APPLE PECTIN AND NATURAL HONEY IN THE CLOSED MILK PROCESSING CYCLE

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Abstract: The paper is based on the methodological approach to using pectin and natural honey in the technology of production of new dairy products. The purpose of the study is to use products of the fractionation of milk by apple pectin – natural casein concentrate (NCC) and whey-pectin fraction (WPF) in natural form for the development of new functional products enriched with natural bee honey. Study of the specifics of the fractionation of whole and skim milk by Russian-manufactured apple pectin with the substantiation of the technological parameters of receiving WPF and NCC was conducted. It was established that the process runs effectively under the following conditions: preliminary heat treatment of milk at a temperature of 76°C, introduction of a 5% polysaccharide solution into milk, concentration of pectin of 0.6% of the weight of milk, temperature of fractionation of 4–6°C. The technological properties of the received fractions were studied. It was determined that NCC is relatively thermostable (withstands heat treatment at a temperature up to 80°C), beats well at a temperature of 5°C (overrun 50–60%), adding honey has a positive effect on the structure of the beaten NCC and reduces the likelihood of the separation of whey during storage. At the pectin content within 0.6–0.7% of the weight of milk (on a dry basis), the yield of WPF from skim milk was within 80–81%, from whole milk – 72–73%, solids content was 6.2–6.3%. The total protein content in WPF was 0.9–1.0%, of which whey proteins – 0.45–0.50%. When adding honey to the WPF, a dense gel was formed after a while, having a tendency to syneresis; in 96 hours the degree of syneresis was 10–12% for the studied concentrations of honey from 1 to 10%. On the basis of the obtained data, the closed milk processing cycle is provided by the technology and the formulations of the two products with honey on the basis of WPF and NCC – a pudding and a "Smoothie".

Keywords: Pectin, natural honey, fractionation, flocculation, natural casein concentrate, whey-pectin fraction, pudding, smoothie

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INTRODUCTION

Virtually all food industry branches, medicine and cosmetology show interest in pectins. Pectins have unique versatile properties due to the structural characteristics of the molecule.

In terms of the chemical nature, pectins are biopolymers of carbohydrate nature, the structural part of the polymer is ά- galacturonic acid. Combining the properties of acids and polyatomic alcohol, pectins can form stable insoluble complexes with polyvalent cations of metals, including toxic, heavy and radioactive metals. Pectins also form similar complexes with organic toxins getting into the human body or forming within it. Pectins are used as an antidote in case of intoxication with heavy metal salts and other toxins. They are figuratively called "a gift of the vegetable kingdom" and "an attendant of human body". Pectin as a dietary supplement is approved by the World Health Organization (WHO) and can be used in all countries of the world without restrictions. The preventive daily dose of pectin, recommended by the World Health Organization, is 4–5 g on a dry basis, 15–16 g in conditions of radioactive contamination. Pectin does not cause side effects and can be used in food on a long-term basis [2].

Properties of pectins as polyhydrophylic colloids are widely used in the food industry: pectins are used as thickeners and stabilizers, for the purpose of the improvement of the rheological properties of products. In dairy products, pectin is used not only as a stabilizer, but also with a view of enhancing health-promoting properties.

Gelling power is characteristic of all high molecular weight hydrocolloids and is shown by each of them at a certain concentration in the system. It should be noted that under certain conditions pectin can, on the contrary, destabilize the polydisperse system of milk with its separation into fractions. This ability of pectin is of scientific and practical interest, since both fractions – natural casein concentrate (NCC) and whey-pectin fraction (WPF) – have high biological value, which makes it possible to use this process in a non-waste milk processing technology.

NCC contains up to 70% of high quality milk protein, which has a complete set of essential and non-essential amino acids with the preservation of native molecular structures, up to 20% of carbohydrates, 7–8% of mineral substances and vitamins. It is a natural casein-calcium- phosphate complex, completely soluble in water. This makes it an especially attractive raw material for the food industry [3, 6].

WPF contains whey proteins, complete in terms of their amino acid composition, lactose, mineral salts, vitamins, and due to the presence of pectin it has a prebiotic effect on the intestine, so any food products, obtained on the basis of WPF, will be functional.

Both fractions (NCC and WPF) are soluble in water in all proportions even in dry form, are well mixed with any of the components of milk and other food raw materials, which makes it possible to use them for the production of liquid, pasty and structured products.

Fundamental research in the field of fractionation and concentration of the proteins of raw milk by pectin were conducted under the supervision of Professor V.V. Molochnikov [3–5]. The biotechnological principles of the production of functional dairy products using polysaccharides were thoroughly studied by T.A. Orlova [6].

The present work is based on the methodological approach to the substantiation of technological parameters of obtaining NCC and its subsequent use for the production of dairy desserts, which are in demand in the market and are popular with consumers due to their organoleptic characteristics.

High nutritional and biological value, as well as the attractive taste characteristics of the new dessert, are ensured by using natural honey in its formulation.

