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Development of Technology for a Creamy Dessert Bioproduct for Healthy Nutrition with Functional Ingredients

ABSTRACT

Relevance. The article provides a detailed analysis of scientific research related to the development of technology for a creamy dessert bioproduct for healthy nutrition based on dairy and vegetable raw materials.

Methods. A biologically active component in the form of berry syrups, which are a valuable source of vitamins, minerals, dietary fibers, organic acids, phenolic compounds and other substances capable of having a healing effect on the human body, has been scientifically substantiated and developed as a source of biologically active components for enriching creamy bioproducts.

Results. It is proved that the use of berry syrups obtained on the basis of wild plant raw materials of the Siberian region of Russia in the technology of dessert bioproduct significantly improves its flavor properties, chemical composition, nutritional and biological value. In addition to berry syrups, in order to enrich the creamy dessert product with functional food ingredients, a binary starter culture containing probiotic microorganisms in immobilized form, iron lactate, ascorbic acid, and dry milk whey were used. These components of functional nutrition play an important role in improving metabolism, normalizing the state of the internal environment of the body, increasing its resistance to harmful environmental influences. The objects of research, the main of which are cream, are described, standard organoleptic, physico-chemical, microbiological and biological research methods using modern devices are applied, mathematical and statistical methods of analyzing experimental data were used. A detailed description of the production technology of berry syrups is presented, the technological parameters of these operations are given in order to maximize the extraction of biologically active substances from plant raw materials. At the final stage of scientific research, the technology of production of creamy dessert bioproduct is presented, the expediency of using biologically active components in its production is justified, quality indicators, nutritional and biological values, storage capacity and shelf life of the new bioproduct are given.

Key words: berry syrup, creamy dessert bioproduct, biologically active agent, probiotic microorganisms

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Разработка технологии сливочного десертного биопродукта здорового питания с функциональными ингредиентами

РЕЗЮМЕ

Актуальность. В статье проведен подробный анализ научных исследований, связанных с разработкой технологии сливочного десертного биопродукта для здорового питания на основе молочного и растительного сырья.

Методы. В качестве источника биологически активных компонентов для обогащения сливочного биопродукта был научно обоснован и разработан биологически активный компонент в виде ягодных сиропов, которые являются ценным источником витаминов, минеральных веществ, пищевых волокон, органических кислот, фенольных соединений и других веществ, способных оказывать оздоровительный эффект на организм человека.

Результаты. Доказано, что применение ягодных сиропов, полученных на основе дикорастущего растительного сырья Сибирского региона России в технологии десертного биопродукта, существенно улучшает его вкусоароматические свойства, химический состав, пищевую и биологическую ценность. Помимо ягодных сиропов, с целью обогащения сливочного десертного продукта функциональными пищевыми ингредиентами использовались бинарная закваска, содержащая пробиотические микроорганизмы в иммобилизованном виде, лактат железа, аскорбиновая кислота, сыворотка молочная сухая. Эти компоненты функционального питания играют важную роль в улучшении обмена веществ, нормализации состояния внутренней среды организма, повышении его сопротивляемости к вредным воздействиям окружающей среды. Описаны объекты исследований, основными из которых являются сливки, применены стандартные органолептические, физико-химические, микробиологические и биологические методы исследований с использованием современных приборов, применялись математико-статистические методы анализа экспериментальных данных. Представлено подробное описание технологии производства ягодных сиропов, приведены технологические параметры данных операций с целью максимального извлечения биологически активных веществ из растительного сырья. На заключительном этапе научных исследований представлена технология производства сливочного десертного биопродукта, обоснована целесообразность использования биологически активных компонентов при его производстве, приведены показатели качества, пищевой и биологической ценности, хранимоспособность и сроки годности нового биопродукта.

Ключевые слова: ягодный сироп, сливочный десертный биопродукт, биологически активный компонент, пробиотические микроорганизмы

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Introduction/Введение

In the current context, both in Russia and in most European countries, in the presence of adverse factors, which increase the risk of human morbidity[1], considerable attention is paid to the creation and consumption of targeted products[2] that have the ability to stimulate the human immune system and are used to treat and prevent diseases [1–4].

