

The expediency of using milk proteins in the technology of butter pastes, dry milk protein concentrate, and dry whey protein concentrate, has been substantiated.

It was determined that the use of protein-polysaccharide complexes in the technology of butter pastes makes it possible to reduce the caloric content of products by 2...3 % and increase the nutritional value by increasing the protein content up to 8.2 %. The biological value of the protein of new types of butter pastes, stabilized protein-polysaccharide complexes based on milk protein, was 43.6 %, based on milk and pea protein isolate – 45.0 %. This can be explained by the partial compensation of the lack of essential acids at the expense of plant protein.

It was established that the introduction of dry powder of blueberries and pea protein isolate makes it possible to enrich the product with a complex of biologically active and mineral substances. The degree of meeting the daily requirement by using 10 g of the product is: calcium – by 1.0 % on average; potassium – 0.6 %, iron – 0.3...0.6 %, rutin – 2.6 %.

The introduction of blueberry micronutrients into the butter paste would increase the biological value of the protein by 2.5 %. The use of pea protein isolate could increase it by 1.5 %, which is due to partial compensation of deficient amino acids through plant components.

Thus, due to the enrichment of the pastes with high-grade protein with a high degree of digestibility, it may become possible to increase the nutritional value of products.

The social effect of the introduction of new types of butter pastes into production is to improve the nutritional structure of the population through the use of low-fat analogs of butter, enriched with protein and micronutrients of blueberries. This would help improve health and prevent microelement-dependent diseases

Keywords: butter paste, protein-polysaccharide complex, blueberry micronutrients, milk protein, plant protein

DETERMINING THE EXPEDIENCY OF USING PROTEIN-POLYSACCHARIDE COMPLEXES BASED ON DAIRY AND VEGETABLE PROTEINS IN THE TECHNOLOGY OF BUTTER PASTES

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1. Introduction

One of the fast-growing segments of the food industry market is the dairy market. According to today's requirements, products must not only have a pleasant taste and be stable during storage but also meet the modern principles of nutrition, as well as safety criteria.

According to the standards, butter is a fatty product made exclusively from milk and/or products derived from it; it is mainly an emulsion of the type "water in fat". According to Codex Alimentarius regulations, the mass fraction of fat in butter should be not less than 80 %, the mass fraction of

moisture – not more than 16 %. In Ukraine and the post-Soviet countries, a wider range of values for the mass fat fraction is acceptable for butter, from 62.5 % to 85 %, the mass fraction of moisture should not exceed 25 %.

The main component of butter is milk fat. Since the melting point of milk fat is close to human temperature (28...33 °C), when it enters the oral cavity, the fat melts, creating a feeling of tenderness and saturation of the product. Also, this melting point ensures the preservation of butter shape and plasticity. This determines not only its consumer properties but also its use as a component of culinary meals and for direct consumption.

Fat plays a biological role in the human body. In particular, it is a source of energy, it protects internal organs from damage, contains essential fatty acids, conjugated linoleic acid, which has anti-cancer properties, as well as the content of phospholipids in fat, fat-soluble vitamins A, E, fat-soluble pigment β -carotene are the integral components of metabolic processes in the body.

Milk fat improves calcium absorption. Butter is recommended for the normal functioning of the brain, joints, heart. In addition, the use of butter is recommended for people with peptic ulcer disease of the digestive tract [1].

Nutritionists recommend daily consumption of butter in the amount of 10...20 g per day. The main limiting factor in the consumption of butter is its caloric content, which is, as an example, for the product whose mass fraction of fat is 82.5 % is 743 kcal per 100 grams.

In addition, butter has a higher price compared to other dairy products, which further limits consumption.

Therefore, a promising area of research is the development of production technologies based on low-calorie milk fat and with high nutritional value. The development of butter paste technologies has prospects in this respect.

An important field of research is the development of functional and technological complexes for butter pastes based on milk and plant proteins. This would allow obtaining a product with the specified physical-chemical, structural-mechanical, and organoleptic properties [2].

The introduction of fruit and berry processed products (syrops, jams, and stews) to formulations could further enrich them with a complex of biologically active micronutrients. The disadvantage of using such fillers is a fairly high sugar content [3].

