Development of technology and study of quality of dry milk preserved products for specialized purposes

I A Ivkova, O V Skryabina, D S Ryabkova and A S Pilyaeva

Omsk State Agrarian University named after P. A. Stolypin, 1, Institutskaya square, Omsk, 644008, Russia

E-mail: ov.skryabina@omgau.org

Abstract. Dairy-based products are of great social significance, both in general and functional nutrition of the population, especially in the risk group. Preserved milk products are included into the set of products of the State Reserve, which is also important for the economic security of the country. During storage, the nutritional value of products decreases, which leads to a loss of quality, shortens the shelf life. Keeping the original native properties in the product and extending the shelf life are an important social task. In this regard, development of methodology and creation of high-quality preserved milk products are an urgent task facing specialists in the dairy industry. The study used standardized and general research methods for preserved milk products in terms of quality, safety, and nutritional value. The paper presents a study on the development of technology for dry high-fat dairy product: dry high-fat cream in gelatin capsules for specialized nutrition of people in autonomous conditions of existence (army, naval forces, space, remote areas of the country), made by freeze dehydration. Preserved food has a long shelf life due to stabilization of antioxidants, increased nutritional and biological value. Based on the study, there was developed a manufacturing technology for dry high-fat cream, the recipe of gelatin capsules for its single-use packaging, there was solved the problem of unstable milk production during the year, and provision of people with dairy products in autonomous conditions of existence.

1. Introduction

Based on the analysis of the literature available to us on the quality of specialized preserved milk, there has been identified necessity and relevance of improving technologies and forming consumer properties of specialized preserved milk [1–4].

The need to develop remote areas of the country caused the development of a state program for the development of territories, including Arctic zone of the Russian Federation [5, 6].

The goal of the program is to develop new dairy products of increased nutritional value with long storage periods for specialized purposes [7, 8].

The purpose of current studies is to develop the manufacturing process to produce dry high-fat cream in gelatin capsules intended for people in autonomous conditions of existence.

To achieve this purpose, the following tasks were performed:
- analysis of foreign and domestic literature on the problem under discussion;
- determining the possibility of extending shelf life of the product by adding an antioxidant;
- development of the formulation and production technology of gelatin capsules;
- comprehensive assessment of the quality and nutritional value of a new type of preserved milk [9, 10].

2. Materials and methods

The process of creating a new technology for dry high-fat cream in gelatin capsules of high nutritional value, resistant to storage, included the development of technological modes of production: temperature processing parameters, homogenization modes, types and dosages of adding antioxidants, as well as their application scheme; development of the formulation and production technology of gelatin capsules for packaging dry products [11].

Stabilization of fat phase of dry high-fat cream in storage involve before drying adding of antioxidant complexes to the normalized mixture; the antioxidant complexes consist of dihydroquercetin (DHQ) and cysteine complete with ascorbic acid as a synergist.

The dosage of adding of dihydroquercetin and ascorbic acid is 0.15 percent to fat.

Dihydroquercetin was dissolved in ethyl alcohol with a concentration of 98 percent and a temperature (60±2) °C at a ratio of 10:1.

Ascorbic acid was dissolved in water at a ratio of 20: 1. The antioxidant is added to the mixture in portions, being mixed thoroughly before being dried.

Drying of the product is carried out using the freeze-drying equipment to the mass fraction of moisture 4-5 percent.

Freeze drying in comparison with spray high-temperature drying provides the elimination of moisture by its transition to a gaseous state bypassing the liquid at a temperature of -30 °C.

Freeze drying helps to preserve all useful properties of the product, vitamins, useful microflora, bifidobacteria, food and biological value and extends its shelf life.

Preserved food was packed in metallized foil of (155±3) g under pressure.

Dry high-fat cream was restored by adding water at a temperature of 60°C for 25 minutes at a ratio of 2: 1.

3. Results and discussion

Dry high-fat cream (DHFC) stabilized with an antioxidant in gelatin capsules belong to the class of dry high-fat preserved milk products obtained by drying a cream mixture stabilized with an antioxidant and packaged in gelatin capsules. Dry high-fat cream is used in special nutrition for people who are located in regions with limited resources of natural dairy raw materials.

