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SCIENTIFIC SUBSTANTIATION OF CREAM HEATING DURATION IN THE TECHNOLOGY OF SOUR CREAM, ENRICHED WITH PROTEIN

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Abstract. Expanding the assortment of sour cream with increased nutritional value is an actual direction of scientific research. The purpose of the work is the scientific explanation of heating process duration based on the analysis of its influence on the sensory and physicochemical indicators of cream, enriched with milk protein concentrates as a basis for the production of baked sour cream. The regularities of changes in the quality indicators of cream (10–20% fat), enriched with 1% of concentrate of whey proteins (94% total solids) and with 30% of liquid concentrate of hydrolyzed whey (40% total solids) under the influence of heat treatment at a temperature of 96±1 ⁰C for 15 to 120 minutes were determined. Due to the introduction of whey protein concentrate into the composition of cream, the protein content increases by 0.77%, and in samples with liquid hydrolyzed whey concentrate by 0.42%. Liquid hydrolyzed whey concentrate also increases the solid content in cream by 9.36–9.37% while simultaneously reducing the lactose content by 6.2–6.7 times, which is promising for the production of low-lactose sour cream. Whey protein concentrate more effectively reduces surface tension, exhibits a higher stabilizing and structuring ability, compared to liquid hydrolyzed whey concentrate. Instead, the concentrate of liquid hydrolyzed whey with a high content of monosaccharides activates the Maillard reaction with the formation of an intense cream color, gives the cream a pronounced sweet taste and baked aroma. Both concentrates significantly improve the sensory properties of cream, which makes it possible to recommend them for use in baked sour cream technology. Based on the results of a comprehensive analysis of the quality indicators of baked cream samples with a fat content of 10–20%, it was concluded that heat treatment of cream with liquid hydrolyzed whey concentrate and cream with whey protein concentrate should be carried for 15 minutes and 30 minutes, respectively, which will allow purposeful regulation of energy consumption in the technology of baked sour cream with increased protein content.

Keywords: baked cream, sour cream, milk protein concentrates, physicochemical properties, sensory indicators

Introduction. Formulation of the problem. In global practice, sour cream technology involves heat treatment of cream at a temperature of 90–95 °C for 3–5 min in order to inactivate pathogenic microorganisms [1]. Under the influence of heat treatment under the indicated regimes, whey proteins are denatured, which leads to the contact of the free thiol group of β-lactoglobulin with κ-casein on the surface of casein micelles through sulfur bridges [2,3]. Complex coagulation of milk proteins during acid coagulation strengthens the protein matrix of the gel and reduces syneresis of protein clots of fermented products [4]. Another advantage of high-temperature pasteurization is an increase in the isoelectric point of protein coagulation to 5.3, which accelerates the process of formation of milk-protein clots [5]. High-temperature pasteurization also modifies lactose with the formation of melanoidins, which has been widely studied in milk beverage technologies [6]. Under the influence of long-term heat treatment, the taste of milk and cream also changes, membranes of fat globules are thermally denatured, lipids are partially degraded with the formation of aromatic compounds [7]. That is why the spinning of milk and cream is widely used to give dairy products original and pronounced organoleptic properties [8]. At the same time, the change in organoleptic indicators of cream, including protein-enriched cream, under the influence of heat treatment is not sufficiently studied and is of interest from the point of view of developing a new type of strained sour cream.

Analysis of recent research and publications

The main source of accumulation in milk and cream of sulfhydryl groups, which take a direct part in the Maiared reaction, is lactoglobulin [9]. The source of sulfhydryl groups is also the shells of fat globules, but due to their very low content in milk and cream, their role in the Maiared reaction is insignificant [10]. Therefore, it can be assumed that melaidin formation should be more pronounced in low-fat creams (10–20%), which contain a sufficient amount of lactose and lactoglobulin.

High-temperature processing also leads to partial hydrolysis of milk fat triglycerides, which increases the content of diglycerides (surface-active compounds) and free volatile fatty acids (flavor-aromatic compounds). Unsaturated fatty acids are partially oxidized to aldehydes and ketones, of which unsaturated aldehydes give milk its characteristic creamy taste [11]. During long-term heat treatment of milk, partial thermal destabilization of fat globules also occurs, which is accompanied by the transition from the shells of fat globules to the plasma of proteins and phospholipids with a simultaneous increase in the size of fat globules [12]. Therefore, long-term heat treatment forms a pleasant nutty taste and creamy color of milk and cream, and can also affect their physical characteristics - viscosity, surface tension, stability of fat emulsion.