Therefore, the development of new types of butter pastes using blueberries is a promising area of research.

Enrichment of butter pastes with blueberry micronutrients would increase the nutritional value by enriching them with a set of macro- and micronutrients in quantities and proportions that meet the modern principles of nutrition.

2. Literature review and problem statement

To form the structure of butter pastes as low-calorie analogs of butter, the use of modified starches, methylcellulose, carboxymethylcellulose sodium salt, and complex stabilization systems, based mainly on polysaccharides (modified starches, pectin, etc.) is suggested [4].

At present, there are the following known technologies of sweet cream butter pastes with flavor components for dessert – with cocoa, chicory, fruit and berry syrups, and snacks – with vegetables, herbs, cheese, and sour cream (with sourdough) [5, 6].

There is a known technology of the butter paste stabilized by a functional-technological complex consisting of cryopowder of beet, flaxseed flour, inulin, and oleophilic emulsifiers “Ester-A” (mono- and diglycerides of oleic acid) and “Polyglycerol polyricinoleate 03” (ethers of polyglycerol and inter-esterified ricin-oleic acids) [7].

However, the development of these products addressed the task of creating low-fat analogs of butter while the issue of increasing the nutritional value was ignored.

Considering the problem of protein deficiency in the diet of a modern person, the introduction of protein nature

ingredients to the composition of butter paste is a relevant field of research [8, 9].

Currently, the functional properties of milk proteins are increasingly used in food technology. Such important characteristics as moisture-binding capacity, swelling, foaming, emulsifying properties, etc. determine the behavior of both proteins and finished products with their use [9, 10]. Proteins determine milk performance in obtaining a variety of foods. Therefore, it is possible to assume that targeting the protein phase could make it possible to achieve the modification of the technological and physical-chemical properties of the original system. Further stabilization of the structure would determine the ability to form dispersed systems of new functionally combined dairy products [4, 11].

Therefore, the development of new types of butter pastes, stabilized by protein-polysaccharide complexes based on dairy and plant proteins, will not only ensure the formation of the structure of products but also increase their nutritional value.

Casein processing products are promising raw materials both directly in the dairy industry and for use in meat processing, baking, confectionery industries [11, 12].

Milk protein concentrate is an ideal source of protein as it contains both casein and whey proteins in almost the same proportions as in natural milk with the maximum preservation of their structure and properties. This concentrate is characterized by high nutritional value, providing a combination of slowly digestible casein and whey protein, for fast absorption [13].

The dry milk protein concentrate, obtained by ultrafiltration, is easily mixed with other dry components and is well dispersed in water, it has a low lactose content, a full amino acid profile, and is an excellent source of calcium. The advantages of using MPC (milk protein concentrate)-UF are:

- ratio of casein to whey proteins close to native milk, which is 80:20;
- low lactose content, 1.6 %;
- low fat content, 0.5 %.

The use of whey protein concentrates in the stabilization complexes' composition, enriched with micronutrients deficient in dairy products, which show physiological activity, in particular manganese, iron, copper, etc., is promising.

It was proven that the introduction of whey protein concentrate into the stabilization complex increases the viscosity of the system significantly and gives it plasticity. This is due to the associative interaction of the components of the binding of tertiary and secondary structures of macromolecules of polysaccharides and whey proteins due to the formation of hydrogen bonds and Van-der-Waals interaction [14].

The use of dry whey protein concentrate allows obtaining more plastic gels that give the tenderness of the product in tactile sensations [15, 16]. Also, whey proteins have a high biological value, so they can serve as an additional enriching component.

Besides, whey proteins, compared to casein, show a better emulsifying ability, which will reduce or even eliminate the emulsifier from the complex.

However, the use of only dry whey protein concentrate in the product composition results in a softer plastic consistency of the butter paste, which limits the choice of packaging type for product packaging. Therefore, it is advisable to combine whey protein concentrate with more active structure-forming agents.

Studies prove the effectiveness of the joint use of casein and whey proteins, which allows increasing the biological value of the composite mixture, to improve the emulsifying and moisture-retaining properties of the system [17, 18]. Although the research did not tackle the technology of butter pastes.

