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INFLUENCE OF TEMPERATURE REGIMES OF RIPENING AND FERMENTATION STAGES ON THE PHYSICAL AND CHEMICAL PROPERTIES OF CREAM AND SOUR-CREAM BUTTER QUALITY INDICATORS

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Abstract. Physical and chemical properties of cream multistep modes of ripening and fermentations are investigation and their role in the production of sour-cream butter is studied. The process of ripening of cream was carried out multistep, regimes were selected depending on seasonal changes in the composition of milk fat. For raw materials of the autumn-winter period, for the values of iodine number 29.1–34.5, the first stage of ripening was carried out at a temperature of 8°C for 2 hours, the second stage – at 21°C for 7 hours, the third stage – at 13°C for 10 hours. For raw of spring-summer period, for the values of iodine number 34.5–40.1, the first stage of ripening was carried out at 21°C for 6 hours, the second stage – at 13°C for 4 hours, the third stage – at 8°C for 8 hours. It has been established that individual modes of low-temperature cream preparation, taking into account seasonal changes in the composition of milk fat, make it possible to obtain cream before churning almost with the same indexes of effective viscosity. The content of the crystalline phase of milk fat under both temperature regimes was 38.7–40.1%, which is sufficient to obtain of proper consistency sour-cream butter. The content of diacetyl and volatile organic acids more depend on the level of fermentation of cream than on the technological regimes of ripening and seasonality of raw materials. It has been proved that an increase in the fermentation degree of cream promotes an increase in the acidity of plasma and the content of aroma-producing components in the butter, and, accordingly, affects the degree of the sour taste. It is recommended for the production of cultured butter to begin the cream when the acidity of the plasma reaches 60ºT, which ensures the formation of high sensorial characteristic of the finished product.

Key words: sour-cream butter, temperature regimes for ripening, crystallization of milk fat, acidity, diacetyl, volatile organic acids

ВПЛИВ ТЕМПЕРАТУРНИХ РЕЖИМІВ ДОЗРІВАННЯ ТА СТУПЕНЯ СКВАШУВАННЯ НА ФІЗИКО-ХІМІЧНІ ВЛАСТИВОСТІ ВЕРШКІВ ТА ПОКАЗНИКИ ЯКОСТІ КИСЛОВЕРШКОВОГО МАСЛА

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Анотація. Досліджено фізико-хімічні властивості вершків за ступінчатих режимів дозрівання та ферментування та їхній влив на якість кисло-вершкового масла. Процес дозрівання вершків здійснювали ступенево, режими обирали залежно від сезонних змін складу молочного жиру. Для сировини осінньо-зимового періоду, за значень йодного числа 29,1–34,5, перший етап дозрівання проводили за температури 8°С протягом 2 год, другий етап – за 21°С протягом 7 год, третій етап – за 13°С протягом 10 год. Для сировини весняно-літнього періоду, за значень йодного числа 34,5–40,1, перший етап дозрівання проводили за температури 21°С протягом 6 год, другий етап – за 13°С протягом 4 год, третій етап – за 8°С протягом 8 год. Встановлено, що індивідуальні режими низькотемпературної підготовки вершків з урахуванням сезонних змін складу молочного жиру, дозволяють отримати вершки перед збиванням майже з однаковими показниками ефективної в'язкості та вмісту твердої фази. Вміст кристалічної фази молочного жиру за обох температурних режимів складав 38,7–40,1%, що є достатнім для отримання необхідної консистенції кисловершкового масла. Встановлено, що вміст діацетилу та летких органічних кислот більше залежить від рівня сквашування вершків, ніж від технологічних режимів дозрівання та сезонності сировини. Доведено, що підвищення ступеня сквашування вершків сприяє підвищенню кислотності плазми та вмісту смако-ароматичних компонентів, що впливає на вираженість кисломолочного смаку. Рекомендовано для виробництва кисловершкового масла розпочинати збивання вершків після досягнення кислотності плазми 60°С, що забезпечує формування високих смакових якостей готового продукту.

Ключові слова: кисловершкове масло, ступінчаті температурні режими дозрівання, кристалізація молочного жиру, кислотність, діацетил, леткі органічні кислоти

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Introduction. Formulation of the problem

One of the challenging issues of the butter production industry is the revival of the production of sour-cream butter. Production of original product was complicated by both the lack of domestic bacterial cultures production and the lack of scientific data for technological parameters of temperature conditions for processing dairy raw materials into cream for the churning.