Honey is the oldest sweet delicacy and a very useful concentrated product. Natural honey is especially rich in monosaccharides – fructose and glucose. Mass fraction of fructose is 33–42%, mass fraction of glucose is 27–36%. Monosaccharides are quickly absorbed into the blood stream, replenishing the energy stores of the body. Honey also contains amino acids, essential oils, hormones, enzymes, organic acids, minerals, vitamins, antibiotics, antifungal, antidiabetic and other beneficial substances in favourable combination. In total, honey contains about 400 different substances, necessary for the human body [1].

Honey has no equal in terms of the amount of mineral substances. The average content of mineral salts in honey is 0.62%. Though they have a low absolute concentration, they are characterized by high physiological activity. In total, honey is found to contain 37 minerals substances, containing essential macro-and microelements. Perhaps, this fact explains the healing properties of honey. Each of the elements plays its own important role in the vital activities of the human body. The concentration of biologically active substances in honey is directly related to the type of honey, pollen and nectar composition [1].

Honey is an excellent dietary and medical food product, used for the prevention and treatment of metabolic disorders in the human body. Vitamins are contained in honey in small amounts, but they also play an important role, because their effect increases in combination with fructose, glucose, dextrines, mineral salts, and organic acids.

Honey falls into the category of functional foods necessary for optimal functioning of the human body as a whole. Honey is widely used as a restorative, tonic and recuperative agent.

Prebiotic properties of honey are associated with the high content of fructose, which is an easily accessible source of energy for the enzyme system of bifidobacteria. In the present work we studied the physical and chemical properties of Russian-manufactured apple pectin and the specifics of the fractionation of whole and skim milk, with the substantiation of the technological parameters of receiving fractions of NCC and WPF.

The purpose of the study is to use products of the fractionation of milk by apple pectin – natural casein concentrate (NCC) and whey-pectin fraction (WPF) in natural form – for the development of new functional products enriched with natural bee honey.

OBJECTS AND METHODS OF STUDY

Research objects were skim and whole cow's milk, apple pectin, manufactured in the Belgorod Region according to TU-9199 012-01014470-04 "Apple pectin, dietary food supplement", natural bee honey produced in the Belgorod Region, products of fractionation − natural casein concentrate (NCC) and whey-pectin fraction (WPF) in natural form, milk (raw milk), produced in farming enterprises. Fractionation of milk (raw milk) by apple pectin was implemented in the field of gravitational forces.

To obtain physical and chemical and microbiological research results, standard methods and methods found in the specialized literature [7, 8] were used.

Study of the impact of the concentration of pectin on the process of flocculation of casein was implemented as follows. A 5% aqueous solution of pectin was added to milk until its concentration in milk amounted to 0.5–1.0 g per 100 g (on a dry basis). The temperature of components in the process of mixing was 20–22°C, the amount of milk was 100 cm^3. The mixture was quickly stirred and dispensed into three rows of biological tubes, having the capacity of 30 cm^3, to ensure three replications for each concentration. The time of completion of the process was determined on the basis of the stabilization of the NCC layer height. The dynamics and efficiency of fractionation were estimated by the height of the whey layer, expressed as percentage of the original height of the mixture in test tubes, and by the solids content in the received fractions. When the volume of the mixture was 30 cm^3, the height of the mixture in tubes reached 25 cm (100%).

PH measurement was implemented using the pH meter/ionomer IPL-201 (MULTITEST "Semiko").

The measurement of the solids content was carried out using the method of drying to a constant weight at a temperature of 102–105°C.

The total protein content and the content of whey proteins were determined by the refractometric method using the refractometer IRF-464.

The impact of acidity on the process of fractionation was evaluated according to the same pattern, by modeling the pH systems by a lactic acid solution.

To determine the impact of temperature on the casein flocculation process, 100 cm^3 of milk were mixed with a pectin solution in the amount of 0.6% of the weight of milk (on a dry basis) at a temperature of components from 10 to 70°C in increments of 10°C. The mixture was stirred thoroughly and poured into seven tubes. The total volume of the mixture in the tubes was 30 cm^3, the height of the mixture layer was 25 cm (100%).

The heat treatment of milk, WPF and NCC was carried out in the laboratory of the Belgorod State Agricultural Univerisity named after V. Gorin using a tank with a heat exchange jacket. Gorin by using tanks with heat jacket.

The whipping of the NCC solution was carried out at the laboratory disperser IKA RW 20 digital at a mixing speed of 2 000 rpm.

The evaluation of taste, consistency and consumer properties of the product was carried out through the experts' tasting assessment on the 10-point scale.

RESULTS AND DISCUSSION

Study of the functional and technological properties of cream with a protein content of about 4%

Pectin was used in the study in the form of an aqueous solution. Physical and chemical properties of pectin are presented in Table 1.

Pectin almost did not dissolve in cold water. The optimal solubility was observed at a water temperature of 70°C. The concentration of the work pectin solution was selected on the basis of the results of the study presented in Table 2.

The optimal concentration of pectin for the fractionation of milk is a 5% solution.

Organoleptic and physical and chemical properties of the 5% aqueous solution of pectin:
– colour – cream white;
– smell – refreshing, apple;
– taste – slightly astringent, slightly sour;
– pH of the solution within 2.48–2.52.

