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FUNCTIONAL FERMENTED MILK DESSERTS BASED ON ACID WHEY

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Abstract: Given the shortage of raw milk, the problem of the rational use of whey as a source of biologically valuable milk components for functional products is urgent. The area of research is the use of acid demineralized whey for the production of functional fermented desserts. Acid whey is characterized by a high content of lactic acid and minerals, which makes its industrial processing difficult and limits the directions of use for food purposes. To solve these problems, the membrane methods area used, they allow regulating the composition and properties of raw materials. Demineralization of acid whey allows removing a significant part of minerals (50%) from it and providing the required acidity in the range, corresponding to raw milk. We set the following objectives: to determine the parameters of whey demineralization, the factors of thermostability; increase stability and improve the consistency of the dairy base from demineralized whey; the effect of the probiotic starter microflora on the characteristics of the final product. In the course of studies, we used a modern membrane equipment, standard and generally accepted research methods. We analysed the composition and properties of demineralized acid whey, considered the theoretical prerequisites to an increase in stability and the ways to improve the consistency of the dairy base. We examined the effect of the dose of stabilizers' salts, dose of the consistency stabilizer and the fat content on physicochemical, organoleptic and rheological parameters of the milk base, as well as the effect of the probiotic cultures ratio in the starter, which make the product functional, on the properties and qualities of the final product. We developed the formulas and technologies of functional desserts. We developed and approved technical specifications for the desserts, based on which the experimental-industrial production is conducted. The feasibility of using demineralized acid whey as a raw material for the production of dessert products is confirmed experimentally.

Keywords: Acid whey, demineralised whey, electrodialysis, membrane processes, functional dairy products

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INTRODUCTION

Due to the increase in production volumes of milk protein products in the Russian Federation such as cheeses and acid, the resources of dairy whey increase proportionally. Given the shortage of raw milk, the problem of using secondary raw materials rationally becomes particularly relevant, and the task of experts of the dairy industry is to come up with such solutions so that valuable dairy whey is used to the fullest, which will ensure the environmental safety and the resource conservation of milk production.

Recently, the sector of drinks and desserts based on dairy whey (around 50 thousands tonne) has become more popular, however, the share of whey, used for these purposes is small [1]. It is due to the features of its composition and properties. Dairy whey is characterized by high content of minerals and increased acidity (especially acid and casein whey), which limits its use for food purposes. However, its valuable composition, significant volume and accessibility predetermine the need for its industrial processing.

Whey includes around 50% of milk solids, 70% of which is accounted for lactose, around 13% is protein components, less than 5% – milk fat and about 11% is minerals. Whey protein is represented by β lactalbumin, β-lactoglobulin, whey albumin, immunoglobulins, lactoferrin, osteopontin, lactoperoxidase and the protease-peptone fraction. These proteins have the highest biological value by the content of essential amino acids among other food proteins. In this regard, whey protein fractions can fully meet the need in protein in the diet of infants, the elderly, athletes, as well as people exposed to stress and engaged in heavy physical labour [2]. Nowadays, the intensive research and scientific works are conducted to create new kinds of dairy products, the raw material for which can be dairy whey as a source of nutrients with the important physiological value, in order to solve the problem of providing the population with biologically full, affordable and safe food products.

The nutrition structure of the Russian population is characterized by low consumption of biologically valuable products. In these circumstances, it is feasible to pay special attention to the production of products that enrich the diet with biologically active substances, bifidogenic additives, functional ingredients that have a beneficial effect on the general state and the metabolism of the body. High nutritional and biological value of dairy whey is well-known and due to the presence of valuable carbohydrates, minerals, enzymes, vitamins, organic acids, easily digestible whey proteins, which are an additional source of essential amino acids, predetermines the need to find the ways how to process it.

Milk processing enterprises are especially interested in acid whey. According to statistics, the share of acid whey in Russia accounts for more than 45% of the total volume of whey [3], due to the fact that acid is a traditional national product in Russia. However, the heat treatment processes, condensation, crystallization, drying of acid whey are complicated by its physical and chemical properties. Acid whey is characterized by an increased content of lactic acid and a significant mineral content, which is due to the characteristics of the acid technological production process. For the same reason, its use is limited in the production of dairy products. The use of new and innovative technological methods can improve the quality characteristics of the products based on acid whey.

