Increasing the bioavailability of nutrients in fermented dairy products

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Abstract. The study describes the development of a new product with increased bioavailability, based on the recipe of an old Russian sour-milk drink “Snezhok”. Using baked milk as the main raw material, it is possible to reduce the fat globules size, which makes the drink more digestible. The paper investigated the effect of long-term exposure of milk in the process of baking on the number and size of fat globules in milk. In addition to changing the fat fraction in clarified milk, a number of other components are changed during exposure to high temperatures. The suggested new drink may be considered a product of high nutritional value, contributing to the improvement of public health.

1. Introduction

Dairy products play a significant role in shaping the right diet for people of all ages. Starting from a very young age, children receive this group of products in their diet. Due to the increased interest of the population and specialists to the formation of attitudes towards a healthy lifestyle, there is a need to transform familiar foods and to increase the bioavailability of their nutrients.

In recent years, a relatively new direction in food production has arisen and become widespread - the development of functional food products, introduction and use of these products in food of the population. In case of their systematic use, they have a regulatory effect on the whole organism, or on individual organs and tissues. Further growth in the functional food market is likely to require a large number of studies aimed at increasing the active ingredients bioavailability, finding evidence of their clinical effect and at the formation of legislative requirements regarding safety for human health [1].

Functional food production has become an urgent task for almost all branches of food industry. Dairy products do not stand aside. The choice for functional dairy products ingredients can be justified by their healing properties, which are widely used in medical, preventive and dietary nutrition. Apparently, it is difficult to distinguish between conventional and medicinal dairy products, since even ordinary dairy products are used for dietary and medicinal purposes because of their chemical composition. In addition, preference is usually given to sour-milk products because of their special dietary and medical properties. [2]. The inclusion of chitosan in the composition of milk drinks and desserts allows to create functional products where the polysaccharide is a technological, bactericidal and fungistatic agent [3].

Fermented dairy products are an excellent source of a wide range of probiotics necessary for health, which increase the nutritional value of regular milk [4]. These products are well known for their positive effect on consumer health due to the presence of probiotics. Among the many beneficial effects from the use of these products in recent years, scientists are attracted by their immunomodulation properties. [5]. There is a growing tendency to use propionic acid bacteria in sour-milk as a probiotic [6].
Given the shortage of raw milk, the urgent problem is the rational use of whey as a source of biologically valuable components of milk for functional products [7]. Whey proteins are widely used as nutritious and functional ingredients in prescription foods because they are relatively inexpensive, generally recognized as a safe ingredient (GRAS), and have important biological, physical, and chemical functional properties. [8].

In this study, the development of a new sour-milk product was carried out on the basis of the formula and technology of sour-milk drink Snezhok (Snowball). The development was aimed at obtaining a new functional food product with a wide range of applications due to technological variations at the stage of raw material preparation. Snezhok is a Russian traditional product beloved by the population. For its production, cultures of Streptococcus thermophilus lactic acid streptococcus and Bulgarian bacillus culture Lactobacillus bulgaricus were used. These probiotics play an important role in the human body, their use is necessary to maintain health and productive longevity, helps the digestion process, is the basis for healthy intestinal microflora formation. Bulgarian bacillus is a unique microorganism, able to change the balance of intestinal eubiosis, due to which the atherosclerotic change in the human body is postponed, the premature aging is delayed.

The Snezhok sour-milk product can be attributed to probiotic food. According to the requirements of GOST R 52349-2005 "Food products. Functional food products. Terms and definitions", this group includes food products containing strains of living microorganisms useful for the human body, which play the role of a physiologically functional food ingredient. The role of this ingredient is to normalize the composition of the human digestive cycle microflora. In accordance with the requirements of GOST 34048-2017 "Sour-milk product" Snezhok". Technical conditions", at the time of expiration, the total viable count (number of mesophilic aerobic and facultative anaerobic microorganisms, TVC) / CFU in g of product must be at least 1 \times 10^7. In the guidelines of the Research Institute of Nutrition RAMS MP 2.3.1.1915-04 “Recommended levels of food and biologically active substances consumption” an adequate level of Lactobacillus bacteria consumption is 5 \times 10^7 CFU/day. Thus, 100 g of the product will provide 20% of the daily requirement for bacteria of this kind, which allows to consider this sour-milk drink as a natural functional food product. The aim of our research was to further increase the nutritional value of this food using the stage of milk stewing and increasing the fat fraction bioavailability.

In order to increase the bioavailability of nutrients in the production of a new sour-milk drink, we used baked milk, an exposure of raw milk at elevated temperatures for a long time. Baked milk is an authentic product of the Slavic peoples, which has a centuries-old tradition and is still popular among Russians. As a result of baking, a change is made in milk components composition – sugars (lactulose) interact with protein amino acids, and as a result, melanoidins are formed, the color and taste of milk change. Some amino acids interact with the formation of sulfide groups, which determine the taste of pasteurization in the product. The content of moisture is reduced, thereby increasing the content of fat, vitamin A, iron and calcium. However, the result of prolonged heat treatment is a decrease in vitamins C and B1. Baked milk is already being used to create functional dairy products. For example, a formulation has been developed for a combined fermented milk product with the addition of a cereal supplement, which makes it possible to obtain a new dairy product of increased nutritional value [9; 10].