A number of legislative documents and projects[3, 4] aimed at improving the quality of life of the country's population, including by adjusting nutrition and expanding the production of healthy, functional[5] and specialized products[6], have been developed; development of technological independence of the food industry by increasing the competitiveness of domestic food products with the aim of import substitution and increasing the volume of its exports [5–8].

An advanced research direction as noted by both Russian and foreign scientists, is the development and production of dessert products for healthy nutrition based on dairy and vegetable raw materials [9–15].

National and foreign scientists, as well as manufacturers of dairy products, carry out dynamic scientific work related to the development of new technologies and recipes of dairy desserts, search for additional sources of non-traditional raw materials, nutrient additives, biologically active substances obtained as a result of enzymatic bioconversion of raw materials of vegetable and animal origin [16–20].

The main directions of research are related to the development of desserts, which not only contain all the nutrients necessary for the body, have a pleasant taste and texture, convenient and beautiful packaging, but also have a positive effect on human health [19–21].

According to the global trends, modern dairy desserts should have the following characteristics: increased nutritional and biological value; reduced energy value; anti-infective properties; immunomodulatory effect; radioprotective properties; hypoallergic properties; antioxidant properties; functional and technological properties [10, 12, 22].

In connection with the above, the goal of research has been determined is to develop biotechnology of a dessert product for healthy nutrition based on dairy raw materials and wild berries of the Siberian Region of Russia.

Materials and methods /
Материалы и методы исследования

In experimental studies, modern standard methods and instruments, that have been tested, are used (2022–2023, Omsk State Agrarian University named after P.A. Stolypin, Omsk, Russia).

Prime subjects for scientific research: cream as raw materials, mass fraction of fat 10, acidity of not more than 6.60 pH, according to GOST 34355[7]; whey powder according to GOST 33958[8]; bacterial concentrate — ALTAY S-Bifi, according to TU 9229-003-43704355-2003[9]; bacterial starter culture Lactobacillus bulgaricus (BSC-LB), according to TU 9229-369-00419785-2004[10]; iron supplements ferrous lactate, according to the Sanitary Regulations and Norms 2.3.2.1293-03[11]; cranberries according to GOST 33309[12]; blackberries according to GOST 33915[13]; blueberries according to GOST 34219[14], as well as excipient feedstock and materials.

The experiments were repeated five times. The processing of experimental data was carried out by methods of mathematical and analytical analysis with the usage of the software product Statistica 6.1. (USA) The reliability of the results was determined with the usage of the Cochran's Test.

Results and discussion / Результаты и обсуждение

Wild-growing raw materials for the production of a biologically active agent were selected according to the following quality indicators: appearance, flavor, colour, aroma, degree of maturity, presence of impurities.

The studied chemical composition of wild berries, cranberries, blackberries and blueberries of the Omsk Region (RU), is presented in Table 1.

In response to the data presented in Table 1, it is obvious that the pulp of wild berries of the northern regions of the

Table 1. **Chemical Composition of Wild Berries of the Omsk Region**

Indicators	Name of berries		
	cranberry	blackberry	blueberry
Mass fraction of moisture, %	88.9	88.0	86.0
Mass fraction of carbohydrates, % including			
total sugar	5.3	4.4	7.6
sucrose	0.1	–	0.2
Pectin substances	0.7	0.5	0.4
polyols	0.5	–	–
fibre	2.0	4.0	1.6
Titratable acidity, %	3.1	2.0	1.2
Ascorbic acid, mg / 100 g	28.0	26.0	23.0
Biologically active flavonoids, mg / 100 g, including			
anthocyanins	740.0	–	1,420.0
catechins	140.0	230.0	170.0
leucoanthocyanins	–	–	1,198.0
Content of *B* vitamins in wild berries, mg / 100 g			
Thiamine (B_1)	0.02	0.01	0.01
Ribofolacine (B_2)	0.02	0.05	0.02
Folacin (B_9)	0.03	–	0.03
Niacin (B_3)	0.15	–	0.30
The content of fat-soluble vitamins in wild berries mg / 100 g			
-carotene (provitamin *A*)	0.05	0.50	0.12
phylloquinone (K_1)	0.90	0.50	0.40
tocopherol (*E*)	–	0.02	–
Macronutrient content, mg/kg			
potassium	119.00	208.00	51.00
sodium	13.80	21.00	33.60
calcium	14.20	–	20.80
magnesium	15.00	–	10.30
phosphorus	11.00	32.00	33.90
Ash, %	0.30	0.70	0.40