Information on the scientific justification of the technological modes of spinning cream of different fat content is practically absent and concerns only the features of spinning cream with a fat content of 27–34% or high-fat cream for the production of butter. Such creams are kept at a temperature of 97–98^{0}C for 10–15 minutes for the formation of sulfhydryl groups and lactones [13].

The existing information on the technology of sour cream is very limited. Back in the times of the USSR, scientists of the UkrNDMyyasomolprom (Ukraine, Kyiv) developed a method of obtaining a strained sour milk product similar to sour cream (Author's certificate A 23C 9/12 SU1616577 A1. The method of obtaining a melted sour milk product), which involves the homogenization of milk under a pressure of 2.4 MPa, followed by its straining at a temperature of 95–99ºC for 3–4 hours and the separation of cream. The resulting cream is re-homogenized (8–10 MPa), leavened and fermented. The structured brewed product is stored for a long time, does not separate the whey, has an original taste, smell, and color. At the same time, the proposed two-stage homogenization of milk raw materials significantly complicates the technology.

The technology of strained sour cream was developed by scientists of the Danone company. To give the cream a characteristic taste, aroma and color, dry skimmed milk is added to their composition in the amount of 1–5 %, which is obtained from fermented lactose-free skimmed milk with its subsequent thickening and drying. The disadvantage of this development is repeated spinning for 0.5–4.0 hours of the cream mixture, which already contains skimmed milk powder, which leads to significant energy consumption (International application A 23C 13/16, WO2017105285A1. Method of production of melted sour cream). The use of dry steamed skimmed milk can be explained by the low content of protein (2.1–2.2%) and DSMR (3.6–4.0%) in cream with a fat content of 25–30%, which complicates the formation of organoleptic characteristics of the steamed product.

The current trend in the production of products from the cream group is to reduce the fat content and enrich these products with proteins [14], which explains the increase in demand for dietary sour cream. L. Shepard at all. [15] studied the sensory properties of sour cream and noted the existing problem of formation of consistency, taste and aroma specifically for a product with reduced fat content. The most important characteristics for sour cream have been identified – the taste of pasteurization, the sweet taste and the intensity of color. Therefore, it is advisable to pay attention to the formation of these organoleptic indicators, in particular, during the development of the technology of strained sour cream with a low fat content, including with an increased protein content.

The recipe composition of dietary sour cream enriched with milk proteins was previously developed by the authors of the article [16].

The organoleptic indicators of sour cream are directly related to the physical properties of cream. Since heat treatment affects the stability of dispersed systems, there is a need for additional study of the stability of milk fat emulsion in cream during spinning, including in the presence of milk protein concentrates. Attention should also be paid to such physical indicators of condensed cream as viscosity, surface tension, active acidity and water activity, which can affect the technological parameters of the production and storage of condensed cream.

Considering the above, **the purpose of the study** is to study the features of the effect of the duration of the spinning process on the organoleptic and physicochemical parameters of cream enriched with milk protein concentrates as a basis for the production of sour cream.

To achieve the goal, it is necessary to solve the following tasks:

– to investigate the influence of the duration of spinning on the physical and chemical properties of creams with a fat content of 10–20 %, including those enriched with milk protein concentrates;

– to conduct a comparative analysis of the organoleptic indicators of heavy creams of different chemical composition;

– to develop recommendations for rational regimes of the spinning process of cream with milk protein concentrates.

Research materials and methods

The following milk protein concentrates (MPC) were used to enrich the cream:

– hydrolyzed whey concentrate (HWC), the technology of which was developed by scientists of the National University of Food Technologies (Ukraine) and the Lublin University of Life Sciences (Poland) (composition: dry matter – 40%, protein – 4.4%, carbohydrates – 33.8%, fat – 0.4%, ash – 1%) [17];

– whey protein concentrate, obtained by the ultrafiltration method (WPC-UF) (manufacturer – OJSC "Hadyachsir" Ukraine, composition: dry matter – 94%, protein – 80%, carbohydrates – 7%, fat – 7%).

The authors established a rational content of selected MPC in sour cream – 1 % WPC-UF and 30 % HWC, which ensures the formation of high indicators of the quality of the finished product [16]. The advantage of using HWC is that, with the overall high content of carbohydrates, after enzymatic hydrolysis, about 5 % of lactose remains in this concentrate, the remaining carbohydrates are monosugars [17].