When heated to a temperature of 20–30°C, the 5% aqueous solution of apple pectin was a dense homogeneous liquid, at a lower temperature the solution turned into nonfluid, homogeneous, very dense system.

The impact of pectin on the acidity of skim milk was noted (Table3).

An increase in the acidity of milk is attributed to the chemical nature of apple pectin, which, though it is a methoxilated (esterified methyl alcohol) biopolimer, has free carboxylic groups, which determine its pronounced acid properties (pH of the solution is within 2.48–2.52).

Study of the technological arameters of the fractionation of skim and whole milk

The impact of the mass fraction of pectin on the efficiency of the process of flocculation of casein in skim milk was studied. The impact of the pectin concentrations of 1, 2, and 4% of the weight of milk (on a dry basis) at the fractionation temperature of 20–22°C was also analyzed (Table 4).

At the pectin content of 1%, milk was divided into two factions. At the polysaccharide concentration of 2 and 4%, the fractionation of milk did not occur, a more viscous homogeneous liquid was formed. Thus, the concentration of pectin in the mixture with skim milk shall be not more than 1 g per 100 g of milk.

The dynamics of the process and the effectiveness of the fractionation of milk at the pectin content within the range of 0.6 to 1.0 g per 100 g of milk are shown in Table 5.

Table 1. Physical and chemical properties of apple pectin (TU 9199-012-01014470-04)

Degree of etherificafion, %	Molecular weight, ×103	Gelling power, Tarr-Baker degrees
75 ± 1	25 ± 2	190 ± 10

Table 2. The impact of the pectin concentration on the solution consistency

Pectin content, g per 100 g of solution	Characteristics of pectin solution at a temperature of 70°C
1.0	The fluidity of the solution is close to that of water, the color is pale yellow
3.0	The fluidity of the solution is close to that of milk, the color is yellow
5.0	The solution is thick, viscous, the color is intense yellow
6.0	The solution is not fluid, very viscous, the color is intense yellow

Table 3. The impact of pectin on the acidity of skim milk

Pectin content, g per 100 g of milk	Acidity of the initial mixtures	
	titratable, °T	active, pH
0.25	22 ± 1	6.47 ± 0.04
0.50	23 ± 1	6.38 ± 0.04
0.75	24 ± 1	6.30 ± 0.04
1.0	24 ± 1	6.22 ± 0.04

Table 4. The impact of different concentrations of pectin on skim milk

Pectin content, g per 100 g of milk	Acidity of the mixture		Visual effect	Time from the beginning of the process, h
	titratable, °T	active, pH		
Control	20 ± 1	6.5 ± 0.04	Cream coloured liquid	0
1	28 ± 1	6.1 ± 0.04	Visible separation of the phases. At the bottom there was concentrated solution of bright white colour, at the top – yellow liquid	1
2	30 ± 1	5.8 ± 0.04	Homogeneous viscous cream coloured liquid	2
4	31 ± 1	5.5 ± 0.04	Homogeneous viscous cream coloured liquid	2

Table 5. The dynamics and the effectiveness of the fractionation of milk at the pectin content within the range of 0.6 to 1.0 g per 100 g of milk

Time from the beginning of the process, min	Pectin content (on a dry basis), g per 100 g of milk					
	0.6		0.75		1.0	
	The height of the whey layer, cm	% of the original height of the mixture	The height of the whey layer, cm	% of the original height of the mixture	The height of the whey layer, cm	% of the original height of the mixture
30	3	12	2	8	0	0
45	16	64	4	16	0	0
60	19	78.1	7	28	3	12
90	19	78.1	10	40	5	20
150	Fractionation process ends after 60 min		12.5	50	10	40
180			14	56	11	44
210			16	64	12	48
240			16	64	12	48
300			Fractionation process ends after 210 min			

It was determined that pectin concentration in the process of fractionation of skim milk should be close to 0.6–0.7 g per 100 g of milk (on a dry basis).

To test the observed effect and to determine the optimal concentration of pectin, additional studies were conducted using pectin concentrations of 0.5%, 0.6% and 0.7% (on a dry substance basis). The yield of NCC and WPF and the solids content in NCC and WPF at different concentrations of pectin is presented in the diagrams (Fig. 1).

The accuracy of determining the yield of fractions was within the range of 0.3–0.5%.

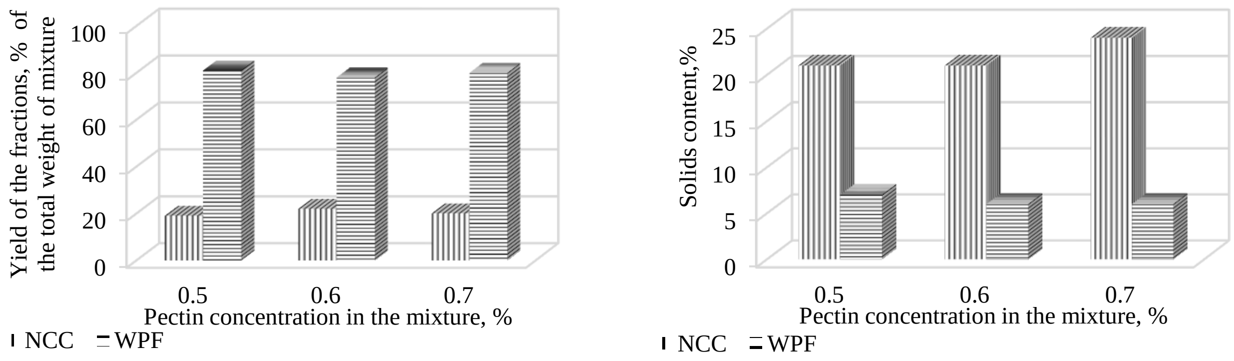
The concentration of pectin in the mixture below 0.5% and over 0.7% resulted in a decrease of solids content and of the yield of NCC, while within 0.6–0.7% these figures changed insignificantly.