Therefore, to ensure the plasticity and strength of the structure of butter pastes, it is advisable to develop protein-polysaccharide complexes based on a combination of milk proteins – dry concentrates of milk and whey proteins.

In addition, the combination of casein and whey proteins could improve the balance of the amino acid composition of the protein complex and increase its biological value.

Modern trends in the animal origin raw materials substitution lead to a thorough study of the structural features of plant materials. In particular, scientists are interested in the products from processing legumes, especially soybeans and peas. These products are widely used as a source of valuable protein because their chemical composition and technological properties are similar to animal proteins and contain a complex of essential amino acids [19, 20].

A mixture or composition of several protein isolates is used to obtain food products, in particular meat and dairy products with the desired properties. This approach has proven effective in the production of sausages made from meat emulsion [21, 22]. Structural changes in protein isolates during hydration are the subject of thorough studies, which can identify the mechanisms of transformation of hydrocolloids and help simplify the search for their ratio in the composition.

At the same time, the issue of partial substitution of raw milk with the isolates of plant proteins, in particular peas, in the technology of butter pastes was not considered.

Pea protein isolate occupies a special place among plant proteins because it has a fairly balanced amino acid composition. It is almost completely devoid of the taste and smell characteristic of legumes. It also does not contain anti-nutrients, has high moisture-binding and emulsifying properties.

Besides, when separating a pea protein isolate, no chemicals are used, and production consists only of dry (purification, grinding) and wet (separation, filtration) processes of raw material treatment, etc. [23, 24]. During production, extraction is conducted with water, without the use of organic solvents.

The analysis of research reveals that pea protein as an ingredient has many advantages over other plant proteins. Namely, it is a functional ingredient – it has moisture- and fat-binding properties and has a neutral taste, the digestibility of this protein is about 98 %. Its emulsifying ability allows creating the necessary texture of a product, stable against heat treatment during the technological process. Pea protein isolate is a concentrated source of easily digestible protein, its amino acid composition is close to the “ideal protein” compared to other plant proteins.

Also, the use of plant protein isolates will have a positive effect on the cost of the product and expand the ability of consumers to choose a low-calorie analog of butter.

Since butter pastes are the products of multicomponent composition, a necessary component of consumer assessment is the biological value of protein. This indicator allows assessing the degree of satisfaction of the human body's needs for essential amino acids and it is a criterion for the development of a stabilizing composition based on a complex of milk proteins, a complex of milk proteins, and pea protein isolate.

Enrichment of butter pastes with a complex of biologically active substances of fruit and berry raw materials is always relevant.

Blueberries (*Vaccinium myrtillus L.*) deserve special attention as the source of a complex of biologically active compounds – vitamins, minerals, organic acids, dietary fiber, pectin, and tannins, etc. [25]. The effectiveness of the blueberries use is proved to improve vision, in the normalization of metabolism, in the prevention and treatment of type 2 diabetes, prevention of cancer, etc. [26].

It is proven that the most effective way of processing blueberries is freeze-drying, as a result of which a high degree of preservation (up to 95 %) of all valuable components of fresh berries is achieved [27].

Since the gathering of berries has a clear seasonality, the use of freeze-dried blueberries will compensate for this shortcoming with maximum preservation of biologically active components of the plant raw material.

The introduction of enriching components into the product's composition requires an assessment of the nutritional value of the target components and determining the degree of satisfaction of the consumer's needs in basic nutrients, biologically active substances, and energy.

3. The aim and objectives of the study

This work aims to substantiate the expediency of using protein-polysaccharide complexes based on dairy and plant proteins in the technology of butter pastes.

The set goal was solved by addressing the following problems:

- to study the amino acid composition of butter pastes stabilized by protein-polysaccharide complexes based on dairy and pea protein isolate;
- to assess the biological value of the protein component of new types of butter pastes;
- to determine the nutritional and energy value of butter pastes stabilized by protein-polysaccharide complexes with the addition of blueberry micronutrients.

