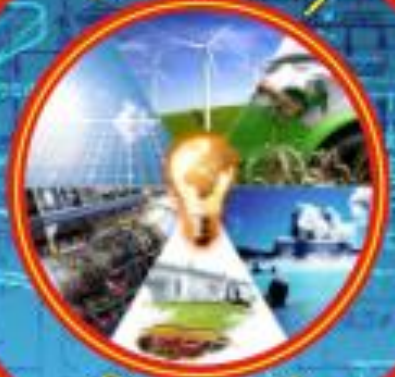
Всеукраїнський науково-технічний журнал
All-Ukrainian Scientific & Technical Journal
ISSN 2520-6168 (Print)
DOI:10.37128/2520-6168-2023

Machinery
Energetics
Transport
of Agribusiness



ТЕХНІКА
ЕНЕРГЕТИКА
ТРАНСПОРТ АПК

Всеукраїнський науково-технічний журнал

ТЕХНІКА, ЕНЕРГЕТИКА, ТРАНСПОРТ АПК

№ 2 (121) / 2023

м. Вінниця - 2023

Журнал науково-виробничого та навчального спрямування
Видавець: Вінницький національний аграрний університет

ТЕХНІКА, ЕНЕРГЕТИКА, ТРАНСПОРТ АПК

Заснований у 1997 році під назвою «Вісник Вінницького державного сільськогосподарського інституту».
Правонаступник видання: Збірник наукових праць Вінницького національного аграрного університету. Серія: Технічні науки.
Свідоцтво про державну реєстрацію засобів масової інформації
КВ № 16644–5116 ПР від 30.04.2010 р.

Всеукраїнський науково – технічний журнал «Техніка, енергетика, транспорт АПК» / Редколегія: Токарчук О.А. (головний редактор) та інші. Вінниця, 2023. № 2 (121). С. 157.

Друкується за рішенням Вченої ради Вінницького національного аграрного університету (протокол № 2 від 25.08.2023 р.)

Свідоцтво про державну реєстрацію засобів масової інформації №21906-11806 Р від 12.03.2016р.

Журнал «Техніка, енергетика, транспорт АПК» включено до переліку наукових фахових видань України з технічних наук (Категорія «Б», Наказ Міністерства освіти і науки України від 02.07.2020 року №886);

- ***присвоєно ідентифікатор цифрового об'єкта (Digital Object Identifier – DOI);***
- ***індексується в CrossRef, Google Scholar;***
- ***індексується в міжнародній наукометричній базі Index Copernicus Value з 2018 року.***

Відповідальний секретар редакції **Полєвода Ю.А.** – к.т.н., доцент, Вінницький національний аграрний університет
Адреса редакції: 21008, Вінниця, вул. Сонячна 3, Вінницький національний аграрний університет, тел. (0432) 46– 00– 03
Сайт журналу: http://tetapk.vsau.org/ **Електронна адреса:** pophv@ukr.net

ЗМІСТ

І. ПРИКЛАДНА МЕХАНІКА. МАТЕРІАЛОЗНАВСТВО. ГАЛУЗЕВЕ МАШИНОБУДУВАННЯ

ІІ. АГРОІНЖЕНЕРІЯ

ІІІ. ЕЛЕКТРОЕНЕРГЕТИКА, ЕЛЕКТРОТЕХНІКА ТА ЕЛЕКТРОМЕХАНІКА

CONTENTS

I. APPLIED MECHANICS. MATERIALS SCIENCE. INDUSTRY MACHINERY BUILDING

II. AGROENGINEERING

III. ELECTRICAL ENERGY, ELECTRICAL ENGINEERING AND ELECTROMECHANICS

UDC 664.1, 664.3
DOI: 10.37128/2520-6168-2023-2-4

DIRECTIONS OF USE OF FOOD AND PROCESSING INDUSTRY WASTE

Oleksii Tokarchuk, Candidate of Technical Sciences, Associate Professor
Liudmila Sosnovska, Assistant
Vinnytsia National Agrarian University

Токарчук Олексій Анатолійович, к.т.н., доцент
Сосновська Людмила Василівна, асистент
Вінницький національний аграрний університет

Every year, there is more and more waste on our planet. This leads to soil, water and air pollution, which negatively affects people's health and quality of life. Therefore, the task of reducing production and consumption waste, as well as choosing effective directions for their use, becomes urgent.