The forecast of the commercial yield of NCC and WPF on the basis of experimental findings is presented in Table 6.

The yield of WPF was 79%; the yield of NCC was 20%, respectively, while the production losses amounted to about 1%.

The impact of temperature on the efficiency of the concentration (flocculation) of casein was studied. Concentration of pectin in skim milk was 0.6% (on a dry basis). The acidity of skim milk was 21–22°T.

The experimental data are presented in Table 7.



(a) (b)

Fig. 1. Yield (a) of NCC and WPF and solids content (b) in NCC and WPF.

Table 6. The forecast of the commercial yield of NCC and WPF

Raw materials	Pectin concentration 0.6% of the weight of milk			Solids content, %
	Yield, %	Acidity		
		°T	pH	
Base mixture (skim milk and pectin)	100	22 ± 1	6.26 ± 0.04	9.12 ± 0.5
WPF	79 ± 1	17 ± 1	6.25 ± 0.04	6.09 ± 0.5
NCC	20 ± 1	47 ± 1	6.31 ± 0.04	25.16 ± 0.5

Table 7. The impact of the temperature of the mixture on the flocculation efficiency of casein

Temperature, °C	After 30 min		After 60 min	
	Characteristics of the system	% NCC of the initial height of the mixture	Characteristics of the system	% NCC of the initial height of the mixture
10	No clear boundary between fractions	—	Clear boundary between fractions	24.0 ± 0.5
20	No clear boundary between fractions	—	Clear boundary between fractions	24.0 ± 0.5
30	No clear boundary between fractions	—	Clear boundary between fractions	24.0 ± 0.5
40	Clear boundary between fractions	24.0 ± 0.5	Clear boundary between fractions	24.0 ± 0.5
50	Clear boundary between fractions	24.0 ± 0.5	Clear boundary between fractions	24.0 ± 0.5
60	Clear boundary between fractions	26.0 ± 0.5	Clear boundary between fractions	26.0 ± 0.5
70	Clear boundary between fractions	22.8 ± 0.5	Clear boundary between fractions	22.8 ± 0.5

On the basis of the results of the study of the impact of temperature on the fractionation process following conclusions were made:

– In the temperature range of 10–30°C the concentration of casein ended after 60 min.

– With the rise in temperature of the mixture, the flocculation of casein proceeded faster and reached a maximum after 30 min.

– At temperatures above 60°C, due to the denaturation of whey proteins, the flocculation of casein decreased.

– Temperature did not have a significant impact on the fractionation of skim milk and the yield of NCC.

Important technological parameters, that can affect the process of fractionation, are the titratable and active acidity of the mixture of raw milk with polysaccharide. It was found that the studied range of acidity of the mixture has almost no impact on the yield of natural casein concentrate in case of using the studied type of apple pectin (Table 8).

However, there is considerable literature data on the significant increase of the mass fraction of protein in the WPF, when the initial acidity of raw milk is below 12 and above 20°T [3].

The stability of casein micelles, as well as the stability of any colloidal lyophilic system, depends on the charge magnitude, influenced by the salt composition, pH and the presence of various hydrophilic colloids in milk. When developing the methods of the separation of casein, it is necessary to take into account the specifics of its structure [10, 11].

Along with the fractionation of skim milk by apple pectin, the possibility of the fractionation of whole milk was analyzed.

A preliminary study on the impact of the pectin

Table 8. The impact of the acidity of skim milk on the flocculation of casein by apple pectin

Acidity of the mixture (milk + pectin)		% NCC of the initial height of the mixture	
Titratable,°T	Active, pH	After 30 min	After 60 min
24	6.52 ± 0.04	24.8 ± 0.5	24.8 ± 0.5
25	6.49 ± 0.04	24.2 ± 0.5	24.2 ± 0.5
26	6.38 ± 0.04	24.2 ± 0.5	24.2 ± 0.5
27	6.26 ± 0.04	23.8 ± 0.5	24.2 ± 0.5
28	6.13 ± 0.04	23.2 ± 0.5	23.2 ± 0.5
29	6.07 ± 0.04	23.0 ± 0.5	23.0 ± 0.5
30	6.00 ± 0.04	23.0 ± 0.5	23.0 ± 0.5

concentration on the fractionation of whole milk made it possible to conclude that the pectin content (on a dry basis) should be within the range of 0.6 to 0.7% of the weight of milk, as it is the case for skim milk.

