Shelf life of canned milk as an indicator of efficiency of the technological process

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Abstract. Preserving milk solves problems related to the seasonality of milk production. It improves the transportability of dairy raw materials, and provides dairy products to the population that does not receive natural milk due to geographical, climatic and other reasons; it also provides specialized nutrition to people who are in extreme conditions. The development of techniques and methods for creating technologies for dry canned food of increased shelf life and nutritional value is a relevant task. Standard methods were used for evaluation of raw materials and finished products. The results of the technologies for high-fat sublimated milk-containing product are presented in this article. The product has a shelf life of up to two years due to stabilization of antioxidants, increased nutritional and biological value, and replacement of part of the milk fat with vegetable fat rich in polyunsaturated fatty acids. The new type of freeze-drying, high-fat canned milk is produced with a resource-saving technology.

1. Introduction
A review of available scientific and technical literature on the topic of the research has revealed that the development of methodology, principles and methods for improving technologies and forming the required quality of products based on long shelf life and improved nutritional value is an important task. Development of innovative technologies and design of healthy canned milk and improvement of nutrition are the main directions in processing raw materials for obtaining specialized products [1–3].

It is necessary that the diets contain about twenty thousand different ingredients to supply the human nutritional needs. A mixed diet contains less than half the required amount of minor ingredients [4]. Recent research has shown that consumption of animal fat has a negative impact on people at risk (with cardiovascular diseases, obesity, etc.) [1, 5].

There is importance of consumption of milk and dairy products for nutrition. Problems of production and consumption will never lose their relevance. An important task is to create dairy products with a long shelf life, improved quality indicators, the development of innovative technologies and new equipment while improving the production standards. New technologies of dairy products should be aimed at improving the quality, safety and competitiveness of products. There is a need to ensure manufacturability, reduce cost and reduce production losses when using all the components of milk.
Recently, production of foods where milk fat is replaced with vegetable fats has been increased [6, 7]. This process provides the possibility of obtaining dairy products with adjusted indicators of quality and composition of fatty acids. The use of vegetable fats provides a change in the composition of the fat base products in the required direction and the creation of products with functional properties for the specialized purpose [8–10]. The design of milk-containing canned food for general and specialized use resulted in the following quality indicators:

- high organoleptic properties (taste, smell, consistency);
- improved storage capacity;
- increased nutritional value;
- equilibrium of fatty acids composition.

The purpose of this research is to establish the possibility and develop a technological process for obtaining the high-fat sublimated milk-containing a product form with a high nutritional and biological value, stable during long-term storage for general and special purposes.

This purpose was achieved by solving the following tasks:

- to make a scientific and technical literature review focusing on the possibility of developing canned dry milk for specialized nutrition in areas with limited natural dairy raw;
- finding ways to extend the shelf life of a dry high-fat milk-containing product by introducing anti-oxidants into the production process;
- adjusting the composition of the fat base of the product in order to replace part of the animal fat with vegetable fats rich in polyunsaturated fatty acids;
- comprehensive assessment of the quality and nutritional value of a new product and setting the shelf life;
- calculation of economic indicators and cost of high-fat sublimated milk-containing product.

2. Materials and methods

This research was conducted at the facilities of dairy enterprise VNIMI-Sibir LLC (Omsk) and Agrarian and Technological Research Center at the Omsk State Agrarian University named after P.A. Stolypin.

One of the process operations in the production of a dry high-fat milk-containing product is the operation of emulsifying a vegetable fat additive and preparing a milk-vegetable mixture with a milk fat substitute Ecolact, produced by EFKO-INGREDIENT LLC. The use of milk fat and “Ecolact” as the replacement of part of animal fat with its substitutes of plant origin, that provides the desired ratio of fatty acids, is recommended due to comprehensive studies. The use of the milk fat substitute "Ecolact" in the product provided the ratio of unsaturated fatty acids as 7/1. Taking into account the results of organoleptic analysis of the milk-vegetable mixture in the recipe for the production of high-fat sublimated milk-containing product, a substitute for milk fat “Ecolact 1443” is proposed. The composition of “Ecolact 1443” contains a protein emulsifying additive that contributes to the effective preparation of a milk-vegetable mixture.

Anti-oxidants were added to the normalized mixture before drying, including the antioxidant dihydroquercitin and vitamin C as a synergist in order to stabilize the fat of high-fat sublimated milk-containing product in storage. The mass of dihydroquercitin was calculated as follows (1):

\[
K = \frac{F \times M \times P}{(100 \times 100)}
\]

where K is the mass of dihydroquercitin (kg); F is the mass fraction of fat in the mixture (%); M is the mass of the milk-vegetable mixture (kg); P is the percentage of dihydroquercitin in the mixture (%).

