Abstract

The paper explores the possibilities the circular economy provides to the manufacturing and processing of food products. The aim of the research is to identify and prove the effectiveness of the innovative circular economy business models for the food products safety, as well as to determine the tasks and instruments that manufacturers may encounter when adopting to these models.

According to more than 50 examined studies published in international journals as: Business Strategy and the Environment, Environmental Economics, Journal of Hygienic Engineering and Design, Sustainability etc., articles and papers represented on the various web platforms like ResearchGate, Accenture, EIONET Portal, Ellen MacArthur Foundation, as well as reports of international institutions like OECD, Club of Rome, WEF, European Environmental Agency regarding modern food technologies and production models using food waste as raw materials the main principles on how the circular business models should be implemented both in food processing and entire value chain were disclosed. It can be concluded that the use of the majority of innovative circular business models (Circular suppliers, Resources recovery, Product life extension, Sharing platforms, Product as a service) have already demonstrated some positive gains in manufacturing. However, the circular business models' features benefiting the highest production and economic efficiency as well as product safety need clarification due to numerous challenges and barriers leading to a predominance of negative externalities over positive ones. The paper represents the basic conditions to make the introduction of the circular models in transformation economies' food industry more economically effective which include the coordinated action between producers, government agencies, and the society. Innovative circular economy business models involve the creation of a complex multicomponent economy and a network of values. The transformation of food production business models to circular ones requires coordinated action between producers, government agencies, and the society. This includes establishment of an effective dialogue between central and local authorities, national producers and academia; development of new spheres of operations through targeted forms of interregional cooperation; development and implementation of industrial and financial policy instruments to stimulate innovative business models for the introduction of a circular economy in food manufacturing and processing.

Summarizing the foreign experience, the authors identified the circular business models of food industry (resources recovery, platform for food-sharing) which would lead to complex circular transformations bringing mutual benefits to companies and consumers. In addition to short-term financial benefits, food industry companies can attain long-term strategic advantages, which include optimising material flows, entering new markets, expanding the customer service scope or after-sales service, as well as obtaining gains from the services related to the closed-loop process.

Key words: Circular economy, Food industry, Business models, Economic Effectiveness.

1. Introduction

One of the main challenges of the future is the increasing impact of environmental factors on economic development - like environmental threats, climate change, waste minimization and reduction of CO₂ emissions. At the present stage, achieving sustainable
economic growth has become an important item on the global agenda. Resource constraints in food industry, as well as increased waste and environmental pollution affecting the resources quality, can increase threats to society’s well-being and, from a commercial point of view, to business competitiveness, profitability, and sustainability. In particular, the food industry has a significant negative impact on water resources, polluting sources with technological water containing high amounts of nitrates, ammonia, etc. [1], summarily causing ¼ of the global greenhouse emissions [2]. Simply put, there is an urgent need for decoupling, or in other words, transition to a circular economy.

This concept became relevant after the recognition of the “growth limits” [3]. Presented in the 1972 Club of Rome Report, the World3 [3], the model demonstrated that per capita industrial output, food, and services are growing exponentially, and industrial capital is reaching a level where an enormous inflow of resources is required, which have been increasingly depleting with the accelerating growth. Testing of the model made it possible to understand that technological solutions allow to prolong the period of demographic and industrial growth, but do not allow to push its final boundaries. This requires a qualitative restructuring of social, economic and political systems.

That is why a lot of food companies have already started working on the principles of sustainable development instead of the principle «earn more, no matter what». To overcome the aforementioned problems, in December 2019 the European Commission presented an ambitious program - European Green Deal [44] - aiming to ensure the sustainability of the EU economy through the transition to a climate-neutral, circular economy by 2050.

Circular economy is a model that is based on closed cycles, with multiple use of resources and high degree waste recycling, reducing their consumption. By transition to a circular economy country can benefit increasing sustainability, creating jobs, protecting the environment, and reducing emissions. At the same time, there are different assessments of the benefits and possible risks, the ratio and structure of which necessitate the differentiation of approaches to the implementation of this concept in countries with different development levels. In the field of food production, in turn, there are also specific risks and challenges associated with food safety: food shelf life, strict storage and packaging requirements, standards and norms of production, various geographical zones of origin of raw materials, national characteristics and traditions of consumption, etc. And these factors should be taken into account in the course of expanding the practice of using circular models in food production.

The paper intends to identify and prove the effectiveness of the innovative circular economy business models for the food products safety, as well as to determine the tasks and instruments the manufacturers may encounter when adopting to these models.

2. International experience of sustainable principles introduction in the food industry and substantiation of the necessity of circular economy development

2.1 The state of art in circular economy introduction at world food industry: literature review

There is a wide range of literature exploring innovative and traditional business models of circular economy in food and agri-food systems. Linder and Willander [4], define a business-model of circular economy as “model in which conceptual logic of value creation is based on the use of economic value retrained in products after applying new offer in production”.