The impact of heat treatment and temperature on the fractionation of whole milk is shown in Table 9.

Heat treatment causes a number of physical and chemical processes in the milk, resulting in the changes in the aggregative stability of casein micelles, which has a positive effect on the fractionation process. In raw milk, virtually no fractionation was observed. The fractionation process proceeded more efficiently in pasteurized milk and within the temperature range of 4–6°C. To provide a quantitative characteristic of the process of fractionation of whole milk, additional research was conducted. The following parameters were determined: yield of fractions, solids content, the acidity of the obtained fractions and the fat content in the WPF. The titratable acidity of the raw milk was 16°T. Whole milk was pasteurized at 76°C for 20 seconds.

The impact of the temperature of the mixture during fractionation on the yield of fractions and the solids content in the obtained fractions is shown in Fig. 2.

The fat content and the acidity of WPF and concentrate (protein-lipid fraction) for pasteurized milk at various temperatures are presented in Table 10.

Table 9. The impact of pasteurization and temperature on the fractionation of whole milk

Raw milk:	
Temperature 20–23°C	Temperature 4–6°C
Insignificant fractionation, at the bottom there is a bright white layer, having a height of less than 1 cm within the tube, there are flocs in the whey	Insignificant fractionation, at the bottom there is a bright white layer, having a height of less than 1 cm within the tube, there are flocs in the whey
Milk pasteurized at 76°C for 20 seconds:	
Temperature 20–23°C	Temperature 4–6°C
Complete separation of milk into fractions: transparent whey and bright white layer (NCC + Fat) at the bottom of the tube. The height of the concentrated layer amounted to 16.8% of the total height of the mixture layer.	Complete separation of milk into fractions: transparent whey and bright white layer (NCC + Fat) at the bottom of the tube. The height of the concentrated layer amounted to 20.0% of the total height of the mixture layer.

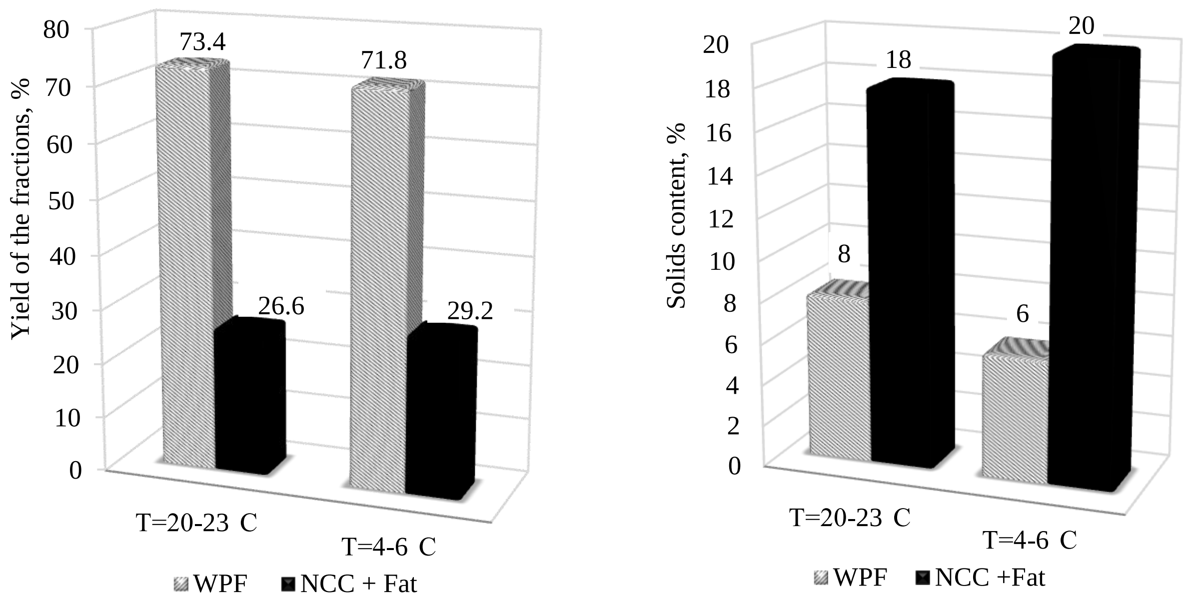


Fig. 2. The impact of temperature on the efficiency of the fractionation of pasteurized whole milk by apple pectin.

Table 10. The fat content and the acidity of the obtained fractions at various temperatures

Parameters	20–23°C		4–6°C	
	WPF	Concentrate (protein-lipid fraction)	WPF	Concentrate (protein-lipid fraction)
Mass fraction of fat,	0.1 ± 0.01	14 ± 0.05	0.05 ± 0.01	14 ± 0.05
Titratable acidity, °T	17 ± 1	37 ± 1	18 ± 1	35 ± 1

Apple pectin is able to efficiently fractionate whole pasteurized milk at a temperature of 4–6°C. The yield of concentrated fraction (protein-lipid fraction) amounted to 29% of the total weight of the mixture, with the solids content of 20%. Milk fat passed almost completely into the layer of concentrated casein. The fat content in the whey fraction was no more than 0.05%.

