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Application of brewer's spent grain in the technology of protein texturates for the meat processing industry

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Abstract. The topic's relevance lies in addressing the rational utilisation of brewing by-products, specifically brewer's spent grain. Containing approximately 20% protein, it can enhance the compositional properties of textured soy protein. The study aimed to develop a formulation for grain-protein texturates within the framework of waste-free technologies and environmentally sustainable production. To achieve this, modern and promising methods for obtaining protein concentrates, isolates, and texturates from plant-based raw materials were reviewed. A technology was developed for producing texturates based on soy flour, soy flakes, gluten, and brewer's spent grain flour. The quality of the resulting texturate was assessed using organoleptic, microbiological, and physicochemical parameters. According to sensory evaluation, a porous textured protein with a fibrous macrostructure was obtained. Moisture content was determined by the drying method to a constant weight at a temperature of $105^{\circ}\text{C}\pm 2^{\circ}\text{C}$; protein content was measured using the Kjeldahl method; fat content was assessed by the Soxhlet method; and fibre content was analysed using the FIBERBAG method. Microbiological indicators were assessed as follows: *Escherichia coli* was detected through inoculation on selective diagnostic media; the count of mesophilic aerobic and facultative microorganisms was determined via inoculation in solid media; yeasts and mould

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fungi were identified by cultivation on nutrient media, followed by classification based on the characteristic growth features and cell morphology of the isolated microorganisms. The study established that the produced texturate complies with the requirements of DSTU 4538:2006. A comparison with the existing standard revealed a 1% increase in protein content and a 46% reduction in fat content. The organoleptic evaluation confirmed that the product is free of foreign odours and tastes, featuring a highly fibrous structure identical to the texture of natural meat. Microbiological analysis confirmed the safety of the product, as no pathogenic microorganisms were detected, and the total microorganism count remained within permissible limits. The practical significance of this research lies in determining the quality of the grain-protein texturate for its subsequent application in the meat processing industry

Keywords: utilisation; gluten; soy flour; protein; organoleptic evaluation; microbiological indicators

Introduction

Recently, according to L. Bal-Prylypko *et al.* (2022), there has been a significant demand for sausages among the Ukrainian population. This has prompted the development of new recipes that combine animal and plant-based ingredients. To achieve a denser sausage filling, M. Nazarenko & I. Ustymenko (2023) proposed combining animal and plant proteins by partially replacing the meat component with spelt flour, a type wild wheat of spelt. The addition of plant-based ingredients to meat products not only expands the product range but also results in a new, high-quality product with functional properties. Studies on the effects of plant proteins on diseases such as diabetes and cardiovascular disease have shown positive results. Patients who regularly consumed products enriched with plant proteins experienced significant reductions in cholesterol and stabilised blood glucose levels (Sharma & Thakur, 2022). Therefore, the question of alternative plant-based protein sources is highly relevant. As noted by M. Zainol *et al.* (2020), legumes are considered the most common, offering a high nutritional profile. Their addition to meat products has improved the sensory qualities and nutritional value of the final products, while also reducing production costs. However, it is not only the lower cost that has encouraged

consumers to reduce their consumption of animal products. A key factor is the balance between taste, texture, price, and nutritional value (Boukid, 2021). Soybeans are the primary ingredient as they are considered a complete protein source, meaning they contain all the essential amino acids and are nutritionally comparable to animal proteins (Azman *et al.*, 2023). The human body can synthesise only some amino acids through carbohydrate or lipid metabolism, and these are called non-essential amino acids. The rest must be obtained from the diet and are called essential amino acids. Human health depends on a balanced diet that provides all the essential amino acids.

Ya. Skorobogatyi *et al.* (2020) indicate that the human diet must provide a mixture containing eight essential and two conditionally essential amino acids. The absence of even one essential amino acid leads to a negative nitrogen balance, impaired central nervous system function, and vitamin deficiency. After analysing the amino acid composition of soy and its products, the authors determined a deficiency of tryptophan and methionine. Tryptophan is an α -amino- β -indolepropionic acid and belongs to the aromatic amino acids (Moroz *et al.*, 2022). It normalises the nervous system and digestion, improves immunity, and its deficiency causes

