professional associations and national governments use their own definitions of food waste. For example, the definition by the Food and Agriculture Organization of the United Nations (FAO) claims that food waste occurs due to the decrease in the quantity or quality of food along the food supply chain at the retail and consumption level. In the FAO publications on food loss and waste, it is emphasized that their causes and consequences are closely linked with the climate change and other environmental issues [10]. In contrast, the EU definition, which was first formulated in 1975 and referred to food waste as "any raw or cooked food substance, which is intended/required to be discarded" [11], until nowadays has been exposed to intensive updates and modifications and as a result has lost one common wording. Across the EU, there are slightly different food waste definitions that are used by the EU member states in their national legislation, and research projects that are implemented in the EU often are aimed at improving the existing food waste management approaches, which also relates to updating and specifying the existing food waste definitions. For example, the European Commission-funded project "Food Use for Social Innovation by Optimising Waste Prevention Strategies" defines food waste as any food and its inedible parts that have been removed from the food supply chain to be recovered or disposed of. It is also explained that to minimize food waste effects, it can be: composted; recovered by anaerobic digestion, used for bio-energy production and co-generation; incinerated; damped in landfills; discarded to water resources [6].

Looking back at the range of food waste management issues in different time periods, explored by Thyberg & Tonjes (2015) [5], it is absolutely clear that the problems, their scale and technological opportunities of food waste management have changed significantly since the beginning of the 20th century. In addition, it is also emphasized that the way in which countries perceive the need to implement and promote waste management systems is highly dependent on the specificities of culture.

The analysis of recent scholarly evidence in academic publications reveal a variety of topics related with reasons for food waste occurring at the business and household levels [12]; the impact assessment of food waste on environment [8], as well as analysis of different food waste prevention measures [13]. Based on the recent findings of other authors published in scientific journals [3-5], the authors conclude that food waste management is a complex set of activities that needs to address very controversial attitudes that exist in different target groups (employers, employees, the government, environmental activists, consumers etc.). Thus, in an ideal situation, waste management implementers need to apply both exogenous approaches (by attracting the EU funds, national support, subsidies, charity, business takeovers etc.) and endogenous approaches (by involving the local population, NGOs etc.). Furthermore, divergent national achievements in population's welfare indicate significant differences in the degree to which society is willing to pay for environmentally friendly solutions for waste management. Despite the devastating impact of the COVID-19 pandemic on the EU economic sectors, the member states still have a strong commitment to continue the European Green Deal advancement. Therefore, to strengthen the awareness of European population, on 1 October 2021 the Inception Impact Assessment on setting EU targets for food waste management was published on the official EU Platform on Food Losses and Food Waste [14].

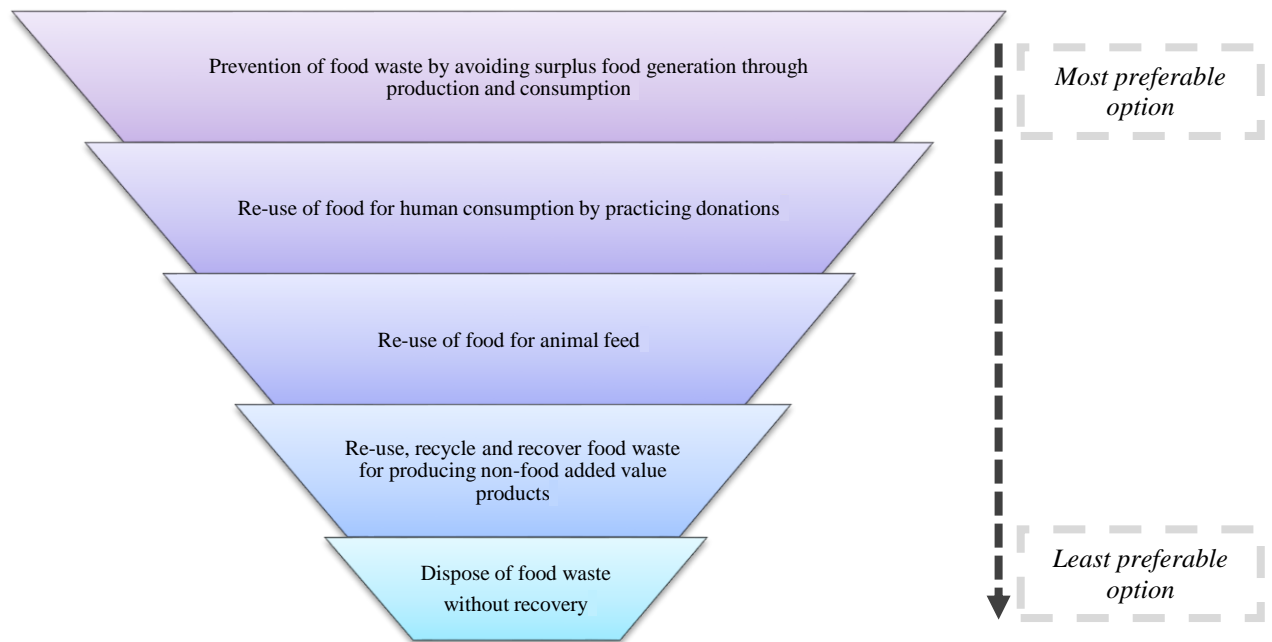


Figure 1. Enhancing environmentally friendly solutions for food waste management in the EU-Source: Illustration created by the authors based on The Inception Impact Assessment on setting EU targets for food waste management [14]