The closed milk processing cycle with the use of apple pectin was implemented in the development of two functional products with honey on the basis of the obtained fractions – WPF and NCC in their natural form.

Study of the technological parameters of producing NCC from skim milk and ITS functional and technological properties

Based on the research results, the technology of producing natural casein concentrate (NCC) from skim milk under the action of pectin was determined. The following technology was used: skim milk was pasteurized at a temperature of 76–78°C for 15–20 seconds, cooled to a temperature of 15–20°C, mixed with 5% aqueous solution of pectin in the amount of 0.6% of the weight of milk, calculated on a dry basis. After thorough stirring, the mixture was left for one hour at a temperature of 4–6°C. Upon the expiry of this time, the flocculation of casein was virtually fully completed, that is, skim milk was separated into two fractions: NCC and WPF. The upper fraction (WPF) was removed by draining, after which the remaining natural concentrate of casein (NCC) with solids content of 23–25% was used. The yield of NCC was approximately 20%.

The obtained NCC solution had a bright white color, a pleasant slightly sour taste, the titratable acidity was 45–47°T, pH was 6.31–6.34. High values of titratable acidity of NCC were attributable to the increased proportion of protein. The same factor also results in the increase of the density of protein to 1 050–1 055 kg/m^3.

The ability of natural concentrate of casein to withstand heat treatment (Table 11) was also noted, which has the following explanation. The basic protein in the NCC is casein – a thermostable protein, the content of whey proteins in the NCC solution does not exceed 1.0%.

Another important technological property of NCC is its whippability/foam-forming ability. The molecular structure of foaming agents has both hydrophilic and hydrophobic properties. This is characteristic of all soluble proteins; during whipping their molecular chains are distributed in a very thin layer on the surface of the bubbles. An important factor of the stability of foam is temperature. With the decrease in temperature, the solubility of gases increases, consequently, more air bubbles are formed. The study showed the whippability of NCC at a temperature below 10°C, the volume of the whipped mass increased by 1.5–1.6 times at a temperature of 5°C.

To ensure foam stability, NCC should contain sugars. Besides, using natural honey as a sweetener for the purpose of improving the biological and nutritional value of NCC is of particular interest. The diagram (Fig. 3) shows the impact of honey and sucrose on the stability of the structure of NCC after 24 hours of storage at a temperature of 4–6°C.

Introduction of carbohydrate components does not affect the degree of overrun, but introduction of honey in amount of 0.5 to 2% improves foam stability over time. The combination of honey and sucrose in various proportions gave the same effect as using pure honey.

To study the ripening ability of NCC, a curd cheese starter culture was used (*Lc. lactis*, *Lc. cremoris*, *Leu. cremoris, Str. thermophilus*), which was added in the amount of 3% of the weight. The samples were thermostated at a temperature of 32°C. The dynamics of the fermentation process is shown in the diagram (Fig. 4).

Table 11. The impact of heat treatment on the structure of NCC

Heating temperature, °C					
68	72	76	80	85	90
The NCC solution preserves the homogeneity				Minor structural changes The appearance of individual protein flocs	Noticeable structural changes The appearance of visible protein flocs

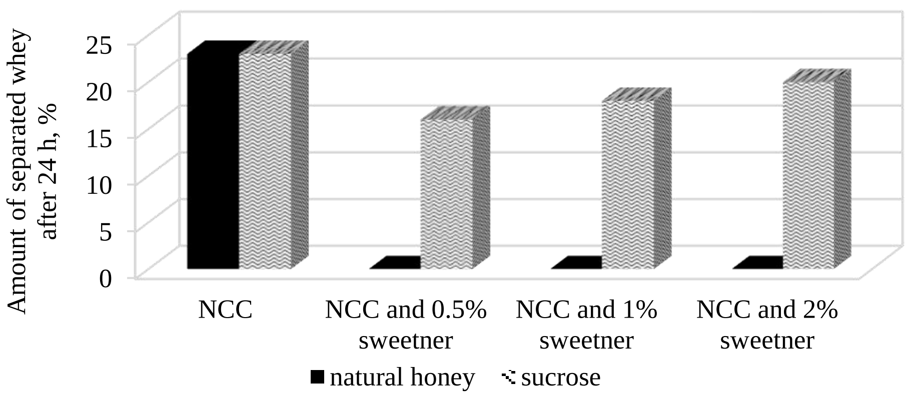


Fig. 3. The impact of natural honey and sucrose on the stability of the structure of NCC after 24 hours of storage.

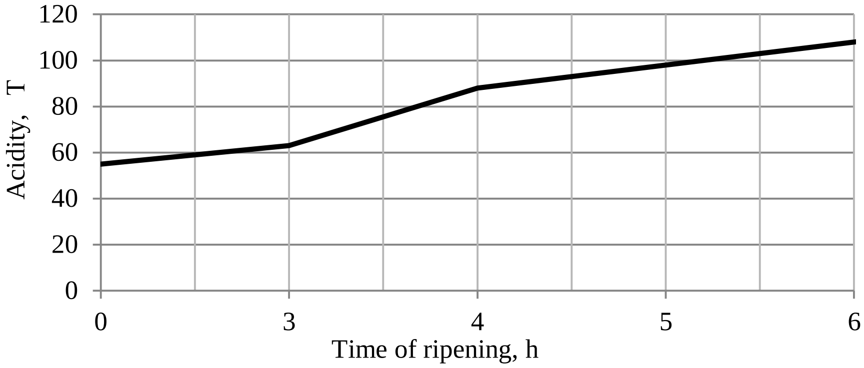


Fig. 4. The dynamics of the process of fermentation of NCC by lactic acid microorganisms.