During the production of food products, waste is mainly of plant and animal origin. The main types of waste generated at processing and food enterprises have been determined: in the fruit and vegetable and canning industry – apple, berry and vegetable pomace, as well as vegetables and fruits that cannot be processed as the main product; in the grain processing industry – wheat bran; in the sugar industry – molasses, pulp; in the dairy industry – whey; in the oil and fat industry – husks, cakes, etc.

It is noted that the most valuable waste is sold abroad or processed into food products. The list of products by areas of use (food, medicine, chemical industry, fertilizers, cosmetic industry, animal feed, fertilizer, energy) that can be obtained from organic waste is given. The types of waste, which are valuable raw materials for chemical, pharmaceutical and cosmetic production, and energy production, have been determined. It is substantiated that in modern conditions in Ukraine it is necessary to intensify the use of waste from processing and food industries as energy carriers – for the production of solid biofuel (briquettes, pellets), biogas, etc. This will help compensate for the lack of energy resources due to damage to traditional energy facilities during Russia's hostilities against Ukraine.

However, there is still a large amount of waste in Ukraine that is buried or poured into the sewers, which causes pollution of water bodies, soils and emissions of greenhouse gases into the atmosphere. With a comprehensive approach and a joint solution to the problem of waste management of various industries, it is possible to ensure the saving of raw materials, the creation of new jobs, and the protection and improvement of the environment.

Key words*: waste, food and processing industry waste, processing, fertilizer, fodder, energy resources, biogas.*

Table. 1. Ref. 17.

1. Problem formulation

The problem of excessive waste generation on a planetary scale is a serious global challenge, and it has several negative consequences for the environment, human health, and the economy. Here are some key aspects of this issue:

1. Increasing volume of waste: with each passing year, the global population grows, leading to an increasing volume of waste. This means more landfills, more incineration, and more waste disposal challenges.
2. Environmental pollution**:** excessive waste can pollute the air, water, and soil, harming plants, animals, and ecosystems. Plastic waste, in particular, poses a significant threat due to its persistence and potential harm to oceans.
3. Threat to human health**:** large dumps can be sources of soil and water contamination, posing a health risk to people through polluted food and drinking water.
4. Energy consumption and greenhouse gs emissions**:** waste disposal often requires energy consumption and can result in greenhouse gas emissions, especially when incineration or other inefficient methods are used.
5. Economic losses**:** the processing and disposal of large volumes of waste require substantial financial resources from governments and local organizations. Moreover, environmental pollution can lead to economic losses through decreased water and soil quality, reduced crop yields, and impacts on tourism.

6. Consumer lifestyle**:** the increasing consumer lifestyle, particularly in developed countries, leads to a significant amount of single-use products and packaging, contributing to the generation of a large volume of waste.

To address this issue, comprehensive measures are needed, including reducing the use of single-use materials, increasing waste recycling and secondary processing, promoting sustainable consumer lifestyles, and raising public awareness about the problem of excessive waste generation.

The generation of waste by enterprises is a significant component of modern production and economic processes. This process represents a major challenge for sustainable development and environmental protection. Businesses around the world are important players in the global economy, but as production increases, they are also becoming significant sources of waste. The generation of waste by enterprises has become a serious issue of the modern economy and ecology. The large scale of production at enterprises leads to the generation of significant volumes of waste. This may include waste from raw materials, products, as well as emissions into the atmosphere and water sources. One of the main sources of waste is the inefficient use of raw materials, as well as waste from the processing and production of goods. Waste treatment and disposal can be costly and require consumption of resources and energy. Not all types of waste can be effectively recycled or disposed of. In different countries and regions, there are different standards and requirements for waste treatment by enterprises. Legislation and regulation can affect the methods and cost of disposal. Calls for waste reduction and the transition to more sustainable consumer lifestyles also influence businesses, encouraging them to reduce waste in production and develop a more sustainable approach.

Waste generation by businesses is a complex problem that requires integrated approach. Businesses should actively seek ways to reduce waste in production, implement more efficient waste disposal and recycling methods, and collaborate with authorities and other stakeholders to create an enabling environment for sustainable waste management. This approach not only reduces the negative impact on the environment, but can also lead to economic benefits for enterprises through optimization of production processes and cost reduction.

Food and processing industry is one of the most important industries of every country. Effective work of processing and food enterprises ensures food security of the country. And the importance of this industry is felt even more in wartime. The production of high-quality food products requires high-quality raw materials, energy, water, and qualified personnel. And as in any production, there is also plant and animal raw material waste; related products formed in the production process; used water; emissions of greenhouse gases.

