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Biotechnology factors influence on formation of curd cheese quality indicators

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Abstract. Considering the growing interest of the Russian society in fermented dairy products, in particular, cream cheese enriched with probiotic cultures and biologically active substances (BAS), it is relevant to conduct research aimed at scientifically justifying the choice of biotechnology of curd production as a raw material for cream cheese by studying the influence of biotechnological and technological factors on the formation of properties of the used curd. The generally accepted methods of qualitative prediction were used. The study of consumer opinion revealed the demand of Russian buyers for curd products enriched with BAS and probiotic cultures. The analysis of the regulatory documentation allowed us to form a set of mandatory requirements for the quality of curd cheese and the curd used, as well as a list of raw materials, biotechnological and technological factors required in the technology of curd cheese production. The study of the influence of each type of biotechnological and technological factors on the properties of the finished product has shown that in the biotechnology of enriched cream cheese it is necessary to use starter from pure cultures of lactococci or a mixture of lactococci and thermophilic lactic acid streptococci, acid method of coagulation of milk protein, whey separation by separation or ultrafiltration, introduction of BAS and flavoring fillers with cream in a separate method of normalization, as well as to exclude the use of milk-clotting enzyme, and also to eliminate the use of milk-clotting enzymes. The results obtained are the basis for the development of new biotechnologies of curd cheese enriched with BAS and/or probiotic cultures.

Introduction

The market of fermented dairy products, including curd-based products such as cream cheese, curd sweet products and curd cheeses, has been actively developing in Russia and globally recently [1, 2]. Their assortment is gradually expanding and includes new items due to the use of various flavor fillers: berries, fruits, vegetables, mushrooms, herbs and seafood [3]. Especially interesting for customers are dairy products enriched with various functional food ingredients of natural origin: probiotics, prebiotics, minerals, BAS (vitamins, antioxidants, etc.) [4-7]. The growing popularity of the fermented dairy market

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segment [8, 9] is reflected in the development of new names of curd products, which requires manufacturers to make prompt changes in formulations [10, 11] and search for universal biotechnological and technical solutions for the purposeful formation of quality indicators of finished products, subject to the need to ensure their identification [12], safety and minimize the risks of production of products with defects [13, 14].

Consumer properties of finished biotechnological food products, as well as their safety, are influenced by all stages of the product life cycle, starting from marketing research and market analysis, selection of primary and secondary raw materials and materials, and ending with the analysis of complaints and data on defective products at the stage of post-sale activities [15]. Of all the stages of the product life cycle for quality and safety indicators, two stages should be emphasized: the design of biotechnology and product quality indicators, as well as its production stage [16, 17].

To ensure the competitiveness of the designed products, it is necessary to carry out biotechnology development and product formulation with minimum labor, financial and time costs, while ensuring the required level of product safety [15, 18] and consumer satisfaction [19]. Detailed laboratory research to study and characterize the processes of biotransformation of raw materials [20] into specified properties of finished products is less demanded by product manufacturers in contrast to ready-made, universal and quick solutions [17, 21].

One of the solutions to this complex integrated objective is qualimetric prediction [15, 17], based on the study of biotransformation of the properties of raw materials in the technological process [22-24].

In the food industry, qualimetric forecasting began in 2008 at the Department of Quality Management and Product Commodity Science within the framework of the development of the scientific school in K.A. Timiryazev Russian State Academy of Agricultural Sciences [15]. At the moment, qualimetric forecasting is a promising scientific and practical direction, allowing on the basis of a set of methods of qualimetry [25] (including expert qualimetry, qualimetric assessment, qualimetric modeling and risk qualimetry), and mathematical modeling to quickly carry out the design of products with specified characteristics on the basis of analysis of the regularities of their formation [15].

The aim of the work is to scientifically substantiate the choice of biotechnology of curd production intended for the production of enriched cream cheese by studying the influence of biotechnological and technological factors on the formation of properties of the curd used.

Materials and methods

Methods of qualimetric forecasting were used in the work, including expert qualimetry (formation of expert groups - the method of mutual recommendations, the number of experts - 6 dairy industry specialists, providing expert coverage), Delphi method, the method of conducting sociological research [9].