skin and hair problems, anaemia, and insomnia. Methionine and cysteine in grain proteins are similar to those in animal proteins, but they are generally lower in legume proteins. Methionine is involved in the synthesis of cysteine through the transsulfuration pathway, which limits the rate of synthesis of the key antioxidant molecule, glutathione. Methionine is also a primary methyl donor in the body, involved in the synthesis of several key metabolites, including creatine and phosphatidylcholine, during periods of high demand. Soy proteins are high in lysine, making them a valuable addition to grains, which are typically low in this amino acid. Therefore, when developing a soy-based protein product, it is essential to carefully combine ingredients to achieve a complete amino acid profile. For example, barley flour contains tryptophan and a significant amount of methionine, so adding brewer's spent grain, which is primarily composed of barley malt and flour, to a soy product can help balance the amino acid profile (Moroz *et al.*, 2022).

To meet the physiological needs of the body, an "ideal" protein is required, but it does not exist in nature. This problem can be solved by combining and rationally utilising protein resources through selection and calculation. Therefore, the main goal of the research was not only to address environmental issues but also to obtain a protein concentrate with functional properties.

Literature Review

The growing interest of scientists in plant-based products has led to an increase in the production of soy protein concentrates due to their functional and nutritional properties (Baune *et al.*, 2022). There are two main methods of obtaining concentrates: dry and liquid. The dry method is based on aspiration and is rarely used due to significant protein losses. The liquid extraction method can be divided into water, alcohol, and acid-based processes. The alcohol method is the most common, as

the resulting concentrate has high organoleptic properties and is free of contaminants. In a scientific article by R. Bou *et al.* (2022), the latest technologies for obtaining high-purity protein isolates and their impact on the technological and functional properties of raw materials and human health are considered. The most modern and promising are ultrafiltration technologies, such as ultrafiltration, reverse osmosis, and electrodialysis. The application of these methods promotes protein dissolution and cell wall disruption, increasing protein yield and reducing the need for solvents, processing time, and waste generation.

Technologies are being developed to modify protein structure to improve digestibility, reduce allergenicity, and tailor technological properties, making soy a sustainable protein source with a promising future as an alternative to meat and meat products. One such technology is texturisation, which creates a product with fibres similar to those found in many meat products. Various methods have been proposed to mimic the fibrous texture of meat; however, extrusion is the only industrially viable option for functionalising and structuring plant materials into fibrous products (Stelick *et al.*, 2021). In this process, proteins are plasticised/melted through a combination of heating, hydration, and mechanical deformation. Depending on the moisture content, high-moisture extrusion (50-80%), which produces textured proteins with a fibrous structure more similar to meat, and low-moisture extrusion (25-35%) can be distinguished. In this study, high-moisture extrusion was used to obtain a product with a fibrous structure that resembles muscle tissue fibres, for use in meat analogue and blended product technology. The primary raw materials for producing textured plant proteins are soy protein, pea protein, and wheat gluten, according to researchers B. Zhang *et al.* (2022). Previous studies have shown that different raw materials have varying effects on the textured material. For instance, pea protein can be

extruded at a moisture content of 55% as high temperatures and rapid heating deteriorate its gel-forming properties. Wheat protein, due to its high water-absorption capacity, can form gluten which is shaped into a plastic structure through high-moisture extrusion. Unlike pea protein, wheat gluten has significantly better gelforming properties, hence it is often mixed with other plant proteins such as soybeans and peas, as indicated in the research by X. Zhang *et al.* (2022). During extrusion, various physical and chemical changes occur, leading to the formation of a unique fibrous structure that affects the functional properties of the protein, enhancing its digestibility (Zhang *et al.*, 2020).

Textured plant proteins are used as partial meat substitutes to enhance colour stability, moisture retention, and juiciness in sausages. Improving the ability of plant-based proteins to mimic meat flavour has gained significant interest among both researchers and manufacturers (Yuliarti *et al.*, 2021; Cornet *et al.*, 2022). Experiments have been conducted to replace meat in sausages with textured proteins at 20%, 50%, and 75%. Results showed a 25% increase in water content due to the high water-holding capacity of texturised proteins (Revilla *et al.*, 2022), and when 20% of pork was replaced, sufficient essential amino acids were retained (Broucke *et al.*, 2022). Particular attention is paid to various protein blends, using different products such as defatted pumpkin and sunflower flour, peanut protein, and others. This article proposes a partial replacement of soy flour with brewers' spent grain flour, a byproduct of the filtration process during beer wort.