Analysis of recent research and publications

Despite the obvious complexity of the technological stage associated with the prolonged ripening of cream, the sour-cream butter produced by classical technology, the knocking method, has significant taste advantages compared to the butter produced by the conversion of high-fat cream [1].

At the heart of the existing technology of sour-cream butter production by the method of whipping cream lies the ability of milk fat to change the aggregate state under the influence of temperature in parallel with the achievement of the required level of acidity and the formation of specific aromatic substances as a result of lactic fermentation by fermented cultures [2-6].

To regulate the structure of butter consistency and minimum fat loss in buttermilk, to strengthen the butter structure in the spring and summer seasons and to reduce mechanical strength at this time by ensuring proper flow and completing phase changes in milk fat glycerides during cream ripening, differentiated multistage temperature regimes of prolonged ripening of cream before beating, which are selected taking into account the chemical composition for the winter and summer periods [7-9]. Typically, the cream maturation regime is selected depending on the iodine value to prevent consistency defects (excessive hardness, brittleness, brittleness [10].

Therefore, it is necessary to focus on such temperature regimes of cream ripening that could simultaneously provide necessary crystallization of milk fat and create optimal conditions for the functioning of the starter microflora, promote the accumulation of aromatic substances and produce butter with a characteristic taste and aroma and a good consistency [10-13].

Despite this, the bacterial cultures must be adapted to the temperature ripening conditions provided for by this technology and to ensure a gradual fermentation of the cream to the required acidity simultaneously with the achievement of a certain level of the crystallization phase of milk fat in cream. Only under such conditions is the guarantee of obtaining the desired product with characteristic acidic taste and excellent consistency.

In addition, for the accumulation of flavor and aromatic compounds, the level of fermentation of cream is important. It is known that with a low level of active acidity in cream, more compounds accumulate, which form the taste and aroma of the finished product. In particular, the aromatic component of diacetyl is actively produced when the cream reaches a pH of 4.5–4.7 units [14].

Therefore, due to bacterial cultures and the right choice of temperature regimes of maturation, it is possible to regulate biochemical and enzymatic processes in cream. In particular, the accumulation of lactic acid and aromatic compounds depends not only on the processability and biochemical activity of the selected bacterial cultures, but also on the degree of fermentation of the cream, which affects the expressiveness of the flavor bouquet of the desired product.

It should be noted that the existing technology of producing sour-cream butter provides for the use of starter cultures. However, to date, increased attention is paid to production workers by bacterial preparations of direct application, which exclude the stage of preparation of the production starter.

In Institute of Food Resources has developed bacterial preparations for the production of sour-cream butter. The value of these crops lies in their ability to develop, aromatic and acid formation, the formation of moderate viscosity in cream at low temperatures, provided for this technology. The introduction of them into the industrial production of sour-cream butter requires verification of the above facts.

Given that active aromatization of lactic acid bacteria occurs only after the accumulation of a certain amount of lactic acid in the medium, it was important to establish the value of the titratable acidity of the cream cream before churning, providing the best organoleptic parameters of the final product.

The purpose of the study – investigation the influence of stepped temperature regimes of maturation and the degree of cracking of the cream on the properties of the cream and the quality of the indicator of sour-cream butter.

Research materials and methods

Fermentation of the cream was carried out by previously activated for 3 hours bacteriai preparations of direct set in skim milk Direct application was done at the rate of 10 g/t. The strains of mesophilic lactococci *Lactococcus lactis ssp lactis, Lactococcus lactis ssp. cremoris and Lactococcus lactis ssp. diacetilactis* were involved in the bacterial preparation "Iprovit KVM-C1". To the bacterial preparation "Iprovit KVM-C2" strains of mesophilic lactococci *Lactococcus lactis ssp lactis, and Lactococcus lactis ssp. diacetilactis* are included.

In order to determine the degree of fermentation of cream, experimental butter production was carried out after reaching acidity of 50°T, 60°T and 70°T in the cream.

Cream maturation was carried out using a three-stage temperature regime, taking into account seasonal changes in the composition of milk fat: autumn-winter for the values of iodine numbers 29.1–34.5 – at 8°C (2 h) – 21°C (7 h) – 13°C (10 h), and spring-summer for values of iodine numbers 34.5–40.1 – under the regime of 21°C (6 h) – 13°C (4 h) – 8°C (8 h).

The titratable acidity of the cream during storage was determined by GOST 3624-92; active acidity (pH) – potentiometric; the degree of crystallization of milk fat – by volume dilatometry [15].The content of acid flavor in the butter was estimated by the amount of diacetyl – by the method of Zalashko and Makarina [16], volatile organic acids – after distillation with water vapor.