4. Materials and methods to study the nutritional value of the new types of butter pastes

During the research, targeted ingredients were used able to not only perform a technological function but also serve as enriching components.

The following raw materials were used for the production of the experimental samples of butter pastes: butter in accordance with DSTU 4339:2005 “Butter. Technical specifications”; skimmed milk with a mass fraction of fat not higher than 0.05 %, acidity not higher than 21 °T, obtained by the separation of skimmed milk in accordance with DSTU 3662:2018 “Cow milk-raw material. Technical specifications”. Whey protein concentrate was obtained by the method of ultrafiltration (MPC-UF) in accordance with TU U 10.5-00419880-123:2014. The concentrate of milk proteins obtained by ultrafiltration (KMB-UF) in accordance with TU U 10.5-00419880-108:2012 with a protein content of 85 %. Stabilization system Createx DA 2100 (κ-carrageenan + potassium chloride); guar gum K1603; xanthan gum; sodium tripolyphosphate food; potassium chloride food

and also powder of blueberries of freeze-drying according to the current regulatory documents.

The technological process of production of butter pastes was performed according to the technological scheme in the following sequence (Fig. 1).

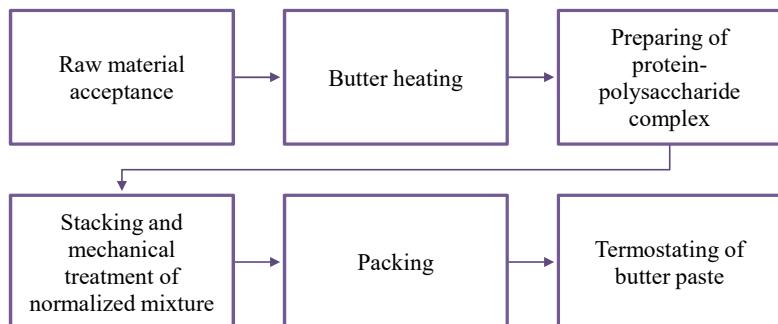


Fig. 1. Production scheme of butter pastes

Butter with a mass fat fraction of 72.5 % is used for the production of butter paste. The butter monolith is cut into pieces of 0.5–1.0 kg, heated by thermostating at a temperature of 20–24 °C until the temperature in the middle of the butter monolith reaches not less than 10–12 °C.

The process of preparation of the stabilizing composition is conducted by mixing the calculated amount of dry components with preheated skimmed milk to a temperature of 38...42 °C, after that the mixture is heated with constant stirring to a temperature of 78...82 °C. Then the mixture is cooled to 18–22 °C, filtered, and cooled to 10–12 °C.

The stabilizing composition for butter paste is prepared at a temperature of 78–82 °C at constant stirring, which leads to gelation and will give it functional and technological properties (moisture-retaining, structuring, and emulsifying abilities).

The mixture is cooled to a temperature of 10–12 °C.

The introduction of the stabilizing composition into the butter paste is carried out, for example in a melting boiler. After adding all the components, the mechanical treatment is performed for 10–14 minutes. The temperature of the mixture in the apparatus is 20–24 °C.

After processing, the butter paste is sent for packing in consumable containers. The thermostating of butter paste is made at a temperature of 0–5 °C for 24 hours. During this period, the butter paste acquires sufficient hardness, heat resistance, and retains its plastic consistency.

Qualitative composition and quantitative content of amino acids were determined using the automatic analyzer T 339 (Czech Republic). The use of an amino acid analyzer makes it possible to determine amino acids qualitatively and quantitatively [28].

The nutritional value was determined by calculating the percentage of compliance of the integrated score of each of the most important components according to daily needs.

The nutritional value was calculated per 100 g of product, the results were compared with the corresponding norms of the physiological needs of the population in basic nutrients.

The biological value of the product was determined by the presence of essential nutrients that are not synthesized in the body or synthesized in limited quantities (amino acids, polyunsaturated fatty acids, vitamins, minerals).

The value of the amino acid SCORE of each essential amino acid is determined by the formula:

$$SCORE_i = A_i / A_{ip} \cdot 100 \%, \tag{1}$$

where A_{ip} is the content of the i -th amino acid in reference protein, mg/g.