A recent Eionet report (from 2021) on the co-creation process for circular economic monitoring [5], provides the results of surveys among respondents who share an interest in a circular economy, studying the importance of certain sectors of the economy to introduce innovative business models of circular economies. As a result, the participants of the survey gave the greatest weight in monitoring construction (14 points), transport (12 points) and the food industry (10 points); agriculture received significantly less (6 points). Thus, nutrition enters the top 3 important industries for tracking circular trends. In an OECD study devoted to circularity, food was recognized as one of the sectors most in need of assessment, especially in the context of waste volume: the amount of food waste generated, the number of food recovery-redistribution actions and food waste avoided through a circular consumption [6]. European Environmental Agency stated that bio-waste recycling is a key for reaching the EU's recycling target for 2035 - 65% recycling of municipal waste. In the same time, the Agency emphasizes the importance of further scale-up of waste sorting for transforming bio-waste into fertilizers and biogas [7].

In 2002, Braungart and McDonough [8], expressed their view on the principles of circular food production, emphasizing that any food waste can become a fertilizer for future crops without pollution, as well as contribute to the maintenance of biodiversity in particular areas. Their concept redefined the role of bio-waste in business models and allowed us to reconsider their possible environmental impact. It has had a significant impact on approaches to the development
of environmental decisions made by humanity within its current and future technological capabilities.

Senior Editor at Ellen MacArthur Foundation, Robertson-Fall [2], highlights 5 main advantages that food business obtains by implementing innovative circular economy business models:

1. Restoration of natural systems. Agro-forest breeding, permaculture, the use of organic fertilizers constitute the basis for the implementation of this principle.
2. Combating climate change. Circular economy reduces greenhouse gas emissions by up to 49%.
3. Increased access to food. Strengthening ties between suburban areas and cities, especially in the context of Covid-19, will create sustainable supply chains and reduce dependence on external supplies of raw materials for food and products.
4. Support of the local communities. About 70% of food consumption is provided for by small farms. However, industrialization and consolidation of agricultural production threaten small farming with gradual destruction. The development of suburban farms will support local communities and increase the level of food security.
5. Decrease of expenditures and creation of value. The Ellen MacArthur Foundation estimates that by 2050, thanks to a circular economy, cities will be able to benefit from 2.6 trillion euros through local food production using regenerative methods.

Robertson-Fall [2], emphasizes that the economic benefits of using circular business models in the food industry are becoming increasingly obvious to business, the state and society and open up new opportunities for the redesign of economic relations.

Ferasso et al., [9], analyzed more than 250 works on the implementation of circular economy business models and were able to determine interconnections between the main categories and terms in the circular economy researches and the white spots that are yet to be studied. In general, the authors identified the following categories of problematic issues for the development of innovative circular economy business models: product (creation of new products through recycling, reuse, and remanufacture ); technology (essence and role of 4.0 technologies in creating new closed-loop business models); industries (features of implementation in various areas of economic activity, as well as the high role of financial support for the transition to a circular economy); strategy (circular strategies development and implementation, the role of strategic partnership); sustainability (circular supply chain creation, estimation of the value of supply chain circular components). However, the work does not specify the types of business models and their distribution in various areas of economic activity, in particular, in the food industry.

Hamam et al., [10], provides a detailed review of works about innovative business models used directly in the food industry. The authors studied 27 publications on circular economy, all related to the models of sustainable business in the field of agri-food production, and, as a result, developed important. Among other things, based on the research of Reike, Vermeulen and Witjes [11], they stipulate that “policy makers and producers should focus their efforts on realizing more desirable and shorter cycle conservation options, such as regeneration, refurbishment, and reuse, considering overall system feasibility and effects” - thus highlighting the key business models for circular economy innovations in food production. They propose to investigate more thoroughly the consumer preferences and attitude to the reuse of food waste, which is one of the main obstacles to the active implementation of circular business models. Another obstacle is the lack of proper state support, since it concerns restarting the entire economy as a whole.

Recently there has been an increasing number of European enterprises called “biorefineries” that turn biomass into valuable products - chemicals, biofuels, food and feed ingredients, biomaterials or fibers. According to the European Environmental Agency, in 2020 there were 803 such enterprises in Europe, 136 of which report taking in waste streams [7]. The study notes the complexity of the organization of such production, since the business model and technology involve the flow of homogeneous waste, which is often agricultural waste and food industry waste. Food waste contains a large amount of organic substances that allow multipurpose processing, in particular - biofuels, phosphate and substrate for VFAs production, but this requires further research. In addition, bioethanol, which is produced from these wastes and is a promising type of fuel, can compete with food and feed production.

More and more works on new technologies of food waste processing and new food products appear lately. Researchers are looking for ways to extract nutrients, as well as applications and recipes for the use of waste, especially when it comes to the primary stages of processing agricultural raw materials and fishery.

Rajković et al., [12], use winemaking as an example for the possible ways of utilization of food waste at different levels of the production chain. The authors proposed a hierarchy of areas of waste use in food production on the principles of the “least desirable” and “most desirable” scenario (Figure 1).
Following areas of waste disposal for plant raw materials (fruits, vegetables) have been proposed: biocompounds extraction (sugar, lipids, amino acids, starch, elastin, hemicellulose, polyphenols, collagen, pectin, chitosan), with subsequent use of bio-catalysis, bioconversion and synthesis - for receiving such by-products as bio-surfactants, bio-fuels, syn-gas, bio-adhesives, cellulose nanocrystals, alcohols, natural chelants etc. For wine-cognac production in particular, it was determined that the main by-product are pomace. Following ways to use them were proposed: 1) production of pomace brandy; 2) functional food; 3) biosurfactants; 4) cosmetics; 5) pharmaceuticals, 6) supplements, 7) organic fertilizer, 8) feed for livestock, and even as 9) a source of biofuel. The authors cited existing processing technologies and summarized that such wastes in food production constitute invaluable raw materials in the context of growing population. The study noted that, in order to intensify the circular economy in food production and processing, it is necessary to establish appropriate legislative incentives. However, the authors did not give an economic justification for the commercialization of these circular models.

