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2. ECONOMICS AND **ADMINISTRATION**

THE ECONOMIC AND ENVIRONMENTAL ISSUES OF BIOPOLYMERS PRODUCTION

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Abstract. *In this research the economic and environmental issues of biopolymers production were discussed. The level of use of polymers in Ukraine and the world was analyzed. It was estimated that in 2019, nearly 370 million tonnes of plastics were manufactured. The main recipient of bioplastics is the packaging industry. It was determined that the improved physical and chemical properties compared to substitutes, its low cost and the potential of mass manufacturing are the reasons for the extensive use of plastic. It was suggested that at least 512 separate animal species, including 86 percent of all sea turtle species, 44 percent of all seabird species and 43 percent of all marine mammal species, have been affected by plastic pollution. The alternative ways of ecological and economic transformation of the traditional sphere of polymers were explored. The ways of formation of ecological consciousness of the modern economic person were analyzed. Public awareness that plastic pollution is a major global environmental problem is very important. Socio-economic advantages of production and use of biopolymers were revealed. In the scientific work, a study was conducted and the approximate cost of manufacturing PLA (namely from corn) was calculated. There is also a SWOT-analysis of the introduction of biopolymers in Ukraine, which showed that bioplastics in Ukraine has a positive effect from various angles and worthy of investment.*

Keywords: *biopolymers, biopolymers production, green economy, sustainable development, sustainability, circular economy.*

I. INTRODUCTION

From 1950 until today, the average annual growth rate of world polymer production was about 9%. According to the UN, world plastic production in 2019 increased by 9 million tons and totaled 368 million tons [18]. One way to overcome the problems of plastic pollution is to create environmentally friendly substitute materials, such as biopolymers. The benefits of using plastic substitutes encourage researchers to develop new, environmentally friendly materials that are easily decomposed. For example, Sumy scientists have developed eco-packaging for food products «FoodBIOPack», which can then be used as an organic fertilizer. Management of biopolymer production is important in the context of improving the efficiency of production and use of biopolymers. Currently, bioplastics account for about 1% of annual plastic production. However, with the growing demand for environmentally friendly materials, the level of bioplastics production is increasing, which is accompanied by the search for new opportunities for its application, in connection with which the work is relevant.

II. LITERATURE ANALYSIS

Many scientists have devoted their work to the study of the role and importance of biopolymers for sustainable development, in particular: E. Stevens, D. Shing, L. Shen, E. Warrell, M. Patel, D. Sawyer, B. Mooney, T. Gerngross, J. William, R. Ganadan, A. Mahon, J. Moore, D. Sharma, B. Saharan, M. Barker, R. Safford, and others. However, the production of biopolymers and its environmental and economic component requires further in-depth research.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The purpose of the work - to analyze the economic and environmental issues of biopolymers production.

Subject of the study is the economic and environmental aspects of biopolymers production.

Object of the study is biopolymers production.

Research methods. The study used methods of system-structural and comparative analysis (to highlight the advantages and disadvantages of traditional polymers and biopolymers), methods of formal-logical analysis (in building a comprehensive management system for the transformation of the traditional field of polymers), economic and statistical methods.

Scientific novelty. The scientific novelty of the obtained results lies in the substantiation of practical principles of improving the organizational and economic mechanism of management of biopolymer production on the basis of substantiation of ecological and economic expediency of transition to biopolymers in Ukraine.

Practical meaning. The results of the study, namely the provisions on the economic justification of promising areas of development of biopolymers production is used by PNP «Center for Economic Research» in elaborating a strategy for the development of Sumy region for 2021-2030 (Appendix A). Besides, the authors of the research have two scientific publications in different Ukrainian journals on the subject of work.

IV. RESULTS

4.1. Analysis of world trends in the production and use of polymers

In 2019, nearly 370 million tonnes of plastics were manufactured (Fig. 1). This statistic raises the peak value in 2018 by an estimate of 9 percent from 1950. China produced almost 60 million tons of plastic in 2018, accompanied by 38 million tons from the USA, 14.5 million tons from Germany and 12 million tons from Brazil [19].