For the production of butter, cream with fat 35% was pasteurized at a temperature of (92±2)°C. The finished products were stored at a temperature of (5±1)°C for 20 days.

Results of the research and their discussion

In the production of sour-cream butter, the acidity of the cream before churning is one of the main indicators, it determines the formation of a specific taste and aroma in the butter. The titrated acidity of the cream plasma is an indicator that quantitatively shows the activity of the ferment in cream, whereas measuring the active acidity of the cream does not give an accurate idea of the activity of the fermented microflora, since the cream is characterized by a certain buffer.

The duration of ripening of the cream before reaching the acidity of 50ºT, 60ºT and 70ºT was 14.5 17–18 and 21–22 h respectively. The change in the controlled indices in cream from the winter and summer cream ripening regimes is shown in Fig. 1–3.

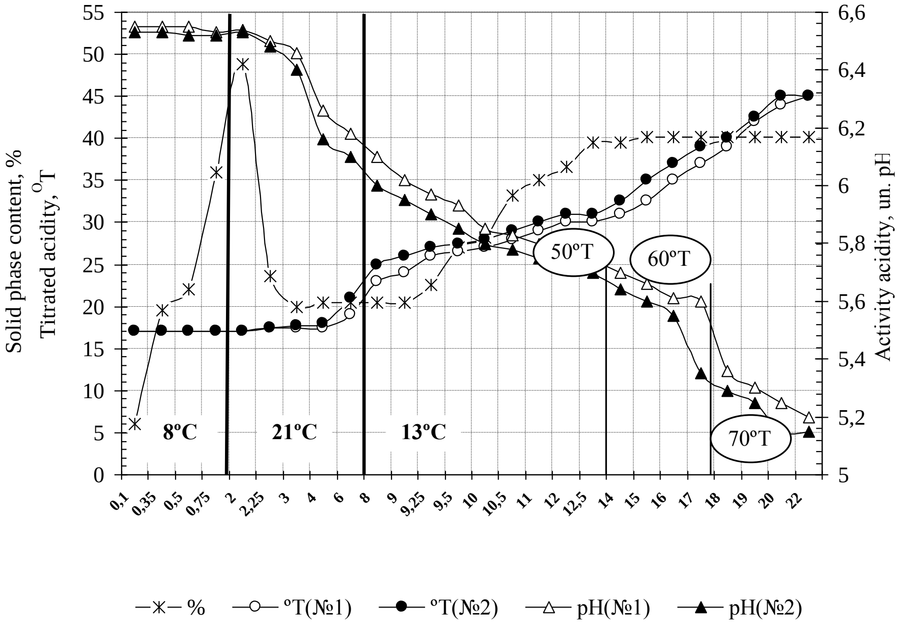

Fig. 1. Change in the physical and chemical properties of cream for the "winter" ripening regime

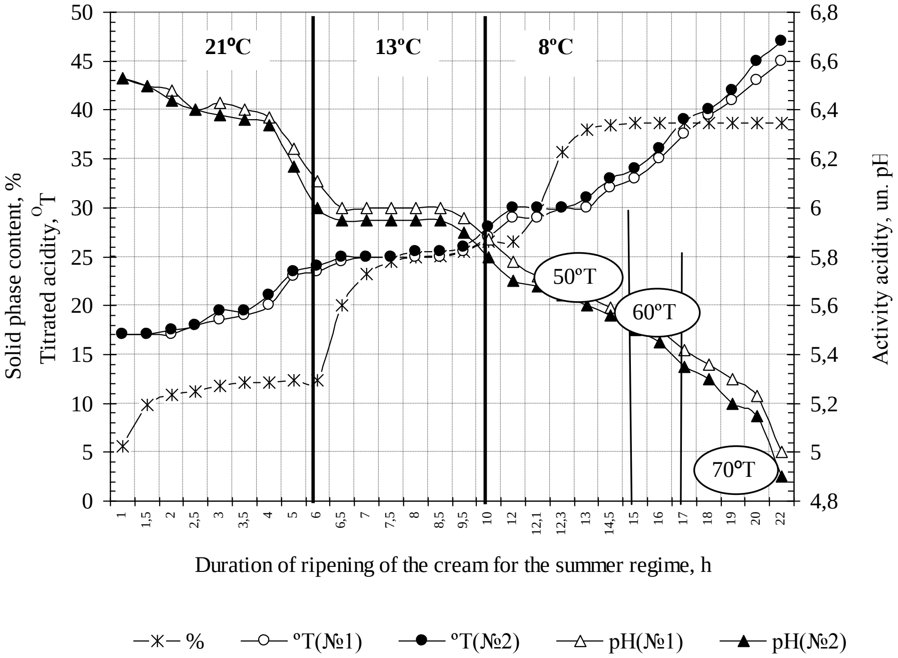

Fig. 2. Change in the physical and chemical properties of cream for the "summer" ripening regime