The primary raw material in brewing is barley malt. To prepare the mash, the grains are crushed and mixed with water. During the mashing process, enzymatic changes occur, resulting in approximately 60-70% of the dry matter being transferred to the wort, while the remainder remains in the brewer's spent grain. After filtration, a wet grain is obtained, consisting of insoluble particles of malt, primarily

from the husks of the malt grains, mixed with endosperm, unfermented starch, and other substances. As noted by researchers M. Parchami *et al.* (2021), spent grain has a very valuable chemical composition, with protein and fibre being particularly noteworthy, accounting for approximately 20% and 70% of its composition, respectively. About 30% of the total protein content consists of essential amino acids, the primary one being lysine, which is considered the limiting amino acid in cereal products. In turn, dietary fibre is primarily composed of cellulose and hemicellulose fibres, which include particles of xylose, arabinose, glucose, and lignin. Spent grain is also rich in minerals, the most common of which are silicon, phosphorus, and calcium.

Due to its valuable composition, research is being conducted into the use of spent grain in various sectors of the food industry, including baking, confectionery, and meat processing (Chetrariu & Dabija, 2023). A known technology involves producing bread with sourdough, with the addition of 25%, 50%, 75%, and 100% spent grain. Samples of bread made with 25% and 50% sourdough exhibited higher porosity, acidity, and appropriate moisture content compared to samples made with 75% and 100% sourdough, which had lower porosity and acidity. Authors O. Saitan *et al.* (2022) also found that the shelf life of the bread increased by 24-48 hours. However, there are known negative consequences of partially adding brewer's spent grain flour during mixing, namely a decrease in gluten yield and a deterioration in its quality, leading to a softer dough. This is due to the prolonged mixing time and the high content of fibre and protein. In terms of appearance, crust, and crumb properties, bread with 10% spent grain did not differ significantly from bread made with wheat flour; however, the bread's colour changed from light cream to brown as the amount of spent grain was increased (Czubaszek *et al.*, 2022). Researchers Y. Shih *et al.* (2020) demonstrated

not only the feasibility of using brewer's spent grain in the confectionery industry but also the functional properties of the resulting products (muffins). A study involving 18 participants who consumed muffins with 30% brewer's spent grain daily for 8 weeks showed positive effects related to reduced blood pressure and insulin levels compared to the control group. This is attributed to the muffins' high content of protein, fibre, and antioxidants, as a serving size contains more than 10% of the recommended daily intake of each nutrient (Combest & Warren, 2022). Additionally, a group of scientists, including M. Nazarenko & I. Ustyenko (2023), investigated the use of brewer's spent grain in the production of meat products, specifically sausages. The authors used fractionated flour and determined that the finished products showed significant improvements in both organoleptic and physicochemical properties.

Materials and Methods

The protein texturate was produced using a traditional technology according to DSTU 4538:2006 (2007). Research was conducted at the innovation and production complex of LLC "KR Ingredients" during the first half of 2024. The subject of the study was soy flour and brewer's spent grain flour (the main raw materials). All ingredients, according to the recipe (Table 1), were mixed with water, intensively mixed at high speeds for 2-5 minutes, and loaded into an extruder, where they were heated to a temperature of 160-210°C using an external ceramic heater. As a result of the high temperature, the raw material is converted into a melt, and the proteins denature. When the melt exits the extruder, there is a sharp decrease in temperature and intensive evaporation of moisture, forming a porous textured protein with a fibrous macrostructure. The texturate recipe is presented in Table 1.

Table 1. Recipe for grain-legume protein texturate

No.	Ingredients	Mass fraction of crude protein (on a dry matter basis), %	Raw material weight per 100 kg of product
1	Defatted soy flour	52	29
2	Soybean meal	46	25
3	Brewer's spent grain flour	22	7.0
4	Gluten	90	7.0
5	Sodium bicarbonate	-	0.5
6	Sodium chloride	-	0.5
7	Water	-	31

Source: developed by the authors

A similar method for producing a textured soy product was patented by S. Glushchenko (2022), which proposed using soybean meal "Bila Peliustka", soy protein isolate, soy flour, wheat gluten, sodium bicarbonate, and sodium chloride as raw materials. The raw materials were mixed with water to a moisture content of 18-30% and the resulting mass was extruded at a temperature range of 110 to 210°C.