NCC is efficiently ripened by lactic acid microorganisms with the formation of a dense clot with high water-holding capacity. The dynamics of the process is similar to the processes taking place during fermentation of any raw milk.

The studied technological properties of NCC make it possible to conclude that it is relatively thermostable, beats well at a temperature of 5°C (overrun 50–60%), adding honey has a positive effect on the structure of the beaten NCC and reduces the likelihood of the separation of whey during storage.

Thus, alongside with high functional characteristics, NCC also has good technological properties. Combination of NCC with other dairy or vegetable raw materials makes it possible to develop various forms of functional food products with adjustable organoleptic and consumer properties.

Development of the technology and formulation of a dairy dessert on the basis of NCC with honey

For the purpose of the practical implementation of the obtained results, the use of the NCC of skim milk in the technology of the production of a new dairy dessert with honey "Smoothie" is proposed.

In everyday understanding, "Smoothie" is a cooled dessert made from crushed pieces of fruits and berries with the addition of milk, yogurt, curd cheese, juice, honey, eggs, sugar, ice and other components. It contains dietary fiber, vitamins and antioxidants, can provide large amounts of energy and is a physiologically useful product.

The use of the following ingredients as basic raw materials for the obtaining of the product was envisaged: NCC solution, natural honey, berry fillers, apple pectin.

The technology of the production of the "Smoothie" product on the basis of natural concentrate of casein consisted of the following processes: obtaining NCC (according to the technology described above), formulation of the recipe and the development of manufacturing operations, ensuring safety and specific organoleptic properties of the "Smoothie" product.

Natural honey was added in the proportion of 3% of the weight of the produced NCC. After stirring, the mixture was pasteurized at a temperature of 76–78°C for 15–20 seconds and cooled to a temperature of 6–8°C. To improve the overrun, the NCC was kept at a temperature of 4–5°C for at least 16 hours. Cold mixture of NCC with honey was whipped until the volume was increased by not less than 50% (2 000 rpm, duration 3 min).

To improve the consumer properties of the product and its customer appeal, natural berry fillers were used: strawberry, cherry, plum and assorted (blackcurrant, strawberry, cherry). Fillers were previously prepared in the following way. Frozen berries were defrosted, poured onto the sieve and carefully washed with cold water from a shower. After draining the excess water from berries, an inspection for the rejection of low quality berries was conducted. Then berry raw materials were mixed with granulated sugar in the proportion of 30% of the weight of berries. The mixture was heated to 95°C and quickly cooled to 20–22°C.

A method for the adding of berry fillers in the product was studied. The overrun and the structure stability were significantly higher, when the filler was added into the previously whipped NCC. The proportion of berry filler in the product was determined experimentally (Table 12).

Table 12. The impact of the proportion of berries on the consistency and organoleptic properties of the product

The proportion of berries, g per 100 g of NCC	Consistency	The taste of the product	Color
70	Dense, nonfluid	Noticeable taste of berries	Pale, faint
100	Dense, nonfluid	Noticeable taste of berries	Characteristic of the type of added berries, not saturated
200	Dense, nonfluid	Noticeable taste of berries	Saturated, characteristic of the type of added berries

The ratio of the weight of berries and NCC was chosen to be 2 : 1.

To ensure the preservation of fluffy structure without signs of syneresis for the whole period of the product sales (7 days), berry filler was stabilized by apple pectin. This supplement also ensures pronounced functional properties of the product.

The optimal amount of apple pectin was determined experimentally. Pectin was added in dry form to the hot (80°C) berry filler under continuous stirring. Then the mixture was cooled to 20–25°C, and after 2 hours the consistency of the berry filler with various pectin content was determined. The impact of the pectin percentage on the consistency of the berry filler is shown in Table 13.

In the formulation of the product, the percentage of pectin was chosen to be 1% of the weight of berry filler.

The developed final formulation of the berry "Smoothie" with honey on the basis of natural concentrate of casein is provided in Table 14.

The product had a soft fluffy consistency, with a pleasant sense of berry pieces. The content of the components in the finished product is shown in Table 15.

The resulting dessert compares favorably with its dairy analogues by having high nutritional and biological value. The "Smoothie" contains casein in its native and easily assimilable form, contains virtually no fat, while adding apple pectin to the formulation ensures high functional properties. Natural honey and berry filler make the product not only attractive to consumers, but also beneficial to health.

Study of the functional and technological properties of WPF

Whey-pectin fraction, containing virtually no fat, was received both from skim and whole milk according to the above-described fractionation technology. WPF was a transparent, greenish-yellow liquid with a sweetish taste, with the titratable acidity of 17–18°T and pH of 6.27–6.25.