MPC was dissolved directly in cream with a fat content of 10, 15 and 20 % at a hydromodule of 1 : 10 and a temperature of 40 ℃ with exposure for 30–40 min for preliminary swelling. The MPC solutions were filtered, cooled, and added while stirring to the normalized cream mixtures before straining.

To increase the heat resistance of the cream, it was pre-homogenized using a laboratory homogenizer-disperser model 15M-8TA "Lab Homogenizer & Sub-Micron Disperser" (GAULIN CORPORATION, Massachusetts, USA) in two stages at a given pressure: on the first stage – 10.0 MPa, on the second – 2.5 MPa at a temperature of 65±2ºC. The homogenized cream was strained at a temperature of 96±1ºC for 15, 30, 60 and 120 min, cooled to a temperature of 8–10ºC, kept for at least 2 hours for crystallization of milk fat, after which the organoleptic and physical characteristics were examined.

The protein content was determined by the Kjeldahl method with a nitrogen still [18], the lactose content by the accelerated colorimetric method [19], the mass fraction of total carbohydrates by the Bertrand method [20], and the mass fraction of dry substances by the well-known method [16].

The surface tension of the cream was determined by the stalagmometric method (Traube stalagmometer) at a temperature of 20 ± 0.5°C [21].

Active acidity was determined by the potentiometric method using an ADWA AD1030 pH meter at a temperature of 20±0.5ºC [22].

The dynamic viscosity of cream samples was determined using an Ostwald viscometer at a temperature of 20 ± 0.5°C [23].

The degree of destabilization of milk fat emulsion in cream was determined by the method of M.V. Faustova [24].

Organoleptic indicators (consistency, smell, taste, color, appearance) were evaluated on a 5-point scale (1 – bad, 2 – acceptable, 3 – good, 4 – very good, 5 – excellent). The taste was evaluated, paying special attention to the aftertaste of pasteurization, sweet and creamy flavors. The impact of each indicator was calculated taking into account the following weighting factors: consistency – 0.2; smell – 0.2; taste – 0.3; color – 0.2; appearance – 0.1. Based on the average scores of each attribute, the overall sensory quality was calculated as a weighted average of the scores. Cream samples were differentiated by quality level, according to the calculated total weighted score, as follows: excellent (20.0–25.0 points); good (16.0–19.9 points); satisfactory (11.0–15.9 points); practically unacceptable (6.0–10.9 points); unacceptable (less than 6 points) [25].

The accuracy of the obtained results was ensured by the three-fold repeatability of the experiment with a confidence probability of P≥0.95.

Results of the research and their discussion

The chemical composition of the control and test cream mixtures, made taking into account the mass fraction of fat and the rational content of MBK, is given in Table. 1.

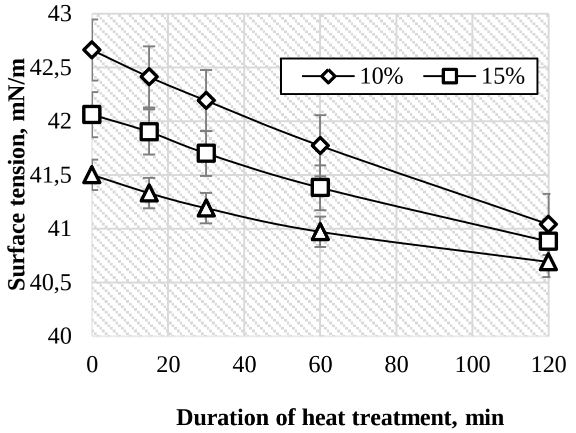
Table 1 – Chemical composition of normalized cream mixtures, %

Constituent components	Mass fraction of cream fat, %			Fat mass fraction of cream from WPC-UF with, %			Fat mass fraction of cream with HWC %		
	10	15	20	10	15	20	10	15	20
dry matter	17.81± 0.61	22.48± 0.96	27.12± 1.0	18.64± 0.77	23.33± 1.05	27.98± 0.95	27.17± 1.20	31.84± 1.41	36.49± 1.11
protein	2.71± 0.17	2.57± 0.15	2.43± 0.11	3.48± 0.19	3.34± 0.14	3.20± 0.11	3.13± 0.17	2.99± 0.12	2.85± 0.12
carbohydrates, including:	4.34± 0.20	4.11± 0.19	3.89± 0.15	4.36± 0.19	4.13± 0.21	3.91± 0.19	13.04± 0.41	12.81± 0.55	12.59± 0.48
lactose	4.33± 0.24	4.11± 0.20	3.87± 0.18	4.35± 0.20	4.13± 0.20	3.90± 0.18	0.65± 0.01	0.64± 0.02	0.62± 0.02