In the recipe for the grain-legume protein texturate, soy flour was partially replaced with brewer's spent grain flour to reduce production

costs and address the issue of waste from the brewing industry. The finished product was analysed for organoleptic, physicochemical, and microbiological parameters. The organoleptic evaluation was conducted on a 5-point scale according to DSTU 4538:2006 (2007). Physicochemical and microbiological parameters were obtained in an accredited testing laboratory for food and light industry products in Cherkasy, Ukraine. Moisture content was determined according to DSTU ISO 6496:2005 (2006); protein content – DSTU 7169:2010 (2011); fat content –

DSTU ISO 1443:2005 (2008); and fibre content – DSTU 8844:2019 (2020).

Microbiological analysis was conducted for the following indicators. It is generally considered that if a product is produced without the involvement of microorganisms that cause fermentation processes, the number of mesophilic aerobic and facultatively anaerobic microorganisms (MAFAM) according to DSTU 8446:2015 (2017) does not exceed 10^5 , and if it increases to 10^6 per 1 g (cm^3) or more, it becomes potentially dangerous for consumers, even if there are no organoleptic signs of product spoilage (Caprelyants, 2020). Coliform bacteria – 1.0 g according to DSTU 30726-2002 (2003); yeasts, colony-forming units (CFU) – 1 g, DSTU 8447:2015 (2017); pathogenic microorganisms, including *Salmonella* – 25 g

(DSTU EN 12824:2004, 2005); moulds – CFU per 1.0 g (DSTU 8447:2015, 2017).

Results and Discussion

Organoleptic properties are subjective and primarily descriptive in nature. Sensory evaluation allows for a quick and objective overall assessment of a food product's quality. The results of the sample were compared to the requirements of the standard DSTU 4538:2006 (2007) and were found to have high sensory characteristics, which were assessed on a five-point scale. In terms of appearance, colour, and taste, the sample received five points. Regarding the odour, a slight malt note was detected, indicating the presence of brewer's spent grain. The organoleptic properties are presented in Table 2.

Table 2. Organoleptic evaluation of the grain-legume protein texturate

No.	Parameter	Points	Characteristics
1	Appearance	5	Fibrous structure resembling muscle tissue fibres
2	Colour	5	Light brown
3	Taste	5	No specific bean taste, bitterness, sourness, or other off-flavours
4	Odour	4	Typical of soy protein texturate, with subtle malty notes

Source: developed by the authors

Textured vegetable protein has a fibrous structure formed by oriented protein macromolecules, resembling muscle fibres (Fig. 1), allowing its use as a protein source in the production of sausages, minced semi-finished products, and meat and meat-plant-based canned goods.



Figure 1. Grain-legume protein texturate

Source: authors' photo

The physicochemical properties of texturised vegetable protein are crucial in meat product manufacturing. The primary property affecting the quality of meat products is the water-binding capacity of proteins. In meat, water is a natural component and is bound to its constituents in various ways, forming stable structural elements. These bonds can be capillary, adsorbed, or osmotic, determining the meat's ability to retain varying amounts of moisture. The amount of bound water and its distribution according to the type and strength of the bond influence the meat's properties, including its texture. In animal proteins, water is more strongly bound to collagen and elastin, which are primarily found in bones, muscles, and animal skin. For the production of sausages, minced meat is used, which

typically has a lower protein content than pieces of muscle meat. In this category of products, animal protein can be replaced with plant-based protein with high functional properties (Day *et al.*, 2022). In the study of

M. Nikolaenko (2021), it was shown that adding 15% plant-based protein to minced meat increased its water-binding capacity. The physicochemical properties based on the results of this research are presented in Table 3.

Table 3. Physicochemical properties of the grain-legume protein texturate

No.	Parameter, units	Reference RD for the test method	Result of testing	Norms according to DSTU 4538:2006 (2007)
1	Mass fraction of raw fibre, recalculated to dry matter, %	DSTU 8844:2019 (2020)	6.4	-
2	Mass fraction of raw fibre, %	DSTU 8844:2019 (2020)	5.9	-
3	Mass fraction of raw fat, recalculated to absolutely dry matter, %	DSTU ISO 1443:2005 (2008)	6.9	15.0
4	Mass fraction of raw fat, %	DSTU ISO 1443:2005 (2008)	6.3	-
5	Mass fraction of raw protein, recalculated to absolutely dry matter, %	DSTU 7169:2010 (2011), p.7	45.4	45.0
6	Mass fraction of raw protein, %	DSTU 7169:2010 (2011), p.7	41.5	-
7	Moisture, %	DSTU ISO 6496:2005 (2006)	8.8	9.0

Source: developed by the authors

According to the standard, the crude protein content on a completely dry matter basis for texturate made from soy flour and meal should be at least 45%. In the obtained sample, it was 45.4%. Regarding fat, compared to the standard, a decrease of 46% was observed. This is due to the fact that both brewer's spent grain flour and soy flour were defatted to increase the hydrophilicity of proteins.