This document aims to enhance the EU member states' efforts and shares best practice in sustainable food waste management. Among other initiatives, this document calls the food sector businesses to action and thus encourages them to minimize their food waste by practicing food donations, recycling of waste into animal feed and non-food products that could be used for heat generation etc. In the author's opinion, the waste management experience in European business sectors so far has been little explored at the micro level. Therefore, the topicality of the current study is justified by the need to explore the best practice of food production enterprises by reflecting their achievements, challenges, employees' view points and their vision for enhancing the waste minimization approaches in the food sector.

3- Methodology

This research used a mixed-method methodology combining both qualitative and quantitative methods and was implemented in consistent methodological steps (Figure 2).

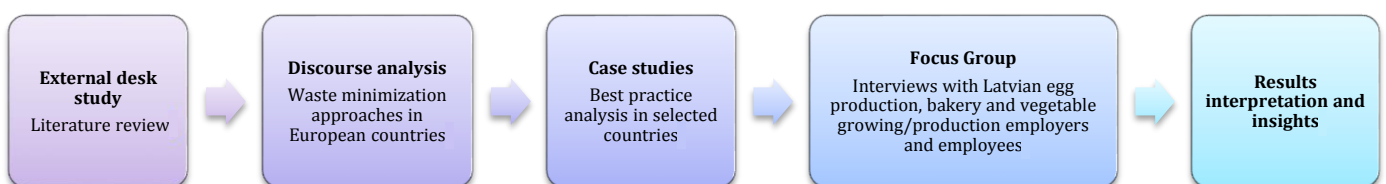


Figure 2. Research methodology steps

To implement the desk study, the discourse analysis and the case studies, the authors analysed the following information sources: peer-reviewed journal articles and periodicals relevant to the research topic; the official information published by international organizations, governmental institutions of the European countries; the data obtained in scope of the international project “Go-Zero - Zero Waste Management in the Food Sector” on the waste management situation in selected countries – Latvia, Lithuania, Spain, the UK and Turkey [7]. *The focus group interviews* with food industry employers and employees were conducted in Latvia and were represented by three popular food production sub-sectors: (1) egg production; (2) bakery production; (3) vegetable growing/production. The study involved the enterprises with long experience and tradition in the national economy, as well as long-term experience in exporting food products. The focus group interviews were structured in the following blocks of questions: 1) waste minimization approaches applied by the enterprises; 2) energy, water and raw material savings by the enterprises; 3) trainings organized in the enterprises for waste minimization. These interviews were conducted in two separate rounds and used the same questions: 1) discussion with employees; 2) discussion with administration representatives.

From the perspective of European countries, there has been a very strong commitment to improve waste minimization by teaming up with Zero Waste Europe (ZWE). The BIC findings suggest that the biowaste management remains unutilized potential for the European Union's further transition to a circular economy (Figure 3). According to the estimates for 2020, only 16% of the potential is currently being utilized, and with appropriate initiatives this number could be multiplied by 5 to reach 85%. This estimate emphasizes the need for European countries to continue and improve their efforts in the collection and treatment of biodegradable food and waste, which are key steps towards soil regeneration, circulation, and climate neutrality [15-18]. As there is no universal solution for all, it is interesting to present an analysis of countries with different populations, sizes, and approaches. A deeper insight into countries' achievements [10] and amounts of collected food waste [18] shows that various efforts have already been made by food production industries to recycle and minimize food and biowaste, several solutions have already been found to move closer to the principles of a circular economy, and there is a potential for more efficient food waste management. Circular economy development is also evaluated in the EU by Circular Economy Index rankings.

4- Results

4-1- Food Waste Minimization Approaches in Europe

The circular economy approach intends to reuse, share, repair, refurbishment, remanufacture, and recycle materials to create a closed-loop system. However, it is important to admit that the need for replacing linear economy approach with circular economy is not new and has been discussed in several publications since the middle of the 20th century [15-17].

The gradual transition of Europe to a circular economy has significantly increased interest in waste recycling options and statistics on waste recycling. At the European level, there is no single database that would give all information on biowaste types and proportions according to waste amount in the countries; as a result, it is very difficult to compare the national data. The authors' attempt to collect organic waste recycling data from different sources revealed either lack of such data or some differences in the amounts of waste that were published in the countries' national databases (e.g. relevant ministries' reports, NGO reports) and the amounts that were disclosed in Eurostat statistical reports. At the European level, the Bio-based Industries Consortium (BIC), which is Europe's leading industry association, is actively involved in the promotion of the circular economy and sustainability, which encourages European entrepreneurs to integrate bioeconomy principles into their business operations.