One of the main development directions of the domestic branch of science is the development of fundamentally new, innovative processes and rational processing technologies of raw milk based on deep fractionation of its components. A priority direction for solving the above problems is the introduction of the membrane technologies, providing for efficient processing of acid (acid) whey, for the subsequent use of the obtained semi-finished products in the food technology. It can be both traditional dairy products, enriched with whey proteins, and new functional products with useful properties. It becomes possible to vary the ratio of milk components and composition, giving new physicochemical, organoleptic and structural and mechanical properties to dairy products.

Electrodialysis is already successfully used to process whey. It is one of the most effective processes for regulating the composition and properties of whey, which opens up possibilities to produce new kinds of functional dairy products. In electromembrane processes, filtration is carried out via the movement of dissociated ions through ion-selective membranes under the influence of direct current. As a result, the acidity and the mineral composition of raw materials are adjusted. Electrodialysis almost completely removes monovalent ions and a significant part of the divalent ions such as calcium, magnesium, as well as hydrophosphates, organic and inorganic acids.

Demineralization of acid whey allows obtaining the base with the necessary titratable (15–25°T) and active acidity (pH 6.0–6.7). As a result of the electrodialysis treatment, organoleptic characteristics significantly improve: the acid whey acquires a sweetish taste already at the desalting level of 50%, and a sweet taste – during further demineralization. This allows expanding the application range of demineralized whey as part of many food products significantly.

Improvement of technological processes, as well as wide processing of secondary dairy raw materials improves the nutritional value of food products, while addressing a number of the issues of rational raw materials use and environmental safety. In this regard, the studies, aimed at the development and introduction of food products based on the principles of comprehensive non-waste milk processing, are relevant.

Let us consider the promising direction of producing dessert products, based on the demineralized acid whey, for the functional use.

To achieve the research goals, it is necessary to solve the following problems:
– to examine the factors, influencing on thermostability of a dairy base;
– to study the possibility of increasing the stability of the dairy base from demineralized acid whey and improving the consistency of dairy products;
– to study the influence of the starter microflora on physicochemical and organoleptic characteristics of the dairy base;
– to develop technological modes for producing dairy desserts.

OBJECTS AND METHODS OF STUDY

The objects of research are the following:
– acid whey, obtained after the production of fat-free acid with the traditional technology, concentrated on the Nano filtration unit and demineralized with the electrodialysis method;
– cream, made from cow's milk, which complies with the requirements of GOST (State Standard) R 53435- 2009;
– stabilizers of consistency, designed for the production of fermented products and dairy desserts in compliance with the corresponding regulatory documentation;
– bacterial concentrates of lactic acid microorganisms: *Lactobacillus acidophilus* (BK-Uglich-AB), *Lactobacillus bulgaricus* (BK-Uglich-B), *Lactococcus lactis subsp. diacetilactis* (BK-Uglich-LD), *Lactobacillus casei* (BK-Uglich-K) TU 9229-369-00419785-04.

The research was carried out in the laboratories of the Department of Applied Biotechnology of the North Caucasus Federal University (SKFU), as well as jointly with NCFU and "MEGA ProfiLine", the international research laboratory "Electro- and baromembrane technologies" of the Institute of living systems. Pilot testing and development of the technological parameters of desserts production were carried out on the basis of the Dairy plant "Stavropol" in the acid products department. In the experimental studies, we used the materials provided by the companies FSUE "Experimental biofactory" (Uglich), LLC "Wimm-Bill-Dann. Food products" (Moscow) and JSC Dairy plant "Stavropol" (Stavropol).

Laboratory and pilot units were used as the membrane equipment in the experimental studies. Approbation was carried out on the pilot and industrial membrane equipment. To concentrate acid whey, we used the Test Unit M20, universal baromembrane unit, equipped with Nanofiltration membranes. The baromembrane unit is designed for research. It can be used with a range of membranes to carry out the processes of reverse osmosis, nanofiltration, ultrafiltration and microfiltration. Nanofiltration membranes have a unique design and are made from a special material, approved for the use with food products and pharmaceuticals.

The main conditions of the Nanofiltration process (corresponding to the industrial operating conditions of the unit):

– temperature of the process – 10°C;
– pressure – 20 bar;
– duration of the process – not more than 20 hours;
– membrane module NF-2517/48.

The process of demineralization was carried out on the laboratory electrodialysis unit ED-mini (JSC "MEGA", the Check Republic) and the pilot electrodialysis unit ED-Epsilon (JSC "MEGA", the Check Republic), equipped with the heterogeneous ion-exchange membranes Ralex®, permitted for the food industry.