Table 3 also shows that the obtained texturate contains a high amount of fibre, a plant polysaccharide that is only obtained from food. As noted by authors I. Bernyk *et al.* (2022), enriching meat products with fibre contributes to the stabilisation of the rheological properties of the mince. Due to its high water-holding capacity, it improves product formation, increases the yield of the finished product, and enhances organoleptic properties. Additionally, it enriches food products with dietary fibre and reduces their calorie content. Fibre is essential for health, lowering cholesterol levels and stabilising blood sugar.

Microbiological control of food products allows for the rapid detection of pathogenic

microflora and eliminates the risk of food poisoning, as well as preventing the growth of saprophytes, which are the primary causative agents of spoilage in finished products. To assess the quality of raw materials, semi-finished products, and finished products according to DSTU 8446:2015 (2017), there is an indicator of the sanitary-hygienic condition, namely the total microbial count. Mesophilic aerobic and facultatively anaerobic microorganisms are microorganisms with an optimal growth temperature of 25-40°C in the presence or absence of oxygen. These primarily include putrefactive spore-forming and non-spore-forming bacteria, cocci (*staphylococci*, *micrococci*, *sarcinae*), and some conditionally pathogenic bacteria. The higher this indicator, the greater the likelihood of pathogens of infectious diseases and food poisoning entering the test object (Solomon *et al.*, 2020).

The primary indicator microorganisms are coliform bacteria, which are divided into three genera: *Escherichia*, *Citrobacter*, and *Enterobacter*, all belonging to the *Enterobacteriaceae* family. *Escherichia* is the most common. As noted

in their research by A. Solomon *et al.* (2020), coliforms are highly variable and can lose many of their characteristic features when exposed to the external environment. Therefore, all types of coliform bacteria are considered as indicator microorganisms. The presence of coliforms in a product indicates a violation of the technological process. Significant contamination of objects with coliforms is an indicator of the possible presence of their companions: cholera and dysentery pathogens. *Salmonella*, the causative agent of typhoid fever and paratyphoid A and B, are resistant to both high and low temperatures.

Microbiological tests on the sample found no pathogenic microorganisms, including

Salmonella, and no coliform bacteria, which fully complies with the requirements of the national standard DSTU 4538:2006 (2007). Regarding mesophilic aerobic and facultatively anaerobic microorganisms (MAFAM), with a maximum permissible level of 1.0×10^5 microorganisms per gram of texturate, 5.1×10^2 were found, indicating the safety of the product.

Moulds and yeasts are indicators of the sanitary condition of food products: moulds produce carcinogenic mycotoxins while yeasts shorten the shelf life of finished products. The results of the coliform test were within the acceptable range, and no yeasts were detected. The obtained microbiological indicators of the protein texturate are presented in Table 4.

Table 4. Microbiological indicators of grain-legume protein texturate

No.	Parameter	Norms according to DSTU 4538:2006 (2007)	Test results	Reference RD for the test method
1	Number of mesophilic aerobic and facultative anaerobic microorganisms, CFU per 1 g, not exceeding	$1.0 \cdot 10^5$	$5.1 \cdot 10^2$	DSTU 8446:2015 (2017)
2	Coliform bacteria (coliforms)	Not allowed	Not detected	DSTU 30726-2002. (2003)
3	Pathogenic microorganisms, including <i>Salmonella</i> species, in 25 g	Not allowed	Not detected	DSTU EN 12824:2004 (2005)
4	Mould fungi, CFU per 1 g, not exceeding	$1.0 \cdot 10^2$	Not detected (less than 10^*)	DSTU 8447:2015 (2017)
5	Yeasts, CFU per 1 g, not exceeding	$1.0 \cdot 10^2$	Not detected (less than 10^*)	DSTU 8447:2015 (2017)

Source: developed by the authors

The obtained results prove the feasibility of producing textured soy protein with a partial replacement of defatted soy flour with brewer's spent grain flour, which will reduce the cost of the product (the cost of dry spent grain is 2.5 times less than the cost of soy flour) and also solve the problem of utilising brewery waste. The developed technology allows for obtaining a product that is safe in terms of microbiological indicators, with a high protein content (41.5%) and a low fat content (6.1%).