According to POLITICO [19], in 2018 the highest circular economy index scores were obtained by Germany, the UK and France. These countries' achievements can be explained by their robust recycling systems and high levels of innovation that have resulted in several patents, significant investment attraction and job creation in circular economy sectors (see Table 1).

The general analysis of the desk study results on the food waste management applications in European countries leads to the conclusion that the national initiatives and success factors vary between the countries.

Since the current research is limited to the case studies of five selected countries – Latvia, the UK, Lithuania, Spain and Turkey, the authors will offer an insight into some specific achievements and challenges of each country in their approaches to food waste minimization.

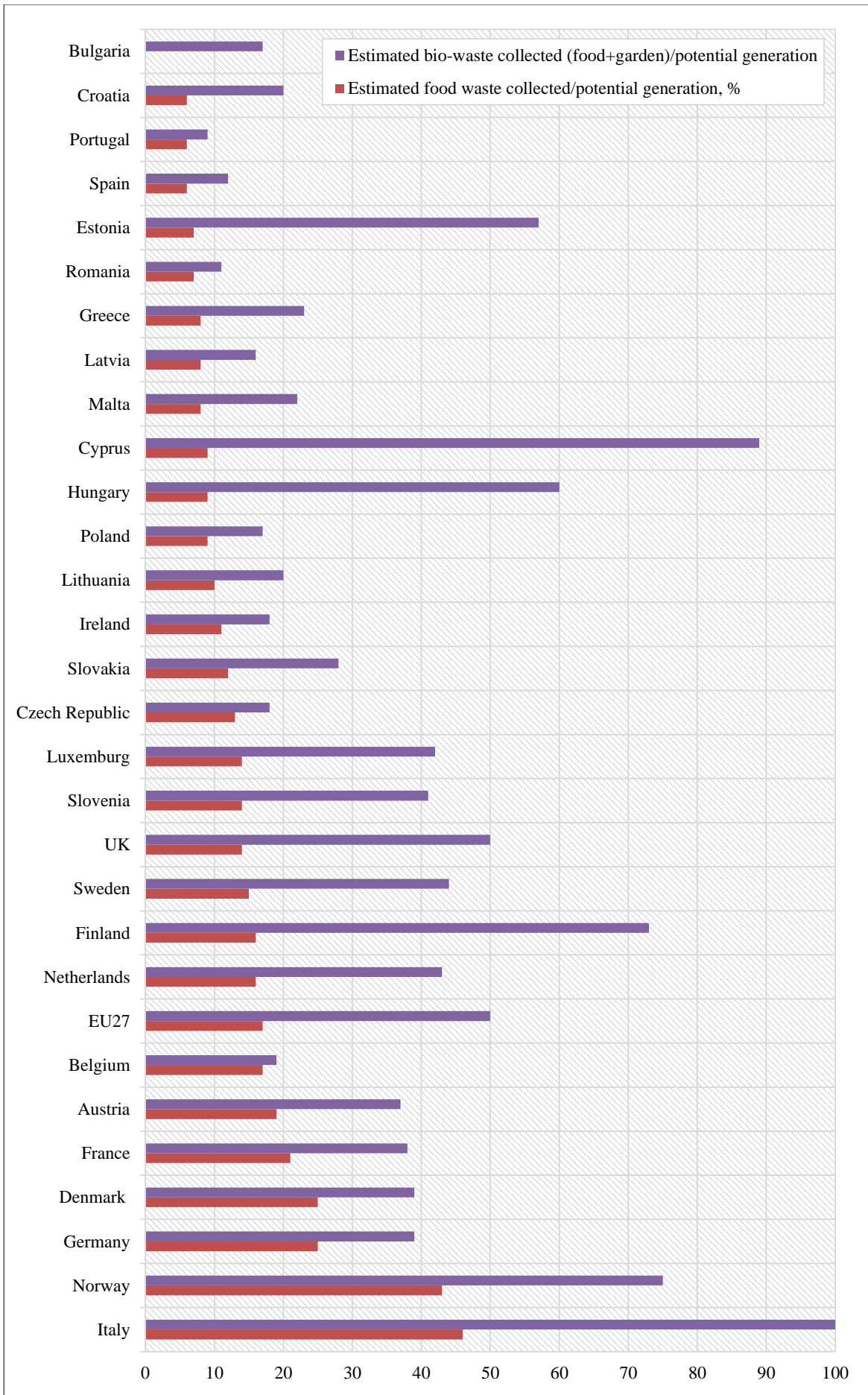


Figure 3. Comparison of theoretical potential vs. currently collected food waste and biowaste

Table 1. The circular economy ranking in the EU in 2018, (POLITICO, 2018)