During the process, acid whey was subjected to demineralization up to the level of 50%. The process was controlled by the specific conductivity value and then by the value of ash in the final product.

The following parameters of the demineralization process are adopted:

– liquid temperature in all circuits – 10–15°C;
– maximum voltage applied to the module – 20 V;
– maximum current – 1.5 A;
– pumping speed in all the chambers – 60 l/h;
– Electrode solution – salt solution with the specific conductivity greater than the specific conductivity of milk whey (16–22 mS/cm).

In the process of electrodialysis, the following parameters were monitored: specific conductivity and active acidity in each circulation circuit. These two parameters were determined by pH/ Cond 340i (manufactured by "WTW", Germany). The concentration of ash residue was determined by phase-by-phase combustion of the accurately weighed milk whey samples at a temperature of 550°C for at least 5 hours in a muffle furnace.

To determine the composition and properties of dairy raw materials and studies samples, as well as during experimental tests we used standard and accepted methods of research.

RESULTS AND DISCUSSION

As known, natural milk whey is characterized by low solids content, but increased salinity and acidity. Therefore, to use whey in the technology of many dairy products it is advisable to concentrate it and then adjust its composition to remove unwanted substances. The most effective way to concentrate whey is to use baromembrane methods such as Nanofiltration and reverse osmosis. These processes can significantly reduce energy consumption for the concentration compared with the most common method of vacuum evaporation. We chose Nanofiltration since during such processing, whey concentration and partial demineralisation of raw materials occur due to the permeability of Nanofiltration elements relative to monovalent ions. During this process, the mineral part of whey is reduced by 20–25%, the total amount of raw materials for further processing reduces at the account of the solids content concentration in the retentate up to 18–20%. Due to partial removal of salts and total increase in the specific conductivity as a result of the concentration solids in whey, the electrodialysis process is intensified.

Technical data and the possibilities of using electrodialysis units allow providing a demineralisation level of raw materials of 50, 70 and even 90% without additional auxiliary processes. Applied heterogeneous ion-exchange membranes Ralex® have high selectivity for removing mono-, divalent ions and lactic acid, which significantly improves the efficiency of electrodialysis. Ability to control the acidity in the process of electrodialysis allows getting the desired product with the required acidity indicators. During preliminary studies it was found that for the use of demineralized whey in the technology, for example, of whole-milk products, a sufficient demineralisation level is 50–70% and the pH range should match the natural pH of raw milk, i.e. 6.5–6.7.

In our experiments, the raw materials were concentrated to the 12–14% content of solids, which is comparable to a content of solids in raw milk, and in the process of electrodialysis treatment of acid whey, the demineralization level was brought to 50% and a pH of 6.7. Thus, when exiting the electrodialysis unit, the acid whey concentrate with the solids content of 11–13% had a titratable acidity not more than 18°T. The resulting semi-finished whey can be successfully used in the production of products such as "drinking" (thin) and "spoon" (thick) yoghurts, acid desserts, dairy drinks at the normalization stage in order to optimize the mixture composition and reduce the cost of raw milk.

The comparative composition and basic physicochemical and organoleptic indicators of non-demineralized and demineralized whey are shown in Table 1.

Table 1. Physicochemical and organoleptic properties of concentrated acid non-demineralized and demineralized whey

Indicator	Value	
	Concentrated acid whey	Concentrated acid whey, 50% wt.
Content of solids, %	12.0–14.0	11.0–13.0
Titratable acidity, °T	125–145	15–18
Active acidity pH	4.2–4.55	6.5–6.7
Density, kg/m^3	1040–1055	1040–1050
Specific conductivity, S/cm	11.0–14.0	3.2–4.0
Lactose, %	9.0–11.0	8.5–10.0
Protein, %	1.2–1.5	1.2–1.4
Fat, %	0.13–0.15	0.11–0.13
Ash, %	1.4–1.5	0.5–0.6
Appearance, consistency	Homogeneous low-viscosity fluid	Homogeneous low-viscosity fluid
Taste and smell	The taste is pronounced wheyish acidic, slightly salty. The smell is wheyish. Without foreign tastes and smells	Pure, sweetish, a bit wheyish taste. Slight wheyish smell. Without foreign tastes and smells
Colour	From light yellow to yellow	From light yellow to yellow

The study on the demineralization of acid whey showed that it is possible to remove up to 50% of minerals with insignificant losses of whey proteins and lactose with titratable acidity being reduced at the same time. As a result of electrodialysis processing, organoleptic indicators of milk whey improve significantly.

