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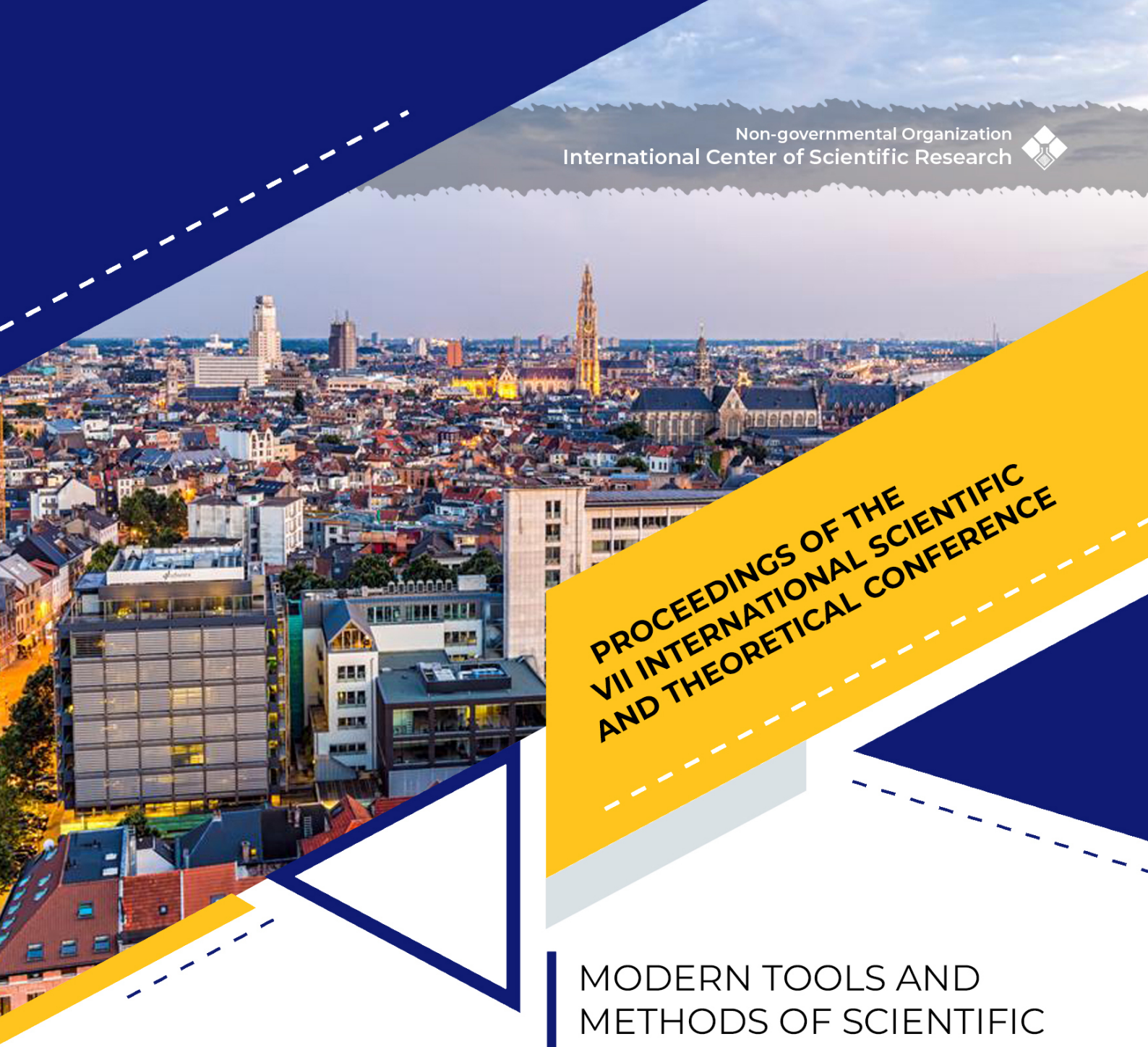

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FOOD PRODUCTION AND TECHNOLOGY

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PROSPECTS FOR THE USE OF WHEY AND BLACK ELDERBERRY JUICE IN BEVERAGE PRODUCTION

Abstract. *The article is devoted to the study of quality indicators of cheese whey and black elderberry juice and their application in the technology of functional beverages aimed at expanding the product range and increasing the biological value of consumers' diets. Experimental studies of organoleptic and physicochemical quality parameters of raw materials were conducted. The obtained results confirm the feasibility of using wild-growing raw materials in beverage formulations based on whey. It was determined that the best organoleptic and physicochemical characteristics are achieved when adding 15% black elderberry juice to the formulation, which not only enriches the composition of the finished product and enhances its nutritional and biological value but also improves its sensory properties.*
Keywords: *whey, black elderberry, chemical composition, juice, beverages, microbiological indicators, quality parameters.*

Analysis of Recent Research and Publications. One of the promising directions for the rational use of whey is its application in the technology of functional beverages. Due to its high nutritional and biological value and its ability to combine with a wide range of plant-based raw materials, whey can serve as a basis for the development of new types of health-oriented beverages. At the same time, the use of wild-growing berries in food technologies contributes not only to expanding the product range but also to a more rational use of natural resources and the promotion of local plant raw materials. The combination of whey with processed products of black elderberry in beverage technology is a promising direction for creating new products with enhanced biological value.