This study determined the effect of prolonged heat treatment on the number and size of fat globules in milk. The size of fat globules is a factor influencing the absorption of fat – the smaller the size of the globules, the higher the efficiency of fat absorption. The main absorption of fats occurs in the small intestine under the action of bile salts. Large droplets of fat are reduced to smaller sizes (0.5 μm or less), then undergo the emulsification and further absorption of fats by lipase. The speed and completeness of their absorption depends on the size of emulsified fats - in this case, the size of fat globules will be the limiting factor, which, in turn, depends on their initial size. Thus, reducing the fat globules size, it is possible to increase the bioavailability of milk fat phase, thereby obtaining a new functional sour-milk product of increased digestibility, recommended for people of all ages, including those with digestive problems.
2. Objects and methods of research
The research object was sour-milk drink “Snezhok” made according to the traditional recipe with the replacement of the main raw material - raw cow milk (GOST 31449-2013) with baked milk (GOST 31450-2013). In the research we used the methods of analysis, synthesis, deduction, the method of fat globules direct calculation in the Goryaev counting chamber.

3. Results and discussion
During the study, the influence of temperature on the fat fraction of raw milk was assessed. For this purpose, three samples of milk were baked at a temperature of 92 ± 2 °C, sample exposure time – 4 h. 30 min., 5 h. and 5 h. 30 min. The recipes of the samples are shown in table 1.

| Raw materials          | Recipe for 100 kg | Sample 1 (exposure time 4.5 h.) | Sample 2 (exposure time 5 h.) | Sample 3 (exposure time 5.5 h.) |
|------------------------|-------------------|---------------------------------|--------------------------------|---------------------------------|
| Baked milk             | 93.99             | 93.99                           | 93.99                          |                                 |
| Ferment                | 0.001             | 0.001                           | 0.001                          |                                 |
| Vanilin                | 0.009             | 0.009                           | 0.009                          |                                 |
| White sugar            | 6.000             | 6.000                           | 6.000                          |                                 |
| Total                  | 100.000           | 100.000                         | 100.000                        |                                 |

To determine the number and size of fat globules, the samples were microscopied using the Goryaev counting chamber. The size of fat globules was divided into groups - small (less than 2 microns), medium (2–4 microns and 4–6 microns) and large (6 microns or more). The fractional composition of the control sample (raw cow milk with a fat content of 3.2% without heat treatment) and of the samples with various time of exposure at the baking stage (drinking milk with a fat content of 4.2%) are shown in table 2.

| Fat globules size | Control sample | Sample 1 (exposure time 4.5 h.) | Sample 2 (exposure time 5 h.) | Sample 3 (exposure time 5.5 h.) |
|-------------------|----------------|---------------------------------|--------------------------------|---------------------------------|
| less than 2 μm    | 2.9            | 2.9                             | 2.9                            | 2.9                             |
| 2-4 μm            | 1.0            | 1.1                             | 1.2                            | 1.2                             |
| 4-6 μm            | 0.4            | 0.5                             | 0.3                            | 0.5                             |
| 6 μm and more     | 0.2            | 0.2                             | 0.2                            | 0.1                             |
| Total             | 4.5            | 4.7                             | 4.6                            | 4.7                             |

According to the data in table 2, the content of the smallest (less than 2 μm) fraction of fat globules in all the studied samples was almost the same and amounted to 2.9 billion in 1 ml of product (from 61.7 to 64.4%) (figure 1).
Figure 1. Fractional composition of baked milk samples.

The number of fat globules of medium fraction – from 2–4 μm and from 4–6 μm slightly increases with the increase of baking time – their number in the control sample was 1.4 bln, after the exposure during 5.5 hours – 1.7 bln, so their content increased by 17.6%. Herewith, the amount of globules 2–4 μm increased by 16.7%, 4-6 μm – by 20%.

Number of large fraction globules (6 μm and more) decreased only in sample 3 and was 0.1 bln in 1 ml of milk relative to 0.2 μm in three previous samples, the percentage reduction was 50%.

The dependence of the fat globules size on the samples exposure time is shown in figure 2.

Figure 2. Dependence of the fat globules size on the samples exposure time.
4. Conclusion
In the course of the study, we found that the temperature treatment affected the milk fat fraction size – the number of fat globules of small and medium fractions increased. During heat treatment, changes occur in the fat globules shells. On their surface, the process of denaturation of enveloped proteins takes place, part of the fat globules are destroyed, in some of them there is a slight warming up of fat, which results in the decrease of their size.

Thus, the results of our study confirm the hypothesis put forward by the authors regarding the increase in bioavailability of the milk fat fraction as a result of its long-term heat treatment. The fat globules become more digestible due to the small size; their absorption rate and completeness increase. The suggested new product using the traditional Snezhok sour-milk drink technology of baked milk as the main raw material, may be considered a product of high nutritional value, contributing to the public health improvement.

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