At the pectin content within 0.6–0.7% of the weight of milk (on a dry basis), the yield of WPF from skim milk was within 80–81%, from whole milk – 72–73%, solids content was 6.2–6.3%. The total protein content in the WPF was 0.9–1.0%, of which whey proteins – 0.45–0.50%.

The developed formulation of the new products included natural honey. Sucrose was used for the control purposes.

The organoleptic characteristics of WPF at the sugar content within the range from 1 to 5%, in increments of 1%, are shown in Table 16.

It was noted that after adding honey to WPF, a dense gel was formed after a while, having a tendency to syneresis; in 96 hours the degree of syneresis was 10–12% for the studied concentrations of honey from 1 to 10% (Table 17).

The ability of honey to transform WFP into gel can be associated with a complexing ability of polyvalent metal ions. Honey contains over 37 macro-and microelements; the high total concentration of sugar molecules (fructose – 33…42%, glucose – 31…36%, sucrose and other sugars – 10%), which possess high hydrophilic properties (can convert free water into the bound form), also contributes to the formation of gel [2, 9].

The primary role of the cations of metals in the formation of the gel of WPF with honey is evidence by the lack of sweet taste in the densifying gel and the presence of pronounced sweetness of the water phase. After adding the mixture of glucose and fructose (1 : 1) in the total amount of 5% of the weight of WPF (maximum amount of honey in the samples), no gel formation was observed. Neutral properties, pleasant smell, and the behavior of WPF when adding honey, were the reason for the selection of the product made on its basis – a pudding.

Table 13. The impact of the pectin percentage on the consistency of the berry filler

Percentage of pectin, %	Consistency of berry filler
0 (control)	Fluid, free moisture
0.5	Fluid, free moisture
1.0	Dense, retains moisture
1.5	Dense, retains moisture
2.0	Very dense

Table 14. The formulation of the berry "Smoothie" with honey on the basis of NCC

Component	Weight, kg
Natural casein concentrate, solids content = 24%	320
Berry filler in 30% syrup	640
Pectin, solids content = 95%	10
Honey, solids content = 83%	30
Total	1000
The solids content in the finished product is not less than 30%	

Table 15. The content of the components in the berry "Smoothie" with honey on the basis of NCC

Parameter	The content in the product
Mass fraction of protein, %	Not less than 7.0
Mass fraction of sucrose, %	Not less than 20.0
Mass fraction of honey, %	Not less than 3.0
Moisture content, %	Not less than 70.0

Table 16. Organoleptic characteristics of samples with honey and sucrose

WPF with honey	WPF with sucrose
The sweetness threshold rises until the honey concentration reaches 4%. A pleasant mild taste with a honey flavor. Further increasing of the concentration doesn't result in increasing sweetness. In WPF with honey, the formation of gel began after some time at a room temperature	The sweetness is more pronounced than that of WPF with honey. With the increase in concentration, the taste becomes too sweet (too sugary). The samples of WPF with sucrose remained liquid with time

Table 17. The impact of the honey concentration on the properties of WPF

Mass fraction of honey, g per 100 g of WPF	Weight of sample = 100 g			
	Consistency		Degree of syneresis, % fluid of the initial weight of gel at 4–6°C	
	after 1 hour	after 24 hours	12 hours	96 hours
0.5	liquid	jelly	3 ± 0.5	10 ± 0.5
1	liquid	dense gel	9 ± 0.5	11 ± 0.5
2	liquid	dense gel	10 ± 0.5	12 ± 0.5
3	slight solidification	dense gel	10 ± 0.5	12 ± 0.5
5	complete solidification	dense gel	10 ± 0.5	12 ± 0.5
10	thick, dense structure	dense gel	10 ± 0.5	12 ± 0.5

Development of a dairy dessert on the basis of WPF with honey

The selection of the components of the pudding formulation was carried out on a step-by-step basis stages, by choosing various ratios between the following components: WPF, skim milk powder, cream, starch and fillers [9]. This paper provides the final version of the formulation (Table 18).

CONCLUSION

Using apple pectin in a closed milk processsing cycle is of interest from both economic and biological perspective. The products obtained by fractionation of raw milk – NCC and WPF – have high nutritional, biological and technological value. On the basis thereof, it is possible to obtain a large variety of functional products. Using natural honey and vegetable raw materials in the manufacturing process ensures high consumer properties and improved functional properties of the products. The practical proof of this are the technologies and formulations of the products on the basis of WPF and NCC (pudding and "Smoothie"), presented in this paper.

Table 18. The formulations of a pudding on the basis of WPF

Components	A pudding on the basis of WPF, mass fraction of fat 3%		
	milk-honey	vanilla	chocolate
WPF, solids 6.2%	703	7	709
Cream, fat content 30%	100	1	94.3
Skim milk powder, solids content 96%	62.2	56.8	47.1
Honey, solids content 83%	50	25	25
Sugar, solids content 99.86%	35	60	60
Starch, solids content 96%	50	50	50
Vanilla, solids content 100%	–	0.5	–
Cocoa powder, solids content 96%	–	–	15
Total	1 000	1 000	1 000

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