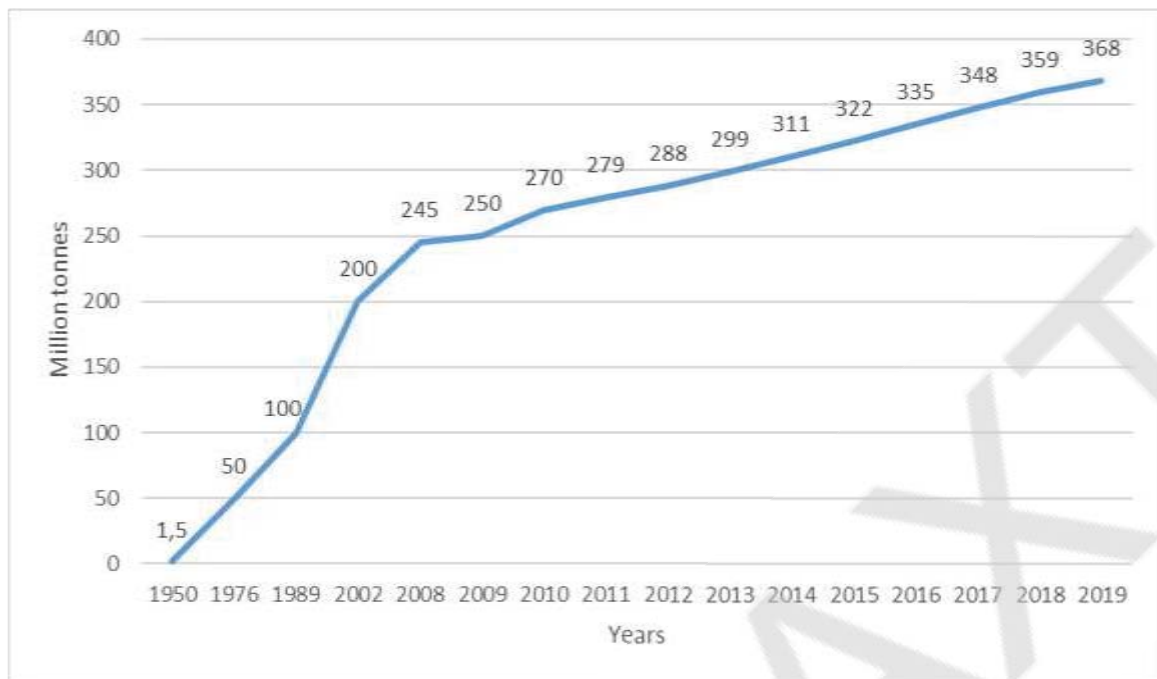


Fig. 1. World plastics production (1950-2018)

The production, on each basis, of plastic products like wrapping that account for about 50% of the use of other plastic products encourages the formation of vast volumes of plastic waste (Fig. 2) [10].