Results and discussion

To ensure high quality of manufactured products and possibility to develop universal solutions of purposeful formation of quality indicators of designed products, we analyzed the factors of quality formation of food fermented biotechnological products.

Curd cheese is a dairy compound product produced from curd and meets the requirements of regulatory documentation (Technical Regulation Customs Union TR CU 033/2013 "On the safety of milk and dairy products", Technical Regulation Customs Union

TR CU 022/2011 "Food products in terms of labeling", Technical Regulation Customs Union TR CU 021/2011 "On the safety of food products" and GOST 33480-2015. "Cream cheese. General technical conditions"). The analysis of the requirements of regulatory documentation to the quality indicators of cream cheese is presented in Table 1.

According to the identification features curd cheeses can be divided into two large groups:

- fermented - enriched with functional food (probiotic microbiological cultures and/or prebiotics and/or biologically active substances) or not enriched;
- heat-treated - enriched with functional food (prebiotics and/or biologically active substances) or not enriched.

Our analysis of the opinion of 100 consumers in the Moscow region showed that the most desirable curd cheese names are: enriched with probiotics and BAS, enriched with BAS, and pasteurized curd cheese with BAS (Figure 1).

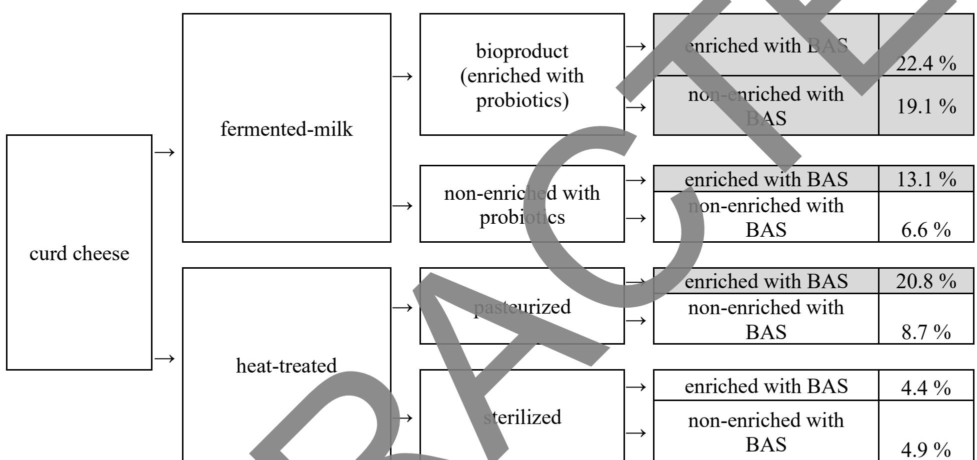

Fig. 1. Types of cream cheese and their desirability for Russian consumers.

The assortment analysis conducted in the period from 01.09.2023 to 01.11.2023 showed that out of 25 items of curd cheese sold in retail chains of three largest hypermarkets ("Auchan", "Perekrestok" and "Azbuka vkusa"), two supermarkets ("Dixy" and "Pyaterochka") and a network of farm products ("VkussVill"), there are no curd cheeses enriched with BAS. This indicates that the existing assortment of curd cheeses does not meet the demand of Russian consumers for natural and healthy products. The data obtained confirm the relevance of the development of new curd cheeses with increased nutritional and biological value, including enriched with probiotic cultures and BAS.

According to the requirements of GOST 33480-2015 "Curd cheese. General technical conditions" curd cheese may be called a product consisting of curd obtained by various methods of its production, with or without subsequent heat treatment, with or without flavoring fillers, whipped or not whipped, and complying with the identification requirements specified in Table 1.

Table 1. Summary table of requirements to the quality of curd cheese established by normative documentation.