As the technologies of all dairy products envisage the process of pasteurization, at the next stage of the study, we examined the stability of demineralized whey in the course of thermal processing.

It is known that in the process of demineralization, monovalent ions (Na^+, K^+, Cl^-) are removed first, and then the anions of phosphoric and citric acids are removed. This leads to the partial dissociation of the complexes that connect Ca^{2+} and Mg^{2+} ions [5, 6], which in turn influence the stability of proteins. As the desalting degree increases, the rate of their removal from whey increases as well, which leads to a shift of the salt equilibrium and, as a consequence, the decrease in thermostability of milk whey at high temperature processing modes.

Typically, the following pasteurization modes are used in the production of dairy products: the product is held for 2–3 seconds at a temperature of 95 ± 2°C or 5–10 minutes at 85 ± 2°C [7, 8]. These modes provide the required microbiological safety and structure of the finished product. Taking into account the thermolability of milk-based whey proteins and the need to ensure the required safety indicators, we will adhere to the second mode of thermal treatment.

Thermal treatment has an important technological value and forms the quality of the finished product. During thermal treatment of raw milk in certain modes, the formation of a complex between casein and whey proteins occurs. The share of whey proteins in raw milk amounts to around 0.65%, the main part of which (0.4%) belongs to β-lactoglobulin. This whey protein has specific functional properties that are of great value in the food industry, as it is able to form complexes with casein micelles, increasing the water holding capacity of clots at higher temperatures. Denaturation of whey proteins under the temperature occurs by specific patterns. Individual fractions of whey proteins have different thermostability and the denaturation rate, depending on the temperature [9]. The increase in the whey protein concentration contributes to higher denaturation rate. The latter is influenced by other factors as well. For example, the increase in lactose concentration slows down denaturation, especially at temperatures lower that 90°C; treatment with ultrahigh pressure, decrease in pH accelerate denaturation. With the increase in pasteurization temperature from 63 to 90°C, the effective viscosity of the intact structure of a fermented milk clot becomes 4 times greater, the relaxation viscosity – more than 2 times, the intensity of whey separation reduces by half. However, in this case, the casein content in the milk base is quite insignificant, that is why mainly whey proteins form the structure [10, 11].

For the milk base with the solids content of around 14%, the denaturation degree of whey proteins, which does not exceed 70–75%, is achieved at 80–85°C with the holding of 5–10 sec [11].

Further studies were aimed at determining the conditions, at which the milk base would be stable with the chosen pasteurization method. To increase thermostability of raw milk, stabilizer salts are used. When choosing the type and doses of stabilizer salts, we applied the recommendations of manufactures and the data in literary sources [12]. However, in regard with the fact that the content of whey proteins in the concentrated demineralized whey is 2 times greater than in milk, we made a decision to increase the concentration of stabilizer salts up to 25%, as well as the dose of salt in the milk base. Then, we studied the effect of the introduced stabilizer salt – potassium citrate –

on the thermo-stability of acid demineralized whey. Potassium citrate was introduced into the samples of demineralized whey as a 25% solution. The resulting mixed were subjected to pasteurization at (85 ± 2)°C, with the holding of 5–10 sec.

After cooling, the amount of residues in the samples was determined by centrifugation. Data on the quantitative content of residues in the samples are presented in Fig. 1.

Based on the conducted study and according to the data in the presented graph, we chose the optimal dose of stabilizer salt. It is 0.8%. We observed the higher stability in the process of heat treatment and the least amount of residues after centrifugation with this dose. Larger amounts of potassium citrate shift the salt equilibrium, protein molecules are destabilized, and after pasteurization the amount of denatured whey proteins increases in comparison with the control sample. Smaller amounts of salt did not give the desired effect.

To obtain the required consistency and structure in the milk base composition, the stabilizer systems are introduced.

Recently, various companies have developed many stabilizers and stabilizer systems, which are specially selected authorized blends of hydrocolloids. Stabilizers are used in the production of dairy drinks, mainly yoghurt, to prevent whey separation, improve the consistency and viscosity of the product.

Based on the preliminary studies with stabilizer systems of various companies, we chose the GRINDSTED® stabilizers ("Danisco", Denmark), which showed the best results.

To carry out the experiments, we took samples of the acid demineralized whey (the solids content of 14 ± 2%, 50% demineralization level). The general characteristic of the used GRINDSTED® stabilizers is given in Table 2.

