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TRANSLATION

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Causes are explained for insufficient cream-forming capacity of butter made in cylindrical butter churns of the existing mass-production line. Basic requirements are formulated for butter to satisfy its cream-forming capacity.

Butter of the mass-production method obtained directly from high butter-fat cream under rapid cooling, is by several indicators of a consistency poorer than by means of beating (1 - 5), is difficult to use for producing confectionery cream. Before beating out the cream, butter is softened in a special machine, then emulsified by adding syrup in surface acting substances. The prepared cream must possess specific elastic-moldable properties (6). However, the majority of cream types from butter of the mass-production process has consistency shortcomings not usually observed in butter from cream obtained in (beating) churns.

The purpose of the present work is to study the causes of inadequate cream-forming capacity of butter produced in the existing mass-production lines. The discovery of these causes will make it possible to purposefully conduct further research on improving the system of obtaining butter by the mass-production method.

"Sharlott" cream of No 21 recipe was whipped at "MIKSe" at 20-21°C with technological requirements maintained. The butter was produced at the experimental plant TsNIIMS in Uglich. Differential-thermal analysis of the butter and determination of open heat melting L of the fat in it was conducted by the method (7). Viscosity of the butter and cream were determined in a ductility viscosimeter in gradients of deformation rate of 0.5 sec^{-1} (6), the crystallization-coagulation nature of the butter structure by conic plastometer by means of finding values of displacement pressure limit R_m of decomposed and undecomposed structure at 20°C, and also the kinetic establishment of solidity of decomposed structure (3, 5). To establish duration of melting sticks of butter were formed in tablets from a cylinder with piston 10 mm in diameter and 5 mm high, which were set aside for 30 minutes after heating to 20°C, and then placed on a drip pan on a water bath at 40°C. The melting time of each form (in seconds) was taken from the average of five parallel determinations (method developed by workers of the Mosgorispolkom Laboratory directed by S. E. Scherbak; they also conducted the determinations).

The first series of experiments was conducted on butter of one stock in April 1961. Forms were produced by beating - in a vat churn, and on mass-production line - in a three-cylinder churn under several of its operating regimes. The cream was whipped in production and laboratory conditions at 20 and 18.5°C (the latter only in laboratory conditions).

The primary objective at this stage is to determine the effect of the degree and nature of glyceridic crystallization of milk fat in butter, depending on changes in equipment and methods, on its cream-forming capacity. Results are given in Table 1. Formulation of organoleptic indices of butter and cream are taken from the document of a special commission.

Only the cream from butter churned by beating (form 1) had normal consistency. Cream much poorer in quality, of crumbling consistency, but still usable for spreading, was obtained only from form 3, churned at increased churned productivity and output product temperature. Mass-produced butter obtained by "optimal" system for the season (form 2), and also under reduced machine productivity and output temperature (form 4) was not suitable for whipping confectionery cream. Cream from mass-produced butter prepared at 18.5°C, although it did have sufficiently high viscosity, was excessively solid and with low specific volume. Appearance immediately after application to a cake was good, but melted at 21-22°C.

Laboratory research showed that the viscosity of butter obtained by beating is higher than by mass-producing. Earlier research (6), and also the data of M. M. Kazanskij and G. V. Tverdokhleb support the indicated regularity. It is necessary only to note that here viscosity should be determined of sufficiently decomposed butter formation at a determined gradient of deformation rate. For undecomposed or insufficiently decomposed structure such laws are not always correct. Butter obtained by beating melts slower.

However, differences are more substantial in fat quantities L in butter at 20°C, and also in temperature ranges of melting of basic groups of mixed crystal of fat glycerides. Since a high melting group of milk fat gylcerides in butter of different churning methods are in one and the same polyform variation, (3, 8), L can be a fairly reliable criterion of hard fat quantity in butter at a given temperature (7, 8). Significantly higher L of fat is in butter made by churning, than by mass-producing means (Table 1), which corresponds to the laws of distinct group glyceride crystallization in milk fat (8, 9). The examined values agree well also with the data of differential-thermal analysis (DTA). As seen from figure 1 in churned butter (a) maximum melting of the basic high-melting group (33.5°C) and the main intermediate group (21.5°C) is greater than those like them in all other forms of mass-produced butter (b, c, d). Besides, in the differencial curves of this butter there are rather clear delays at 13.5 and -6.5°C. In butter made at increased output temperature and machine production rate (b), corresponding maximum temperatures change somewhat, 31.3 and 21°C. Reduction of output temperatures to 16-15°C (fig. 1c) changes them still more (to 31 and 21°C). Groups with maximum melting near 11-13°C and in the negative temperature region were almost not expressed. Further reduction of output temperature to 11.5-12.5°C with reduced production rate (fig. 1d) still more distinctly showed up in temperature of melting range groups formed - of them only two practically remained which had still lower maximum temperatures (30 and 17.5°C).