Parameter name	Parameter value
Mass fraction of fat in dry matter, %	4-80
Mass moisture content, %	40-80
Mass fraction of milk protein, %, at least	6.0
Mass fraction of table salt (sodium chloride), %, max.	2.0
Mass fraction of sucrose (for sweet product), %, max.	20.0
Acidity, °T	70-200
Active acidity, pH units	4.0-6.0
Product overrun, %	5-20
External appearance	The product is packed hermetically. A small amount of whey on the surface of the product is allowed. Shape - low cylinder, or package shape, or other arbitrary shape
Consistency	From soft, delicate, plastic, smeary to dense and homogeneous throughout the entire mass. For whipped and/or aerated product, with air voids. When introducing food flavoring products, with the presence of particles of food flavoring products
Flavor and aroma	Pure, sour, characteristic of soft cheeses without ripening, without extraneous flavors and odors. When introducing food flavoring products, with the appropriate taste and odor of the introduced food flavoring products. For products made from the milk of other animal species - with the flavor and odor characteristic of this type of milk
Color	White to light cream, uniform throughout the entire mass. When adding food flavoring products due to the color of the added products

As an object of research was chosen quark, intended for curd cheese, as the most complex food system, formed under the influence of a set of unique biotechnological factors due to the action of enzymes produced by starter microorganisms, as well as introduced milk-clotting preparations (if used), which occur in the process of milk fermentation during curd cheese production. Changes in acidity towards lower pH, salt balance, and temperature regimes are also involved in this process.

There are several methods of curd production, differing from each other by a number of technological features and significant differences in consumer properties. All the variety of curd produced according to the current classification has one name on the label - cottage cheese. The results of analyzing the requirements of regulatory documentation (GOST 31453-2013 "Quark. Technical conditions" and TR CU 033/2013) to the identification indicators of quark quality are presented in Table 2.

Table 2. Summary table of quark quality requirements established by regulatory documentation.

Parameter name	Norm for product with mass fraction of fat, %, not less than											Regulatory document
	defatted, less than 1.8	2.0	3.0	3.8	4	5	7	9	12-15	18-20	23	
Protein mass fraction, %, not less than	18.0				16.0				14.0			GOST 31453-2013
	12.0*								8.0*			TR CU 033/2013
	7.0 (for quark produced using ultrafiltration or separation)											TR CU 033/2013
Mass fraction of nonfat milk solids, %, not less than	13.5*									10.0*		TR CU 033/2013
Mass fraction of moisture, %, max.	80.0	76.0			75.0		73.0		70.0	65.0	60.0	GOST 31453-2013
Acidity, °T, max.	240		230				220		210		200	GOST 31453-2013
Number of lactic acid microorganisms, CFU/cm^3(g), at least	1x10^6											TR CU 033/2013
For products enriched with bifido-bacteria and other probiotic microorganisms, CFU/cm^3, at least	1x10^6											TR CU 033/2013
Consistency and external appearance	Soft, spreadable or crumbly with or without perceptible milk protein particles. For defatted product there may be a slight separation of whey. Inclusions of insoluble particles characteristic of the ingredients introduced are permissible											GOST 31453-2013, TR CU 033/2013
Flavor and aroma	Pure, sour milk, without extraneous flavors or odors. For reconstituted milk product with milk powder flavor. For quark with fillers - with the corresponding taste and aroma of the added ingredients											GOST 31453-2013, TR CU 033/2013
Color	White or cream-colored, uniform throughout the mass or due to the color of the ingredients, homogeneous or with insoluble particles.											GOST 31453-2013, TR CU 033/2013

TR CU 033/2013 requires that a number of the following raw material, biotechnology and technological factors be involved in the production of quark:

1. raw materials factors:

1.1 product composition - quark should be made of milk or milk raw materials from healthy farm animals (if non-cow milk is used, it is necessary to indicate "goat milk", "sheep milk", etc.), leaven, technical aids (calcium chloride, milk-converting enzyme), with possible introduction of flavoring fillers, without the use of milk fat and protein substitutes;

2. biotechnology factors:

2.1 presence in the technology of the stage of milk fermentation, in which biotechnological processes occur that ensure the formation of the required properties of the final product;

2.2 type of starter microorganisms - mandatory use of starter containing pure cultures of lactococci or a mixture of lactococci and thermophilic lactic acid streptococci;

2.3 multiplication of microorganisms - active development of starter microorganisms ensuring their high content in the finished product of 1 x 10^6CFU/g by the end of shelf life (except for quark produced using ultrafiltration, separation, and granulated quark);