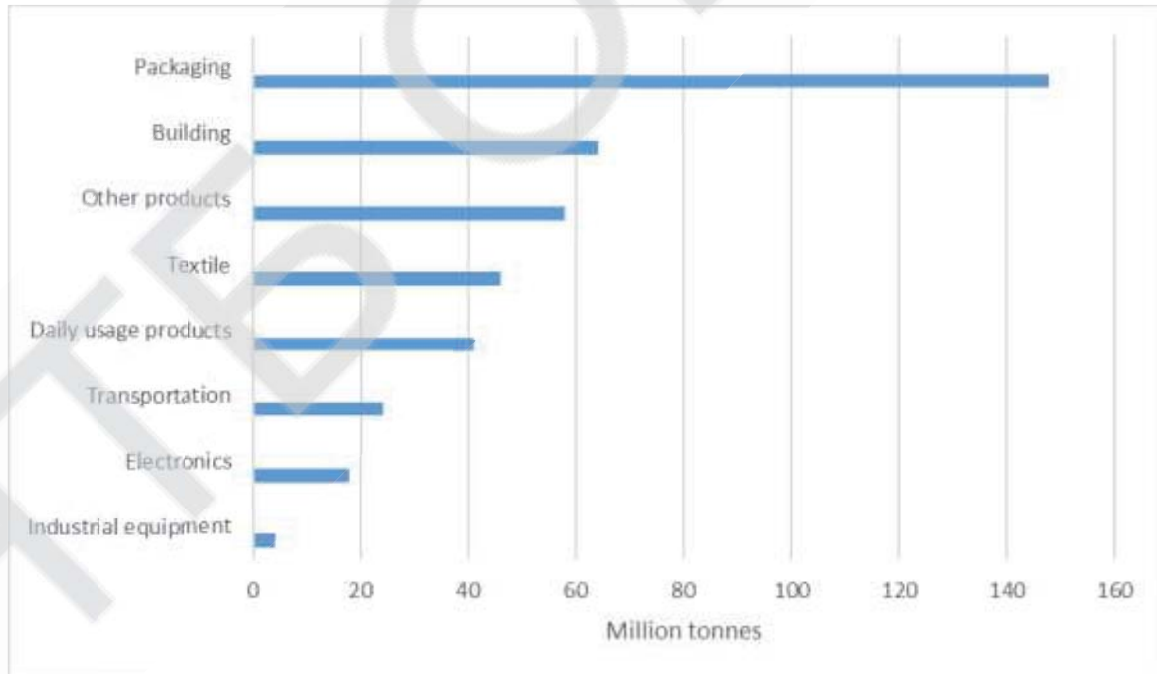


Fig. 2. World plastics production (by groups of goods)

The improved physical and chemical properties compared to substitutes, its low cost and the potential of mass manufacturing are the reasons for the extensive use of plastic.

Plastic pollution has a huge effect on human wellbeing and ecological systems. The waste plastic, from the Arctic to the Antarctic, is totally anywhere. It devastates down street water in our towns and piles up on mount Everest. It squalls picnic areas and parks. Yet plastic becomes more popular in the world oceans due to the pollution as well as the passion to spill waste directly into a local river or lake.

UNEP estimates that, due to different factors, plastic pollution kills up to a million seabirds, 100,000 sea animals and numerous whales. Researches suggest that at least 512 separate animal species, including 86 percent of all sea turtle species, 44 percent of all seabird species and 43 percent of all marine mammal species, have been affected by plastic pollution [16].

To decide the rate of accumulation and the feasibility of any environmental clean-up initiatives, measuring the amount of waste is critical. The majority of studies measure the quantity of all sources of caused by human activity waste, including data on plastic and/or plastic products, as a different group, suggesting that the overall quantity of waste is an essential component of plastic waste.

4.2. Formation of ecological consciousness of the modern economic person

It has long been recognized that the release of plastic items into the environment has a detrimental effect on wildlife. Public awareness that plastic pollution is a major global environmental problem is very important [5].

If we consider the situation from the point of view of consumer consciousness in their choice of goods, we can form eight basic steps that should be taken to motivate people to preserve the environment.

1. Informing people about the behavior of their environmental behavior by highlighting the negative impact of pollution and the need for protection through the introduction of advertising posters, banners, electronic and paper media, such as newspapers.

This can be achieved by governmental and non-governmental bodies, voluntary organizations and citizens who are well aware of the dangerous effects of environmental pollution on human society. You can also implement weeks of environmental protection.

2. The organizational activities of the above bodies may help to review and control environmental pollution. Non-governmental bodies should be empowered to take strict measures against those who harm the environment and help to pollute it.

Various powerful and influential industrial organizations, even government agencies such as municipalities, corporations, the transport services sector, and power plants cause great damage to our environment. They ignore protests from residents and the public.

In such situations, group activism (ie organized group protest) is a very powerful and effective technique for reducing environmental pollution. Those who do not listen individually are frightened when people protest in groups.

3. The introduction of nature protection education and knowledge of the adverse effects of the polluted environment can be ensured by teaching children in schools. Today, many schools and colleges around the world have incorporated environmental science into their curricula to achieve this goal [9].

4. Legal actions. It often turns out that when the enemies of the environment do not listen to the protests of the general public or individuals, they are submitted either by voluntary organizations or by interested citizens who need to stop anti-environmental activities.

When honorary courts order an end to environmental pollution, it works.

5. Simple life and economical use of resources. In this era due to the use of various electrical devices, uneconomical use of plastic, etc. a lot of resources and energy are expended. If these earth resources are used sparingly, efficiently and in accordance with needs, the world's environmental problems can be solved peacefully.

Therefore, needs must be reduced through a simple life. Everyone needs to be aware of the scarcity of resources so that people can limit their use. In the past, our environment was not as polluted as it is today because of simple living habits.

6. Specific actions to be encouraged. People should be encouraged through books, newspapers and television to reduce energy and resource use through energy-efficient devices and resource-saving goods.

For example, instead of each family member buying new plastic bags, you can introduce the use of reusable biopacks for garbage and other needs.