Bazarnova et al., [13], conclude that a significant proportion of fishery waste is occupied by the by-products of salmon processing, the flesh of which has high nutritional value. The percentage of food waste (ridges, fins) is 30 - 40%, while salmon fillets only 10%. The authors proposed the use of spines in the manufacture of fish sausages, which also have a significant nutritional value. They provide high chemical, biological and organoleptic indicators of new developed products.

Donner and de Vries [14], analyze several cases, which played an important role in creating and disseminating innovative circular economy business models in the agri-food sector. In 2004, in Germany, when the biogas boom unfolded, farmers began to consider bio-waste as a resource for fuel production. And when they faced restrictions on land resources, they began to direct bio waste to fertilizer production. At the same time, the transition to the circular economy had a multiplier effect, since in parallel electric vehicles entered the markets, and the heat produced was directed to heating homes in the village. Another successful case concerned the use of by-products of cereals as resources for construction.

Finn and Roversi [15], explore cases when food waste is formed due to defective (cosmetic defects or inconsistencies in size) vegetables entering the market, as well as large volumes of freshly cut vegetables after food processing. Matriark Foods recycles them into nutritious broths and basics for use in large catering enterprises (in schools, hospitals, food banks). Of the 680kg of such by-products, 80,000 servings of vegetable broth are created. ReGrained by-products brewing (waste grain) produces highly nutritious flour, which is sold to other enterprises of the food industry. A similar model is used by Coffee Cherry Company, which produces flour from coffee husks used in confectionery products. Co-owners of Hidden Gems found that avocado seeds contain a high dose of antioxidants. They boil them to produce drinks, and compost softened seeds. The authors emphasize the effectiveness of the creative component when disseminating information about these models of food waste processing. These examples show only a small fraction of what becomes waste, which can be used to produce innovative food with a long shelf life and the possibility of transportation to different regions of the planet, where the need for food is extremely high. To do this, as some companies emphasize, it is necessary to create a whole economic industry.

The main idea of the presented works is that the restructuring of food systems based on the circular economy principles can contribute to solving the global problem of food waste by reducing food production chains and increasing their efficiency in terms of resource use.

2.2 Effectiveness and feasibility of innovative circular business models introduction

Expanding the circular economy to the global level requires a combination of business models, technological advances and innovations, as well as the joint efforts of stakeholders, including business and government.

Business models may function as a tool or source of innovation. As a tool, they provide the ability to implement the results of various types of innovation in products and services, processes and/or in various organizational settings; as a source of innovation, they help to bring existing products and services to the market in a new way.
Circular business models can also play both roles at the same time when products and services, processes and organizational structures are implemented, and ways to deliver them to existing or new markets are developed. They are based on the implementation of 10R principles, acknowledged in 2018 by the World Economic Forum: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover. Some European companies have already been able to successfully "embed" these principles in the modernization of industrial production, while ensuring a level of profitability guarantees a timely return on investment and further growth of the business. They partially refuse to use products made of materials that are difficult to process or apply the trade-in system - the exchange of goods that have already been in use for new ones [16].

The Ellen MacArthur Foundation estimates that the introduction of a closed-loop economy could boost GDP to 12 - 15% by 2025 and boost the global economy's revenue by more than $1 trillion. The transition to a circular economy will create huge opportunities for the modernization of production and the introduction of industrial innovations, providing an annual productivity increase of 3%, and, as a result, a GDP growth of 7% [17]. These impressive figures are the best motivation for the transition to a circular economy, both for politicians and for industrial entrepreneurs.

Application of these approaches in the formation of business models of circular economy innovation in the food industry should be based on the existing sector specifics.

If we consider the geography of Europe in terms of food waste generated by households, then, according to UNEP estimates [18], for 10 Eastern European countries, Hungary takes the last place in terms of household food waste (94 kg/capita/year); The 8th and 9th places are divided by Ukraine and the Republic of Moldova (76 kg/capita/year), and the first and second places are taken by the Russian Federation (33 kg/capita/year) and Poland (56 kg/capita/year), respectively. In Northern Europe, the lowest level is that of Ireland (55 kg/capita/year), and the highest is for Denmark and Sweden (81 kg/capita/year). In Southern Europe, Slovenia (34 kg/capita/year) is the leader, and the largest load of food waste is typical for Greece (142 kg/capita/year) and Malta (129 kg/capita/year). The indicators of the rest of the countries in this region, except for Spain and Italy, range from 83 - 84 kg/capita/year (Albania, Andorra, Bosnia and Herzegovina, Croatia, Gibraltar, Macedonia, Montenegro, Portugal, San Marino, and Serbia). In Western Europe, Belgium and the Netherlands demonstrate the least proportional amount of food waste (with a volume of 50 kg/capita/year), while the largest belongs to Luxembourg (90 kg/capita/year).