The amino acid for which SCORE is the lowest is considered to be limiting and determines the degree of protein digestibility of the product.

For the quantitative assessment of the biological value, the coefficient of divergence of the amino acid composition was determined from the formula:

$$DAAC_i = (SCORE_i - SCORE_{lim}). \tag{2}$$

$SCORE_{lim}$ is the SCORE value of limiting amino acid.

The coefficient of discrepancy of the amino acid composition is calculated from the formula:

$$CDAAC = (\sum_{i=1}^n DAAC) / n, \tag{3}$$

where n is the number of essential amino acids that were taken into consideration at calculations ($n=6$).

The indicator of biological value is calculated from the formula:

$$B_y = 100 - CDAAC, \%, \tag{4}$$

The degree of the daily requirement in each of the components ($D_n, \%$) was calculated from the formula:

$$D_r = M_{cm} / M_{fzh} \cdot 100, \tag{5}$$

where M_{cm} is the component content per 100 g of the product, g; M_{fzh} is the daily requirement of the body in each of the component, g.

The calculation of amino acid score, chemical composition, and nutritional value [29] was carried out for butter pastes with a mass fraction of fat of 40 % by the formulations given in Table 1.

Table 1

Butter paste formulations with a mass fat fraction of 40 %

| No. of entry | Component title | Component weight, kg | | |
|--------------|---------------------------|----------------------|---------|---------|
| | | Formulation, No. | | |
| | | 1 | 2 | 3 |
| 1 | Butter, m. f. f. – 72.5 % | 551.72 | 551.72 | 551.72 |
| 2 | Skimmed milk | 384.00 | 378.66 | 354.16 |
| 3 | CMPC-UF | 44.82 | 39.45 | 43.86 |
| 4 | Plant protein isolate | – | 11.21 | – |
| 5 | MPC-UF | 13.43 | 13.43 | 13.02 |
| 6 | κ-carrageenan | 0.22 | 0.22 | 0.208 |
| 7 | Guar gum | 1.35 | 1.35 | 1.25 |
| 8 | Sodium tripolyphosphate | 4.45 | 3.95 | 4.17 |
| 9 | Potassium chloride | 0.01 | 0.01 | 0.008 |
| 10 | Dry powder of blueberries | – | – | 31.6 |
| | Total | 1,000.0 | 1,000.0 | 1,000.0 |

5. Results of studying the nutritional value of butter pastes

5.1. Results of studying the amino acid composition of butter pastes

The protein content of the new types of butter pastes was determined, which was 5.2 % for butter paste stabilized with milk protein, 5.5 % for butter paste stabilized with milk protein with the addition of micronutrients of blueberries (Table 2). Because dried crushed blueberries contain protein compounds, the protein content of butter paste with blueberry micronutrients is slightly higher. The protein content of butter paste, stabilized by a complex of dairy and plant protein isolate is 6.1 %.

The amino acid composition was studied, the amino acid score was calculated and the biological value of new types of butter pastes was assessed (Table 3).

The limiting amino acid for butter pastes is valine, which is explained by the peculiarities of the amino acid composition of the protein-polysaccharide complex. Moreover, the highest SCORE of the limited amino acid is observed in the butter paste stabilized by the protein-polysaccharide complex based on milk protein, that is, 74.4 %, whereas in the butter paste stabilized by the protein-polysaccharide complex based on milk and plant protein isolate, this indicator was 64.2 %.

At the same time, the coefficient of the deficiency of amino acid composition for butter paste stabilized by protein-polysaccharide complex based on dairy and plant protein isolate was slightly lower, by 1.4 %.

Therefore, for the sample of butter paste, the stabilization complex of which includes a pea protein isolate, the biological value is 1.5 % higher.