2.4 enzyme addition - the use of a milk-forming enzyme in the method of acid-cheese coagulation of milk protein;

2.5 acidity - increasing the acidity to ensure that the finished product has an acidity of 70 to 200 ºT by the end of shelf life;

2.6 introduction of probiotics - additional introduction of probiotic cultures, ensuring their high content in the finished product 1 x 10^6CFU/ g by the end of the shelf life (for bio-quark - probiotic-enriched quark varieties);

<u>3. technological factors:</u>

3.1 pasteurization - a mandatory stage of thermal treatment of raw materials used, which ensures the death of vegetative forms of native microflora of dairy raw materials and excludes the possibility of transmission of infections from animals to humans through the product;

3.2 normalization - ensuring the required content of protein and fat in the raw material, which allows to obtain a finished product with the required nutritional value;

3.3 whey removal - to ensure the required organoleptic characteristics and levels of protein, fat and solids content (by self-pressing, and/or pressing, and/or separation (centrifugation), and/or ultrafiltration);

3.4 packaging - wrapping and labeling that ensures the established and confirmed shelf life of the product and contains all necessary and required by the regulatory documentation (TR CU 033/2013, TR CU 021/2011 and TR CU 022/2011 "Food products with regard to their labeling") information for the consumer, for product identification and traceability.

As shown above, out of 11 mandatory from the point of view of regulatory documentation conditions of quark production, 6 are biotechnological factors, which is more than half of the factors. Thus, we can say that most of the factors that form the normative quality indicators of quark, which is used to produce curd cheese, are biotechnological.

At the final stage of research, we have studied the influence of biotechnological factors of formation of quality indicators of quark, intended for the production of curd cheese. For this purpose, we analyzed biotechnology and technological factors of formation of quark quality used in different methods of its production quark. The results of research are systematized and presented in Table 3.

Table 3. Analysis of biotechnology and technological factors influence of different methods of quark production on its properties (specifics of technologies).

Features of production technology	Name of factor group	Biotechnology / technological processes	Generated product properties
Milk protein coagulation methods			
Acidic	Biotechnological (fermentation)	Growth of starter microorganisms added to milk	Obtaining a curd clot, which, depending on the type of subsequent processing of the curd grain, can give the consistency of quark from soft, tender and smeary to quite dense. Possibility of obtaining quark with a higher moisture content, which is economically beneficial for the producer. Inability to obtain curd cheese with very dense consistency. Preferred method for soft curd cheeses containing flavoring ingredients
		Production of lactose-degrading enzymes by sourdough microorganisms	
		Hydrolysis of lactose to form lactic acid	
		Decrease in pH value	
		Disturbance of salt equilibrium due to introduced calcium chloride	
		Coagulation of casein micelles under the action of salt balance disturbance and reaching the isoelectric point	
Acid-curd	Biotechnological (fermentation simultaneously with leavening)	Changes in the structure and properties of casein micelle under the influence of introduced milk-converting enzyme	Obtaining a dense curd clot, forming distinct flakes, perceptible to the taste. Possibility of obtaining quark with higher solids and protein content. More expensive technology in terms of cost. Inability to obtain curd cheese with soft, tender, plastic and smeary consistency
Clot processing and whey removal			
Stirring the curd clot	Technological (clot processing)	Separation of whey from fermented milk, formation of curd clots	In combination with heating, it forms a sufficiently dense consistency and high protein and solids content in quark
Heating the curd clot		Active whey separation, curd grain formation	The use of high temperatures makes it possible to obtain a clear curd grain with a dense consistency and a high content of protein and solids. Impossibility to obtain curd cheese with soft, tender, plastic and smeary consistency. Partial death of starter microorganisms. Difficulties in ensuring their number by the end of shelf life of products. It is impossible to use probiotic-enriched products in technologies
Pouring curd clot into special bags or containers	Technological (whey removal)	Self-pressing of quark under its own weight and removal of whey	Obtaining curd clot with a sufficiently dense consistency. Possibility of obtaining quark with medium solids and protein content
Serum separation on the Y9-OPT line		The curd clot, heated to 45-50 ºC, falls into a rotating cloth-covered cylinder, where the whey is separated and pressed.	Obtaining a crumbly quark with a dense consistency of curd grains and a high content of protein and solids. Failure to obtain curd cheese with soft, smooth, malleable and spreadable consistency
Centrifugation of curd clot on the curd separator of the curd maker		Separation of the curd clot with whey separation through nozzles	Production of quark with a soft, smooth and spreadable consistency. Possibility of obtaining quark with a higher moisture content, which is economically advantageous for the producer. Inability to obtain curd cheese with very dense consistency. Preferred method for soft curd cheeses containing flavoring ingredients
Ultrafiltration of curd clot		Separation of whey from curd clot using ultrafiltration units	
Methods of normalization (ensuring the required indicators of nutritional value of quark)			
Traditional way	Technological (fat normalization)	Milk separation prior to pasteurization and milk fermentation	Used in defatted quark technology and to produce crumbly quark, with a higher dry matter content
Split method		Adding pasteurized cream to the curd obtained after whey separation	Used in quark production, which has a soft, smooth, creamy consistency. An easier way to ensure the required nutritional value of the finished product