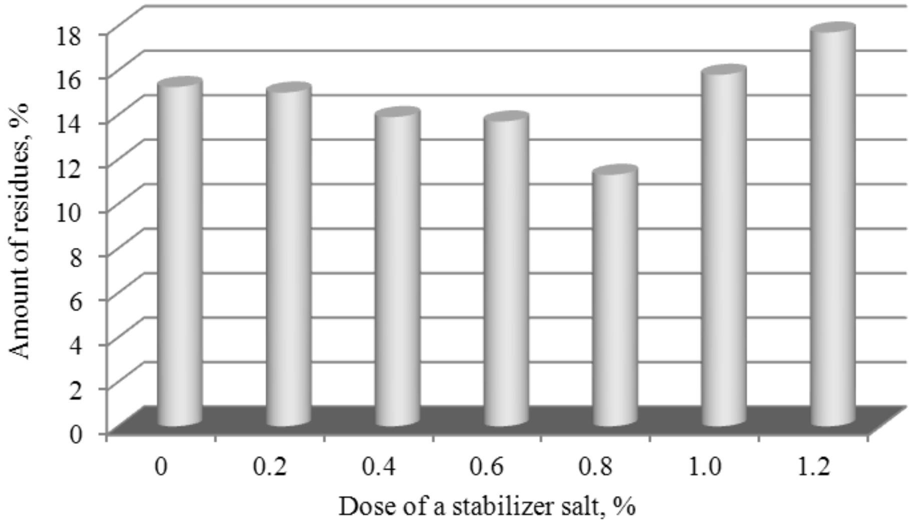

Fig. 1. The effect of dose of stabilizer salt on the thermostability of the milk base.

Table 2. General characteristic of the complex stabilizers ("Danisco")

Name	Application	Composition	Properties	Dosage
GRINDSTED® SB 251	Sour cream, yoghurt, dairy products (kefir, fermented baked milk, varenets (boiled fermented milk), etc.	Gelatine, modified starch (E1422), pectin (E440)	It increases viscosity, glossiness, binds free moisture, prevents whey separation, makes the texture creamier, replaces a part of non-fat milk solids	0.5–0.8%
GRINDSTED® SB 550A	Sour cream, yoghurt, dairy desserts	Modified starch (E1422), pectin (E440)	It binds free moisture, prevents whey separation and increases viscosity during cooling. Does not contain gelatine	0.9–1.3%
GRINDSTED® SB 271	Low-fat/non-fat yoghurt, dairy drinks (kefir)	Milk solids; modified starch (E1422), pectin (E440)	Enhances creamy taste, binds free moisture, prevents whey separation, replaces a part of non-fat milk solids and increases viscosity	0.9–1.3%
GRINDSTED® ES 258	Yoghurt, sour cream, thermostatic dairy products	Modified Starch (E1422), emulsifier (E471), pectin (E440)	A mixture of food emulsifiers and stabilizers. It increases viscosity, improves the consistency, binds free moisture, prevents whey separation, reduces the effect of spraying during packing	0.9–1.3%

We prepared milk-base samples with a different dose of each type of stabilizer. The amount of stabilizer in the samples was determined, based on the manufacturer's recommendations – we introduced a minimum, maximum and an average dose of stabilizer. Then these samples were pasteurized at a chosen mode: (85 ± 2)°C, with the holding of (5–10) s.

After pasteurization and cooling, separation in the milk base and its consistency was evaluated visually, the amount of residues was determined by centrifugation as well. The best result was achieved with the GRINDSTED® ES 258. After thermal treatment, there was no whey separation, the milk base structure was even, homogeneous, of white colour with a yellowish hue, tasted and smelled nice. This is due to the presence of emulsifies and stabilizing additives in the content of this stabilizer system, which allow getting even, smooth, homogeneous consistency, its emulsifying effect is also positive with the higher fat content in the base. The optimal average dose is 1.1%. With this does, the milk base had satisfactory indicator, smaller amount of stabilizer did not give a required pronounced affect, and the maximum dose gave the base an aftertaste of the stabilizer.

We conducted a series of experiments to normalize whey with cream to assess the influence of fat content on the structure and organoleptic indicators of the milk base. Concentrated demineralized whey was normalized with milk cream with 20% fat content and was homogenized on a laboratory dispersant. Then, the resulting mixtures were subjected to pasteurization at (85 ± 2)°C, with the holding of 5–10 s. Organoleptic and physicochemical indicators were determined in cooled samples. The results are given in Table 3 and Fig. 2.