Table 2

Amino acid composition of butter pastes stabilized by milk-polysaccharide complexes based on dairy and pea protein isolate

| No. | Amino acid name | Amino acid content, mg/g of protein | | |
|-------------------------------------|--------------------------|-------------------------------------|---|--------------------------------------|
| | | butter paste enriched with | | |
| | | milk protein | milk protein and blueberry micronutrients | milk protein and pea protein isolate |
| Essential amino acids | | | | |
| 1 | Valine | 37.2 | 34.9 | 32.1 |
| 2 | Leucine | 91.2 | 89.4 | 87.7 |
| 3 | Isoleucine | 40.6 | 38.4 | 35.3 |
| 4 | Lysine | 79.1 | 75.9 | 76.5 |
| 5 | Methionine | 24.6 | 21.9 | 17.1 |
| 6 | Threonine | 41.9 | 42.4 | 39.3 |
| 7 | Phenylalanine | 45.6 | 46.9 | 49.1 |
| Conditionally essential amino acids | | | | |
| 8 | Arginine | 53.1 | 48.9 | 61.3 |
| 9 | Histidine | 26.8 | 28.4 | 29.1 |
| 10 | Tyrosine | 52.1 | 44.7 | 45.2 |
| Non-essential amino acids | | | | |
| 11 | Alanine | 28.8 | 31.2 | 36.6 |
| 12 | Aspartic acid | 76.8 | 85.7 | 97.5 |
| 13 | Glycine | 16.8 | 19.6 | 27.2 |
| 14 | Glutamic acid | 218.5 | 228.3 | 220.7 |
| 15 | Proline | 91.4 | 89.8 | 69.9 |
| 16 | Serine | 50.6 | 53.1 | 54.8 |
| 17 | Cystine | 25.0 | 20.5 | 20.5 |
| | Total | 1,000.00 | 1,000.00 | 1,000.00 |
| | Protein mass fraction, % | 5.2 | 5.5 | 6.1 |

5.2. Results of the comparative assessment of the biological value of the protein component of the new types of butter pastes

The comparative assessment of the amino acid SCORE and the biological value of the new types of butter pastes is given in Table 3.

Table 3

Comparative assessment of the amino acid SCORE and biological value of new types of butter pastes

| Essential amino acid | The "ideal protein" by FAO/WHO | Butter paste enriched with | | | | | | | | |
|------------------------|--------------------------------|----------------------------------|----------|---------|--|----------|---------|--|----------|---------|
| | | milk protein (formulation No. 1) | | | milk protein and plant protein isolate (formulation No. 2) | | | milk protein and blueberry micronutrients(formulation No. 3) | | |
| | | mg/1 g of protein | SCORE, % | DAAC, % | mg/1 g of protein | SCORE, % | DAAC, % | mg/1 g of protein | SCORE, % | DAAC, % |
| Valine | 50 | 37.2 | 74.4 | 0 | 32.1 | 64.2 | 0 | 34.9 | 69.8 | 0 |
| Leucine | 70 | 91.1 | 130.1 | 55.7 | 87.7 | 125.3 | 61.1 | 89.4 | 127.7 | 57.9 |
| Isoleucine | 40 | 40.6 | 101.5 | 27.1 | 35.3 | 88.3 | 24.1 | 38.4 | 96.0 | 26.2 |
| Lysine | 55 | 79.1 | 143.8 | 69.4 | 76.5 | 139.1 | 74.9 | 75.9 | 138.0 | 68.2 |
| Methionine+cystine | 35 | 24.6+25.0 | 141.7 | 67.3 | 17.1+20.5 | 107.4 | 43.2 | 21.9+20.5 | 121.1 | 51.3 |
| Threonine | 40 | 41.9 | 104.8 | 30.4 | 39.3 | 98.0 | 33.8 | 42.4 | 106.0 | 36.2 |
| Phenylalanine+tyrosine | 60 | 45.6+52.1 | 162.8 | 88.4 | 49.1+45.2 | 157.2 | 93.0 | 46.9+44.7 | 152.7 | 82.9 |
| DAAC Σ, % | – | – | – | 338.3 | – | – | 330.1 | – | – | 332.7 |
| CDAAC, % | – | – | – | 56.4 | – | – | 55.0 | – | – | 53.8 |
| BV, % | – | – | – | 43.6 | – | – | 45.0 | – | – | 46.2 |

5.3. The results of studying the nutritional and energy value of butter pastes

The calculation of the chemical composition and nutritional value of butter pastes according to the content of essential nutrients is given in Table 4.