According to IFCO, Australia is the most economical in terms of food waste in the world (losses constitute 5 - 6% across the entire length of the value chain). The leader in the rate of reduction of food waste is the United Kingdom - for the period of 2007 - 2018 the country managed to reduce it by 27%. A key role was played by the commitments made by supermarkets and food industry manufacturers, and educational programs such as “Love Food, Hate Waste” [19].

Reduction of food and waste losses was established in 2015 as one of the Sustainable Development Goals for 2030 (#12.3). However, after 6 years, this Goal is still difficult to meet for many countries around the world.

The estimated volume of food and food waste losses globally varies from 194 to 389 kg per person per year, in Europe - from 158 to 298 kg [20]. In 2018 the World Bank reported the size of the world's population as 7.6 billion people [21], which suggests global volumes of food waste for that period are between 1.47 billion tons and 2.96 billion tons; in the EU - from 70.6 million tons to 133.2 million tons.

The UNEP Food Waste Index Report 2021 noted food waste volumes at 121 kg/capita/year - about 61% from households, 26% from food service and 13% from retail [18; 22]. The total amount of global food waste in 2019 was estimated at 931 million tons. While globally there is more food produced than humanity can consume, its disproportional dissemination is the reason for 795 million people remaining undernourished [23].

The problem is mainly widespread among the countries with a low level of development, which: (1) are limited by trade agreements and agreements with international financial organizations and are unable to effectively manage structural changes in their national economies; (2) Due to the popularity of policies in the field alternative energy sources, they reorient a significant share of land resources to the cultivation of technical crops; (3) due to the lack of financial resources, they are unable to engage in agricultural R&D. In order to provide food to the entire population by 2050 under the business-as-usual scenario, it is necessary to increase food production by 60%. Circular economy models can contribute to reducing the use of natural resources by avoiding waste, building value chains based on the use of food waste from previous and/or subsequent links, prolonging the life of food products through innovative technologies of their production and storage, etc.
There are several approaches to the formation of circular business models in global practices. Accenture's experts have compiled a popular classification of innovative business models that are implemented both separately and jointly [24]. They consist of follows: circular supplies, resources recovery, product life extension, sharing platforms, and product as a service.

1. Circular supplies - a model in which limited resources are replaced by fully renewable sources. It is based on a long-term research and development, provides for the supply of fully renewable sources, recycled or biodegradable resources that form the basis of a circular system of production and consumption. Automotive and energy industries are the leaders in the implementation of this model.

2. Resources recovery is the model that uses technological innovations and opportunities to recover and reuse resources, which eliminates their losses by reducing waste and increasing the profitability of production from reverse flows. This model is most suitable for companies that produce large amounts of by-products, as well as those that can effectively recover and recycle waste. Examples include the closed recycling cycle involving the recycling of waste into new resources.

One of the most shining examples is the example of Danish companies: the drug manufacturer Novo Nordisk, the enzyme manufacturer Novozymes and DONG Energy, together with Denmark’s largest oil refinery run by Statoil, exchange waste and by-products. Steam from the DONG power plant is piped to Novo Nordisk and Novozymes, where it is used as a cleaning agent, and to a refinery, where it is used in several processes. Power plant waste – slag and gypsum – is used in the production of cement and drywall. Novo Nordisk and Novozymes wastewater is treated for municipal use, while the rest of the biomass is converted into fertilizer. Statoil has also reduced emissions by converting unnecessary sulphur and nitrogen into fertilizers [26].

At the Mexican Heineken brewery, the production process that has been renovated in 2018, employs all resources comprehensively (water, heat, sludge, waste grain, broken glass, paper labels from beer bottles, etc.) [27].

While producing the world-famous ketchup, Heinz processes about 2 million tons of tomatoes per year. In 2012, a working group of specialists from Ford, Coca-Cola, Nike Inc. and Procter and Gamble was established, for the development of plastic material from the plant’s by-products, to be used in the processing of the car, as well as in packaging and clothing [28].

Bakers give stale and unsold bread to brewers, who use it to make craft frothy drink. The most famous examples of such cooperation are Brussels Beer Project [29], and Suffolk Brewery Adnams [30].

3. Product life extension - a model that allows companies to extend the life cycle of their products through repair, modernization, reconstruction or restoration. It is more suitable for manufacturers of industrial equipment, where the new models provide a miniscule increase in productivity compared to the previous ones. This model also involves the transition from the sale of things to the sale of services for their use.

Treasure Company (State of California, USA) has developed a cutting-edge technology of vegetable waste dehydration (cabbage, pepper and beets) into nutritious chips and powders that have comparatively long shelf life, unlike the vegetables themselves [15].

4. Sharing platforms - a model that is based around the exchange or sharing of goods or assets. For example, using digital platforms for rent, sale, exchange and reuse. It provides for the promotion of platforms for product users cooperation (individuals or organizations), thereby increasing the level of their use. They are most interesting for the manufacturers with low product utilization or underutilized capacity. This business model has led to significant changes in the field of consumer relations (consumer to consumer - C2C), business and consumer (business to consumer - B2C) and has significant potential in the field of business to business relations (B2B), as it allows potential competitors to cooperate in order to distribute fixed costs, increase the use of assets, generate revenue from the joint exploitation of equipment and increase overall efficiency.