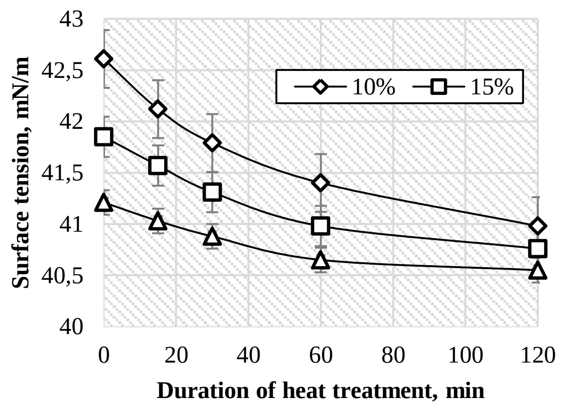
According to the results of the analysis of the data presented in the table. 1, milk-protein concentrates increase the protein content in cream by 0.77% (samples from WPC-UF) and by 0.42% (samples from HWC), compared to control samples. At the same time, in contrast to the samples from WPC-UF, the dry matter content in the samples from HWC significantly increases – by 9.36–9.37%. In samples from WPC-UF, the increase in the content of dry matter is quite moderate – only by 0.83–0.86%. It should also be noted that there is no significant difference in the content and composition of carbohydrates between the control samples and the cream samples from WPC-UF, unlike the samples from HWC. In the latter case, when the total carbohydrate content exceeds 8.7 %, the lactose content decreases by 6.2–6.7 times, compared to the control samples. Analysis of the chemical composition of the control and researched samples will allow to explain the peculiarities of changes in the physical and organoleptic properties of creams of different chemical composition.

At the next stage, the influence of the duration of the spinning process on the physical and chemical parameters of the cream was investigated. The results of determining the surface tension of cream with a fat content of 10, 15, and 20 % of the control and test samples for different durations of the spinning process are shown in Fig.1.

It is known that milk, which contains surface-active compounds – fatty acids, proteins, phospholipids, has a lower surface tension (42.7–56.1 mN/m) than water (72 mN/m) [26,27]. It was established that the surface tension of cream with a fat content of 10–20% with an increased content of phospholipids and a sufficient amount of proteins is even lower than the surface tension of milk. According to fig. 1, an increase in the content of fat in cream as a carrier of surface-active phospholipids and a corresponding decrease in the content of water as a solvent for proteins with an increase in the concentration of their colloidal solution significantly affects the surface tension, reducing it. It is obvious that this pattern is characteristic not only for cream of standard composition (Fig. 1a), but also for cream enriched with proteins (Fig. 1b,c).



a)



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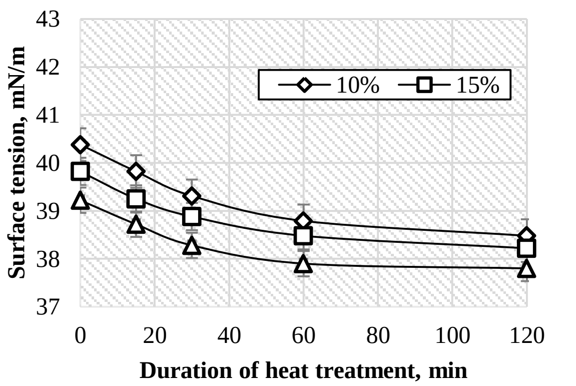

c)

Fig. 1. Surface tension of creams with a fat content of 10, 15 and 20% for different durations of spinning: a – cream (control); b – cream from WPC-UF; c – cream from HWC

Extending the duration of cream spinning slightly reduces the surface tension of all cream samples, which can hypothetically be explained by partial thermal hydrolysis of fat, resulting in the formation of surface-active compounds – fatty acids, mono- and diglycerides. Under the influence of heat treatment, intermolecular forces of interaction decrease, which also reduces surface tension. At the same time, for an almost linear decrease in surface tension in creams without MBC during the spinning process, in creams with HWC such a decrease is somewhat inhibited after 60 min of heat treatment. This tendency is even more pronounced for WPC-UF cream. The increased content of whey proteins in such creams causes additional precipitation of these proteins during spinning on the surface of casein micelles. This leads to a partial blocking of the access of surface-active groups of more heat-resistant casein to the surface of the phase separation, which can reduce its surface activity. But the partial simultaneous loss of surface activity by both whey proteins and casein is compensated by more pronounced hydrolysis of milk fat after 60 min of spinning, which explains the slight but further decrease in surface tension.