But even by using recycled products, pollution can be reduced. It is necessary to motivate people's behavior to these changes. It is necessary to use various programs to motivate people to reduce the consumption of non-environmental resources. This technique works better than personal approaches [4].

7. Adhere to certain rules of conduct. Government bodies and public sector organizations must comply with specific and clear environmental regulations to protect people and industries from contributing to pollution.

8. Introduction of waste sorting. Manual sorting is used to classify the collected waste into the following categories: plastics, paper, metals, aluminum, leather-wood-textile-rubber, organic waste, non-combustible and others. Ideally, there should be a combination of mechanical sorting, thermochemical processes and the conversion of waste into materials and energy.

Rules and regulations must be strictly adhered to without any action, so that people and industrialists do not dare to behave in an anti-environmental manner. This will improve the situation to some extent.

In general, for the development of environmental behavior, all of the above should be applied separately or together. Motivation and the desire to save the environment must come from within. Every citizen of society must realize that not only does the environment affect us, we also influence the environment through our actions and behavior. Therefore, our behavior towards the environment must be friendly and positive. We will always keep in mind that our environment is like our mother's, and instead of polluting the air, water, instead of consuming resources carelessly, we must try to keep the environment clean and unpolluted to save the world from catastrophic consequences.

4.3. Greening the needs of society and demand management

Our society has grown through the extraction and use of natural resources. However, for many natural resources on earth, supply is under threat. If the flow of

natural resources continues, we will need more than one planet to support our consumption and production patterns. To balance economic growth and consumption of natural resources, our society has to use resources more efficiently [12].

To fully implement the idea of sustainable development in a market economy, it is necessary to motivate society to an environmentally oriented mood. Such knowledge is necessary when choosing environmental products that will be quickly perceived by the market, as well as to create opportunities to manage consumer motivation in order to its environmental orientation.

One of the important tasks of the enterprise focused on the production of ecological goods is the study of the motivation of ecologically oriented consumption at the state level. In order to stop the current disastrous changes in the environment, the consumer must behave in an environmentally sound manner. This is possible only if there is a sufficient level of environmental motivation and culture.

Today, the level of motivation to consume environmentally friendly food, environmentally friendly household goods and other environmentally friendly personal consumption products is increasing. This is not only due to the increase in environmental pollution, but also due to the increased sensitivity of people to environmental factors, as well as due to the growing attention to environmental issues, environmental education, environmental education.

Diagnosis of ecological consciousness of consumers is important for research of motives of ecological consumption. It allows us to answer the following questions [2]: What is the place of ecology in the minds of consumers? What place do they occupy in everyday consciousness? What are the qualitative features of a particular environmental consciousness of the consumer?

In domestic conditions it is easier to actualize rational motives of greening of consumption. Rational motives for the consumption of ecologically clean food, the use of ecological utensils for cooking, quality filters for drinking water purification are to promote better health. Accordingly, the cost of drugs and treatment measures is reduced. This also applies to environmentally friendly materials and equipment for production and everyday life.

The needs of Maslow's hierarchy theory are divided into 5 groups, which are often depicted as a pyramid, which is based on primary needs, and the top is secondary [3].

If the environmental friendliness of the product is necessary to meet the primary needs, then more people agree to pay for it (because the impact of environmental friendliness on health occurs immediately and is more noticeable), and for the satisfaction of secondary needs pays fewer people. who has a high level of needs and income).

Therefore, in the process of production of environmental goods, it should be borne in mind that the needs of the lower levels require immediate satisfaction, and therefore affect human behavior earlier than the needs of higher levels [20].

With the change of attitude to environmental problems and the development of production, some needs arise and develop, others weaken and disappear. A person's needs and preferences change objectively depending on his age, status, financial status, season, week or day.

The market is still a sphere of sales. In the market to consumers of ecological products apply such stimulating measures, as granting of discounts and privileges, subsidies and exemptions from taxes, crediting, leasing, etc.

Prices for organic products are usually higher than for their non-organic counterparts. Often, even environmentally oriented consumers do not want to overpay for environmental friendliness. Demand falls with increasing prices, especially when its excess compared to the usual is more than 50%. High margins are allowed only if the buyer receives additional benefits from the purchase of goods.

Also very important is the availability of goods, some consumers are actively searching for environmental goods. Their absence in the usual place of purchase for many consumers is a major obstacle to the implementation of environmentally friendly choices and the reason for buying a less environmentally friendly or non-environmentally friendly counterpart.