The shaded portions in figure 1 correspond to the relative quantity of glycerides remaining in the solid state at 20°C. The significantly large quantity of this portion (with respect to the unshaded portion defined by the differential curve and the base line) is in churned butter, which falls in agreement with calorimetric data (table 1). A reduction of this area is observed in mass-produced butter according to reduction of output temperature of production rate (Fig. 1b, c, d). A lower quantity of hard fat in mass-produced butter at room temperatures, undoubtedly, must effect its structural-mechanical properties, especially, it will lead to a noticeable reduction of viscosity. Some increase in the value of the hard phase in separate forms of mass-produced butter, along with increased melting temperature of basic groups of mixed gat crystal glycerides in them, only somewhat improves the quality of confectionery cream, (table 1). At the same time, churned butter from the same stock has higher melting temperatures of the basic high-melting mixed crystal groups, harder fat at room temperatures, and therefore higher viscosity and satisfactory cream-forming capacity. This, undoubtedly, is also shown in the thermal stability of the butter (more exactly - shape stability at higher temperatures).

The second series of experiments was conducted on forms of a single stock in September 1961. Since the first series of experiments established the poor cream-forming apacity of butter obtained at reduced output temperatures and production rate, no further work was conducted along similar methods. Butter was made by beating in a KL-1600 type churn. Basic attention was given to the effect of the nature of the crystallization-coagulation structure of butter on its cream-forming capacity, and simultaneously all the remaining indicators were determined. Result are given in Table 2. This time too, good quality cream was obtained only from butter made by churning (form 5). Mass-produced butter obtained in a seasonally optimal system (form 3), was less suitable for cream than that produced at somewhat higher output temperature and production rate (form 2). With significantly increased production rate and temperature (forms 1 and 4) also had more sharply defined defects of viscosity and briability. The melting temperature of fat at 20°C found in butter obtained by churning (Table 2), as in the first series, was higher than in mass-produced butters, but lower in absolute value - significantly lower than for butter mass-produced in the first series, totally unsuitable for whipping confectionery cream (Table 1, form 4). The value of L for form 4 butter (Table 2) obtained with greater production rate and temperature was higher than L for other forms of butter forms of the given production method (of the season tested). Even then it was completely unsuitable for confectionery cream. Thermograms of DTA heating, not given in the article, showed the regularity noted for butters of the first series, although they were significantly less distinctly shown. As seen from Table 2, the regularity of change in duration of melting of butter was maintained, however, these values are far lower in comparison to those obtained for butter in the spring production (compare Table 2 and 1).

The most important difference in the forms studied was the relationship in the structure of butter of features of crystallization and coagulation type (5, 9, 10). At the same time that butter of the churning method had a comparatively low value of breakdown pressure limit for undecomposed structure and relatively high for decomposed, mass-produced butter was characterized by opposite indicators, (Table 2). Besides this, churned butter possessed a relatively low stage of decomposition and high degree of established structure stability, whereas mass-produced butter was of comparatively low, and the latter greatly depended on the working regime of the churn.

From the data obtained it is seen that in the structure of butter, the methods of churning dominate the features of the coagulated type, but in mass-produced butter, of the crystallized type (3, 5). This can be reasonably well explained by the process of formation of secondary crystallization structure because of penetration in the product after churning of polymorphous conversions of composite crystal of the high-melting milk fat glyceride group and related features of separate-group character of glyceride congealing (3, 5, 8, 9).

The best correlation to cream-forming capacity of butter was the degree of decomposition and rate of establishing solidity of its decomposed structure at 20°C (Fig. 2). Comparison of the data in the illustration and table 2 shows the following. Churned butter, possessing good cream-forming capability, although at the same time solidifying of its decomposed structure being somewhat slower, even so has relatively high density immediately after decomposition - about 10g/cm^2 (Fig. 2, curve 5). All the same, butter produced in the cylindrical churn has immediately after structural deterioration, a significantly lower index of breakdown pressure limit - 2-3 g/cm^2. Form 2 butter, which had the greatest rate of solid structure set-up, especially in the first several hours after deterioration, (Fig. 2), displayed the best of the mass-produced in cream-forming capacity also. The butter in which solidity of deteriorated structure practically did not set up, however (forms 1 and 4), showed complete unsuitability for whipping confectionery cream also. In it the indices of the crystallization type were most sharply displayed (Table 2). Butter obtained by seasonally "optimal" mass-production working system (form 3), occupied an intermediate position.