Observations of the change in titratable acidity and pH during the fermentation of cream (Figure 1) showed that after 2 hours of fermentation at 8°C and subsequent exposure at 21°C for 1 hour, the initial pH (6.5 units) and titrated acidity (17ºT) cream did not change, which may be due to the adaptation of cells of lactobacteria to a radical change in temperature. After 3 hours of fermentation, a gradual decrease in active acidity was noted, and for 14 hours of fermentation of cream the value was 5.70–5.64 units. pH. Continuation of fermentation of cream to 18 hours led to a slight decrease in pH – by another 0.35 units, and by 21–22 hours. this figure reached 5.15–5.20 units.

It should be noted that the fermentation of the cream with the "Iprovit KVM-C1" bacon concentrate was delayed for 1 hour until the acidity reached 60–70°T.

Thus, it is shown that the value of acidity depends on the active vital activity of the fermented microflora.

The study of the phase transitions in cream with the change in the state of the system (viscosity, pH, solids content) over the winter time regime using starter cultures showed that during the first stage of fermentation of cream at 8°C the amount of solid phase reached 48.8%, active and titrated acidity, as well as the viscosity did not change and amounted to 6.5 units, respectively. pH, 17ºT and $(10.0–10.3)\cdot10^{-3}$ Pa·s. After heating to 21°C, the crystalline fat content was reduced to 48.4% and was maintained without significant changes until the next cooling. In particular, for a period of exposure from 3 hours to 6 hours, the amount of solid phase increased by only 2.4%. Despite a significant decrease in pH, the viscosity remained unchanged for about 6 hours. The main crystallization occurred at 13°C for 4 hours, but the equilibrium state only occurred after 8 hours with the hardened fat content 40.1%, while the fermentation of creams and the change in viscosity continued.

Our data shows that during the 2 hours of physical fermentation the bulk of high- and low-melting triglycerides crystallizes, that is, at sufficiently low temperatures of the first stage of preparation, not only the formation of crystallization centers occurs, but also the linear growth of crystals. For 1°C the process of crystallization occurs due to solidification of a limited number of triglyceride fractions without attracting low melting fractions.

Cooling cream at the first stage is necessary for the formation of a large number of crystallization centers. After the following temperature increase, which is most favorable for crystal growth, crystallization of high melting triglycerides occurs and liquid fat remains in the fat globules, from which only a small amount of crystals can form at a temperature above 10°C.

Thus, a sufficient amount of liquid fat is achieved in the finished product, which is a continuous liquid phase during whipping, which will ensure good spreadability and prevent the formation of a too dense product structure during the winter production period.

During the summer cream ripening first stage at 21°C, despite the decrease in active acidity in the 6.0-6.1 pH range and the increase in titratable acidity from 17 ºT to 23.5–24.0ºT, crystallization of the cream was observed on 6.8% without changing the viscosity for 4 hours. After cooling the cream to 13°C, the acidity growth rate decreased. The crystallization process during this period occurred quickly enough and slowed down after 2.5 hours of aging. At the end of 13°C, the content of the solid phase was 26.5%.

Cooling the cream to 8°C significantly slowed the growth of acidity, but led to an increase in crystalline fat of 1.5 times compared to the previous exposure at 13°C – up to 38.7%. It should be noted that the rate of solidification at this stage was lower than 13°C. The equilibrium state between the liquid and solid phases was reached after 6 hours.

According to the summer method of preparation, the crystallization of milk fat was completed at a temperature of 8°C. Under these conditions, crystalline mixtures and mixed crystals containing low- and high-melting glycerides are formed. Due to not too much liquid fat, the remaining butter acquires a fairly dense consistency

At the end of fermentation, the content of the crystalline phase of milk fat from both temperature regimes was 38.7–40.1%, which is sufficient to obtain a good consistency butter, since its optimal value should be 40±3% [3].

Thus, such individual modes of low-temperature cream preparation with different chemical composition will allow obtaining butter with almost the same content of solid phase and not significant differences in consistency.

According to the results of the effective viscosity of cream at a shear rate of 729 s^{-1}, ripening by the winter temperature regime, we can distinguish 3 conditional zones: 1 - the zone of decline (2–4 h); 2 – zone of relative stability (4–10 hours) 3 – zone of active growth (10–22 hours).