Stimulation of ecologically oriented consumer can be carried out at the levels of consumer, producer and at the state level [1].

Consumers can stimulate eco-attributive consumption by creating a positive and negative attitude towards certain products.

The producer can influence consumers of ecological products by means of the means making a complex of stimulation: advertising, stimulation of sale, propaganda, personal sale. Of particular importance is the information about the environmental properties of the product.

At the state level, consumers are persuaded to consume environmental goods through environmental education and training.

Consumption of ecological products can also be influenced by situational factors. These include, first, various kinds of events and situations in the environment, such as emergencies, which increase the motivation of environmentally friendly consumption. Yes, man-made situations, environmental cataclysms, etc. encourage the consumption of such types of environmental goods that are able to improve the situation, protect it from environmental influences, neutralize the adverse effects on the human body or society, increase immunity or improve health.

Secondly, they include random and predictable situations of interaction between the consumer and environmental products, which encourage a decrease or increase in the volume of environmentally-oriented consumption. From this point of view, one of the measures to actualize the situational factors of motivation is merchandising, which is especially effective in the case of the sale of goods of daily demand.

Knowledge of the main components of motivation of ecologically oriented consumption, namely motives, needs, interests, incentives and situational factors, motivate the consumer to make ecologically oriented choice, allow the company, first, to take into account the state of consumer motivation in its development and, secondly, to choose effective tools to influence the motivation and, accordingly, consumer behavior in the direction of its environmental orientation.

4.4. Socio-economic advantages of production and use of biopolymers

A good solution to the environmental problems connected with the traditional plastics usage will be the production of biopackages from grains [7]. For example, we

can pay attention to the fact that now in Ukraine there is very high competition for growing and selling corn. Due to the overproduction of these grains, their prices are relatively low, which is a good indicator for price competition with the producers of plastic bags. Unlike other cereals, corn grain does not crumble, so it can be harvested without loss. Making biopackages from corn can be a really profitable and environmentally friendly business. In Ukraine, corn is grown mainly as a fodder and industrial crop, which leads to an understanding of cheapness. So you should look at the harvest from another angle. Due to this, we will create additional demand for grain. For the production of biopackages use biopolymer - polylactic acid (polylactic acid, PLA). PLA, unlike polyethylene, is a 100% biodegradable and composted material. When decomposed, PLA forms water and carbon dioxide [14].

As for the range, on the basis of biopolymers can be made rigid packaging for vegetables and fruits, threads for 3-D printers, fibers for clothing, disposable tableware, hygiene items, etc. The by-product may be gluten and nitrogen fertilizer ammonium sulfate.

When creating such a business, first of all you need to pay attention to attracting people to buy products from biopolymers. The needs and interests of humanity must be considered.

First, the national environmental interests are the desire of society to have a state of the environment that ensures normal reproduction and vital functions. Thus, we can assume that the introduction of biopackages from corn will be cost-effective and profitable for both the entrepreneur and for humanity in general.

Consumers of ecological biopackages can be not only the society, but also commodity producers; government, in particular through government procurement; foreign enterprises; intermediaries of different types. The interests of each of the consumer groups differ significantly. Thus, the socio-economic advantages of our product, which are of most interest to end consumers, should include the greening of nature, health, price, reduction of operating costs and others. Consumer producers are also interested in the possibility of income. State institutions are interested in environmental goods that provide: environmental and economic security of the country, the rise of the national economy: the country's competitiveness; the health of the nation; replenishment of the state budget. Consumers such as foreign companies and unions are interested in slightly different characteristics of environmental goods, such as the absence of emissions during operation and disposal, resource conservation. Intermediaries are more interested in the price, the possibility of making a profit, increasing sales, etc.

As for the advantages of manufacturing, the production of biological bags takes as much time as the production of polyethylene. The technology allows you to create quality products that can equally compete with paper bags, and sometimes even win the price.

4.5. Management of the structure of biopolymer production in Ukraine

The introduction of biopolymer production in Ukraine involves a number of economic and social aspects that can significantly affect (both positively and negatively) the management of such production.

In particular, the economic component of biopolymer production management is an approximate calculation of the cost of biopolymer products. The main components of the cost of PLA shown in the diagram:

- 1) The cost of biomaterials.
- 2) Chemicals associated with bacterial fermentation.
- 3) Depreciation of production capacity.
- 4) Energy costs.