The technological process of dry high-fat cream production includes the following operations:

- preparation of raw materials;
- normalization of milk;
- technological treatment;
- condensing;
- stabilization with antioxidants;
- drying;
- cooling of dry high-fat cream.

The production of gelatin capsules includes the following operations:

- preparation of a gelatinous mixture;
- swelling of the mixture;
- heating;
- evacuation;
- sterilization;
- cooling;
- production of gelatin capsules;
- drying of the capsules.

The product is pasteurized at a temperature of (98±2) °C and sent to a vacuum apparatus, where it is condensed to the mass fraction of dry matter (55±3)%.

In order to reduce fat residue in the
condensed product, it is homogenized at a pressure of 6-7 MPa and a temperature of 50 degrees Celsius.

To extend the shelf life of dry high-fat cream, the antioxidant dihydroquercetin (the amount of 0.15 percent of fat) and the synergist ascorbic acid in the same ratio are added in the process of condensing. The mixture after the vacuum device is sent to the tower of the spray drying unit and is dried at a temperature of 175-185 °C to a moisture content of no more than 5 percent. After drying tower DHFC is sieved using sieve with a maximum size of 4 x 4 mm. Then the product is cooled to a temperature of 4-5 °C.

In case of freeze drying, the mixture is cooled after the vacuum evaporation unit and placed on a baking tray of a freeze dryer, frozen and dried to a moisture content of no more than 5 percent.

Gelatin mixture for the manufacture of gelatin capsules is made in accordance with the developed recipe, then it is heated to 60 °C and vacuumed for 2.5 hours at vacuum pressure of 80 kPa, after which it is subjected to sterilization at 110-115 °C for 10 minutes.

The formula of mixture for making gelatin capsules: water - 90 gram; glycerine -13 gram; gelatin - 26 gram.

Capsules are dried using equipment for the production of gelatin capsules at a temperature of (45±1) °C for 45-55 minutes. Then they are tightly filled with a product of 5-6 grams each. 10 pieces of capsules DHFC are packed into a combined film based on a metallized foil under pressure. The product is used as a high-calorie dietary supplement for specialized nutrition (army, naval forces, space, remote areas of the country, including Arctic zone of the Russian Federation).

Table 1. Organoleptic characteristics of dry high-fat cream

| Consistency | Taste |
|-------------|-------|
| Dried powder with a small amount of lumps that crumble when lightly pressed | Clear, slightly sweet, similar to dry high-fat dairy product, without foreign taste and smell |

Nutritional values of dry high-fat cream: protein 7.8%, fat 76.0%, carbohydrates 1.3%, retinol 1.3 mg, calciferol 0.08 mg, tocopherol 4.5 mg, ascorbic acid 17.0 mg, energy value: 3140 kJ.

Data show that dry high-fat cream has a high content of complex of vitamins of A, D and E, as well as vitamin C.

The evaluation of biological value of a new type of high-fat dry cream was based on the study of amino acid composition and the calculation of amino acid score of essential acids in accordance with the ideal protein.

The chemical numbers of amino acids were calculated after their determination using the following formula (1):

\[ C = \frac{X1 \times 100}{X2} \]  

where C is score of desired amino acid, %; X1 - mass fraction of amino acid in 1 gram of the product; X2 - mass fraction of amino acid in 1 gram of an ideal protein.

The amino acid composition of dry high-fat cream, presented in table 2, indicates that dry high-fat cream has a good biological value as per essential amino acids. The exception is the amino acids that limit the biological value: methionine, cysteine.
Table 2. Chemical numbers of proteins of dry high-fat cream

| Essential amino acid | Ideal protein (FAO/WHO) m/g of protein | Dry high-fat cream (DHFC) content, mg/g | Amino acid score, % |
|----------------------|----------------------------------------|----------------------------------------|--------------------|
| Valine               | 50.0                                   | 32.5                                   | 65                 |
| Isoleucine           | 40.0                                   | 27.6                                   | 67                 |
| Leucine              | 70.0                                   | 58.5                                   | 84                 |
| Lysine               | 55.0                                   | 42.8                                   | 79                 |
| Methionine + cystine | 35.0                                   | 3.9                                    | 8                  |
| Threonine            | 40.0                                   | 29.8                                   | 75                 |
| Tryptophan           | 10.0                                   | traces                                 | -                  |
| Phenylalanine + tyrosine | 60.0                               | 48.3                                   | 81                 |

In dry high-fat cream, valine, leucine, lysine, phenylalanine + tyrosine are dominant. The biological value (BV) of proteins of dry high-fat cream was confirmed by calculating the coefficient "CDAS", determined by the following formula (2):

\[ CDAS = 100 - BV \] (2)

where CDAS is coefficient of differences in amino acid score.