Whey contains more than two hundred vital biologically active nutrients.

About 25% of these are protein substances represented by whey proteins (α-lactalbumin, β-lactoglobulin, serum albumin, immunoglobulins, and proteose-peptones), which are rich in essential amino acids (lysine, tryptophan, methionine, threonine) and cysteine, allowing them to be classified among the most biologically valuable fractions of milk proteins [6, 17]. The biological value of whey is also обусловлена the presence of finely dispersed fat and milk sugar, which is very well absorbed by the human body (99,7%) [1, 3, 10]. In addition to its energy function, lactose also performs the role of a structural carbohydrate. Furthermore, due to its slow absorption, it supports the activity of lactic acid bacteria. Lactic acid produced from lactose inhibits the development of putrefactive microflora in the human intestinal tract [10, 19].

The complex of mineral salts in whey, from a biological point of view, is the most optimal both in terms of spectrum and composition of compounds. Enzymes, vitamins, phospholipids, and other biologically active substances in whey also play an important role in metabolism and protein breakdown. The energy value of whey is significantly lower than that of milk due to its lower fat and protein content; however, its biological value is approximately the same, which determines the feasibility of its use in dietary nutrition [6, 11, 13].

Black elderberry fruits contain a number of beneficial substances, including ascorbic and malic acids, rutin, carotene, sambucin, sugars (glucose and fructose), tannins, pectins, anthocyanin pigments, and polyphenols. Scientific studies confirm that phytochemical compounds with high antioxidant capacity include polyphenolic substances, particularly flavonoids, which comprise flavonols, flavones, flavanones, isoflavones, anthocyanidins, and proanthocyanidins. Black elderberry contains a whole complex of these substances [15, 16].

The fruits and berries of black elderberry contain antioxidants capable of neutralizing free radicals. Dietary supplements, herbal preparations, and food products containing these berries have a tonic effect and enhance performance. Due to the presence of ascorbic acid and anthocyanins, black elderberry increases immunity and activates the body's protective mechanisms against viral infections [4, 14]. Elderberry-based preparations help in the treatment of hyperlipidemia, reduce the risk of cardiovascular diseases, and address many other health issues [9, 10].

Studies show that ripe elderberries contain 83–85% moisture, 6–8% monosaccharides (mainly glucose and fructose in approximately equal amounts), 1,5–2,0% sucrose, 1,3–1,4% organic acids, 1,0–1,2% pectin substances, as well as small amounts of amino acids and carboxylic acids. Mineral components include Mn, Ca, K, and Ba [9].

The antioxidant activity of black elderberries is determined by the presence of phenolic compounds, mainly pigments. Among phenolic substances, anthocyanins represented by cyanidin glycosides dominate [14].

The relevance of the conducted research lies in the use of wild-growing raw materials as components of beverage formulations based on whey, which makes it possible to simultaneously solve the problem of utilizing secondary raw materials in food technology and to enrich finished products with a complex of biologically active plant ingredients.

Purpose of the Study. The aim of the research is to use processed products of black elderberry in the technology of whey-based beverages.

Presentation of the Main Research Material with Full Justification of the Obtained Scientific Results. Whey is a promising component for the development of functional beverages with health-promoting properties due to its high nutritional and biological value. It is rich in whey proteins, which have a complete amino acid composition, are easily digestible, and support important metabolic processes in the human body, including muscle tissue synthesis and immune system functioning. In addition, whey contains water-soluble vitamins, mineral elements, and trace elements, including calcium, magnesium, phosphorus, and B-group vitamins, which contribute to the normalization of nervous activity, maintenance of mineral metabolism, and homeostasis [2, 5, 10].

At the first stage of the study, quality indicators of the raw materials—whey and elderberry berries—were determined (Tables 1–3).

Table 1

Organoleptic Characteristics of Raw Materials

Raw material	Appearance	Color	Taste	Odor
Whey	homogeneous, clear liquid with slight sediment	white with a grayish tint	slightly sour aftertaste	characteristic of the product
Black elderberry	oval-shaped berries, relatively small, d ≈ 4 mm	purple-black	sweet, specific	light, characteristic

Source: developed by the authors

For the study, cheese whey was used with the following parameters: dry matter content – 5,6±0,15%, including lactose – 3,5±0,3%; fat content – 0,2±0,03%; density – 1020 kg/m³; titratable acidity – 53 °T; active acidity (pH) – 4,5 pH units (Table 2).

It has been scientifically proven that the high biological value of whey is обусловлена the presence of proteins, vitamins, hormones, organic acids, and trace

elements. Lactose predominates in the carbohydrate composition of whey. The acids present in whey include lactic, propionic, formic, acetic, citric, and other acids. Almost all organic acids found in whey are products of the metabolic activity of microorganisms developing in it, with the exception of citric acid [6]. However, in terms of organoleptic characteristics, whey has a weak color and a slightly sour taste; therefore, considering its high biological value, it is advisable to combine it with a component that would impart a more pronounced color to the beverage and improve its biological value and sensory properties.