The cost of PLA production is shown in more detail in the diagram. The diagram represents the interest costs for each major cost factor (excluding production costs, taxes, insurance, maintenance, return on investment, etc.) [15].

Based on a study of biopolymer production technologies [8], its economic aspect [22] and analysis of prices for raw materials, chemicals in the Ukrainian market, the necessary equipment, taking into account utility tariffs (as of 01.12.2020), established by the National Commission for issues of energy and housing and communal services and local governments in the city of Sumy, was calculated the approximate cost of production of 1 kilogram of PLA, which is 28.16 UAH. (Fig. 3, Table 1).

As the production of biopolymers in Ukraine has not reached industrial scale, the retail price of one kilogram of PLA of foreign production is from two to four US dollars, not including the cost of delivery. The establishment of industrial production of biopolymers in the Sumy region will allow you to buy biopolymers at lower prices.

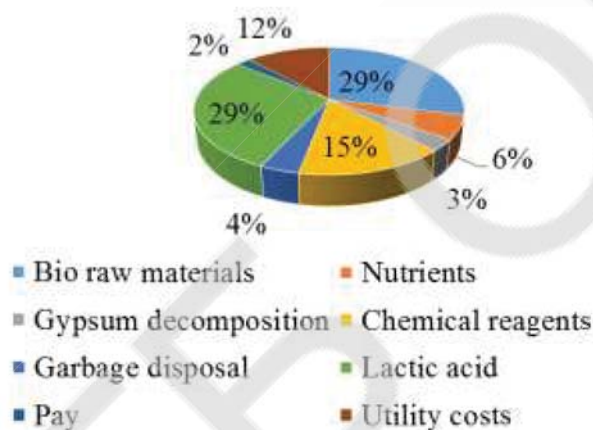


Fig. 3. Production costs of PLA (as a percentage of the various components of production)

Table 1. Calculation of the cost of manufacturing PLA (1 kg)

Production component	Cost
Bio raw materials	UAH 8.05 (approximate calculation)
Nutrients	1.38 UAH
Lactic acid	1.49 UAH
Gypsum decomposition	1.11 UAH
Other chemical reagents	2.24 UAH
Utilities	3.54 UAH
Pay	2.29 UAH
Social contributions	0.50 UAH
Garbage disposal	0.12 UAH
Depreciation of fixed assets	7.44 UAH
IN GENERAL	28.16 UAH

Economic component of production from the creation of biopolymer production in Sumy region accompanied by, in particular, the social effect (in particular, increasing the number of jobs in biopolymer industry). Economist G. Gregory studied the Italian experience of full-scale implementation of biopolymers, which confirmed the social effect, in particular: the production of 1000 tons of biopolymers can create more than 70 jobs (25% - in agriculture, 20% - in construction and construction, 15% - directly in the biopolymer industry, 35% - in the composting of biopolymers, 5% - in science) [17].

Also, some studies have shown that samples made from corn and rice starch have better biodegradability than existing plastic materials. The average thickness of the bioplastic is 0.25 mm (250 μm). The average moisture content is 13.2%. The solubility in water is 11.9%. The biodegradability of the sample is 48.7%, and this is achieved after 15 days. The maximum tensile strength of bioplastics is 12.5 MPa [6]. Therefore, it can be concluded that bioplastics can be used as packaging materials and usually compete in the market, making an alternative to plastic bags.

Polyethylene packaging is a growing concern for the environment due to high production volumes, often short use times and problems related to waste and garbage management [11].

Based on the analysis of data in the implementation of biopolymers, researchers have confirmed that green marketing has encouraging effects in business. It is established that there is a positive relationship between the fact that environmental products are economical to meet all customer needs.

To calculate the ecological and economic effect of biopolymer production, it is advisable to use comparative tables and SWOT-analysis, which shows the advantages and disadvantages of the introduction of biopolymers in Ukraine (Table 2).