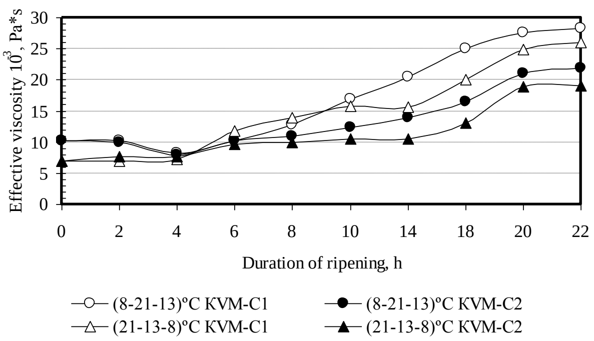

Fig. 3. Change the effective viscosity of the cream during fermentation

Keeping cream at elevated temperatures of 21°C for 2–4 hours it was observed a rapid decline in effective viscosity – up to 8.0–8.3 Pa·s in cream fermented with both bacultures. The following increase in viscosity is due to the denaturing of the protein phase of the cream as a result of active lactic acid synthesis by microorganisms. It should be noted that cooling the cream from 21°C to 13°C after 8 hours of exposure somewhat influenced their viscosity, but not significantly.

Within 18 hours of cream ripening in summer regime, a gradual increase in their viscosity was observed. However, the following exposure led to its rapid growth. A sharp increase in the viscosity of fermented cream after cooling is associated with the formation of milk fat crystals at a given temperature. As a result, the fat globules are destroyed and the amount of free fat increases, which directly affects the rheological parameters of the system.

In general, with increasing duration of fermentation of cream, their viscosity increases. In the case of their 14-hour exposure to an acidity of 50°T, the effective viscosity was the lowest – 10.5–17.0. By the end of the twenty second hour of fermentation the viscosity of the cream, regardless of the temperature regime, was almost at the same level: 26–28 Pa·s during fermentation with the bacterial preparation " Sprovit KVM-C1" and 19–22 Pa·s with the participation of "Iprovit KVM-C2". The formation of a viscous consistency can be explained by the biological features of the fermented " Iprovit KBM-C1" culture used, in particular the ability of L. cremoris to produce exopolysaccharides at low pH values of the plasma.

Thus, it could be stated the influence of the activity of fermented microflora on the viscosity of cream. In particular, the introduction of a ferment allows for a slight increase in the viscosity of the cream during the ripening process, but with marginal energy costs when further machining them to produce cultured butter.

So we found the dependancy of cream fermentation in the titratable acidity of plasma 50ºT, 60ºT and 70ºT on the level of flavoring substances of the manufactured cultured butter for winter and summer periods. It was noted that with increasing duration of fermentation and acidity of cream, their quantity increased. In particular, the concentration of diacetyl increased 1.6–1.7 times from 0.15–0.17 mg/100 g to 0.24–0.28 mg/100 g and from 0.14–0.16 mg/100 g to 0.22–0.26 mg/100 g in sour-cream butter produced from fermented cream in accordance with the participation of bacterial preparations "Iproovit KVM-C1" and "Iproovit KVM-C2" (Fig. 4a,b).