This model is the most innovative in the food industry and is embodied in food sharing web platforms and/or mobile apps. It helps reduce edible food waste [31]. It’s a collaborative consumption model based on access to cheaper local food. Such platforms as Tabete (Japan), foodsharing.de (Germany) helped to save hundreds kilograms of food that in other case could not be sold out during the quarantine of Covid-19.

5. Product as a service - a model in which customers use products through «rent», with payment upon use. It is
an alternative to the traditional “buy-own” model, and may constitute lease or rent, etc. If the manufacturer retains ownership of all materials and equipment, there is an incentive to create a product with a long-life cycle (to ensure the longevity of the service contract), requiring minimal maintenance (to reduce overhead costs and maintain customer satisfaction), optimized for reuse or disposal of individual parts after its service life.

This business model is more applicable for machine-building and IT companies. For example, using this business model, Philips implements the Circular Lighting program, where the company provides lighting services instead of lighting fixtures. In this case, all technical aspects (maintenance, replacement, modernization, and optimization) remain the responsibility of Philips. This has two important consequences: a) for the beneficiary (consumer) it simplifies the organization of lighting services; b) for the supplier (Philips) the whole process becomes more efficient because it integrates vertically the design, production, selection of solutions for lighting, implementation, maintenance and replacement of lighting equipment. By concluding a contract for the lighting organization, Philips, in agreement with the customer, develops a lighting project, selects lighting fixtures, and installs a system to monitor their functioning, and provides further replacement. Those electrical appliances (light bulbs) that have failed are taken away by the company for recycling. In 2017, the income from such activities amounted to 9% of the total income of the company, and by 2020 the goal is to increase this figure to 15% [32].

Donner and de Vries [14], have proposed a new conceptual scheme for an agri-food circular business model of innovation, built on Lean Canvas principles. It involves combining the interests of farmers and food producers who acquire new partners in business - suppliers of bio-waste and by-products, considering the latter as new resources. As a result, they form a new value proposition, create and attract new segments of markets and consumers, focusing on future sustainable needs. At the same time, they are moved by both external trends and drivers (political, legal, economic, technological, environmental and social), and internal drivers (economic, marketing, organizational, spatial).

Currently, the greatest spread of innovative circular economy business models in the food industry can be observed in Finland: some Finnish restaurants prepare dishes from freely obtained food industry residues. Finnish restaurants and chains of stores today use special offers for the sale of food, the shelf life of which is approaching the end, as well as for the sale at reduced prices of surplus groceries in the afternoon or before the store closes. There are social movements that organize free distribution of shop and restaurant leftovers, as well as prepare food from them and provide it to those in need free of charge or at nominal price. Helsinki also conducts experiments with the placement of so-called public refrigerators in the city, in which anyone can leave excess food or take it [33]. These models are already penetrating the lives of many other European countries, including Ukraine. However, most countries are not yet fully ready to implement the social component of such models.

Gakhovych, Kushnirenko and Zarudna [34], review the most widespread innovative business models (per the Accenture classification) by the economic branches - food, light, pulp and paper, electronic, chemical, services, repair and maintenance of ships. Among them - reuse, upcycling, product life extension, sharing economy, resource use rationale based on digital technologies etc. The authors analyze the main obstacles to the implementation of these models in the practice of Ukrainian business and conclude that circular value chains will be actively formed only if the institutional and legal frameworks are updated, production management methods are improved, logistics infrastructure is developed, and the range of funding for circular economy projects is expanded for small and medium-sized businesses, as well as if the active position of the state in these matters arises and sustains.

When exploring the peculiarities of the European circular strategy and policies covering various areas of application, one may observe that small businesses and socially active entrepreneurs are playing the main role there. That includes climate change and resource saving, reuse and recycling of plastic, preservation of biodiversity, sustainable consumption and use, smart specialization, resource efficient and green economy.

The repair and restoration industry can create a lot of new jobs and have a positive impact on the welfare of people. Therefore, based on the examples of the EU countries, the Ukrainian leaders of integration into the processing circular value chains can be found in the food industry, based on such principles of business models as resources recovery and sharing platforms. Ukraine is already taking the first steps to implementing the principles of circular economy at such enterprises as:
- Tetra Pak that changes the design of packaging to the style of circular economy;
- “Myronivsky Hliboproduct” company, which builds biogas complexes for processing waste from poultry farms and obtaining energy;
- concern “Obolon” that by-products of beer
production to agricultural companies, which later become animal feed;
- “Silpo” supermarket chain, where special heat recovery tanks from refrigeration equipment are installed to meet the need for hot water supply;
- Brand “Morshynska”, which revised its packaging design, reducing the amount of plastic by 15%.

According to a study by Mehmod et al., [35], the effectiveness of the introduction of innovative circular business models in food and other industries is due to the environmental, political, economic and financial benefits. At the same time, institutional, financial and technological risks are the main obstacles to the implementation of such business models. To overcome them, the authors propose to develop and introduce internationally recognized standards and frameworks for circular economy practices that will be applied globally, especially in the agricultural sector.