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[7] GOST 34355-2017 Cream raw material. Technical conditions.
[8] GOST 33958-2016 Dry whey. Technical conditions.
[9] TU 9229-003-43704355-03 Lyophilized concentrates of lactic acid bacteria and bifidobacteria (BK-ALTAI-SBifi, BK-ALTAI-LSBifi).
[10] TU 9229-369-00419785-04 Starters, bacterial concentrates, yeast and test cultures.
[11] URL: https://meganorm.ru/Data2/1/4293834/4293834154.htm?ysclid=ly8isfvhfc489359586
[12] GOST 33309-2015 Fresh cranberries. Technical conditions.
[13] GOST 33915-2016 Fresh raspberries and blackberries. Technical conditions.
[14] GOST 34219-2017 Fresh blueberries and bilberries. Specifications.

Omsk Region is a source of sugars, fibre, biologically active flavonoids, vitamins and minerals, which makes it a valuable raw material in the production of dairy products for functional nutrition in the form of concentrated syrups [9].

The quality of wild berries syrups largely depends on the method of pressing wild berries, the temperature and duration of heating sugar or sorbitol syrup during its manufacture.

The berry raw material prepared for pressing was sent to the loading hopper and then to the conical rotating auger. As the berries moved along the axis of rotation of the auger, they were compressed and the liquid phase separated from the dense one.

Experimental data on the yield of juice and the resulting raw materials, depending on the mesh size (Table 2).

As a result, it was found that the most optimal mesh size when pressing blueberries is 2.5 mm, cranberries and blackberries — 2.0 mm. The selected mesh size allows you to juice out of the berries as much as possible and ensures the uninterrupted operations of the juicer.

After obtaining the juice, the septum from their production was concentrated to the mass fraction of moisture (13.0 ± 0.5)%. For a more complete extraction of useful substances, the obtaining septum was poured with hot water of temperature of 95–100 °C and infused for 2 hours. The amount of water and septum in the infusions varied: 1:3, 1:5 and 1:8. To assess the quality of infusions from the septum of wild berries, the content of dry soluble substances and organoleptic characteristics were taken into account (Table 3).

At the same time, it is noted that infusions with dry solids content (4.0 ± 0.5) are characterized by the best organoleptic characteristics. However, in order to improve the taste and aroma properties and increase the biological value in the production of syrups from wild berries, it is desirable to use a berry infusion with a mass fraction of dry solids not more than 7.0%.

As can be seen from table 3, the hydromodule for obtaining an infusion with a dry solids content of (4.5 ± 0.2)% was 1:5 (septum:water). This dry solid content is acceptable for obtaining syrups with sufficiently high organoleptic and physicochemical characteristics. The percentage of dry solids in the syrup can be increased by using the previously obtained infusion from the septum and wild berry juice instead of water.

It is known that high sugar concentration guarantees product safety, so the preparation of syrups from wild plants can be done with sugar or with its substitute, sorbitol. The addition of sorbitol-dextrose syrup as a sweetening component into the composition for obtaining a biological product makes it possible to use it for nutrition of persons suffering from diabetes mellitus, that gives the product a preventive effect and improves its organoleptic characteristics.

After the preparation of sugar or sorbitol-dextrose syrup, they were mixed with berry juice and sent to a vacuum evaporator with a vacuum of 0.001 MPa and a solution circulation rate of 1.0–1.5 m/s, which makes it possible to obtain berry syrups with a high biological value and long shelf life. The dry solids content of wild berry syrups ranges from 73 to 74%.