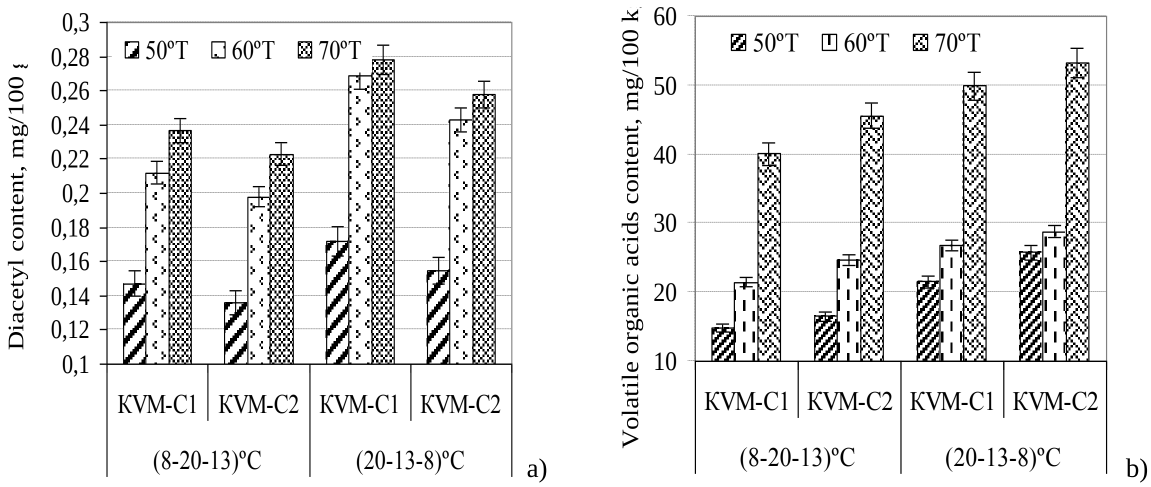

Fig. 4. Content of flavoring in cultured butter for the winter and summer cream ripening: a) diacetyl; b) volatile organic acids

Fixed small amounts of diacetyl in sour-cream butter could be explained by a decrease in the biological activity of dairy raw materials, which adversely affects the development of fermented microflora. Weak synthesis of diacetyl is also associated with the negative effect of the highest amount of yeast in the winter [7]. So, fermented cream with bacterial preparations up to 50ºT, 60ºT, 70ºT during the summer period contributed to a high content of diacetyl in the acidic oil by 14.0–17.0%, 22.7–26.9% and 15.7–17.3% compared to products made from winter raw materials.

Analysis of volatile organic acids showed that their content depended more on the level of fermentation of cream than on technological regimes of ripening and seasonality of raw materials. Thus, the amount of these compounds increased by factor of 2.0–2.7 with an increase in the acidity of the cream, whereas products made from cream in the summer season had only 1.1–1.2 times more acids (Fig. 4b).

Thus, by adjusting the fermentation of the cream it is possible to adjust the aromatic properties of the target product.

The results of the study of the physicochemical indices of experimental samples of sour-cream butter produced from cream under different temperature regimes and fermenting to different titrable acidity are presented in Table. 1/

The degree of fermentation affected the acidity of the plasma of butter, milk fat, and sensorial characteristics of the product. The increase in the degree of cream fermenting helped to increase the acidity of the plasma and the content of dry skim milk residue in butter. Indirect evidence of the high activity of the starter microflora can be a significant increase in titrable acidity of the plasma.

Table 1 - Characteristic of sour-cream butter made for winter and summer maturation of cream

Indicators	Sour-cream butter from sour with acidity of plasma		
	№1 (50ºT)	№2 (60ºT)	№3 (70ºT)
The duration of maturation of cream at 13 ºC, hours	4.5	7–8	11
Mass fraction of fat,%	80.45±0.78	79.95±0.80	79.57±0.83
Mass fraction of dry skim milk residue,%	1.95±0.21	2.05±0.23	2.13±0.28
Mass fraction of moisture,%	17.60±0.19	18.00±0.18	18.30±0.18
Solid phase content,%	38.0–39.1	39.80–40.12	39.80–40.12
The acidity of the plasma sour-cream butter after 25 days of storage at a temperature (6±1) ºC	56–57	69–70	93–96
Acidity Fat, ºK	1.42–1.50	1.78–1.90	2.1–2.25
Peroxide number of fresh made butter,% J	0.002–03	0.012–0.123	0.015–0.019
Peroxide number after 20 days storage at 5 ºC, % J	0.057–65	0.0381–0.055	0.081–0.178

Lactic acid, which is formed during maturation, also affects the stability of the butter during its storage. Therefore, these samples of sour-cream butter have been investigated immediately after manufacturing and after 20 days of storage at a temperature (5±1)ºC.

Investigation of the peroxide value during the storage of products, as an indicator of the deterioration of milk fat, suggests that all analyzed samples conventionally belonged to the category "fresh". However, the change in the peroxide value of milk fat is indicative of more intensive oxidizing processes of butter produced from sour cream with an acidity of 70ºT.

Thus, fermenting of cream with bacterial preparations "Iplovit KVM-C1" and "Iprovit KVM-C2" to the plasma acidity of 60ºT ensures the formation of the desired flavor and aroma of sour-cream butter.

Obviously, the oxidation processes depend on the degree of cream fermenting and confirm the appropriateness of moderate fermenting of the cream for the manufacture of sour-cream butter. Therefore, the regulation of the process of squeezing cream is of great practical importance in the production of high quality of sour-cream butter.