100-120 million tons of waste of plant origin and by-products of the agricultural industry are generated annually in the food industry of Ukraine. No more than 10-15% of this waste is processed today [1].

The current state of waste management in Ukraine does not allow to fully utilize its useful potential. It is often lost when the waste is not recycled, but simply buried.

2. Analysis of recent research and publications

The problem of effective waste management is being studied by many scientists. Thus, the main characteristics of sewage sludge are analyzed in the work [17]. M.P. Mykytenko and H.P. Khomych studied the prospects of using waste in the production of bread products [1]. V.S. Huts, O.A. Topchii, K.P. Nelina considered the rational use of secondary raw materials of the dairy and grain processing industry [2]. A.S. Martyniuk and H.S. Pastukh considered the current trends in the utilization of sugar production waste [6].

Modern trends in the use of waste include energy one – the use of organic origin waste for the production of energy resources. Thus, I.V. Chekhova considered directions of the use of oil crops in the bioenergy industry [11]. D.M. Tokarchuk, N.V. Pryshlyak, Ya.V. Palamarenko developed a strategy for handling waste from agrarian enterprises, which includes: rational management of crop production waste, animal tissue waste, animal manure, agrochemical waste. An important place among the areas of waste management proposed by them belongs to the production of biogas [16]. M. Modelska, M. Bincharski, P. Dzyugan, S. Nowak, Z. Romanowska-Duda investigated the potential of biomass waste from the sugar industry for the use as fuel additives in Poland [7].

The potential of food and processing waste of Ukrainian enterprises, especially its energy component, needs further research.

3. Aim of the researches

The aim of this work is to identify, characterize and quantify food and processing industry waste and explore possible directions for its reuse in order to save natural resources and protect the environment.

4. Results of the researches

For high-quality and economically efficient functioning of food and processing enterprises, it is necessary to improve and introduce low-waste and zero-waste technologies into production, use waste as secondary raw materials in integrated enterprises, their associations and other branches of the national economy. The use of waste in the production process makes it possible to turn it into a valuable and sometimes scarce raw material [2].

First, let's analyze the available waste of the food and processing industry in Ukraine and the most common methods of their processing.

Waste in the fruit and vegetable and canning industry is 0.5-0.9 million tons per year – apple, berry and vegetable pomace, as well as 0.1-0.12 million tons per year – fruit stones, nut shells. Currently, no more than 22% of waste is subjected to industrial processing [3].

Waste also includes vegetables and fruit that cannot be processed as the main product (inappropriate shape, degree of maturity), it can be sent for drying, salting, fermentation. There are technologies that allow you to create dyes from tomato and beet waste. Extracts formed during the production of juices, fruit purees, tomato paste and similar productions can be fed raw to livestock or dried and made into various compound feeds. Raw squeezes have a short shelf life and ferment quickly. In this case, it is advisable to send them for composting to obtain organic fertilizers. Depending on the type of pomace, the following substances can be produced from them: pectins, organic acids, aromatic substances, gelling concentrates, fodder flour, tartaric acids, oils, fruit powders.

Wheat bran is the waste of grain processing enterprises of the agro-industrial complex. It has an increased fiber content, that is, it is a valuable source of dietary fiber [4].

The sugar industry is one of the main branches of the food industry of Ukraine. The main product produced by sugar factories is sugar. During its production, waste is formed: molasses, pulp, feces. Molasses contains about 50% sugar and is used entirely for the production of alcohol. But the pulp is not so easy to use. The pulp yield is 80-83% of the mass of processed beets. In 2022, almost 9 million tons of sugar beets were processed. And about 7 million tons of it was received. Today, part of the pulp is used to feed livestock, but due to the increase in transport costs and the decrease in the number of cattle, this amount is constantly decreasing. The pulp can be dried and granulated. This extends its shelf life and reduces transportation costs. But not all factories have appropriate drying units and deep pressing presses. Therefore, most of the pulp is dumped in pulp pits, and later taken out of the territory. This leads to environmental pollution and, accordingly, large fines for factories.

Another method of beet pulp processing is the production of dietary fibers. Dietary fibers are the remains of plant cells that are resistant to hydrolysis by human digestive enzymes. Fibers with a particle size of 0.25–0.5 mm can be used as an additive in meat products, and fibers with a particle size of 0.25 mm and smaller are recommended for use in bakery, confectionery, dairy and other food industries. The combination of food fibers, which have standardized technological characteristics, with other food and functional ingredients will make it possible to obtain products with specified organoleptic and physicochemical properties.