After preparation, the berry syrups are cooled to the temperature of addition to the dessert product (38 ± 2) °C, or to the temperature (4 ± 2) °C, packed and sent to the refrigerating chamber for intermediate storage. The shelf life of the biologically active agent is 5 days at a temperature of (4 ± 2) °C.

In addition to a new type of biologically active agent, a source of vitamins, minerals, organic acids, nitrogenous and tannins, bioflavonoids, pectins and other substances with a pronounced pharmacological effect, a binary starter culture containing immobilized probiotic cultures ALTAI S-Bifi which is a concentrate of lactic acid bacteria (*Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. diacetilactis, Streptococcus thermophilus*) and bifidus bacteria (*Bifidobacterium bifidum* or *Bifidobacterium longum*) was used.

Also, ferrous lactate, ascorbic acid (vitamin C) and a source of essential amino acids (whey powder) were included in the recipe of the new product to increase its biological value and healing effect (Table 4).

Organoleptic, physicochemical and physicochemical characteristics of the creamy dessert bioproduct are stated in the Tables 5 and 6.

The concept of biological value is more specific than the concept of nutritional value and reflects the quality of nutrients associated with their digestibility, and for proteins — with a degree of balanced amino acid

Table 2. **Yield of Juice and Secondary Raw Materials, Depending on the Mesh Size**

Mesh Size, mm	Blackberry		Cranberry		Blueberry	
	juice, %	septum, %	juice, %	septum, %	juice, %	septum, %
2.0	63.84	36.16	58.64	41.36	50.45	49.55
2.5	60.42	39.58	56.66	43.34	47.56	52.44
3.0	58.66	41.34	53.88	46.12	43.84	56.16

Table 3. **Organoleptic Characteristics of Infusions from the Septum from Wild Berries**

Proportion Septum:water	Mass fraction of dry solids, %	Infusion colour	Flavor and aroma
1:3	5.0–6.0	Intense, dark coloured	Pronounced flavor and aroma that are characteristic of a wild berry
1:5	3.7–4.5	Coloured enough	
1:8	3.1–3.3	Light, soft	Weak aroma, unexpressed flavor

Table 4. **Cream Dessert Bioproduct Recipe**

Name of raw materials	Raw materials consumption for the production of 1000 kg of creamy dessert bioproduct		
	cranberry	blackberry	blueberry
Cream with mass fraction of fat 10%	749.65	749.65	749.65
Whey powder	30.00	30.00	30.00
Starter culture	50.00	50.00	50.00
Ferrous lactate	0.15	0.15	0.15
Ascorbic acid	0.20	0.20	0.20
Syrups from:			
cranberry	170.00	–	–
blackberry	–	170.00	-
blueberry	–	–	170.00
Yield	1000.00	1000.00	1000.00

Table 5. **Organoleptic Characteristics of the Dairy Dessert**

Characteristic	Type of bioproduct		
	cranberry	blackberry	blueberry
Appearance and consistency	The surface of the product is smooth, glossy; the consistency is homogeneous, fine, non-fluid, sticky (jelly-like), the addition of filler is allowed.		
Flavor and aroma	Pure fermented milk, moderately sweet, with a flavor of added berries		
Colour	Delicate shade of pink, uniform throughout the mass	Pink, rich, uniform throughout the mass	Pink, rich, uniform throughout the mass

composition. The biological value of proteins in nutrients depends on the ratio of essential amino acids in them, that cannot be synthesized in the human body and must enter the human body from the outside, that is, only with food.

Protein quality indicators are associated with the assessment of the amino acid composition of the product. Table 7 shows the indicators of the amino acid composition of new bioproducts.

It should be noted that the biological value of products is characterized not only by the amino acid composition of proteins, but also by the value of the amino acid rate of essential amino acids.

The composition of essential amino acids and amino-acid score of new types of bioproducts are presented in Table 8.

Comparative analysis of the data reflected in Table 8 shows that the developed cream dessert bioproducts do not contain limiting amino acids, which indicates the biological value of the new products.

Vitamins and vitamin complexes are necessary for normal human activity. Many of such organic compounds are involved in metabolism, have antioxidant properties, and play an important role in the regulation of certain physiological processes.