The change in surface tension in cream can be an important factor influencing the stability of milk fat emulsion, and can also be correlated with other physical characteristics [28], which must be investigated at the next stage of the experiment. The results of determination of active acidity during the cream spinning process are given in Table 2.

According to the Table 2, the pH level of cream without MBK before the start of heat treatment fluctuated in the range of ±0.01–0.02 pH units, depending on the fat content. The active acidity of cream with MBC is slightly lower than the additional binding of a part of free water by proteins, which leads to a slight concentration of the solution of water-soluble compounds. In addition, mineral compounds in the composition of the hydrolyzed whey concentrate affect the reduction of the pH of the cream.

It should be noted the decrease in the active acidity of all samples under the influence of heat treatment, which is explained by the strengthening of the dissociation of potential electrolytes and water. In samples from HWC, this effect is most pronounced with an increased content of mineral compounds in them. The active acidity of all cream samples decreased the fastest in the first 15–30 min of spinning, with a subsequent slowing of this process and even some increase of this indicator. Probably, during heat treatment during the first 15–30 minutes, regardless of the loss of CO_2, in cream with a low and medium fat content, the processes of converting a part of soluble calcium and phosphorus into insoluble calcium phosphate with the release of acidic phosphates prevail. This can explain the most pronounced decrease in the pH level for cream samples with an increased content of mineral compounds, namely for cream with HWC. The increase in the pH level after 60 min of heating, which was observed and described by Jasim Al-Saadi for milk [29], was not observed in the systems we studied due to a different chemical composition of the cream.

The dynamic viscosity of creams of different chemical composition, which were subjected to straining, is given in the Table 3.

Milk, the viscosity of which at 20°C is on average from 1.5 to 2.0 $\bullet 10^{-3}$ Pa•s, is tentatively classified as a Newtonian liquid. Creams with a fat content of 10–20% are also close to Newtonian liquids, but when the fat content exceeds 30%, they significantly structure and acquire the properties of non-Newtonian liquids [30,31]. According to the evidence in the Table 3, the viscosity of the studied cream depends significantly on the content of milk fat and protein, in particular, whey proteins, which correlates with the evidence of N. Biglarian et al. [32]. This pattern is observed for all cream samples with a fat content of 10 to 20% and a protein content of 2.43 (20% cream without MBC) to 3.75% (10 fat cream with 1% WPC-UF). The presence of monosugars and mineral compounds in the composition of HWC with the additional binding of free water due to the difference in the mass fraction of dry substances of 8.6 % improves the structuring of the cream.

Table 2 – Active acidity of cream (pH units) for different durations of spinning (n=3; P≥0.95)

Mass fraction of fat, %	**Spinning duration, min**				
	0	15	30	60	120
cream					
10	6.67±0.19	6.62±0.17	6.57±0.11	6.55±0.17	6.54±0.13
15	6.65±0.18	6.59±0.17	6.54±0.16	6.50±0.11	6.49±0.14
20	6.64±0.15	6.57±0.15	6.52±0.12	6.48±0.13	6.46±0.16
cream from WPC-UF					
10	6.65±0.17	6.50±0.15	6.42±0.16	6.36±0.12	6.35±0.14
15	6.64±0.14	6.48±0.13	6.38±0.17	6.32±0.13	6.30±0.13
20	6.64±0.15	6.42±0.13	6.3±0.15	6.26±0.11	6.25±0.13
cream from HWC					
10	6.64±0.15	6.33±0.12	6.26±0.10	6.22±0.11	6.18±0.12
15	6.62±0.12	6.27±0.11	6.22±0.10	6.19±0.10	6.15±0.09
20	6.63±0.10	6.25±0.13	6.20±0.11	6.17±0.13	6.14±0.10

Table 3 – Dynamic viscosity of cream (mPa•s) for different durations of spinning (n=3; P≥0.95)