Organoleptic indicators were determined on a scale from 1 to 5, by the total points of the following parameters: consistency, appearance, taste, smell and colour.

Organoleptic indicators of the samples with the increased fat content improve: whey aftertaste becomes less pronounced, pleasant milky smell, the products tastes more like a yoghurt, the consistency becomes more viscous.

The increase in the fat content of the product improves organoleptic indicators of the milk base, but does not give a necessary structure and consistency, similar to the structure of traditional yoghurt, as well as does not have a significant influence on thermostability of the milk base during thermal treatment, i.e. does not exclude the use of stabilizers, selected earlier. The optimal fat content of the mixture – (4 ± 0.2)%, it was determined by the results of the experiment. With this fat content, the milk base had a viscous consistency; sweet, pleasant, creamy taste; clean, creamy smell; creamy colour. Smaller amount of cream in the mixture did not give necessary organoleptic indicator, larger amount definitely improved the flavour profile of the milk base. However, the increased fat content, firstly, significantly increases the energy value of the product, and secondly, it increases its cost.

Table 3. Physicochemical indicators of the samples of demineralized whey, normalized according to fat content

Sample	Fat content, %	Acidity, °T	Solids, %	Viscosity, mPa×s
1	0 (Control)	15.6 ± 1	13.4 ± 0.5	18.3 ± 1.5
2	2.0	16.0 ± 1	15.1 ± 0.5	36.6 ± 2.0
3	4.0	16.0 ± 1	16.4 ± 0.5	108.6 ± 5.5
4	6.0	16.3 ± 1	17.2 ± 0.5	184.6 ± 10.0
5	8.0	15.3 ± 1	18.6 ± 0.5	355.0 ± 20.0

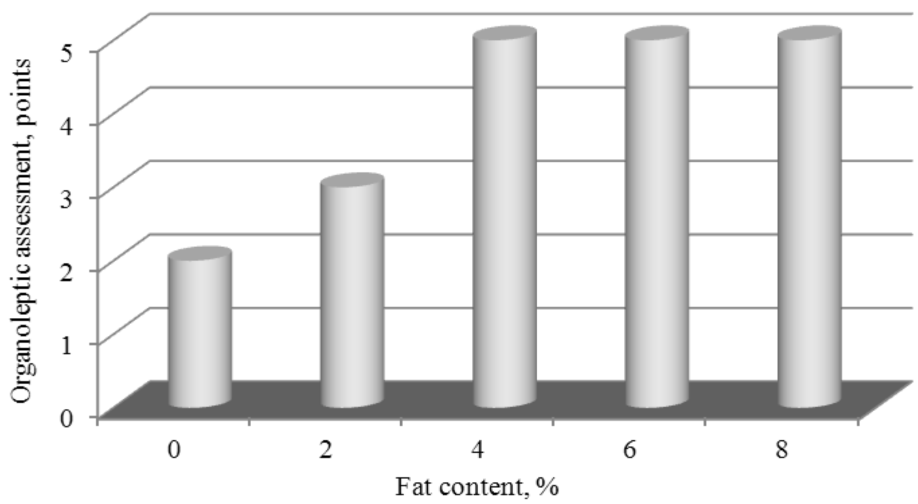

Fig. 2. Organoleptic indicators of demineralized whey, normalized by the fat content (on a scale from 1 to 5).

Thus, the series of conducted experiments led us to the following conclusions:
– demineralized whey can be a milk base for the production of dessert products;
– the optimal mode of heat treatment of the milk base is (85 ± 2)°C, with the holding of 5–10 sec;
– the optimal amount of the GRINDSTED® ES 258 stabilizer, that gives the milk base a homogeneous, viscous consistency, amounts to 1.1%;
– the optimal dosage of the stabilizer salt – (0.8 ± 0.05)%, it provides thermostability of the milk base during pasteurization;
– the optimal fat content of the milk base – (4 ± 0.2)%, it significantly improves its organoleptic indicators.

The goal of the experiments was to make a functional fermented dessert based on demineralized whey. Its functionality is determined not only by the valuable content of the milk base, which contains larger amount of biologically full whey proteins, but also by the composition and properties of the starter's microflora, which provides probiotic properties of the product.

The composition and properties of starters have a great impact on the structure and indicator of fermented products. Depending on the type of a starter, fermented microorganisms form clots with different consistency types during milk ripening: Prickly, more viscous or with a different degree of ductility [10, 13].