The value of CDAS is the sum of differences in amino acid score for the desired amino acid in comparison with the most deficient one. This calculation method confirms the increase in biological value of dry high-fat cream. Maximum biological value of the product is approaching 55 percent, the coefficient of differences in the amino acid score is 60%.

4. Conclusion

1. A new type of dry preserved milk products was created: dry high-fat cream in gelatin capsules with high nutritional value, resistance to long-term storage, a number of studies of which were conducted on the basis of the Resource Sharing Center “Agrarian and Technological Research”;

2. Use of flavonoid antioxidant dihydroquercetin, which has P-vitamin activity, a synergist of vitamin C in the production of dry high-fat cream, made it possible to obtain a product with a high nutritional value, both in fresh form and in the process of long-term (up to 24 months) storage.

3. Dry high-fat cream is characterized by a high index of biological value for essential amino acids compared to the ideal protein (FAO/WHO). Dominant amino acids are leucine, lysine.

4. Development of a new type of dry preserved milk products allows expanding the range of products with improved organoleptic characteristics, high nutritional value, resistant to storage, with a high content of essential substances of protein and lipid nature, vitamins, and minerals.

Technologies for the production of dry high-fat cream can be implemented using standard equipment and implemented in dairy enterprises without converting production capacity.

References

[1] Azeredo H M C 2009 Nanocomposites for food packaging application Food Res. Int. 42(9) 1240-1253
[2] Chernopolskaya N, Gavrilova N and Rebezov M 2019 Biotechnology of specialized product for sports nutrition *International Journal of Engineering and Advanced Technology (IJEAT)* **4**(8) 40-45

[3] Skryabina O V, Vikulov V V, Ryabkova D S and Diner Y A 2020 Advanced Specialized Foods Production Technologies within the Framework of Foodnet *Proceedings of the International Scientific Conference The Fifth Technological Order: Prospects for the Development and Modernization of the Russian Agro-Industrial Sector (TFTS 2019)* **393** 130-134

[4] Lizko N N and Andrianov S A 2011 Products of the XXI century. Analysis of the situation and prospects for market development *Milk industry* **6** 26-27

[5] Borisova G V and Bessonova O V 2013 Histidine biotransformation mediated by l-histidine-ammonia-lyase *Foods and Raw Materials* **1**(2) 37-41

[6] The program of development of the Arctic "On approval of the RF State program "Socio-economic development of the Arctic zone of the Russian Federation for the period till 2020." A Russian Federation government decree No. 366 dd. 21.04.14 (Moscow)

[7] Spirichev B V and Shatnyuk L N 2006 Fortification of food products with micronutrients – a reliable way to correct nutrition and health *Current priorities of nutrition, food industry and trade: proceedings* (Moscow – Kemerovo) pp 76-78

[8] Williams K and Sanders T 2000 Relationship between health and protein, carbohydrate and fat consumption *Nutrition issues* **3** 54-57

[9] Shatnyuk L N 2001 Fortification of dairy products with micronutrients *Food industry* **9** 49-51

[10] Kosenchuk O V, Aleshchenko V V, Stukach V F, Zinich A V and Leushkina V V 2016 *Study of the problems of sustainable development of rural territories* **13**(6) 2391-2407

[11] Ivkova I A, Zubareva E A, Zabolotnykh M V and Zhidik I Y 2020 Effect of Vegetable Fats on the Quality and Safety of Food Products Available *Proceedings of the International Scientific Conference The Fifth Technological Order: Prospects for the Development and Modernization of the Russian Agro-Industrial Sector (TFTS 2019)* **393** 73-77