One more valuable product that can be obtained from beet pulp is pectin. Pectins normalize intestinal microflora, improve digestion and have bactericidal properties. Pectin obtained from beet has the best complexing ability and as a detoxifying natural substance has no analogue in the world. Research data show that of all types of pectin (apple, citrus, and beet), beet pectin has three times higher complexing capacity, that is, the ability to bind metals and remove toxic substances and radionuclides from the body [5].

Pectin production in Ukraine is not established due to high energy consumption, in particular for drying beet pulp, inconsistency of the quality of dry pulp with the requirements of pectin production and imperfect technical solutions of pectin production technology. There are more than enough raw materials in Ukraine. It remains important to develop production technology and improve existing equipment [6].

Sugar production waste is a high-quality raw material for the chemical industry. Researches are being conducted to obtain more and more new substances from pulp and molasses. Furfural obtained from acid hydrolysis of sugar waste can be further converted into more valuable chemical compounds such as furfuryl alcohol and tetrahydrofurfuryl alcohol. Furfuryl alcohol is used in the production of cork casting resin, synthetic fibers, fragrances, paints, non-reactive thinners for epoxy resins and modifiers for phenolic and urea resins, and in the production of other chemicals. Tetrahydrofurfuryl alcohol has been successfully tested as a fuel additive. It allows to mix ethanol with diesel, while obtaining cleaner fuel [7].

Today, there are researches that pulp can become a valuable raw material. Beet pulp contains sugar and can be used as raw material for biogas plants. Pulp processing at biogas plants will make it possible to obtain biogas, electrical energy, thermal energy and biofertilizers. This will improve the environmental situation around the plants, and will make it possible to obtain 60-70 cubic meters of gas from 1 ton of raw materials. The pulp contains sugar, which with the help of yeast or other microorganisms through fermentation can be converted into ethanol, which is a promising fuel.

Lactic acid can be obtained from the sugars that remain in the pulp and molasses, thanks to biotechnological processes. It is used as an acidulant, flavoring or preservative metabolite in many industries, including the food, pharmaceutical, leather and textile industries. This substance is also of interest as a chemical platform and can undergo numerous transformations. Both small compounds, such as propylene glycol or acrylic acid, and high-molecular polymers, such as biodegradable polymers, can be obtained from lactic acid [8].

The oil and fat industry is strategically important for our state. It provides the population with a number of basic products: oil, margarine, mayonnaise, toilet and laundry soap, olive oil, transesterified fats, glycerin, mustard. The capacity of oil and fat production is constantly increasing. Ukraine is among the top five oil exporters. The sunflower harvest in 2023 is expected at the level of 12.7 million tons due to an increase in the area sown under it by 800 thousand hectares this year compared to last year (in 2021 – 16.9 million tons, in 2022 – 11.1 million tons), the processing of sunflower into oil may reach 11.5 million tons. The rapeseed harvest in 2023 is tentatively estimated at 3.8 million tons, while the processing is expected at the level of 0.3 million tons. The soybean crop is forecast at the level of almost 4.4 million tons, and processing – 1.4 million tons. With the increase in the production of basic products, the amount of by-products increases, which includes cake, crude glycerin, phosphatide concentrates.

During the processing of oilseeds, waste husks, seed shells, fat shoulders, fuzz, tars, and other fats are formed [9]. The oil and fat industry is one of the least waste-free industries. Thus, husk and seed coat waste is used for the production of fuel briquettes or directly burned to obtain thermal energy [11]. The pomace can be fed to farm animals and birds. The pomace contains a large amount of protein (60%), vitamins B, E and A and fiber. There is also a great demand for pomace in France, Israel and other countries [12].

Fat-containing waste, which cannot be used for food production, can be used in other industries. There are studies of the use of oil and fat industry waste for surface modification of mineral fillers, which can be used to create new polymer composite materials [10]. Due to its high biological value, the phosphatide concentrate obtained in the process of water hydration of oil is used in the bakery industry [9].

Pasteurized milk, butter, various types of cheese, yogurt, kefir and similar products are made from milk in the dairy industry. Secondary raw materials are obtained in the production process in the form of skimmed milk, shavings and milk whey, molasses.