The percentage dosage of dihydroquercitin and ascorbic acid was 0.15% of the product’s fat phase. The antioxidant was dissolved in an alcohol solution at a temperature of 55-60 degrees in a ratio of 10:1. Ascorbic acid was dissolved in distilled water in a ratio of 20:1. Solutions of antioxidants were added to the normalized mixture with constant stirring before drying in small quantities.
Drying of the product was carried out by the sublimation method to the final moisture content in the range of 4-5%. The freeze-drying method ensures the preservation of all the useful properties of vitamins, minerals, microflora in the finished product, ensuring the preservation of food and biological value without changing and lengthens the shelf life of dry products.

The high-fat sublimated milk-containing product was packed in a package made of a polymer composite material on a metallic foil base of 100-105 g under vacuum in an atmosphere of inert gases. Recovery of high-fat sublimated milk-containing product was carried out with potable water within a temperature of 50-55 degrees for 10 minutes with a water-product ratio of 2:1.

3. Results and discussion
The high-fat sublimated milk-containing product belongs to the class of dry milk-containing products; it is produced by drying a normalized cream-vegetable mixture with a subsequent process of thickening, homogenization, introduction of antioxidants and drying by thermal method, or by sublimation.

![Process scheme of high-fat sublimated milk-containing product.](image-url)
The product has high nutritional and biological values, is resistant to long-term storage and designed for general and special nutrition. High-fat sublimated milk-containing product has the following process scheme (Fig. 1).

The milk-vegetable mixture is prepared in the following sequence: to the pasteurized milk base at a temperature of 55±5°C, a substitute for milk fat is introduced in the ointment state. The milk-vegetable mixture is emulsified for 25±5 minutes at a temperature of 55±5°C, then normalized, pasteurized at a temperature of 93±4°C and condensed to 450% dry matter on a vacuum evaporation unit, homogenized at a temperature of 60±3°C and p=8-9 MPa. Then, the mixture of the antioxidant complexes of dihydroquercetin is added, which also has P-vitamin activity with the synergist ascorbic acid: dihydroquercitin+vitamin C (0.15% and 0.15% to the product fat, respectively). Drying is carried out by sublimation to the final moisture content of no more than 5%. The finished product is packed in bags of 130±5 g under vacuum in an inert gas atmosphere.

The organoleptic properties of high-fat sublimated milk-containing product are shown in table 1.

**Table 1.** Organoleptic properties of high-fat sublimated milk-containing product.

| Consistency | Taste |
|-------------|-------|
| dry powder with a small lumps that crumble when lightly pressed | clean, sweet, without foreign taste and smell |

Indicators of the nutritional and energy value of high-fat sublimated milk-containing product are presented in table 2.

**Table 2.** Nutritional and energy value of high-fat sublimated milk-containing product.

| Protein | Fat | Carbohydrates | A | D | E | C | Energy value (kJ/kcal) |
|---------|-----|---------------|---|---|---|---|------------------------|
| 7.5     | 76.0| 15.3          | 2.5| 0.16| 5.6| 18.1| 3168/756               |

Dry canned milk with the replacement of the part of milk fat with vegetable fats were produced based on the developed recipes, cost of the main and auxiliary raw materials, packaging materials, production costs, etc. at the dairy enterprise VNIMI-Sibir LLC. This enterprise performed a check of the production process during the period of our research.

The economic feasibility of producing products with partial replacement of milk fat with vegetable fat was revealed in comparison with the cost of the planned cost calculation of products made from milk and milk-containing products.

Comparison of the cost of recipes (raw materials, basic materials and costs) in the production of high-fat sublimated milk-containing product revealed the obvious economic feasibility of producing milk-containing products, where part of the expensive and scarce milk fat is replaced with less expensive vegetable fat and indicates the feasibility of implementing the developed technologies.

The economic effect of implementing resource-saving technologies is more than 30%.

**4. Conclusion**

As a result of our research we have the following:
• development of high-fat sublimated milk-containing product has allowed to expand the range of dairy products for special nutrition: the product is dried by freeze-drying with the preservation of all useful properties of nutritional value;
• introduction of an antioxidant complex of flavonoid character into the product, which also has P-vitamin activity, increases the stability of the product in storage for 24 months and enriches the product with vitamins;
• partial replacement of milk fat with its substitute Ecolact 1443 increases the content of unsaturated fatty acids, in particular polyunsaturated ones, while reducing the amount of saturated ones.

The production of a new type of dry milk product will expand the range of competitive products with improved organoleptic properties, increased nutritional value, resistant to long-term storage, meeting the modern requirements to healthy nutrition, taking into account the safety, balance and high content of vital substances. The high quality of the resulting product confirmed the correctness of the selected technological modes of production, which allowed preserving the indicators of the freshly processed product during long-term storage.

Improving and preserving the quality of canned milk products, increasing the shelf life solve the most important social task – providing the population with full-fledged dairy products for both general nutrition and nutrition for specialized purposes.

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