Country	Municipal waste (per year per person)	Food waste (per year per person)	Municipal waste recycling rate	Share of goods traded that are recyclable raw materials	Material re-use rate	Patents related to circular economy (since 2000)	Investment in circular economy sectors
Austria	564 kg	209 kg	58%	0.32%	9%	122	€3.5M
Belgium	420 kg	345 kg	54%	0.22%	17%	105	€2.8M
Bulgaria	404 kg	105 kg	32%	0.11%	3%	10	€0.5M
Croatia	403 kg	91 kg	21%	0.23%	5%	4	€0.6M
Cyprus	640 kg	327 kg	17%	0.13%	3%	4	€0.1M
Czech Republic	339 kg	81 kg	34%	0.25%	7%	72	-
Denmark	777 kg	146 kg	48%	0.31%	10%	53	€2.3M
Estonia	376 kg	265 kg	28%	0.26%	11%	3	-
Finland	504 kg	189 kg	42%	0.06%	7%	111	€2M
France	511 kg	136 kg	42%	0.24%	18%	542	€21.3M
Germany	627 kg	149 kg	66%	0.25%	11%	1260	€28.7M
Greece	498 kg	80 kg	17%	0.14%	1%	5	€0.6M
Hungary	379 kg	175 kg	35%	0.23%	5%	36	€0.9M
Ireland	563 kg	216 kg	41%	0.18%	2%	38	-
Italy	497 kg	179 kg	45%	0.19%	19%	294	€17.8M
Latvia	410 kg	110 kg	25%	0.18%	3%	11	€0.2M
Lithuania	444 kg	119 kg	48%	0.15%	4%	19	€0.4M
Luxembour g	614 kg	175 kg	48%	0.97%	11%	24	-
Malta	621 kg	76 kg	7%	0.12%	10%	1	-
Netherlands	520 kg	541 kg	53%	0.17%	27%	169	€5.2M
Poland	307 kg	247 kg	44%	0.18%	13%	298	€4.7M
Portugal	461 kg	132 kg	31%	0.26%	2%	22	€1.4M
Romania	261 kg	76 kg	13%	0.13%	2%	34	€1.1M
Slovakia	348 kg	111 kg	23%	0.15%	5%	10	€0.6M
Slovenia	466 kg	72 kg	58%	0.41%	8%	8	€0.5M
Spain	443 kg	135 kg	30%	0.20%	8%	210	€11M
Sweden	443 kg	212 kg	49%	0.19%	7%	49	€4.1M
United Kingdom	483 kg	236 kg	44%	0.35%	15%	292	€31M

4-1-1- Latvia

The latest macroeconomic studies in Latvia suggest that consumers have changed their consumption patterns for economic and health reasons, moving away from more expensive and often unhealthy products and goods, and more often supporting vegetarian diets that have grown in popularity in society. Compared with the situation ten years ago, the population consumes less meat, bread, alcohol, and tobacco on average. The decline in total domestic food and beverage consumption has naturally encouraged producers to look more towards exports. There are many new investment projects that promise both to expand production and to provide greater automation of work, thus solving the current problem of staff shortages [20, 21]. The main subsectors or complementary industries for the food industry are education and science industries, which help to solve the problem of resources and create new, innovative products, as well as look for solutions for waste management. Bio packaging produced in Latvia is also one of the important subsectors as well as the fast growing zero waste cafe and shop sector. In this regard, the investigation of packaging-related issues shows that manufacturers and retailers would like to switch to smart packaging and are ready to pay more for it if it mitigates risks and improves resource-efficient and sustainable development [21]. Various projects are being implemented to promote the development of the circular economy. For example, in 2016 the project 'Development of pre-treatment conditions for food waste and catering waste for further processing using biotechnology' was completed, which aimed to develop conditions for the processing of food waste using biotechnology [22].

Regarding food waste management, there are several regulations in Latvia. The Cabinet of Ministers has issued order No. 489 "On the Action Plan for the Transition to a Circular Economy 2020-2027" that states that food is used efficiently and food losses throughout the food chain, including production and supply, are prevented, and one of the actions is to

create a fair, healthy and environmentally friendly food chain system [23]. In the Waste Management Law, the Cabinet of Ministers determines the content of the food waste prevention programme and the procedures to implement the monitoring of waste prevention measures [24]. Cabinet Regulation No. 45 "On the National Waste Management Plan for 2021-2028" include the food waste prevention programme [25]. One of the priorities of Latvia's sustainable development strategy "Latvia 2030" is to be the EU leader in the preservation, increase and sustainable use of natural capital, which also includes sustainable food production [26].

Several examples could be mentioned as good practices at business level. Food retail chain "*Rimi Latvija*" Ltd. donates food with the expiration date "Recommended until..." or food products that have passed the minimum expiration date [22]. The Association "Green Freedom" carries out various educational campaigns, including reducing household food crashes, as well as waste audits in schools, and has developed a Food Waste Measurement Manual under the supervision of the Ministry of Environmental Protection and Regional Development [27].

At the level of food production business, partial preventive measures are implemented [28, 29]. Biopolymer materials are an alternative that is used in the development of sustainable packaging materials. By "biopolymers," we mean two types of materials: those polymers that are produced from renewable raw materials, such as PLA or PHA, or polymers that can be made entirely or partly from renewable resources but which are not biodegradable, such as PET or PE. It is thermoplastic PLA that is the most practical alternative to produce thermoformed packaging, especially for the packaging of fresh fruits and vegetables. Another approach to producing the packaging, which is easy to recycle, is to use only one material, i.e. monomer materials. Materials made of PP (polypropylene) or APET (amorphous polyethylene terephthalate or PET film) are commonly used [30].