Additional arguments in favor of transition to circular business models in the food industry can be the following: cross-sectoral relations, synergies and externalities that come along with by-product valorization in multi-use systems [36].

The range of the reviewed scientific works in the field of innovative business models of circular production is not exhaustive. However, these and other existing studies emphasize that the creation of innovative circular economy business models is the result of close collaboration within the “quadruple helix”, when the efforts of the state and research institutions to implement circular principles are supported by producers and consumers.

### 2.3 Policy tools for innovative circular models implementation in food production and processing

Transition to innovative circular models in the food industry is a complex and lengthy process that requires hard work at all levels, taking into account the experience of developed countries that have passed such tests and have achieved a high level of development. These instruments are aimed at creating favorable conditions for eco-innovation transformations and are implemented at the level of interstate cooperation, state management bodies, regional institutions and enterprises, as shown in Table 1.

Given the complex influence that circular business models have on economic processes, it is impossible to imagine a single tool that would be able to accelerate their implementation. In that regard, it is useful to turn to the experience of leading countries in the area. In 2004, the European Commission adopted the Eco-Innovation Action Plan (ETAP) [45], which aims to promote European competitiveness in the field of eco-innovation and environmental technologies and give the EU the position of the recognized global leader.

Examples of the best eco-innovation practices are presented in Table 2.

These examples demonstrate that, with the proper state stimulation (the formation of framework provisions and political measures), it is possible to accelerate and simplify the transition to a circular economy.

Mechanisms that contribute to the development of circular models include elements such as the formation of an institutional structure and a management system (system of bodies and organizations); legislation (holding public hearings before the proposal of new legislation, specific legislation from interested parties); innovative policy (support for eco-innovation); support for small and medium-sized enterprises; awareness raising campaigns (Figure 2).

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<th>№</th>
<th>Level of impact</th>
<th>Characteristics</th>
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<td>1</td>
<td>International cooperation</td>
<td>Fulfillment of the country’s international obligations under international agreements, in particular, the European Green Deal.</td>
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<td>2</td>
<td>Government</td>
<td>Development of an effective industrial policy, modernization of institutional infrastructure, which provides for systematic reforms in all sectors of the economy, creation of innovative environmentally oriented infrastructure.</td>
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<td>3</td>
<td>Regional authorities</td>
<td>Implementation of effective support measures at the level of regions and local communities, to transform lag regions into regional innovation clusters.</td>
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<td>4</td>
<td>Enterprises</td>
<td>Innovative update of the material and technical production base, on the basis of energy-efficient technologies; introduction of new methods of processing, technologies and new materials; improvement of existing methods of production and management, development and implementation of new types of products, introduction of new production facilities, restructuring of the organizational system.</td>
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Table 2. European states policy instruments for innovative circular business models

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<th>Country</th>
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<tr>
<td>Germany</td>
<td>The green economy policy in Germany is aimed at developing environmental innovations that contribute to the development of international competitiveness in the field of environmentally friendly goods and services based on renewable energy. Among the examples of the development of a “circular” economy, we can highlight the experience of Germany, in which the Waste Management Programme was adopted back in 1986. In 1994, a three-level waste hierarchy was introduced: recycling – recycling – placement. In the Law on the Implementation of the Waste Framework Directive (September 17, 2020), this hierarchy was expanded to five levels. Additionally, the Federal Ministry of the Environment forms GreenTech Atlas of German companies, offering affordable green technologies (assortment, commercial data, reference projects for large, small and medium-sized businesses).</td>
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<tr>
<td>Denmark</td>
<td>Denmark has adopted the Danish National Circular Economy Strategy, which aims to reduce greenhouse gas emissions by 70% by 2030 and aims to create a climate-neutral waste sector by 2030. Full climate neutrality is targeted by 2050, while the processing of 60% of household waste in Denmark and 70% of packaging waste is planned to be achieved by 2030 [37]. Adoption of the “Guide to the collection and interpretation of innovative data” offers the best practices in the development of eco-industrial parks. A good example is the industrial park in Kalundborg, where the industrial symbiotic ecosystem has been successfully introduced. Technology lies in the following: the by-product (waste) of one company becomes an important resource for one or more other companies. As a result, reduced resource consumption and a significant reduction in the environmental burden have been achieved. Partners also benefit financially from cooperation, as individual agreements are based on the commercial basis. Thus, in Kalundborg, excess thermal energy is used by the municipality and fisheries, the slag power plant uses a cement plant, the yeast suspension of the enterprise is used in pig farms, and there are also other examples of exchange between enterprises of wastewater, steam, water for cooling.</td>
</tr>
<tr>
<td>Norway</td>
<td>At present Norway is approaching to Sustainable Development Goals and goals of circular economy within the Strategy for Green Competitiveness “Better growth, lower emissions” adopted in 2017. In addition, several industries have developed their roadmaps on the way to circular transformation and presented them as input to the expert committee on green competitiveness. The resource-saving potential of the food sector has been acknowledged in Norway almost 20 years ago when Research Council of Norway initiated the first National Action Plan (NHP1) in 2010. KuttMatsvinn2020 (prevention of food waste initiative) was launched to reduce food waste in participating restaurants by 20 percent by 2020. The overall goal now is to contribute to the achieving the UN’s Sustainability Goal 12.3 to halve food waste by 2030, which is in line with the goal of the Industry Agreement on reducing food waste between the Norwegian food industry and the authorities.</td>
</tr>
<tr>
<td>Sweden</td>
<td>The Government has adopted a national circular economy strategy that defines the directions and ambitions for a long-term and sustainable transition of Swedish society. This is an important step towards Sweden becoming the world’s first fossil-free state [38].</td>
</tr>
<tr>
<td>Poland</td>
<td>In September 2019, the Polish government approved the Roadmap for the transition to a circular economy, which aims to identify end-to-end measures and priorities, namely sustainable industrial production, sustainable consumption, bioeconomics, new business models, implementation, monitoring and financing of circular initiatives.</td>
</tr>
</tbody>
</table>