During the production of dairy products, the most whey is formed, about 90% of the volume of milk that is processed. This is about 80-90 tons of whey per day and 20 tons of molasses per day at milk processing enterprises of average productivity. Whey is a valuable product. It contains proteins that do not contain limited amino acids. Whey proteins are a valuable source of leucine, tryptophan, methionine, histidine and arginine. Whey contains almost all the macro- and microelements of milk, most of the lactose, as well as water-soluble vitamins. Cream products, protein products, drinks, biologically processed products, milk sugar, thickened and dry concentrates, ice cream, cheeses can be made with whey content. Whey is still used to a limited extent in the production of similar food products in Ukraine. Whey in raw form can be used for fattening domestic animals. But this share may be small, since the increase in whey in the diet of animals significantly reduces its digestibility. Whey drying is an energy-consuming process, and it is not economically justified in the production of fodder from it. Dry whey is also poorly absorbed.

Currently, studies are being conducted on the processing of milk whey in order to obtain concentrated nutrients from it. This is carried out by biophysical methods: ultrafiltration, that is, fractionation with simultaneous concentration; at the same time, with the help of a pressure gradient and the use of semipermeable membranes, the distribution of serum components according to their structure and molecular weight is achieved; by reverse osmosis – concentration of all constituent parts of serum except water; gel filtration, which allows to separate the low-molecular components of serum during its passage through a column filled with a separating medium; bottom exchange, which is used in cases when it is necessary to selectively (depending on the properties of the carrier) separate the components of the serum; electrodialysis is the process of extracting individual mineral components from serum [13].

But from an ecological point of view, whey is a dangerous product. When 1 cubic meter of serum is dumped into a reservoir, it pollutes the reservoir, as can 100 cubic meters of domestic wastewater. The COC (chemical oxygen consumption) of serum reaches 70,000-80,000 mg O_2/cubic decimeter, while the COC of the general runoff does not exceed 3,000 mg O_2/cubic decimeter, which leads to an increase in the load on sewage treatment facilities. And today, about 50% of the produced serum is poured into the sewer. This leads to significant soil acidification, the death of microflora and suppression of the growth of many agricultural crops. Whey has a significant concentration of organic compounds that require a large amount of oxygen for their oxidation, which causes a decrease in dissolved oxygen in water bodies, which negatively affects the state of the aquatic ecosystem [4, 13].

Meat-processing enterprises always have a large amount of organic residues: meat and bone waste, casings, intestines, blood, offal, skin, skins, bristles, feathers and yin. In 2020, Ukraine produced 2,477.5 thousand tons of meat raw materials of all kinds [14]. Landfilling of such waste is unacceptable due to its toxicity. They are processed into meat and bone meal, which can be fed to pigs and poultry. The technology of chemical dissolution and drying of production waste makes it possible to produce protein, which can be used in sausage production in the future. The dry extrusion method allows to process the waste of meat enterprises with the addition of leguminous and cereal crops, pomace and bran to obtain sterilized and stabilized feed for domestic animals with a shelf life of more than 6 months.

Beer grains are considered waste in the brewing industry. They can be used as fodder for calves after drying. Drying beer grain ensures a long shelf life and makes transportation cheaper. Due to its productive effect, dry beer grain can be a substitute for high-protein fodder in animal diets, which makes it possible to save high-quality grain fodder and improve the ecological condition of the adjacent territories of breweries [15].

Liquid brewer's yeast is also actively used in agriculture – to prepare compost, which is then used to fertilize fields. Yeast has valuable nutritional and medicinal properties, it contains B vitamins, pantothenic acid, biotin, inositol, vitamin E and others. In addition, yeast fertilizer effectively affects the soil, rebuilding its composition and thus activating the activity of beneficial microorganisms in it.

Thus, it can be concluded that there is more than enough waste and by-products of production in the food and processing industry. In the vast majority, the most valuable of them are sold abroad, a small part is sent for secondary processing, everything else is thrown away, which causes a negative impact on the natural environment. But most of the food and processing industry waste can be processed into new valuable food products, medicines, household goods, animal feed, fertilizer, methane, etc. Almost all food and processing industry waste can become secondary raw materials for a wide variety of industries.

Table 1 shows the list of products obtained from processing and food industry waste.