Unfortunately, due to the spread of Covid-19 in stores [31], several groups of goods that were not previously packaged are recently packaged in different packages. This is also provided for in the order of the Ministry of Agriculture issued at the end of March 2020 "On Additional Regulation of the Food Chain during an Emergency Situation". To promote the recycling of packaging and the implementation of the basic principles of the circulation economy already in the process of packaging production and product packaging, JSC "Latvijas Zalais punkts" has created an initiative and the trademark "Zali pakots". It aims to ensure that businesses use recyclable packaging to pack their products, which citizens can sort and be sure will be recycled into new raw materials [32].

There are several activities and innovative processes in the business field that are implemented for utilizing food waste. However, most of them relate to individual business decisions, which are not included in the overall national statistics. Currently, "ZAAO" (waste management organization established by Vidzeme regional municipalities) is building a biodegradable waste processing plant in one of the Latvian parishes with the support of the EU Funds. Initiatives have been set up to encourage food waste not to be disposed of in general waste but to be composted. Another innovative food waste minimization approach is Latvia's common practice to process the by-product of cheese processing - whey - into protein drinks [28].

4-1-2- The United Kingdom

Regarding the UK Food Waste Management Strategy, it was estimated that the United Kingdom dumps 10 million tonnes of food each year, of which it would be possible to use 6 million tonnes with a retail value of GBP 17 billion. Based on the estimates of the Waste and Resources Action Plan (WRAP), the UK Government has admitted that there are several benefits that could be put into practice by minimising food waste. For example, decreasing the pressure on environmental pollution (cleaner land and water resources, protecting endangered species; decreasing expenditures on landfill tax for population). Consequently, the UK Government and WARP have determined four dimensions where a meaningful policy intervention could help to reduce food waste: food waste on agricultural farms; food waste in households; food waste in the supply chain, and food once it becomes waste [7, 33, 34].

In the UK, food waste on the farm issues are specially highlighted. The EU-funded FUSIONS project recently estimated that around 1-2 million tonnes of food waste occurred on the farm in countries producing similar levels of food to the UK. WARP has proposed several strategies to help reduce farm food waste, including: Whole Crop Purchase (WCP) – WCP is a system whereby contracts between farmers and retailers are concluded with commitment to purchase whole crops instead of just a part of the crop. Market information suggests that, for some crops, almost 1/4 is wasted because they do not comply with the appearance standards set by retailers. WCP could result in such production which does not meet the required standards for retail and thus can be used in other parts of retailers' supply chains, for example, in production of canned vegetables or soups. According to this approach, farmers would be more careful with over-production. Waste Minimisation Plans (WMP) – WMPs could be efficient in the reduction of food waste on the farm, as they would motivate food producers and food processing companies to develop their food surplus and waste minimisation plans [34-37].

Food waste in households is also a huge challenge in the UK. According to estimates, every year households generate approximately 7 million tonnes of unused food, which cost GBP 700 to a family. Analysis of this situation suggests that

more convenience is needed for households with options that make it easier or more economically rational to be less wasteful. It is also admitted that universities, colleges and schools need to work more actively to enhance understanding at all levels of food waste and ways to reduce it. One of the ways to enhance this understanding is, for example, portion size guidance, which was developed jointly by the Department of Health, Public Health England and Defra and could be used as the guidance for consumers on food packaging facts, calories, discounts to eliminate irrational and emotional buying decisions.

The issues related to food waste in supply chains are also challenges that need to be solved. According to market estimates, the food production industry and the HoReCa (hotel, restaurant and catering) sector generate 2.6 million tonnes of food waste each year, which is equivalent to 3.7 billion GBP [36, 37]. Lately, the public procurement policy gives evidence that the UK Government can insist that their suppliers present a food surplus and minimisation management plan, which needs to be included in applying for public procurement. Moreover, progress reports on waste minimizations are also required as an integral part of procurement.

The desk study of UK waste management approaches in the scope of the project 'Go Zero – Zero Waste Management in the Food Sector' reveals that the development of annual food surplus and waste minimization plans also has potential in the UK. This approach encourages waste prevention and redistribution to humans and animals, for example, recycling and anaerobic digestion (AD) [38]. Regarding food once it becomes waste, it could be emphasized that the most desirable outcome is prevention, which is first aimed at preventing food from becoming waste. This means eliminating situations in which food waste is disposed of in landfills, contributing to GHG emissions. Instead of this common approach, food waste should be recycled at anaerobic digestion (AD) sites for generation of biogas, a methane-rich gas that could be later used as fuel or fertiliser.

The UK HoReCa sector generates almost 1 million tonnes of food waste every year, of which 88% are sent to landfill or residual waste treatment. However, the calculations of the Renewable Energy Association show that for large and medium food producers, it is possible to save 10% of their annual waste collection costs by using appropriate waste recycling [7, 39].