Institutional structure
- A system of supranational bodies and international organizations that ensure the implementation of the circular economy principles
- European Commission, European Economic and Social Committee, UNIDO, Ellen MacArthur Foundation and others.

Legislative initiatives
- The food waste goals are part of the European Commission’s “Circular Economy Package”, a broader legal framework aimed at fostering sustainable growth and includes recycling targets.

Communication campaign on awareness and popularization
- The effectiveness of circular economy mechanisms and tools depends on their ability to change individual and collective behavior.
- Waste collection and reuse must be accepted and put into practice in all aspects of civil society: households, industry and agriculture.

Market tools
- Integrated policy/environmental design.
- Green public procurement.
- Development and implementation of eco-innovations.
- Development of organic agriculture (farming).
- Ecosystem services.
- Environmental certification (environmental management and audit schemes).
- Green standardization (IEC, CEN, CENELEC).
- Voluntary agreements.

Figure 2. Frameworks of circular business models development
The existence of circular processes in developing countries, most of which involve sorting and reuse of waste, provides so-called “growth points” that will allow governments, private sector and other stakeholders to promote innovative models [39]. According to the European Environmental Agency, the key to success in the circular economy in the field of food and other bio-waste should begin with sorting [7]. In encouraging this activity, important part is played by state educational activities and introduction of programs for communal enterprises and housing cooperatives on sorted garbage collection; educational programs for young people in order to foster progressive views on responsible consumption; creation of appropriate infrastructure in rural and urban areas. Analysis by European countries has shown that currently, out of 39 European countries, only 12 have a proper system of sorted garbage collection; only 11 have developed quality management systems in this area and only 13 have adopted national standards for compost quality.

In its report “The State of Food and Agriculture 2019/ Moving Forward in Food Loss and Waste Reduction”, FAO [40], presented guidance for the implementation of policies in the field of food loss and waste reduction. The main component of such a policy should be to encourage private producers and retailers to reduce food waste, as they face a number of obstacles in this activity - from the lack of information to the significant distance to sales markets. It includes informing suppliers and consumers of food products about the possibility of introducing circular business models, providing financial incentives, reducing the regulation of prices for agri-food products (the higher the price – the higher is the value of the purchased goods, the less is the waste).

Among the measures that have proven their effectiveness, the mentioned report offers such as: (a) Improving product storage technologies to reduce farm losses and increase farmers’ income. (b) Improvement of fish smoking and drying methods with loss prevention. (c) Cooling technologies that do not adversely affect climate change. (d) Extending the shelf life of products without the use of plastic packaging or cooling devices. (e) Automatic reduction of prices for products that are nearing expiration. (f) Encourage farmers, producers and retailers to make charitable donations to food products by simplifying legislative procedures. (j) The introduction of awareness raising campaigns for consumers and manufacturers. (h) Stimulating R&D in the field of food waste processing and reuse.

Among the innovative solutions that raised from the active digitalization of the sphere of production and sales of products are software applications that allow to trace food products. For example, Kolev and Maksimova [41], proposed introducing food traceability systems for meat products. Such systems allow real-time monitoring of the temperature, color and humidity of products. Thus, it is possible to timely detect violations of transportation and storage procedures, thus reducing food waste in the form of spoiled products.

PACE Platform [42], has developed a manifesto of 10 key positions to help transition to a circular economy in the field of agri-food production (Figure 3).

These manifestations stipulate for a complete change of the model of food production and consumption – starting with “what to grow and how to grow” and ending with the processing of food waste into useful by-products (fertilizers, biofuels, etc.) and ensuring traceability of products.

In order to implement these measures and form appropriate mechanisms, coordinated efforts should be made by:

1. Enable Transitions to Planetary Health Diets
2. Scale Productive and Regenerative Agriculture Practices
3. Increase Value of Nature-Regenerative Food Production To Farmers
4. Better Understand Hotspots of Food Loss and Waste
5. Integrate Food Loss and Waste More Broadly in the SDG Agenda
6. Increase Investment in Food Loss and Waste Reduction
7. Reframe Wasted Food and Byproducts as Valuable Resources
8. Facilitate Secondary Market Development and Access
9. Enable Sanitary Ovens for Human Waste
10. Increase Information Accessibility and Data Utilization