Enrichment of finished products with functional food ingredients			
Probiotic supplementation	Biotechnological (probiotic supplementation)	Additional supplementation of probiotic cultures	The content in the finished product is at least 1 x 10^6CFU/g by the end of shelf life. Difficulty of ensuring this: exclusion of heating of curd clot after welling, loss of live probiotic microorganisms during whey separation, when introducing specific flavoring ingredients with bactericidal properties (for instance, garlic), losses during product storage, etc.
Supplementation of functional food ingredients (minerals, BAS, prebiotics, etc.)	Technological (introduction of functional food ingredients)	Additional supplementation of functional food ingredients (mainly at the stage of cream and flavoring components at the separate production method)	The end-of-life content of functional food ingredients in the product is at least 15% of the recommended daily intake. Difficulty in ensuring this due to partial destruction of BAS during production and storage.

On the basis of the obtained data, it is possible to formulate the main criteria for the selection of biotechnological and technological processes for the purposeful formation of the required properties of the final product based on quark. It was found that the most suitable technologies for the production of quark are those that provide soft, tender and greasy consistency. Thus, when developing the biotechnology of curd cheese, it is necessary to exclude: introduction of milk-converting enzyme preparation, heating of curd during its processing, whey separation by pressing and self-pressing and normalization by fat in the traditional production method. The latter cannot be used because this method produces a dense, crumbly curd, which is not suitable for providing the consistency characteristic of curd, or a defatted curd (0.5%), which produces a defatted curd, which is impossible because it does not meet the requirements for the minimum milk fat content in curd, which is 4% in dry matter.

In order to be able to give the curd cheese the status of a product enriched with BAS and/or probiotics, it is also necessary to apply a separate production method, to exclude the use of pressing and self-pressing methods from the technology, and to achieve a soft, smooth, greasy consistency. This is achieved by separation or ultrafiltration of the curd lump, subsequent introduction of BAS dissolved in cream, mixing and further packaging of the resulting curd. This method also offers the possibility of introducing flavored fillers (vegetables, herbs, berries, fruits, etc.) together with cream and BAS, which will broaden the range of interesting products for consumers.

Conclusions

The obtained results of the conducted research revealed the peculiarities of the influence of biotechnology and technological factors on the formation of quality indicators of curd and products based on it, in particular, curd cheese, required by regulatory documentation.

It has been established that for the most desirable curd cheeses for Russian consumers (sour milk and pasteurized curd cheeses enriched with BAS) the technology including acid method of milk protein coagulation, absence of heating during curd processing (or low heating temperatures), whey removal by separation or ultrafiltration, demulsification of BAS and flavoring ingredients together with cream after curd production, packaging of the finished product is preferable. In the production technologies of thermally processed enriched curd cheese, it is necessary to provide high CFU content of BAS and mineral substances, taking into account their losses during thermal processing and storage. This method of curd cheese production has a number of advantages associated with long shelf life and low risk of microbial spoilage of the product, but excludes the possibility of enrichment with probiotic cultures.

The results obtained allow us to scientifically justify the choice of biotechnology and technological factors to control the given characteristics of the designed products based on quark, in particular curd cheese.

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