The UK has made a good progress by defining its strategies towards circular and bioeconomy development; food waste minimization initiatives are implemented voluntarily by population, and there is a special food waste regulation integrated into the domestic law for business agents; the government has special support mechanisms. Moreover, being a megacity, London participates in the C40 network [40], which unites the world's megacities committed to addressing climate change by sharing experiences and promoting significant, measurable and sustainable activities on climate change as well as paying special attention to food waste management problems in cities. However, in the UK the commitment to the food waste minimization has also resulted in some operational burdens, thus food sectors are motivated to apply new waste management approaches but still are prudent and temporizing. Accordingly, the process of sustainable food waste management currently needs some technical improvements.

4-1-3- Lithuania

Currently, there are no specific governmental regulations on food waste management in Lithuania, nevertheless, the food production factories and catering companies are responsibly managing food waste and collect separately food waste without mixing it with other waste. It is also mandatory to have fat traps or floaters in slaughterhouses. Animal by-products shall be handled in accordance with Regulation (EC) No. 1774/2002. 1069/2009 requirements [7, 41].

There are individual initiatives launched by the Department of Environment, the Lithuanian Government or the Agricultural Department of Lithuania which encourage institutions and enterprises to treat their food waste as required, but this functions only as recommendations. Among some good examples which could be mentioned, the international company *DUSSMAN* could be highlighted, which provides catering services for schools, old people's homes, kindergartens, hospitals, schools, and companies. As the founder of *DUSSMAN SERVICE UAB* is a German company, the Lithuanian subsidiary has adopted their established policy of waste treatment, including food waste. The company has special action guidelines "when / where who" with transparent information and a specification of persons who are responsible of waste to be collected and transported to various facilities for utilization or reuse. The company also has several water and energy saving programmes [42]. In Lithuania, food producing companies take preventive measures for waste minimization, e.g. using eco packages, sorting packages, promoting the reducing of packaging material volumes throughout their supply chains. Eco-labelling application functions work well in Lithuania and the number of products containing this label is increasing every year [7].

4-1-4- Spain

Currently, compared with the other countries that were analysed in the scope of the project "Go Zero - Zero Waste Management in the Food Sector", Spain has the largest number of associations (21 associations) related to waste management, and they all are mentioned on the official website of the Ministry for the Ecological Transition and

Demographic Challenge. It is important to note that Spain has established the Spanish Composting Network, which provides very important functions for the waste management system – accumulates specific national statistical data and maintains the network of composting services [7, 43].

Among some good practices in food waste management, BIGAS ALSINA Sociedad Anónima, which is a family business specialized in the manufacture of machinery for the food sector, could be mentioned. This family business aims to commercialize *PigHeat*, a novel technology that allows the processing of pig skin and the roughing of pigs. Through the proposed *PigHeat* processes, pig skin and roughing can be used as an alternative fuel source that generates steam and service water instead of using gas, diesel, or electricity. This is achieved in four steps: 1) homogenization; 2) hydrolysis; 3) drying; 4) combustion. The product obtained is a CO₂ neutral biomass with an exceptionally high heating value (even higher than wood pellets) that can be used in the daily operations of the same facility. The meat processing industry consumes a lot of energy. Using pork skin and offcuts as fuel, an environmental waste problem is transformed into an important way to save 15% of heating energy, while promoting waste valorisation and a circular economy within the sector [7, 44].

Although Spain has reached more progress in food waste management compared with Latvia and Lithuania, all these three countries still lack confidence in waste recycling and re-use processes. Therefore, in Spain, Latvia and Lithuania, there is an urgent need to invest in research on environmentally sustainable production models, which as a future objective implies economic benefits. Promoting an effective waste minimization culture in the food sector is also of relevance to both businesses and consumers.

4-1-5- Turkey

When the current situation with circular economy initiatives is analysed, it can be concluded that the circular economy is an emerging concept in Turkey; therefore, it would be appropriate to say that there is not a solid initiative by the Turkish government to stimulate the circular economy in the food sector. However, there are few companies improving their businesses in parallel with the concept of circular economy. For example, an alcoholic beverage company re-evaluated the by-product of Stum production and reintegrated it into the circular economy [45]. Waste is generated at several stages throughout the food supply chain. At the agricultural production stage, the total food loss and waste was estimated to be 13.7 million tonnes, which was equal to 11.9% of the total food output; furthermore, the largest food loss and waste were recorded in fruit and vegetable production followed by cereal and milk & egg production. At the post-harvest handling and storage stage, the total food loss and waste was estimated to be 4.35 million tonnes, which was equal to 3.75% of the total food output; additionally, the largest food loss and waste were recorded in the fruit and vegetable industry, whereas the smallest was recorded in the fish and seafood industry. At the commercialization stage (processing, packaging and distribution), the total loss and waste of food was estimated to be 3.44 million tonnes, which was equivalent to 2.99% of the total food output; in addition to that, in the processing and packaging steps, the largest loss and waste of food were recorded in the cereal industry followed by the fruit and vegetable industry, while in the distribution step, the largest was recorded in the fruit and vegetable industry followed by the milk industry. At the consumption stage, the total food loss and waste were estimated to be more than 8.6 million tonnes/year and less than 16.5 million tonnes/year regarding the household food waste, and the total food loss and waste were observed the most for vegetables, meat, chicken and fish, and bakery products regarding the food waste from the food service sector. Fruit juice was the main beverage group that was wasted in the food service sector. At the end-of-life stage, the total household food loss and waste were estimated to be 8.61 million tonnes/year, which was equal to 28% of the total municipal solid waste [7, 46].