The tasting of experimental butter samples showed that the butter obtained by cream whipping with acidity of 60ºT (sample №2) was characterized by the expressed sour-milk taste and aroma, for which it received the highest amount of points for taste – 9 points for the first and 20 days of storage (from 10 possible). Product №3 had a unsufficiently aroma, and during the storage of butter appeared too sour taste. The rating of 8 points at the beginning of storage decreased to 5 points in 20 days. Product № 1 was marked by unexpressed taste and aroma on the first day after the whipping (8 points), and with the expressed sour-milk taste and aroma for 20 days, this product received 9 points.

Fermentating of cream with bacterial preparations "Iprovit KVM-C1" and "Iprovit KVM-C2" to the plasma acidity of 60ºT ensures the formation of the desired flavor and aroma of sour-cream butter.

Conclusion

New bacterial preparations are adapted to stepped ripening modes of cream, which can accumulate enough of the taste-aromatic components to form a flavorful bouquet of sour-cream butter. Due to the regulation of the process whipping cream on the physical and chemical parameters, it is possible to control the process of aroma formation in sour-cream butter. In order to maintain the stability of the sour-cream butter during storage, the optimum value of the acidity of the plasma of the cream before churning is 60ºT. The fermenting of cream to acidity of 70ºT can be used in the production of butter intended for quick sale.

List of references:

1. Исследования технологии кислосливочного масла / Вишемирский Ф.А. и др. // Сыроделие и маслоделие. 2008, № 5. С. 45-46.
2. Гуляев-Зайцев С.С. Развитие научных основ процессов маслообразования, интенсификация существующих и разработка новых технологий в маслоделии: дисс. докт. техн. наук: 05.18.04: захист / науч. рук. Киев: Технол. НИИ молока и мяса, 1988. 441 с.
3. Bakirci I., Çelik S., Özdemir C. The effects of commercial starter culture and storage temperature on the oxidative stability and diacetyl production in butter // International Journal of Dairy Technology. 2002; Vol. 55(4), P. 177-181. DOI: 10.1046/j.1471-0307.2002.00056.x.
4. Clark S., Winter C.K. Diacetyl in Foods – a review of safety and sensory characteristics. Comprehensive Reviews in Food Science and Food Safety. 2015; Vol. 14, P. 633-643. DOI: 10.1111/1541-4337.12150
5. Mallia S., Escher F., Schlichtherle-Cerny H. Aroma-active compounds of butter - a review // European food research and technology. 2008. Vol. 226. P. 315–325. DOI: 10.1007/s00217-006-0555-y
6. Macciola V., Candella G., Leonardis A. Rapid gas-chromatographic method for the determination of diacetyl in milk, fermented milk and butter // Food control. 2008. Vol. 19(9), P. 873–878.
7. Майборода Ю.В. Дослідження витрат енергії на сколочування вершків у масло з метою інтенсифікації процесу та розрахунку обладнання: автореферат канд. техн. наук.: спеціальність:захист дата / наук. кер. Гуляев-Зайцев С.С., Київ: Національни університет харчових технологій, 2003. 20 с.
8. Funahashi H., Horiuchi J. Characteristics of the churning process in continuous butter manufacture and modelling using an artificial neural network International // Journal of Dairy Technology. 2008; Vol. 18, P. 323-328. DOI: 10.1016/j.idairyj.2007.08.001
9. Rønholt S., Mortensen K., Knudsen J.C. The Effective Factors on the Structure of Butter and Other Milk Fat Based Products // Comprehensive Reviews in Food Science and Food Safety. 2013. Vol. 12. P. 468-482. DOI: 10.1111/1541-4337.12022

10. Тищенко Л.Н. Исследование состава и свойств молочного жира и усовершенствование технологии сливочного масла: дисс. канд. техн. наук: 06.18.16: защита / науч. рук. Гуляев-Зайцев С.С., Киев: Технологический институт молока и мяса, 2009. 177 с.
11. Мусій Л.Я., Цісарик О.Й. Динаміка зростання кислотності вершків за різних температурних режимів їх сквашування і визрівання при виробництві кисловершкового масла // Науковий вісник ЛНУВМ та БТ ім. С.З. Гжицького. Львів, 2013. Вип. 57, Т.15, Ч.4,№3. С.84-89.
12. Мусій Л.Я., Цісарик О.Й., Голубець О.В., Шкаруба С.М. Смако-ароматичні речовини у кисловершковому маслі залежно від складу заквашувальної композиції і умов культивування // Науковий вісник ЛНУВМ та БТ ім. С.З. Гжицького. Львів. 2014. Вип. 59, Т.16, Ч.4, №2. С.103-112.
13. Buldo P., Kirkensgaard J.K., Wiking L. Crystallization mechanisms in cream during ripening and initial butter // Journal of Dairy Science. 1996. P. 6782–6791.
14. Шершнева В. Производство кислосливочного масла. Москва: Пищепромиздат, 1957. 62 с.
15. Ересько Г.А., Работягова Н.П. Дилатометрический метод исследования отвердевания молочного жира // Пищевая промышленность. 1977. № 23. С. 61-64.
16. Инихов Г.С. Биохимия молока и молочных продуктов. Москва: Пищевая промышленность, 1970. 423с.