Table 2

Chemical Composition of Whey (n = 3, p ≤ 0.05)

Parameter	Unit	Value
Mass fraction of dry matter, including:	%	5,60
– protein content	%	0,82
– fat content	%	0,20
Titratable acidity	°T	53,00
Active acidity	pH units	4,50
Density	kg/m³	1020.00

Source: developed by the authors

Black elderberry juice was selected as such a component. To obtain the juice, the berries were pretreated: washed, sorted, crushed, and the juice was extracted by pressing. The quality indicators of the finished juice were determined and are presented in Table 3.

Table 3

Physicochemical Parameters of Black Elderberry Juice

Indicator	Unit	Value
Soluble solids	%	13,20
Titratable acidity	%	0,65
Pectin substances	%	0,60
Active acidity	pH units	4,50

Source: developed by the authors

According to organoleptic evaluation, black elderberry juice had a dark purple color, a sweet специфічний taste, and a mild aroma characteristic of elderberries.

Black elderberry juice contains approximately 7.8% sugars; among organic acids, citric acid predominates, although malic and succinic acids are also present [9, 14].

The main indicator characterizing the antioxidant activity of black elderberries

is the presence of L-ascorbic acid and phenolic compounds, among which coloring substances predominate (Table 4).

Table 4

Content of Biologically Active Compounds in Black Elderberry Juice

Indicator	Unit	Value
L-ascorbic acid	mg/100 g	30,50
Coloring substances*	mg/100 g	370,00
Phenolic compounds	mg/100 g	580,00
Biological activity	conventional units	4000,00

** expressed as cyanidin equivalents*

Source: developed by the authors

The obtained juice was found to contain L-ascorbic acid (30,50 mg/100 g) and a significant amount of phenolic compounds (580 mg/100 g), which influence the level of biological activity. The presence of such antioxidants as L-ascorbic acid and flavonoids, as well as their interaction, determines the value of the biological activity indicator.

Based on the analysis of the physicochemical parameters of the raw materials, it can be concluded that the selected raw materials are suitable for compositional combination and can be used for the production of functional beverages.

To develop the formulation of whey-based beverages, different ratios of whey and black elderberry juice were experimentally studied. According to organoleptic, physicochemical, and microbiological indicators, the optimal ratio was found to be 85:15 (whey : sterilized black elderberry juice).

For the study, a whey-based beverage was prepared as follows: cheese whey was filtered, heated to a temperature of 93±2 °C, held for 30 minutes, and cooled to 35 °C for 5–6 hours for clarification; it was then re-filtered, mixed with juice and sugar, and cooled to 4±2 °C.

The beverage with elderberry juice is characterized by moderate titratable acidity (81 °T), indicating a balanced acid–base reaction, and a density of 1,027 g/cm³, which corresponds to typical values for whey-based beverages. The low fat content (0,25%) makes the product dietary, while the protein content (0,76%) and lactose content (4,85%) provide the body with easily digestible proteins and carbohydrates, contributing to the normalization of digestion and maintenance of intestinal microflora. The total dry matter content (7,4%) determines the consistency and taste characteristics of the beverage.

According to microbiological indicators, both the raw materials and the beverage produced on their basis comply with the required standards and do not

exceed the permissible limits.

Whey belongs to perishable food products that require specific temperature conditions to maintain quality and safety; without such conditions, irreversible changes occur, leading to spoilage. Black elderberry juice belongs to the group of low-acid products, which also necessitates strict adherence to storage requirements.

According to the results of the conducted studies, it was established that in beverages recommended for sale in food service establishments, the total microbial count amounted to $3{,}4\times10^3$ CFU/g, which is lower than the established regulatory limits. No coliform bacteria were detected in the tested samples, nor were pathogenic microorganisms, including representatives of the genera *Salmonella* and *Staphylococcus* (Table 5).

Table 5

Microbiological Parameters of the Obtained Beverage

Indicator	Standard (DSTU 8549:2015, beverages)	Beverage
Total viable count (TVC), CFU/g, not more than	1×10^5	3.4×10^3
Coliform bacteria in 1 g	not allowed	not detected
Pathogenic microorganisms, including *Salmonella* (in 25 g)	not allowed	not detected
Molds, CFU/g, not more than	50	not detected
Yeasts, CFU/g, not more than	50	not detected

In addition, microbiological parameters were analyzed after storage of the products for 72 hours. The obtained results for samples stored for three days at a temperature of +2…+4 °C indicate that the level of total microbial contamination remained within acceptable limits.

Conclusions. The results of the experimental studies confirm the feasibility of using black elderberry juice in the formulation of whey-based beverages. The compositional combination of whey and black elderberry juice has a positive effect on the organoleptic and physicochemical characteristics of the beverage, enhances its biological value, and allows for the efficient utilization of the resource potential of secondary dairy raw materials.

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