The Turkish Ministry of Agriculture and Forestry and the Food and Agriculture Organization of the United Nations have prepared and published the National Strategy Document and the Action Plan on Prevention, Reduction and Management of Food Loss and Waste in Turkey (2020), highlighting the importance of collaboration between public institutions, industry, consumers, academia, and NGOs [47].

There are several examples to share in terms of the measures that food production companies take to minimize packaging waste. One of them belongs to a large supermarket chain that also has its own food and beverage brand. In 2008, it became the first company in Turkey to use biodegradable Oxo bags with the aim of controlling the use of plastic bags. In 2019, it succeeded in reducing the use of plastic bags by 74% in comparison with the previous year by selling more than 2.5 million environmentally friendly non-woven bags and cloth bags. Furthermore, to minimize the use of plastic in packaging in view of product quality, polystyrene and carbon black are not used in the company's own products, and in packaging that is in direct contact with the product, no PVC is used. Compared with the same products of the leading brands, the packaging material of the detergent and paper (toilet paper, paper towel, etc.) product groups contains 405 tonnes less plastic. In 2019, through increasing the basis weights of yogurt, ketchup, and mayonnaise products, it was established that 46 tonnes less plastic was introduced into the market. The company has managed to make the upper films used in the modified atmosphere packaging (MAP) of meat products thinner, which led to the prevention of 5 tonnes of plastic waste; it has also managed to make the MAP 100% recyclable, which resulted in the

prevention of 100 tonnes of packaging material being wasted. Overall, the company managed to recycle 12,600 tonnes of packaging waste in 2017, and this number increased to 17,173 tonnes in 2019 [48-51]. Another example belongs to a drinking water company that uses 100% recyclable materials and 50% recycled plastic in the packaging of its products, which has reduced plastic use by 33%. [7, 49].

Although circular and bioeconomy strategies are still in the process of being developed and refined, Turkey has integrated food waste regulation into domestic law, and the government supports food waste minimization by special programmes that encourage food sector companies to adopt new approaches. The Turkish Ministry of Environment and Urbanization has also claimed that the EU Landfill Directive (99/31/EC) will be carried out by 2025 [50].

However, currently due to the absence of binding international agreements, Turkey lags behind the biggest European countries in its national data analysis on waste management and making sound commitments to combat climate change on both national and international level [14]. Despite the lack of commitment to take more convincing steps towards the transition to a circular economy, Istanbul can be regarded as a positive example at the European level as it is jointly with the world's megacities participating in the C40 network and thus taking initiative for raising awareness of new approaches that food sectors can use to reduce their waste. Currently, the main challenge for Turkey is enhancing food waste minimization initiatives for further industrial symbiosis and the promotion of the circular economy in the country.

4-2- Focus Group Interviews with Food Industry Employers and Employees

In the focus group meeting with Latvian food industry employers/company owners, three subsectors were represented - the sector of bakery production, egg production and vegetable growing and production. All the employers in the meeting claimed that they were highly interested and aware of the need to improve their food waste management and introduce some of zero waste principles. In all the three enterprises waste management strategies had been elaborated and practically implemented.

Although the technological processes to produce bakery, eggs, and vegetables are very different, the authors discovered more similarities than differences in the responses of the representatives to the questions of waste management and resource savings. In the focus group meeting with employees, the authors identified that the work experience among the participants varied within the diapason 5-15 years. However, their opinions and suggestions showed that work experience had no effect on comprehension of waste management processes in the enterprise. In both discussions (with administration and employees), several good practice examples were identified that could be benchmarked by other enterprises.

In the process of waste minimization and management, both external and internal impact factors were identified by employees and employers. In the external environment, the dominant influencing factor that was mentioned was the lack of political support and coordination of waste management at the national level. Although strategic goals have been set for sustainable development of the environment in various policy documents, laws, strategies and plans, in the focus group meetings it was emphasized that the development of waste minimization and resource saving processes have been implemented predominantly to strengthen the company's corporate image, which is especially important in dealing with business partners in the EU export markets, to attract available financial support, and only then as a less significant factor was indicated the intention to become more environmentally friendly and save resources. However, economic benefits of the resource saving by reuse and recycling of food waste were highlighted as perspective motivators for future transition to new waste management approaches. In the process of waste management, the most common activity implemented in all the represented subsectors was waste recycling, focusing on the recycling of paper and plastics. The other activity implemented in all enterprises was the reuse of food waste for animal food or the transfer of food waste to biogas production or agricultural enterprises for the bio fertilizer of compost. The respondents emphasized that the implementation of these activities currently cannot be taken for granted and can be organized only based on excellent collaboration with reliable partners in other sectors and thus allowed to reuse more than 50% of food waste.