Figure 3. Ten calls-to-action to accelerate the transition, by PACE [42]
• Government (optimization of subsidization of agricultural producers, development of programs for reducing food waste and investing in the relevant national and regional projects, including the principle of circularity in public procurement criteria, combating illegal disposal of food waste, implementation of rules for controlling nutrient content in coordination with the stakeholders from the private sector).
• Business (transition to sustainable production methods and search for partners on the basis of business sustainability, introduction of dynamic pricing for food products to reduce waste, development of new technologies and infrastructure for farms that plan to switch to circular business models).
• Society (consolidation of stakeholders and coordination of interests for the development and implementation of circular transition strategies, usage of various platforms for training and education, actualization of R&D, creation and implementation of circular transition projects).
• Financial sector (search and development of innovative ways to finance circular projects throughout the value chain, reimagining of risk models to determine the price of risks in the context of the transition to innovative business models of circular economy in the food industry, creation of circular-oriented impact funds).
• Science (development of new technologies and new food products, systems of production, processing and disposal, food loss and waste cells mapping for value chains, development and analysis of the effectiveness of models for preventing losses and wastes in the food industry, identification of alternative ways to use agri-food raw materials, determination of the consequences of introducing innovative circular economy models and comparing them to other macroeconomic, environmental, socio-political trends).

Food companies, in their turn, should pass eight steps to provide a transition of a circular economy, as Foodware365 suggests [43]. They include: (1) design and market new products; (2) change production to fit a sustainable model; (3) profit from smart distribution; (4) consumer choice impacting circular economy; (5) availability of re-usable products; (6) recycling agricultural and food waste; (7) preventing food losses with actionable results; (8) raise more awareness towards a circular economy. So, their goals are responsive to the goals of a state.

3. Conclusions
- Thus, the analysis of the existing works on the types of innovative circular economy business models in the food industry and means of ensuring food safety, as well as measures and tools of state policy aimed at stimulating and building mechanisms for the formation of circular business models, made it possible to conclude that the problem is sufficiently relevant and many studies are being carried out in order to develop new technologies for bio-waste management in order to use them in production and consumption.
- Developed countries, when changing the existing structure of production and consumption, play a leading role in the introduction of circular systems, and in the future will support the transition of food industry to a circular economy in developing countries through financing support and technology transfer.
- Innovative circular economy business models arise and develop primarily in the urbanized and environmentally responsible environment, and are aimed at reducing dependence on material resources, increasing efficiency and increasing profits. At the same time, new technologies and resource recovery processes can help build circular value-added chains. But changing the mindset of stakeholders and consumers is the key to a circular economy. As circular economy involves the creation of a complex multi-component economy and network of values, it is accompanied by numerous challenges and barriers that arise when creating the novel business models.
- The study of the global experience of implementing the five basic innovative business models in food industry, which are gradually transformed into the benchmark ones, shows that:
  ✓ Both companies and consumers benefit from the introduction of a circular economy.
  ✓ In addition to the short-term financial benefits, companies receive long-term strategic advantages, which include optimization of material flows, access to new markets; expanding the scope of customer service or after-sales service, as well as obtaining additional profits in the provision of services related to the closed-loop process.
  ✓ Innovative models are not always well-founded and can lead to a predominance of negative externalities in the given economy instead of positive ones. Therefore, careful implementation and a priori assessment of possible effects on the environment and human health are required.
- Among the five business models innovation determined by Accenture - circular supplies, resources recovery, product life extensions, sharing platforms, and product as a service, the applicable for food industry are the circular supplies, product life extension (less), and resources recovery and platforms for food-sharing (the most). The first mentioned innovative business models still require the deepening of research and development in the natural sciences fields like chemistry, biotechnology, biophysics etc. The latter ones had already proved their economic effectiveness and can be scaled in different interested and highly motivated communities, business networks and groups.
- Expanding the scale of circular economy is possible only with a comprehensive systemic restructuring, ranging from legislation, technology, financing and business practices to the readiness of society as a whole to change their habits towards the widespread use of circular products and creation of new platforms and schemes for circular producers and consumer goods. One needs to start small: with the transition to digital technologies, replacement of chemical fertilizers by organic ones, separate food waste collection on a permanent basis and participation in the financing of food waste collection and recycling systems.

- The active involvement of the state in implementing the development of circular economy for food safety ensuring anticipates the setting of the following strategic priorities:
  ✓ A drafted and approved Action Plan for the development of a circular economy.
  ✓ Increased budget funding for environmental activities, based on the participation of the state and business in the implementation of joint projects on circular economy.
  ✓ Establishing the “quadruple helix” partnership to stimulate food industry to avoid and/or to reduce the food waste including extensive outreach activities.
  ✓ Norms of ecological regulation strengthened by the introduction of additional sanctions for violation of ecological norms.
  ✓ Joint development and introduction of worldwide recognized standards, frameworks and patterns of circular economy in agri-food industry.

- Management of food costs and waste through the implementation of innovative circular economy business models in the food industry will help strengthen value chains, increase food security and reduce the number of starving people in the world, reduce greenhouse gases and improve the environment.

- The results obtained, however, prove that the topic requires further research. Many issues remain open ranging from legislation, technology, financing and business practices to the readiness of society as a whole to change their habits towards the widespread use of circular products and creation of new platforms and schemes for circular producers and consumer goods.

4. References


Accessed 02 November 2021.