Table 2. SWOT-analysis of the production of biopolymers in Ukraine

Strengths	Weaknesses
Positive environmental effect from the use of biopolymers, namely climate protection. Reducing the use of plastic packaging, and thus saving fossil fuels. Advantage in the packaging market due to environmental friendliness. Relatively low cost of materials, namely corn. Gaining experience and knowledge in the market of biological packaging. Development of scientific and economic research on the production of biopolymers in higher education institutions.	The cost of research and development of new or improved packaging options from biopolymers. Higher price for biopolymer packaging, and lower for polyethylene packaging. This means that your own profits may be low at first. Additional advertising costs.
Opportunities	Threats
Higher consumer demand for greener products, which means more potential interest from manufacturers who have decided to meet the requirements of their customer. As fossil fuels deplete and oil prices rise, the need for biodegradable packaging is a good solution.	Some methods of recycling biopolymers lead to the release of methane, which is a more harmful greenhouse gas than carbon dioxide. Insufficient attention of governmental and regulatory bodies to environmental activities.

<p>As some countries encourage the use of environmentally friendly packaging, this represents an opportunity for exports and demand growth.</p> <p>Ukraine's integration into the European Union (in particular, possible approximation to European environmental law).</p> <p>Creating new jobs in agriculture and in the biopolymer industry.</p>	<p>The mentality of Ukrainians regarding environmental friendliness can lead to indifference.</p> <p>Large polyethylene retailers may introduce discounts and other measures that will reduce the environmental market and increase vulnerability.</p> <p>Oil prices may begin to fall due to the discovery of large amounts of fossil fuels. In this case, the need for biopackages may be pushed into the future, which threatens to stop environmental pollution.</p>
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In large cities, customers are more aware of environmentally friendly products. Having started using biopackages, the society will get considerable pleasure. Customers usually need to be aware of the details of biopackages that are positively associated with their level of satisfaction. Many new green products have started to hit the market, and the availability of these products also affects customer satisfaction. Pricing and savings in green products play an important role in consumer decision making. Consumers are satisfied if the products meet their economic range.

Because the environment is heavily polluted with petroleum-based plastics, bioplastics industries thrive on cost-effectiveness and are easily degradable. Bioplastic industries have many advantages, such as fossil fuel economy, climate protection. Because bioplastics are made from renewable sources, they are considered more environmentally friendly than conventional renewable plastics [13].

It should also be noted that in order to achieve a truly sustainable bioeconomy, our prospects must be a more localized life, reduced consumption and more efficient use of resources in various ways. In the future, renewable resources, such as biomass, will be used more efficiently, but unlimited use is not advisable. Thus, the consumer must take care of the environment and strive to make packaging simpler and more environmentally friendly.

V. CONCLUSIONS

The demand for bioplastics is constantly growing, as they are used in different contexts to make increasingly complex products. In 2017, the number of biodegradable plastics produced globally was about 880 Gg, which is less than 0.3% of the total number of plastics produced this year (320,000 gigagrams). Demand for bioplastics is expected to grow to about 6 million tons per year. This is the global problem of the universe and must be solved by all states, not just the leading ones.

The main recipient of bioplastics is the packaging industry. In recent years, many packaging materials have been developed based on starch, polylactide, polyhydroxyalkanoates, polyglycolic acid (PGA), aliphatic-aromatic polyesters, cellulose or lignin, which are currently present in small quantities on the market. Bioresources play an important role in the production of new materials based on biological materials.

The design of plastics used in disposable packaging and consumer goods must be made of bioplastics and ensure that they are environmentally friendly. Corn starch,

as an environmentally important tool, is a good solution not only for waste management, but also for sustainable business.

In the scientific work, a study was conducted and the approximate cost of manufacturing PLA (namely from corn), which is 28.16 UAH per kilogram, was calculated.

There is also a SWOT-analysis of the introduction of biopolymers in Ukraine, which showed that bioplastics in Ukraine has a positive effect from various angles and worthy of investment. The state, in turn, should support this type of activity and provide certain benefits for the distribution of biologically clean goods.

But, first of all, we must conclude from this work that our behavior towards the environment must be careful and reasonable. We will always keep in mind that our environment is very important to us and future generations, and instead of polluting the air, water, instead of consuming resources carelessly, we should try to keep the environment clean to save the world from catastrophic consequences.

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APPENDIX A

APPROVED

Deputy director of the enterprise
Center for Economic Research



I. Dehtyarova

№ 03/01 "03" January 2021

Act

on the implementation of the results of the study on the work

«The economic and environmental challenges of biopolymers production»

The results of the study, namely the provisions on the economic justification of promising areas of development of biopolymers production is used by PNP "Center for Economic Research" in developing a strategy for the development of Sumy region for 2021-2030.

The act was issued to submit a work for participation in the International competition of student research papers.

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