Mass fraction of fat, %	Spinning duration, min				
	0	15	30	60	120
cream					
10	2.60±0.01	3.2±0.02	3.2±0.02	2.8±0.03	2.2±0.01
15	8.51±0.04	8.9±0.03	8.9±0.04	8.7±0.03	8.2±0.03
20	11.9±0.03	12.3±0.03	12.4±0.03	12.2±0.04	11.8±0.04
cream from HWC					
10	18.2±0.03	18.9±0.03	19.0±0.04	18.3±0.04	17.1±0.03
15	28.1±0.04	30.1±0.05	30.0±0.04	29.3±0.04	27.8±0.04
20	39.3±0.06	41.5±0.05	41.5±0.05	41.2±0.04	39.2±0.05
cream from WPC-UF					
10	16.0±0.03	17.2±0.04	17.1±0.03	16.9±0.04	15.8±0.03
15	25.2±0.04	25.7±0.03	25.7±0.04	25.2±0.05	24.0±0.03
20	37.3±0.04	38.1±0.04	38.1±0.05	37.4±0.06	36.8±0.04

A peculiarity of the influence of the duration of temperature treatment on dynamic viscosity is that, during the first 15–30 minutes of probable initial aggregation of proteins, the structuring ability of the cream even increased slightly. With the further influence of high temperature on milk proteins due to the increase in the size of casein particles and the complex formation between the fractions of whey proteins and casein [33], the viscosity of the cream decreased. This regularity is especially characteristic of cream with a mass fraction of 10% fat and an increased content of whey proteins. A decrease in the viscosity of cream during prolonged heat treatment can also be a consequence of the process of partial destabilization of the milk fat emulsion. Therefore, at the next stage, the degree of destabilization of the emulsion was investigated depending on the duration of cream spinning.

The regularities of the influence of the duration of spinning on the degree of destabilization of milk fat emulsion (Dmf) in creams of different chemical composition are shown in Fig. 2.

According to the data presented in Fig. 2, the duration of spinning of all cream samples significantly affects the degree of destabilization of the milk fat emulsion. This indicator increases with an increase in the mass fraction of fat in all cream samples, which probably depends on an increase in the area of separation of "fat-plasma" phases and a corresponding increase in the need for emulsifiers, which include milk proteins [34].

The increased content of whey proteins in cream with MBC significantly stabilizes the milk fat emulsion. A comparative analysis of the stabilizing effect of protein concentrates gives reason to conclude that the WPC-UF efficiency is higher, which can be explained by the higher protein content in the cream (0.2% on average). The increased content of dry substances in cream with HWC, compared to cream with WPC-UF, indicates that the non-protein components of HWC do not show stabilization ability.