The main requirements to the clot imply high viscosity after ripening; moderate degree of destruction during mixing; ability to recover the structure after mixing maximally; ability to retain whey during storage. Structured systems that are formed in raw milk during production of fermented products, contain both strong bonds of the condensation type, that irreversibly break down, and weak thixotropic reversible bonds of the coagulation type that give elasticity and plasticity [9, 14].

Content of bacterial starters is an important factor that determines the density and other structural and mechanical properties of acid protein clots. Many studies showed that there is a close interconnection between the strength of the clot, the degree of its recovery after a break down, water holding capacity and the content of a bacterial starter, development conditions of its microflora, the accumulation rate of milk acid and some other factors. Such cultures as *Lact. lactis (subsp. lactis, biovar diacetilactis, subsp. cremoris), Lb. delbrueckii subsp. bulgaricus, Str. swalivarius subsp. thermophilus* are able to form extracellular polymers that are carbohydrate-protein complexes [10, 15, 16].

Adding high-energy acidifiers to the content of bacterial starters helps making a dense clot with intensive whey separation, adding low-energy acidifiers (aroma-producing streptococci) – a more gentle clot. The use of *Lac. cremoris* and *Lb. acidophilus* in starters gives the clot elastic properties and hinders whey separation. Thus, with a certain combination of fermented bacteria it is possible to obtain the product with a desired consistency.

For further studies, the concentrated demineralized whey was normalized by milk cream to 4% fat content, 1.1% wt. of GRINDSTED® ES 258 was introduced into the mixture, as well as (0.8 ± 0.1)% of the stabilizer salt. Then the mixture was homogenized on the laboratory dispersant, pasteurized at the temperature of (85 ± 2)°C with the holding of 10 seconds. Five percent wt. of starter was introduced into the mixture, cooled down to a required temperature. Preliminary studies showed that the increased content of whey proteins in raw milk contributed to the intensification of the milk fermentation process at the account of the increased buffer capacity of the medium. Noted features of the lactic acid bacteria, including those produced as bacterial concentrates with the cryo- frozen microbial mass [17], are taken into account in the development of the probiotic fermented milk desserts, and the buffer capacity increase – in the regulation of physico-chemical indicators of the finished product [3].

Based on the preliminary studies on the ripening process of the mixture by different monotype lactic acid microorganisms, we selected representatives for the combines ripening that showed the optimal results on acid-forming and water-holding capacity, viscosity, organoleptic and probiotic properties.

The analysis of rheological and organoleptic indicators showed that samples with the best characteristics are ripened with the following cultures: *Lb. casei, Lb. acidophilus* and *Lac. lactis subsp. diacetilactis*. A milk base, ripened with *Lb. acidophilus* and *Lb. casei* had a more viscous, homogeneous structure and a pleasant sourish taste and the *Lac. diacetilactis* culture gave the product a lactic acid aroma, characteristic for diacetyl. Samples, ripened with *Lb. delbrueckii subsp. bulgaricus*, tasted a bit too sour.

Pure whey has a specific aftertaste, which negatively affects the product's organoleptic indicators. That is why, in the selection of a starter, the preference should be given to the cultures that mask this aftertaste or make it less pronounced after ripening. *Lb. acidophilus, Lb. casei*, *Lac. diacetilactis* meet these requirements in the best way possible. They mask whey smell, give the product a pleasant lactic acid taste and specific aroma, the required consistency. Then, we matched the optimal ratio of cultures in the starter.

The combination of cultures in the starter (in percentage) was as follows:

Starter 1: *Lb. acidophilus* : *Lb. casei* : *Lac. diacetilactis* = 30 : 40 : 30;

Starter 2: *Lb. acidophilus* : *Lb. casei* : *Lac. diacetilactis* = 50 : 30 : 20.

Temperatures of fermentation and ripening were determined by the content of a starter. For the first sample, it amounted to (35 ± 1)°C, for the second (40 ± 1)°C. The choice of the indicated temperature values is due to the fact that in the composition of each starter there were mesophilic cultures, the optimum for which is 35°C, and thermophilic cultures (lactobacilli) with the optimum of (40–42)°C. At the same time, the percentage of each type of cultures in the starter was taken into account. The starter was introduced into the prepared samples in the amount of 5% of the mixture volume. Ripening was conducted at the specified temperatures during 7–8 hours until the milk base gets to the (80–90)°T titratable acidity for the starter 1 and (100–110)°T – for the starter 2.