Table 9 shows the content of vitamins

Table 10 shows the content of minerals in cream dessert bioproducts.

Minerals are also among the essential food factors. Minerals have no caloric content, but are necessary for various physiological processes in the human body.

By experimental way, we have determined the nutritional value and caloric content of creamy dessert bioproducts (Table 11).

As a result of the discussion of the analytical data obtained by the experimental way, the recipes and biotechnological parameters for production of creamy fermented dessert products for healthy nutrition have been developed.

Table 6. **Physicochemical and Physicochemical Characteristics of the Creamy Dessert Bioproduct**

Characteristic	Type of bioproduct		
	cranberry	blackberry	blueberry
Mass fraction of fat, %, not less than	7.58 ± 0.2	7.60 ± 0.2	7.61 ± 0.2
Mass fraction of protein, %	2.50 ± 0.2	2.56 ± 0.2	2.54 ± 0.2
Mass fraction of carbohydrates, %	13.04 ± 0.1	13.09 ± 0.1	13.31 ± 0.1
Dry solids content, %, not less than	24.77 ± 0.1	24.95 ± 0.1	25.13 ± 0.1
Ash, %	0.73 ± 0.3	0.76 ± 0.3	0.74 ± 0.3
Ascorbic acid (C)	22.5	22.5	21.84
Fe (iron)	4.13	4.16	4.14
Active acidity, pH	4.65–4.55 pH	4.65–4.77 pH	4.68–4.77 pH
Titratable acidity, °T	65–70	60–65	60–63
Temperature when leaving the factory, °C, not higher	6	6	6
Total number of mesophilic aerobic and facultative anaerobic microorganisms (MAFAM)	$6.6 \cdot 10^8$–$7.2 \cdot 10^8$	$7.0 \cdot 10^8$–$7.8 \cdot 10^8$	$6.4 \cdot 10^8$–$7.1 \cdot 10^8$

Table 7. **Amino Acid Composition of Cream Dessert Bioproducts, mg / 100 g of the Product**

Amino Acid	Type of bioproduct		
	cranberry	blackberry	blueberry
Essential:	1,199	1,224	1,206
valine	187	186	188
isoleucine	168	169	170
leucine	265	270	267
lysine	208	208	210
methionine	67	76	67
threonine	128	135	127
tryptophan	39	40	40
phenyl alanine	136	139	137
Partially non-essential:	181	185	178
arginine	107	110	103
histidine	74	75	75
Non-essential:	1,120	1,153	1,157
alanine	58	63	66
aspartic acid	133	124	132
glycine	47	45	44
glutamic acid	468	467	463
proline	216	244	243
serine	98	110	106
tyrosine	83	82	87
cysteine	17	18	16
Total number of amino acids	2,500	2,562.0	2,541.0

Table 8. **Amino-Acid Score of New Types of Bioproducts**

Amino acids	FAO/WHO reference scale		Type of bioproduct					
			cranberry		blackberry		blueberry	
	C	A	C	A	C	A	C	A
Valine	50	100	74.8	149.6	72.6	145.2	73.9	147.8
Isoleucine	40	100	67.3	168.2	66.0	164.9	66.9	167.2
Lysine	55	100	83.3	151.5	81.1	147.4	82.8	150.5
Methionine + cysteine	35	100	36.2	103.4	38.9	111.1	35.3	100.8
Leucine	70	100	106.1	151.5	105.6	150.8	105.2	150.3
Tryptophan	10	100	15.7	157.0	15.8	158	15.6	156.0
Threonine	40	100	51.39	128.4	52.9	132.3	50.1	125.2
Phenyl alanine + tyrosine	60	100	111.9	186.5	114.0	190	111	185.0

Note: C — amino acid content in mg / 1 g of product protein; A — amino-acid score, % relative to the FAO/WHO reference scale.