Table 1

Products obtained from food and processing industry waste

Directions for use	Obtained product	Secondary raw materials
1	2	3
Food	Pectin	Fruit juices, pulp
	Organic acids	Fruit and vegetable juices, pulp
	Dyes	Fruit and vegetable juices, substandard raw materials
	Aromatic substances	Vegetable and fruit juices
	Gelling concentrates	Juices from vegetables and fruits, bones
	Oils	Fruit juices, substandard fruits and vegetables, fruit stone cores
	Food fibers	Bran, groats
	Food powders	Squeezes
	Alcohol	Molasses, pomace, grape combs
	Alcohol Drinks	Pressed grapes, apples
	Drinks and dietary products	Whey
	Protein	Meat and bone waste
Medicine	Vegetable oil	Stones of grapes and fruits
	Polyphenol concentrates (quercitin, resveratrol)	Pressed grapes
	Activated carbon	Fruit stone shell

Continuation of the Table 1

1	2	3
Chemical Industry	Furfural, tetrafurfural alcohol, lactic acid	Pulp
	Glycerin	Crude glycerin
	Polymer composite materials	Fatty waste of oil production
	Surface-active substances	Grape squeezes, fat
	Ethanol	Wine residue
	Glue	Bones
Cosmetic industry	Natural antioxidants	Grape skin
	Vegetable oils	Squeezes, pits of grapes and fruits
Fodder for animals	Combined feed	Squeezes, molasses, beer grain, wine lees
	Fodder flour	Extracts, meat and bone waste
	Additive to compound feed	Whey
	Feed in raw or dried form	Squeezes, jam, pomace
Fertilizers	Mineral fertilizer	Bunches of grapes
	Compost	Squeezes, liquid brewer's yeast, meat and fish industry waste
	Spent substrate from a biogas plant (digestate)	Pulp, other organic remains of plant and animal origin, subject to fermentation
Energy	Biogas, hydrogen	Pulp
	Ethanol	Pulp
	Fuel briquettes, pellets	Sunflower husks, buckwheat; straw

A special place among the directions of waste management of processing and food enterprises is occupied by the production of energy from them. Organic waste can be used for the production of fuel briquettes or pellets (sunflower husks, buckwheat, cereal straw, etc.), bioethanol (pulp), as well as biogas.

Processing of organic substances in biogas plants takes place anaerobically, which consists of three stages: hydrolysis, methanogenesis, and acidogenesis. During the first two stages, hydrogen and fatty acids are formed. And at the next stage, methane is formed from the obtained organic acids. Hydrogen is formed only during the first two days of the process, methane can be formed for up to 20 days. Today, the production of biohydrogen still needs improvements in the technological process, its separation from the mixture of gases, and storage.

In order to achieve effective results, it is necessary to holistically approach the issue of processing and food industry waste management and involve enterprises from other industries due to the fact that one substance can be used as a raw material for different production of goods.

5. Conclusions

Food and processing industry waste is very diverse and can become high-quality secondary raw material for the production of food products, medicines, cosmetics, new chemical compounds, animal feed, fertilizers, heat, electricity and fuel. Also, waste recycling will reduce the negative impact on the soil, water and air.

Of course, many technologies today remain economically unprofitable and technically imperfect. But investing money, time, and effort into their research will pay off and will make it possible to reduce the negative impact on nature, reduce payments for fines, create jobs, and will make us able to sell goods with a large added value, instead of cheap raw materials.

Given the destruction of the energy system of Ukraine due to russian aggression, our state is experiencing a shortage of energy resources. Therefore, the use of organic waste from processing and food industries for energy purposes is becoming one of the most promising directions.

References

[1] Mykytenko, M.P., Khomych, H.P. (2019). Vykorystannia vidkhodiv pererobky khenomelesu v tekhnolohii khlibnykh produktiv [Use of henomeles processing waste in the technology of bread

products]. *Ekoloho-enerhetychni problemy suchasnosti:* Proceedings of the All-Ukrainian Scientific and Technical Conference of Young Scientists and Students (pp. 6–7). Odessa [in Ukrainian].

[2] Holian, V.A., Luchechko, Yu.M, Hordiichuk, A.I., Shmarov, D.M. (2020). Kompleksnyi rozvytok sfery pererobky silskohospodarskoi syrovyny v konteksti dyversyfikatsii investytsiinykh potokiv v ahrarnyi sector [Comprehensive development of the sphere of processing of agricultural raw materials in the context of diversification of investment flows in the agricultural sector]. *Ahrosvit,* 9, 27–37 [in Ukrainian].

[3] Baibierova, S.S. (2017). Vykorystannia prohresyvnykh resursozberihaiuchykh tekhnolohii v kharchovii promyslovosti [The use of progressive resource-saving technologies in the food industry]. *Problemy ta perspektyvy staloho rozvytku APK:* Proceedings of the International Scientific and Practical Conference TDATU. (pp. 5-6). Melitopil [in Ukrainian].