From the perspective of the internal environment, the focus group participants identified the following impact factors:

- The need for technological solutions and availability of new, energy-efficient technologies for production processes that provide food waste minimization;
- The need for all level managers' involvement and interest in waste management processes;
- The need to work for better collaboration within the sector on ideas how to eliminate food production waste;
- Involving all level employees in waste and energy-saving processes;
- Enhancing the internal communication between managers and all level employees about waste management and energy saving processes;
- Organizing of informative seminars, training programmes on zero waste possibilities and exchange of experiences between companies about solutions for waste management and resource savings;

To involve more enterprises in the waste management processes, the focus group participants in the discussion suggested that it is necessary to strengthen the support by two initiatives:

- More support at the national level from the government (lowering of administrative burdens, motivating support, training opportunities for food industry students and employees);
- More options/solutions for food waste reuse and recycling for smaller enterprises that are currently forced to dispose of their food waste in the least efficient way because they cannot reach a minimum volume that waste processing companies require and thus are ignored.

In the employee discussion, respondents had many ideas how to reuse food packaging, however they admitted that their ideas lacked the financial justification.

Regarding general questions on resource saving, it was identified that water was the resource that was most often purposefully saved by different activities at all levels of production. Although all of the analysed enterprises had their own independent water filtration systems, they all emphasized the importance of strict monitoring and control processes in water management as they provide a good economic benefit.

Energy-saving processes in enterprises include the use of LED lights, sensors, monitoring capacities, and the replacement of old production technologies with new ones. All enterprises could mention some good-practice examples of how they used heat that was generated in the production process for heating systems in their premises, and two employers in the near future were planning to construct new production buildings that were energy efficient.

5- Conclusions, Recommendations, Future Directions

- The minimization of food waste in the European Union is a significant precondition for an economically justifiable transition to a circular economy. In the EU, only 16% of the biowaste potential is currently being utilized. However, with appropriate initiatives, this number could be multiplied by 5 to reach 85%. This estimate emphasizes the need for European countries to continue and enhance their commitments to the collection, separation, and treatment of food waste. The general analysis of the study results on the food waste management applications in European countries leads to the conclusion that the national initiatives and success factors vary between the countries. The biggest countries are more efficient in their food waste minimization. These countries' achievements can be explained by larger financial investments in circular economy sectors that can create robust recycling systems and higher levels of innovation, more patents and job creation in circular economy sectors.
- Of the five selected countries, the UK has made the most progress in food waste minimization. The UK has made good progress by defining its strategies towards circular and bioeconomy development; food waste minimization initiatives are implemented voluntarily by efficient food waste regulation that is integrated into domestic law for business agents as well as special government support mechanisms. However, in the UK, the commitment to food waste minimization has also resulted in some operational burdens, and although the food sectors are motivated to apply new waste management approaches, they are still prudent and temporizing. Accordingly, the process of sustainable food waste management currently needs some technical improvements.
- Spain has obviously made better progress in food waste minimization compared with Latvia and Lithuania. However, the three analysed countries still lack confidence in food waste recycling and re-use processes. Therefore, in Spain, Latvia, and Lithuania, there is an urgent need to invest in research on environmentally sustainable waste minimization models, which as a future objective implies economic benefits. Promoting an effective waste minimization culture in the food sector is also of relevance to both businesses and consumers.
- Although circular and bioeconomy strategies are still in the process of being developed and refined, Turkey has already integrated food waste regulation into domestic law, and the government supports food waste minimization through special programs that encourage food sector companies to adopt new approaches. However, currently, due to the absence of binding international agreements, Turkey lags behind the biggest European countries in food waste minimization achievements. Currently, the main challenge for Turkey is enhancing food waste minimization initiatives for further industrial symbiosis and the promotion of the circular economy in the country.
- The focus group discussions with Latvian food sector enterprises revealed that employers and employees would be interested in improving their knowledge of food waste minimization practices. It was also discovered that the first aspect that needs to be improved to enhance waste minimization in the food sector is the invention of a national, economically justified, and sustainable food waste minimization system that is available for all enterprises regardless of their food waste production volumes. Also, industrial symbiosis in waste reuse and recycling should be promoted more actively by the Ministry of Environmental Protection and Regional Development, which implies intersectoral discussions, training programs, informative materials, and the exchange of best practices that provide real expertise in developing waste minimization processes.

- In the authors' opinion, the current study highlights some directions for further research. As mentioned before, food production waste minimization is a comparatively new trend in waste management, for which economic benefits have not been estimated at the micro level. Therefore, the authors' future research focus will be directed at the Latvian food sub-sectors' economic benefits from their production waste recycling.

The varying and contrasting statistical data available on food waste recycling processes in the EU member states, the UK and Turkey limited the depth and scope of the current study.

6- Declarations

6-1- Author Contributions

Conceptualization, G.G.Z.; methodology, G.G.Z. and A.Z.; validation, G.G.Z. and A.Z.; writing—original draft preparation, G.G.Z. and A.Z.; writing—review and editing, G.G.Z. and A.Z. All authors have read and agreed to the published version of the manuscript.

6-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6-3- Funding

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6-5- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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