References:

1. Vyshemyrskyi FA, Topnykova EV, Pavlova TA, Perfylev HD, Matevosian LS. Issledovaniya tekhnolohyy kysloslyvochnoho masla. Syrodelye i maslodelye. 2008; 5: 45-46.
2. Huliaev-Zaitsev SS. Razvytye nauchnykh osnov protsessov masloobrazovanyia, intensyfykatsyia sushchestvuiushchykh i razrabotka novikh tekhnolohyi v maslodelyy. Diss. dokt. tekhn. nauk: 05.18.04. Tekhnol. NII moloka i myasa. K, 1988.
3. Bakirci I, Çelik S, Özdemir C. The effects of commercial starter culture and storage temperature on the oxidative stability and diacetyl production in butter. International Journal of Dairy Technology. 2002; 55(4): 177-181. DOI: 10.1046/j.1471-0307.2002.00056.x
4. Clark S, Winter CK. Diacetyl in Foods – a review of safety and sensory characteristics. Comprehensive Reviews in Food Science and Food Safety. 2015; 14: 633-643. DOI: 10.1111/1541-4337.12150
5. Mallia S, Escher F, Schlichtherle-Cerny H. Aroma-active compounds of butter - a review. European food research and technology. 2008; 226: 315-325. DOI: 10.1007/s00217-006-0555-y
6. Macciola V, Candella G, Leonardis A. Rapid gas-chromatographic method for the determination of diacetyl in milk, fermented milk and butter. Food control. 2008; 19(9): 873-878.
7. Mayboroda YuV. Doslidzhennia vytrat enerhii na skolochuvannia vershkiv u maslo z metoiu intensyfikatsii protsesu ta rozrakhunku obladnannia: Avtoreferat kand. tekhn. nauk. K; 2003.
8. Funahashi H, Horiuchi J. Characteristics of the churning process in continuous butter manufacture and modelling using an artificial neural network International. Journal of Dairy Technology. 2008; 18: 323-328. DOI: 10.1016/j.idairyj.2007.08.001
9. Rønholt S, Mortensen K, Knudsen JC. The Effective Factors on the Structure of Butter and Other Milk Fat Based Products – a reviews. Food science and food safety. 2013; 12: 468-482. DOI: 10.1111/1541-4337.12022
10. Tyshchenko LN. Issledovaniye sostava i svoistv molochnoho zhyra i usovershenstvovanye tekhnolohyy slyvochnoho masla // Diss. Kand. tekhn. nauk: 06.18.16 / Tekhnolohycheskyi instytut moloka i miasa; 2009.
11. Musii LYa, Tsisaryk OY. Dynamika zrostannia kyslotnosti vershkiv za riznykh temperaturnykh rezhymiv yikh skvashuvannia i vyzrivannia pry vyrobnytstvi kyslovershkovoho masla. Naukovyi visnyk LNUVMB imeni S.Z. Gzhytskoho. 2013; 57(15), 3: 84-89.
12. Musii LYa., Tsisaryk OY, Holubets OV, Shkaruba SM. Smako-aromatychni rechovyny u kyslovershkovomu masli zalezhno vid skladu zakvashuvalnoi kompozytsii i umov kultyvuvannia. Naukovyi visnyk LNUVMB imeni S.Z. Gzhytskoho. 2014; 59(16), 2: 103-112.
13. Buldo P, Kirkensgaard JK, Wiking L. Crystallization mechanisms in cream during ripening and initial butter. Journal of Dairy Science. 1996; 86(5): 6782-6791. DOI: 10.3168/jds.2012-6066
14. Shershneva V. Proyzvodstvo kysloslyvochnoho masla. Moskva: Pyshchepromyzdat, 1957.
15. Yeresko GA, Rabotiahova NP. Dylatometrycheskyi metod issledovanyia otverdevanyia molochnoho zhyra. Pyshchevaia promyshlennost. 1977; 23: 61-64.
16. Inykhov HS. Byokhymyia moloka i molochnykh produktov. Moskva: Pyshchevaia promyshlennost; 1970.

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