[4] Huts, V.S., Topchii, O.A., Nelina, K.P. (2005). Ratsionalne vykorystannia vtorynnykh syrovynnykh resursiv molochnoi i zernopererobnoi promyslovosti [Rational use of secondary raw materials of the dairy and grain processing industry]. *Kharchova promyslovist, 4,* 13–15 [in Ukrainian].

[5] Pastukh, H.S. (2018). Rozroblennia tekhnolohii pektynu z vtorynnoi kartoplianoi syrovyny [Rational use of secondary raw materials of the dairy and grain processing industry]. *Candidate's thesis.* Kyiv: NUKhT [in Ukrainian].

[6] Martyniuk, A.S., Pastukh, H.S. (2019). Aktualni napriamy utylizatsii vidkhodiv tsukrovoho vyrobnytstva [Current trends in the utilization of sugar production waste]. *Ekolohichni nauky, 2 (25),* 187–190. DOI: https://doi.org/10.32846/2306-9716-2019-2-25-31 [in Ukrainian].

[7] Modelska, M., Binczarski, M., Dziugan, P., Nowak, S., Romanowska-Duda, Z. (2020). Potential of Waste Biomass from the Sugar Industry as a Source of Furfural and Its Derivatives for Use as Fuel Additives in Poland. *Energies, 13 (21),* 6684. DOI: https://doi.org/10.3390/en13246684 [in English].

[8] Tomaszewska, J., Bielinski, D., Binczarski, M., Berlowska, J. (2018). Products of sugar beet processing as raw materials for chemicals and biodegradable polymers. *RSC Advances, 8,* 3161–3177. DOI: 10.1039/c7ra12782k rsc.li/rsc-advances [in English].

[9] Boiko, O.S., and Heiko, L.M. (2020). Suchasnyi stan pidpryiemstv oliino-zhyrovoi promyslovosti Ukrainy [The current state of enterprises of the oil and fat industry of Ukraine]. *Ekonomichnyi prostir, 157,* 32–37. DOI: https://doi.org/10.32782/2224-6282/157-6 [in Ukrainian].

[10] Chobit, M.R., Vasyliev, V.P., Kot, V.A. (2015). Modyfikatsiia kreidy roslynnymy oliiamy [Modification of chalk with vegetable oils]. *Visnyk Natsionalnoho universytetu "Lvivska politekhnika", 812,* 438–443. [in Ukrainian].

[11] Chekhova, I.V. (2014). Napriamky vykorystannia oliinykh kultur v bioenerhetychnii haluzi [Directions for the use of oil crops in the bioenergy industry]. *Naukovo-tekhnichnyi biuleten Instytutu oliinykh kultur NAAN, 21,* 172–179 [in Ukrainian].

[12] Onyshchenko, O.V., Kurenna, O.O., Krykunenko, A.S. (2018). Innovatsiini shliakhy rozvytku oliino-zhyrovoi haluzi [Innovative ways of development of the oil and fat industry]. *Elektronne naukove fakhove vydannia z ekonomichnykh nauk «Modern Economics», 7,* 114–122 [in Ukrainian].

[13] Borodai, S.V., Hrek, O.V., Polishchuk, H.E., Solontseva, I.V. (2007). Obrobka syrovatky membrannymy metodamy [Processing of whey by membrane methods]. *Tavriiskyi naukovyi visnyk, 2,* 104–109 [in Ukrainian].

[14] Derzhavna sluzhba statystyky Ukrainy (2021). *Tvarynnytstvo v Ukraini u 2020 rotsi: statystychnyi zbirnyk [Animal husbandry in Ukraine in 2020: statistical collection]*. Kyiv: Derzhavna sluzhba statystyky Ukrainy [in Ukrainian].

[15] Tymchak, V.S. (2016). Innovatsiini napriamky vykorystannia vidkhodiv pyvovarnoi haluzi [Innovative ways of using waste from the brewing industry]. *Naukovyi visnyk Uzhhorodskoho natsionalnoho universytetu Seriia: Mizhnarodni ekonomichni vidnosyny ta svitove hospodarstvo, 10 (2),* 113–117 [in Ukrainian].

[16] Tokarchuk, D.M., Pryshliak, N.V., Palamarenko Ya.V. (2021). Stratehiia povodzhennia z vidkhodamy ahrarnykh pidpryiemstv: ratsionalne povodzhennia vidkhodamy roslynnytstva, vidkhodamy tkanyn tvaryn, tvarynnym hnoiem, ahrokhimichnymy vidkhodamy [Waste management strategy of agricultural enterprises: rational management of crop production waste, animal tissue waste, animal manure, agrochemical waste]. *Efektyvna ekonomika*, 12. Retrieved from: http://www.economy.nayka.com.ua/pdf/12_2021/106.pdf. DOI: https://doi.org/10.32702/2307-2105-2021.12.104 [in Ukrainian].