The second series of experiments shows that the very crystallization-coagulation characteristic of its structure has the greatest effect on cream-forming capacity. To all appearances, butter suitable for producing cream must be that in which the coagulating type structure predominates (11) and which, besides, contains a sufficient amount of hard fat at room temperatures. It must have, immediately after structure deterioration, a sufficiently decomposition pressure limit.

Research results show also that butter at existing mass-production lines is poorly suited for making it into confectionery cream. The cause is concealed in the sharp change in conditions of cooling and crystallization of fat glycerides in comparison with the finished technology of churning butter, developed without sufficient knowledge of fat hardening processess. The last greatly effects the character of distinct group crystallization of glycerides (9) and formation basically on account of polymorphous conversion of secondary crystallization structure of butter in mass-production (3, 5). The significantly lower cream-forming capacity of butter produced in the so-called "optimal" system, compared with that obtained at somewhat increased temperature and production rate can speak of the inadequate features of the "optimal" system.

Consequently, along with the perfection and development of technology of whipping confectionery cream adaptable to butter from production lines it is necessary to devote serious attention to the perfection of butter-producing equipment. Such equipment is essential which, while preserving all the desirable properties of the given type of butter, would make it nearer in structure to that obtained by the churning method, especially not degrading in cream-forming capacity. The first efforts to develope such equipment have been made (12).

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CONCLUSIONS

1. To insure good cream-forming capacity of butter, indices of the coagulation type and the essential quantity of hard fat at the whipping temperature of the cream must prevail in it.

2. Butter obtained by churning, satisfying the indicated qualities, has sufficiently high viscosity and decomposition pressure limit of decomposed structure, and consequently possesses good cream-forming capacity.

3. By the majority, butter of mass-produced method is poorly suited for making confectionery cream, since in its structure prevail characteristics of the crystallzation type, basically on account of infusion of polymorphous conversions in the fat after coming from the churn. It is essential to develope a system improving its structure. In it must be better shown characteristics of coagulation type with provision of sufficient quantity of hard fat at room temperatures and satisfactory consistency.

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Table 1

Form	Cream Characteristics		Butter-producing equipment		Butter Characteristics			
	Organo-leptic Features	viscosity at 20.5°C, $pz \cdot 10^{-4}$	Productivity of churns Mass-prod, kg/hr	Output temp, °C	Viscosity at 20.5°C, $pz \cdot 10^{-4}$	L at 20°C, cal/g of fat	Melting time, sec	Consistensy
1	Structure normal. Insignificantly splitting fluid stage. Simple appearance on cake distinct, retains shape	3.9	beaten		13.9	11.2	85	porous, crumbling 22 pt.
2	Consistency uniform, viscous, like sour cream. Shiny surface, Application to cake melts. Not suitable for spreading and cake-making.	0.13	500	11.5--12.5	0.4	8.3	60	Good, 24 pt.
3	Consistency non-uniform, like sour cream. Plain application to cake easily melts. Suitable for spreading.	2.7	700	17--18	0.5	8.9	60	Lightly crumbling 21 pt.
4	Consistency weak. Not suitable for spreading and cake-making.*	0.13	200	16--15	0.3	8.1	60	Soft, 23 pt.

* Cream was beaten in laboratory conditions. In production, butter separated before becoming cream.

Table 2

Form	Cream Characteristics: Organo-leptic Features	Viscosity at 20°C, $pz \cdot 10^{-4}$	Butter-producing equipment: Churn Rate Mass-prod, kg/hr	Butter-producing equipment: Output temp., °c.	Butter Characteristics: R_m, g/cm^2, at 20°C. Right after structure breakdown	Butter Characteristics: R_m, g/cm^2, at 20°C. Unbroken struc-ture	Stage of Set-up of solidi-y after break down, %	L at 20°C, cal/g fat	Melting time, sec.	Consis-tency
1	Weak, sour cream consistency. Not suitable for application to cake or spreading.	1.6	800	19	2.1	73.0	13	6.02	30	Crumbling 22 point
2	Appearance*indistinct. Suitable for plain confection and spread-ing. Slightly parting with pres-ervation.	2.7	650	17	2.4	82.0	35	6.22	26	Weakly crumbling 23 point
3	Appearance*separated, falls with keeping.	2.4	580	14	2.6	50.0	40	6.651	25	Normal 24 point
4	Separated after beating. Not usable.		900	18-19	3.1	94.0	12	6.83	38	Strongly crumbling
5	Good quality, suitable for making cakes and application of complex art.	3.6	obtained by beating		10.3	17.0	92	7.20	59	Porous, 23 point

* (in art application)