Conclusions

Given the global decline in livestock farming and the increasing demand for food, scientists are seeking alternative sources of high-quality food. The utilisation of brewer's spent grain, a byproduct of the brewing industry, has emerged as a promising approach. It has been established that this material is a rich source of proteins, minerals, fatty acids, amino acids, fibre, and bioactive compounds, making it a suitable raw material for protein texturate.

This not only reduces the amount of waste in beer production but also enhances the nutritional value of the final product.

Based on experimental characteristics, the produced grain-legume texturate exhibits excellent organoleptic and physicochemical properties. Although the odour had slightly sweet notes, this did not significantly impact the overall sensory evaluation. Analysis of the product's chemical composition revealed that its high protein content and fibre presence enhance the water-binding and water-holding capacity of meat fillings, resulting in increased yields of finished sausages. Additionally, the developed texturate is distinguished by its fibre content, which positively impacts gut health.

The grain-legume texturate produced using the developed technology is almost indistinguishable in terms of consumer qualities from the texturate produced using traditional technology. Therefore, grain-legume texturate can be used both for the preparation of vegan products and in the meat processing industry for the

production of sausages and semi-finished products. Consequently, there is an urgent need to utilise this byproduct and develop sustainable methods for its use. Prospective directions for further research include adding grain-legume texturate to the formulation of cooked/smoked sausages. The positive results of the research indicate that this technology requires further study and development. Therefore, this study will continue to determine the organoleptic and physicochemical characteristics of finished products depending on the concentration of texturate in the products.

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Conflict of Interest

None.

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Застосування пивної дробини у технології білкових текстуратів для м'ясопереробної промисловості

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Анотація. Актуальність теми полягає у вирішенні питання щодо раціонального способу утилізації побічних продуктів пивоваріння, а саме пивної дробини. До її складу входить близько 20 % білка, що дозволяє поліпшити композиційні характеристики соєвих текстуратів. Метою роботи було розробити рецептуру зерно-білкового текстурату на основі створення безвідходних технологій та екологічно чистих виробництв. Для її реалізації було розглянуто сучасні та перспективні способи отримання білкових концентратів, ізолятів та текстуратів з рослинної сировини та розроблено технологію отримання текстурату на основі соєвого борошна, соєвої «пелюстки», глютену та борошна пивної дробини. Якість отриманого текстурату визначали за органолептичним, мікробіологічними та фізико-хімічними показниками. Відповідно до сенсорної оцінки, отримали пористий текстурований білок з волокнистою макроструктурою. Вологу визначали методом висушування до постійної маси за температури $105^{\circ}\text{C} \pm 2^{\circ}\text{C}$; вміст білка – методом К'єндаля; вміст жиру – методом Сокслета; клітковину – методом «FIBERBAG». Щодо мікробіологічних показників визначали: бактерії *Escherichia coli* шляхом посіву на селективно-діагностичні середовища; кількість мезофільних аеробних та факультативних мікроорганізмів – посівом у тверді середовища; дріжджі та плісеневі гриби – шляхом культивуванням на поживних середовищах, з подальшим визначенням належності виділених мікроорганізмів до плісневих грибів і дріжджів за характерними ознаками росту і морфологією клітин. Встановили, що отриманий продукт відповідає ДСТУ 4538:2006. Порівнюючи отриманий текстурат з існуючим стандартом, визначили, що вміст білка збільшився на 1 %, натомість вміст жиру зменшився на 46 %. За органолептичними показниками отримали продукт без сторонніх запахів і присмаків, який має високоволокнисту структуру, ідентичну текстурі натурального м'яса. Мікробіологічний аналіз підтвердив показники безпечності продукту, оскільки патогенна мікрофлора відсутня, а кількість мікроорганізмів знаходилась в межах норми. Практичне значення проведених досліджень полягає у визначенні якості зернобілкового текстурату з подальшим використанням його в м'ясопереробній промисловості

Ключові слова: утилізація; глютен; соєве борошно; білок; органолептична оцінка; мікробіологічні показники