[17] Tokarchuk, O.A., Paziuk, V.M. (2022). Osnovni kharakterystyky osadiv stichnykh vod [Basic characteristics of sewage sludge]. *Tekhnika, enerhetyka, transport APK, 1 (116)*, 96–104. DOI: 10.37128/2520-6168-2022-1-11 [in Ukrainian].

НАПРЯМКИ ВИКОРИСТАННЯ ВІДХОДІВ ХАРЧОВОЇ І ПЕРЕРОБНОЇ ПРОМИСЛОВОСТІ

Відходів з кожним роком на нашій планеті стає все більше. Це призводить до забруднення ґрунтів, водойм і повітря, що негативно впливає на здоров'я і якість життя людей. Тому стає актуальною задача зменшення утворення відходів виробництв і споживання, а також вибір ефективних напрямків їх використання.

При виробництві продуктів харчування утворюються відходи переважно рослинного і тваринного походження. Визначено основні види відходів, що утворюються на переробних і харчових підприємствах: у плодоовочевій та консервній галузі – яблучні, ягідні та овочеві вичавки, а також овочі і фрукти, які не підлягають переробленню як основний продукт; у зернопереробній галузі – пшеничні висівки; у цукровій промисловості – меляса, жом; у *молочній галузі – сироватка; в оліє-жировій галузі – лушпиння, макуха тощо.*

Зазначено, що найбільш цінні з відходів продаються за кордон або переробляються на продукти харчування. Наведено перелік продуктів за напрямами використання (продукти харчування, ліки, хімічна промисловість, добрива, косметична галузь, корми для тварин, добриво, енергія), які можна отримати з органічних відходів. Визначено види відходів, які є цінною сировиною для хімічного, фармацевтичного і косметичного виробництв, отримання енергії.

Обґрунтовано, що в сучасних умовах в Україні необхідно активізувати використання відходів переробних та харчових виробництв в якості енергоносіїв – на виробництво твердого біопалива (брикети, пелети), біогазу тощо. Це допоможе компенсувати нестачу енергетичних ресурсів через пошкодження об'єктів традиційної енергетики в ході бойових дій росії проти України.

Проте, в Україні ще залишається велика кількість відходів, які захороняються або зливаються в каналізацію, чим спричинюють забруднення водойм, ґрунтів і викидів парникових газів у атмосферу. При комплексному підході і спільному вирішенні проблеми поводження з відходами різних галузей промисловості можна забезпечити економію витрат на сировину, створення нових робочих місць та охорону і оздоровлення навколишнього середовища.

Ключові слова: *відходи, відходи харчової і переробної промисловості, переробка, добриво, корм, енергетичні ресурси, біогаз.*

Табл. 1. Літ. 17.

INFORMATION ABOUT THE AUTHORS

Oleksii Tokarchuk – Candidate of Technical Sciences, Associate Professor of the Department of "Technological Processes and Equipment of Processing and Food Productions" of the Vinnytsia National Agrarian University (3, Solnyshchaya St., Vinnytsia, 21008, Ukraine, e-mail: tokarchuk@vsau.vin.ua, https://orcid.org/0000-0001-8036-1743).

Liudmila Sosnovska – Assistant of the Department of "Technological Processes and Equipment of Processing and Food Productions" of the Vinnytsia National Agrarian University (3, Solnyshchaya St., Vinnytsia, 21008, Ukraine, e-mail: lyudka_dushkant@ukr.net, https://orcid.org/0000-0003-4976-7838).

Токарчук Олексій Анатолійович – кандидат технічних наук, доцент кафедри технологічних процесів та обладнання переробних і харчових виробництв Вінницького національного аграрного університету (вул. Сонячна, 3, м. Вінниця, 21008, Україна, e-mail: tokarchuk@vsau.vin.ua, https://orcid.org/0000-0001-8036-1743).

Сосновська Людмила Василівна – асистент кафедри технологічних процесів та обладнання переробних і харчових виробництв Вінницького національного аграрного університету (вул. Сонячна, 3, м. Вінниця, 21008, Україна, e-mail: lyudka_dushkant@ukr.net, https://orcid.org/0000-0003-4976-7838).