Table 4

Chemical composition and nutritional value of butter pastes

| Nutritional substance | Nutritional substance content per 100 g of butter pastes | | |
|--------------------------|--|-------|-------|
| | Formulation No. | | |
| | 1 | 2 | 3 |
| protein | 5.2 | 6.1 | 5.5 |
| fat | 40.0 | 40.0 | 40.0 |
| carbohydrates | 3.1 | 3.2 | 5.4 |
| moisture | 49.2 | 48.9 | 46.5 |
| mineral substance, mg | | | |
| Na | 86.9 | 85.2 | 85.1 |
| K | 144.1 | 146.5 | 140.4 |
| Ca | 115.4 | 111.1 | 111.0 |
| Mg | 15.3 | 15.7 | 14.9 |
| Fe | 0.4 | 0.5 | 0.6 |
| vitamin, mg | | | |
| A | 0.2 | 0.2 | 0.2 |
| C | 0.8 | 0.8 | 1.0 |
| B1 | 0.1 | 0.1 | 0.1 |
| B2 | 0.8 | 0.8 | 0.7 |
| PP | 0.1 | 0.1 | 0.1 |
| phenolic compound | | | |
| rutin | – | 1.2 | 6.7 |
| tannin | – | 0.5 | 3.4 |
| catechin | – | 0.7 | 3.8 |
| Energy value, kcal/100 g | 407.0 | 401.4 | 407.4 |

Butter contains such important mineral elements as calcium, sodium, magnesium, potassium, iron. Therefore, the combination of a fat-containing base with milk, plant proteins together with blueberry micronutrients allows enriching the product with basic minerals.

This combination will also enrich the product with vitamins A, C, group B up to 1 %. The addition of plant ingredients to butter pastes will serve as a source of biologically active substances with P-vitamin activity and tannin, which are predicted to slow down the conversion of constituent products during storage.

The calculation of the energy value indicates that the caloric content of butter-based butter pastes is in the range of 401–408 kcal/100 g. Thus, the daily requirement for butter paste is 40...45 g.

It is determined that when using 10 g of butter paste, the degree of daily needs of the human body in protein is up to 1.2 %; in fats – up to 5.9 % (Table 5).

blueberries into butter paste allows enriching the product with a complex of micronutrients. When using a small amount of product – 10 g, the degree of satisfaction of calcium needs is about 1 %, iron – 0.3...0.5 %.

Butter is rich in vitamins, including A, B₁, and B₂. The presence of water-soluble vitamins of group B is associated with the use of dairy ingredients in formulations, as well as blueberries.

Table 5

Degree of providing with the daily requirement of the basic nutrient substances using 10 g of butter paste

| Nutritional substance | Daily requirement | Degree of providing the daily requirement, % | | |
|-----------------------|-------------------|--|------|------|
| | | Formulation No. | | |
| | | 1 | 2 | 3 |
| protein | 67 g | 1.2 | 1.0 | 0.9 |
| fat | 68 g | 5.9 | 5.9 | 5.9 |
| carbohydrates | 392 g | 0.08 | 0.08 | 0.1 |
| mineral substances | | | | |
| Na | 4,000 mg | 0.2 | 0.2 | 0.2 |
| K | 2,500 mg | 0.6 | 0.6 | 0.6 |
| Ca | 1,200 mg | 1.0 | 1.0 | 1.0 |
| Mg | 400 mg | 0.4 | 0.4 | 0.4 |
| Fe | 15 mg | 0.3 | 0.3 | 0.4 |
| vitamins | | | | |
| A | 1.0 mg | 2.4 | 2.4 | 2.4 |
| C | 80.0 mg | 0.1 | 0.1 | 0.1 |
| B ₁ | 1.6 mg | 1.0 | 1.0 | 1.0 |
| B ₂ | 2.0 mg | 3.9 | 3.8 | 3.6 |
| PP | 16 mg | 0.07 | 0.07 | 0.07 |
| phenolic compounds | | | | |
| rutin | 30.0 mg | – | 0.4 | 2.2 |
| tannin | 200.0 mg | – | 0.2 | 0.2 |
| catechin | 100.0 mg | – | 0.07 | 0.4 |

It is determined that the introduction of dry powder of The degree of the daily requirement for vitamins is vitamin B₁ – up to 1.0 %, vitamin B₂ – up to 3.8 %. The introduction of pea protein isolate and dry powder of blueberries into the formulations of butter pastes provides a daily requirement of rutin – up to 2.6 %, and catechins – up to 0.5 %.