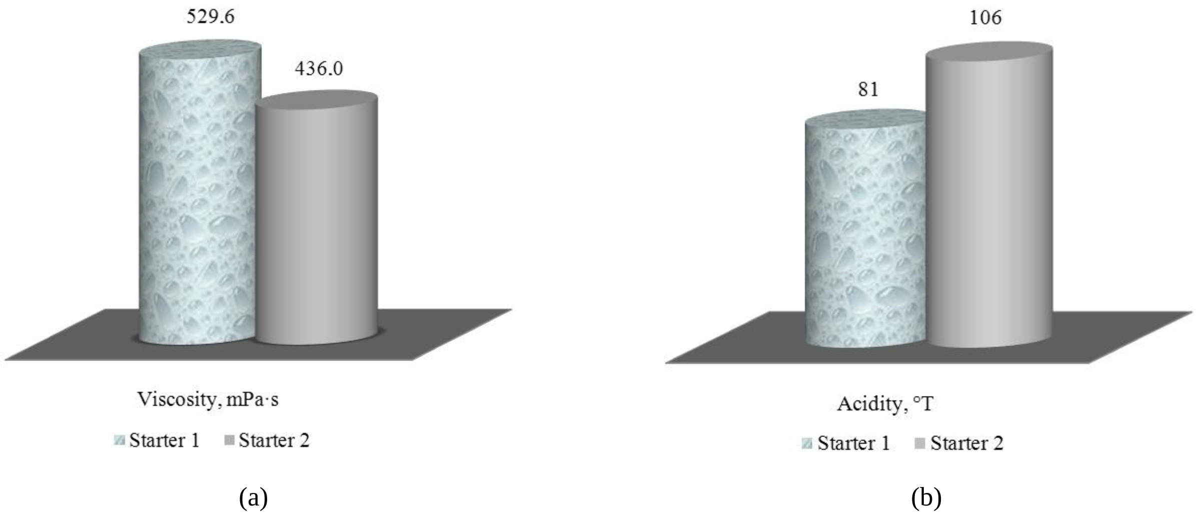

Fig. 3. The value of viscosity (a) and titratable acidity (b) of repined samples, depending on the content of a starter.

The results of the experiment on mixture fermentation with mixed starters are given in Fig. 3.

The obtained data confirms that exopolysaccharides, produced by lactic acid microorganisms (in particular, *Lac. lactis subsp. diacetilactis*), influence the consistency of the finished product. Temperatures of starters' cultivation also influences the structure of fermented milk drinks. The ripening temperature decrease to 35°C (even with the use of thermophilic cultures in the starter content) contributes to smaller amount of lactic acid and larger amount of exopolysaccharides, which leads to a product with the more pronounced stability of consistency and viscosity, as well as to the accumulation of a large amount of aromatic compounds, improving the taste and aroma of the product. However, both combinations of starter cultures can be used, depending on necessary organoleptic indicators of the finished product. Starter 1 is best suited for a functional fermented milk dessert, to make a products with a softer taste and aroma, a more viscous and denser consistency. Starter 2 can be used to produce a "drinking" (thin) dessert product. Obtained compositions can be successfully combined with different fruit and berry fillings to expand the range of products and meet the consumer preferences. Based on the conducted studies, we developed formulas of functional fermented milk desserts, tested technological modes for producing demineralized whey, milk mixture and finished products first on the pilot equipment and then under industrial conditions. It served as a basis for developing technical documentation of the product and obtaining a patent of the Russian federation No. 2493718 "Production method of the product based on milk whey".

As a result of the conducted studies, we showed a fundamentally new possibility of using demineralized acid whey for the production of functional milk desserts, which leads to a broader range of this product category, and opens up an opportunity of using secondary raw milk rationally, reduces the risk of environmental pollution by run-offs of a dairy plant. Demineralization of milk whey transforms this type of raw material from the problematic to a high-quality and cost-effective product, which is in demand in the food industry. The use of membrane equipment opens up new possibilities for enterprises. It allows processing raw materials, adjusting its composition, but maintaining its biological value and improving technological characteristic of raw materials, as well as producing new functional products with regulated composition and properties.

Milk desserts perfectly fit into the idea of a healthy lifestyle and nutrition. Even if the product is not enriched with functional ingredients, the buyer is convinced that a milk-based dessert does not only bring pleasure, but also a certain benefit to the body. This way, buyers form a belief that they take care of their health and improve quality of life. With the population being more and more aware of healthy nutrition, consumers prefer natural dessert products of high quality without dyes and preservatives, even despite their high cost. Experts consider the market of milk desserts as one of the most dynamically developing and marginal markets.

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