Table 9. **Content of Vitamins in Cream Dessert Bioproducts**

Vitamins, mg / 100 g	Type of bioproduct		
	cranberry	blackberry	blueberry
Vitamin B_1 (thiamin)	0.03	0.03	0.03
Vitamin B_2 (riboflavin)	0.12	0.12	0.12
Vitamin B_5 (pantothenic acid)	0.013	0.025	0.015
Vitamin B_6 (pyridoxine)	0.009	0.005	0.009
Vitamin *C* (ascorbic acid)	22.5	22.5	21.84
Vitamin *PP* (niacin)	0.27	0.28	0.23
Tocopherol equivalent (vitamin *E* equivalent)	0.30	0.31	0.32
b-carotene (provitamin *A*)	0.09	0.03	0.03

Table 10. **Content of Minerals in Cream Dessert Bioproducts**

Minerals, mg / 100 g	Type of bioproduct		
	cranberry	blackberry	blueberry
Na (sodium)	55.6	57.1	56.1
K (potassium)	147.0	153.2	142.2
Ca (calcium)	102.9	104.1	103.1
Mg (magnesium)	13.5	14.5	12.9
P (phosphorus)	102.4	103.9	102.6
Fe (iron)	4.1	4.1	4.1

Table 11. **Caloric Content of Cream Dessert Bioproducts**

Type of bioproduct	Mass fraction, %				Caloric content, kcal
	fats	proteins	carbohydrates	ash	
Cranberry	7.58 ± 0.2	2.50 ± 0.2	13.04 ± 0.1	0.73 ± 0.3	127.03
Blackberry	7.60 ± 0.2	2.56 ± 0.2	13.09 ± 0.1	0.76 ± 0.3	127.63
Blueberry	7.61 ± 0.2	2.54 ± 0.2	13.31 ± 0.1	0.74 ± 0.3	128.47

Milk intended for the production of a product is cleaned from mechanical impurities, heated to a temperature of (43 ± 2) °C and separated to obtain cream with a mass fraction of fat 10%, into which whey powder is added with stirring until the dry solids content in the standardized mixture is not less than 16.4% and mass fraction of fat 7.6%. Then the obtaining normalized mixture is stirred for 10–15 minutes and heated to a temperature of (6–70) °C, homogenized at a pressure of (18 ± 2) MPa for 3–5 seconds, pasteurized at a temperature of (90 ± 3) °C with holding for 50–60 seconds. The pasteurized cream mixture is cooled to the fermentation temperature (39 ± 1) °C.

A starter culture containing bifidobacteria, lactic acid streptococci and lactic acid bacteria in an amount of 5% of the weight of the fermented normalized mixture is added into the cooled normalized mixture. The mixture with the starter culture is stirred for 10–15 minutes and left for 3.5–4.0 hours until the titratable acidity increases within 4.65–4.77 pH.

Then, pre-prepared and cooled to a temperature of 38–40 °C berry syrup and pre-prepared solutions of ferrous lactate and ascorbic acid are added into the normalized mixture fermented at a temperature of 38–40 °C.

The final product is packed at a temperature of 38–40 °C into polystyrene cups weighing 125 g. The packaged product is sent to the refrigerating chamber for additional cooling to a temperature of (4 ± 2) ° C and thermostating for 2.0–3.0 h, while the formation of the product structure is in progress.

The creamy dessert bioproduct is recommended both as standard foods and for people suffering from diabetes mellitus and atherosclerosis. The possibility of consume this product by people suffering from diabetes mellitus is achieved mainly due to the use of a sugar substitute, sorbitol, and the usage of cream with mass fraction of fat 10% provides the human body with a sufficient amount of lecithin, which is involved in the normalization of cholesterol balance.

The new bioproducts are completely balanced in their chemical composition, have high nutritional value, probiotic properties, preventive effect, organoleptic characteristics and reduced cost price.

Conclusions/Выводы

The above analytical and experimental results indicate that the goal set in the scientific and experimental work has been achieved: a biologically active agent based on wild berry raw materials of the Siberian Region of Russia in the form of berry syrups has been developed; recipe and biotechnological parameters for production of a new type of creamy dessert bioproduct enriched functional ingredients, thanks to which it can be classified as a healthy food product, have been developed.

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