6. Discussion of obtained results of using the protein-polysaccharide complexes in the technology of butter pastes

The new types of butter pastes are characterized by high protein content (due to complexes based on milk proteins, milk proteins, and pea protein isolate) and enriched with micronutrients of blueberries. Such products differ favorably from analogs and are predicted to be products of high nutritional value.

Since butter pastes are positioned as butter low-fat analogs, the target component in their composition is milk fat, while new types of butter pastes are additionally enriched with a protein component – up to 6.1 % (Table 2). In butter, the protein content is much lower and ranges from 0.5 to 0.9 %. The ratio of protein: fat of new types of butter pastes is in the range from 1: 6.5 to 1: 8, which significantly increases the nutritional value of the product.

The protein of the stabilizing complexes of butter pastes is characterized by a fairly balanced amino acid composition due to the use of biologically valuable milk proteins and pea protein isolate, which is characterized by a balanced amino acid composition among other plant proteins (Table 3). The value of the coefficient of divergence of the amino acid com-

position of the protein of new types of butter pastes is in the range of 14.2...18.7 %.

The use of protein-polysaccharide complex in the technology of butter pastes allows reducing the caloric content of the product by 2...3 % by excluding skimmed milk powder, which is a component of most formulations for butter pastes [3, 5, 6].

The introduction of freeze-dried blueberries in the amount of 3 % allows enriching the products with a complex of biologically active compounds and does not require additional sugar and favorably distinguishes new products from analogs [3, 5–7].

Enrichment of butter paste with blueberry micronutrients will increase the biological value of protein by 2.5 % and the use of pea protein isolate – by 1.5 %. This can be explained by the partial compensation of the difference in amino acid composition due to plant protein.

As revealed by the analysis of data given in Table 4, the introduction of dry powder of blueberries and pea protein isolate allows enriching the product with a complex of biologically active and mineral substances. Thus, when consuming products within the rational norms (10 g) the degree of meeting the human body's needs in calcium is about 1 %, iron – 0.3... 0.5 %, vitamins B₁ – up to 1.0 %, B₂ – up to 3.8 %, rutin – up to 2.6 % and catechins – up to 0.5 % (Table 5).

The analysis of research results showed that the development of protein-polysaccharide complexes to stabilize the structure of butter pastes allows not only achieving a technological effect but also enriching the product with complete protein and increase the nutritional value of products. The introduction of blueberry micronutrients to the composition of butter pastes allows further enriching the complex of nutritious and biologically valuable ingredients.

Thus, the improvement of butter paste technology by the enrichment with a complex of biologically valuable and

technologically effective macro- and micronutrients is a promising area of research and needs further development.

7. Conclusions

1. Based on the analysis of the amino acid composition of the new types of butter pastes, it was found that the limiting amino acid is valine, which can be explained by the peculiarities of the protein-polysaccharide complex.

2. It was found that the introduction of blueberry micronutrients in the butter paste slightly increases the biological value of protein – by 2.5 %, the use of pea protein isolate – by 1.5 %, due to the partial compensation of deficient amino acids due to plant components.

3. The use of protein-polysaccharide complexes in the technology of butter pastes allows reducing the caloric content of products by 2...3 %, and increasing the nutritional value by increasing the protein content up to 8.2 %. The introduction of dry powder of blueberries and pea protein isolate allows enriching the product with a complex of biologically active and mineral compounds. The degree of meeting the daily requirement when using 10 g of the product is in calcium – on average by 1.0 %, potassium – 0.6 %, iron 0.3...0.6 %, rutin – by 2.6 %.

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