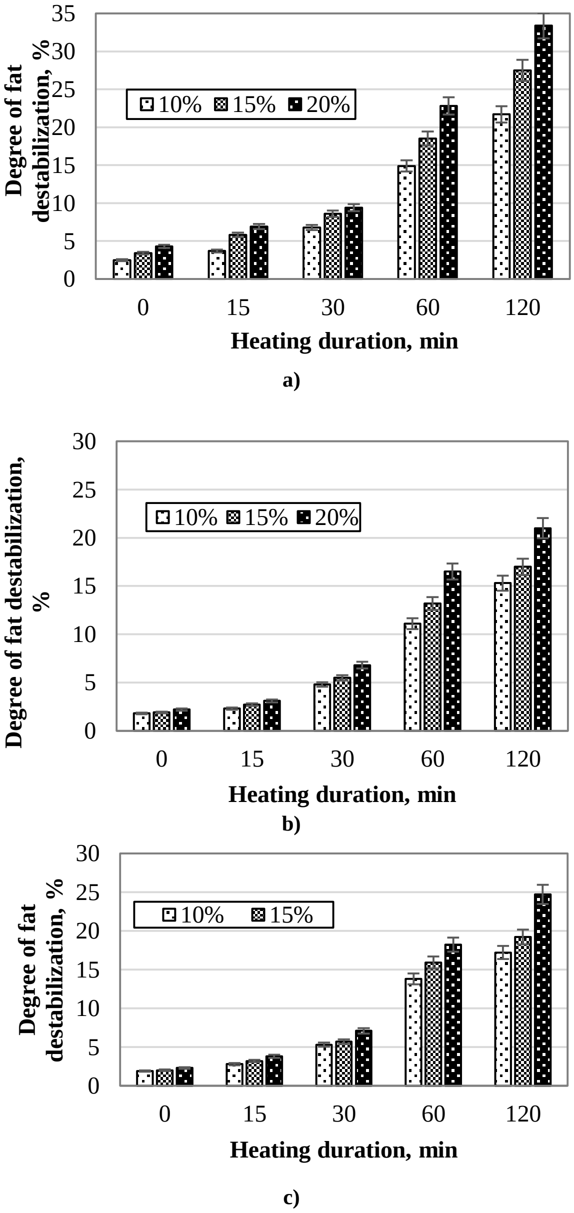

Fig. 2. The dynamics of changes in the degree of destabilization of the milk fat emulsion in cream (a), cream with WPC-UF (b) and cream with HWC (c) depending on the duration of the spinning process

Based on the results of the analysis of the research results, it can be concluded that after 30 minutes of the spinning process, it is not advisable to continue the heat treatment of the cream, because it leads to a degree of destabilization of the emulsion above 10%, which is a rather high indicator and indicates a significant destruction of the dispersed "fat-water" system ". Such destabilization of the milk fat emulsion requires repeated homogenization of the cream before fermentation, and can also lead to a non-uniform consistency of sour cream due to the formation of agglomerates of fat balls.

At the final stage, the organoleptic indicators of control and experimental samples of whipped cream were studied.

The total weighted score of the organoleptic evaluation and the quality level of the cream samples are given in the Table 4 and 5.

Complex organoleptic assessment of cream samples allows us to characterize their quality level as the result of single indicators, taking into account the accepted weighting coefficients. In some cases, different indicators of the same sample were evaluated as high, such and low scores. For example, control samples of cream with a fat content of 15 and 20 % after 30 min of spinning according to taste received quite high points, but the destabilized fat, the content of which was most pronounced for the cream with a fat content of 20 %, gave it a grainy consistency due to the lumps formed by the destabilized fat, which is unacceptable . It should also be noted that the cream from WPC-UF had the best consistency, and the cream from HWC had the most pronounced and extremely pleasant taste, smell and color.

The most significant change in the color of whipped cream with hydrolyzed whey concentrate is explained by its rather high content of monosaccharides as products of lactose hydrolysis, which correlates with the data of Naranjo GB at all. regarding the detection of a similar effect in lactose-hydrolyzed dry milk [35]. The revealed effect requires a more detailed study. Therefore, the dependence of the degree of coloring on the chemical composition of the cream and spinning modes is planned to be carried out in the following studies using the NCS colorimeter.

Creams from HWC with an increased content of monosaccharides acquired a high level of quality after 15 min of spinning, and creams from WPC-UF – after 30 min of spinning. The established parameters of the cream spinning process are rational and can be recommended in the technology of strained sour cream enriched with proteins.

Table 4 – Total weighted score of organoleptic evaluation of cream samples

Mass fraction of fat, %	**Spinning duration, min**				
	0	15	30	60	120
cream					
10	16.7	19.0	19.5	19.5	16.2
15	17.2	19.3	20.7	18.0	15.9
20	17.8	19.6	20.9	15.9	15.6
cream from HWC					
10	18.1	24.0	24.2	23.7	21.5
15	18.5	23.8	24.5	22.6	19.7
20	19.2	23.5	24.0	22.0	18.5
cream from WPC-UF					
10	17.4	19.3	24.0	24.0	21.0
15	17.9	19.3	23.7	23.2	22.2
20	18.9	20.7	22.9	21.8	19.4

Table 5 – Quality level of cream samples

Mass fraction of fat, %	**Spinning duration, min**				
	0	15	30	60	120
cream					
10	good	good	good	good	good
15	good	good	distinctive	good	satisfactory
20	good	good	distinctive	satisfactory	satisfactory
cream from HWC					
10	good	distinctive	distinctive	distinctive	distinctive
15	good	distinctive	distinctive	distinctive	good
20	good	distinctive	distinctive	distinctive	good
cream from WPC-UF					
10	good	good	distinctive	distinctive	distinctive
15	good	good	distinctive	distinctive	distinctive
20	good	distinctive	distinctive	distinctive	good

Note: Dark gray background indicates excellent quality, gray indicates good quality, light gray indicates satisfactory quality.

Approbation of research results. The results of the conducted research are of practical significance, as they are a scientific justification of the technological modes of heat treatment of cream in the technology of a new type of sour cream of increased nutritional value with organoleptic properties attractive to consumers. Sour cream based on cream with hydrolyzed whey concentrate, which contains only 0.62–0.65% lactose, can be classified as low-lactose products, which will contribute to improving the nutrition structure of consumers. Developed on the basis of the formulated practical recommendations, the protein-enriched strained sour cream technology is promising for wide implementation at dairy enterprises, since the process of heat treatment of cream can be carried out in a periodic way on the existing capacious equipment equipped with a heat exchange jacket and a stirrer.

Conclusions

The concentrate of whey proteins obtained by the ultrafiltration method in the amount of 1 % effectively reduces the surface tension, shows a higher stabilizing and structuring ability in the composition of cream with a fat content of 10–20 %, which is subjected to straining.

Hydrolyzed whey concentrate in the amount of 30% during spinning activates the Maillard reaction in the cream with the corresponding formation of an intense cream color, and also gives the cream a pronounced sweet taste and an intense aroma of spinning.

In order to obtain a high quality level of cream with hydrolyzed whey concentrate, it is recommended to subject it to fermentation at a temperature of 96 ± 1ºC for 15 minutes. The duration of spinning cream with whey protein concentrate obtained by the ultrafiltration method should be 30 minutes at the same temperature. These recommendations will allow you to purposefully regulate energy consumption in the technology of strained sour cream with an increased protein content.

Both concentrates significantly improve the sensory properties of creams, in particular with a fat content of 10–15 %, compared to control samples, and can be recommended for wide use in the technology of strained low-calorie sour cream. The use of hydrolyzed whey concentrate in sour cream also makes it possible to expand the range of dairy products with a low lactose content.

Prospects for further research are to study the influence of the spinning process on the intensity of color of whipped cream of different chemical composition, as well as to identify the peculiarities of the flow of lactic acid fermentation during the fermentation of whipped cream with milk protein concentrates.

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НАУКОВЕ ОБГРУНТУВАННЯ ТРИВАЛОСТІ ПРЯЖЕННЯ ВЕРШКІВ У ТЕХНОЛОГІЇ СМЕТАНИ, ЗБАГАЧЕНОЇ БІЛКАМИ

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Анотація. Розширення асортименту сметани підвищеної харчової цінності є актуальним напрямом наукового дослідження. Метою роботи є наукове обгрунтування тривалості процесу пряження на основі аналізу його впливу на органолептичні та фізико-хімічні показники вершків, збагачених молочно-білковими концентратами як основи для виробництва сметани пряженої. Досліджено закономірності зміни показників якості вершків з масовою часткою жиру 10–20%, збагачених концентратом сироваткових білків (м.ч. сухих речовин 94%) у кількості 1% і концентратом гідролізованої сироватки (м.ч. сухих речовин 40%) у кількості 30% під впливом теплового оброблення за температури 96±1⁰С впродовж від 15 хв до 120 хв. За рахунок уведення до складу вершків концентрату сироваткових білків масова частка білку підвищується на 0,77%, а у зразках з концентратом гідролізованої сироватки − на 0,42%. Концентрат гідролізованої сироватки також підвищує вміст сухих речовин у вершках на 9,36–9,37% за одночасного зниження вмісту лактози у 6,2–6,7 рази, що є перспективним для одержання низьколактозної сметани. Концентрат сироваткового білка ефективніше знижує поверхневий натяг, виявляє вищу стабілізуючу і структуруючу здатність, порівняно з концентратом гідролізованої сироватки. Натомість, концентрат гідролізованої сироватки з високим вмістом моноцукрів активує реакцію Майяра з формуванням інтенсивного кремового кольору, надає вершкам яскраво вираженого солодкуватого присмаку та аромату пряження. Обидва концентрати суттєво покращують сенсорні властивості вершків, що дозволяє рекомендувати їх до застосування у технології пряженої сметани. За результатами комплексного аналізу показників якості зразків пряжених вершків жирністю 10–20% зроблено висновок про доцільність проведення теплового оброблення вершків з концентратом гідролізованої сироватки і вершків з концентратом сироваткових білків впродовж 15-ти хв і 30-ти хв, відповідно, що дозволить цілеспрямовано регулювати енерговитрати у технології пряженої сметани з підвищеним вмістом білку.

Ключові слова: пряжені вершки, сметана, молочно-білкові концентрати, фізико-хімічні властивості, органолептичні показники.