The study of factors affecting the drying process and the quality of dry cheese

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Abstract. The article presents the results of studies of the characteristics of the production of superhard (dry) cheese. The most rational drying method was selected, which allows to increase the consumer properties of the finished product and its shelf life, as well as improve the organoleptic and physico-chemical characteristics of cheese. The advantages of freeze-drying are described. Various drying factors affecting the quality of the cheese are considered, such as the duration of the freezing of the cheese depending on the geometric portion sizes and the drying conditions. Cheeses are recommended to produce a round shape with a diameter of 2 to 4 centimeters. The optimum temperature for pre-freezing the product, taking into account the moisture content in the final product, was \(-15^\circ\) C. A method for the production of dry cheese with the addition of a plant component, a source of dietary fiber, is proposed. The choice of vegetable filler is justified and a cheese formulation using chia seeds has been developed. The optimal content of chia seeds in the formulation of dry cheeses is 5.0-8.0%.

1. Introduction.

In the organization of proper nutrition, dairy products play a paramount role. This fully applies to cheese, the nutritional value of which is due to the high concentration of milk protein and fat in it, the presence of essential amino acids, calcium and phosphorus salts, so necessary for the normal development of the human body. Given the policy of a healthy diet, the additional enrichment of dairy products with herbal supplements is currently relevant. Cheese is one of the most common dairy products in mass consumption. Today, cheese production and its consumption around the world is growing steadily. According to the UN Food and Agriculture Organization, the annual growth in cheese production in the world is 1-2\% [1]. Cheeses have such disadvantages as an unbalanced composition and a lack of dietary fiber. Dietary fiber - are substances of various chemical nature (all of them are polymers of monosaccharides and their derivatives), which are not split in the small intestine, but undergo bacterial fermentation in the colon. Most dietary fiber is found in the peel and in other hard parts, as well as in the shells of grains and seeds.

The use of chia seeds is a promising area for creating functional products. Chia seeds contain about 40\% of oil, about 16\% of protein and zero cholesterol. Seeds consist of a significant amount of fiber, antioxidants and vitamins B3, B2, B1 including a wide range of vital minerals such as calcium, iron, potassium, zinc, etc. The most important property of chia seeds is the high content of essential fatty acid alpha-linoleic omega 3, more than in fish or other grains and seeds. Another interesting property of chia seeds is their high fiber content. Seeds have the ability to absorb large volumes of water, 10-12 times the weight of the seed itself. Swollen, saturated seeds occupy a significant part of the stomach, are a source of fiber and slow down the digestion of simple carbohydrates, representing a special kind of barrier between food and the walls of the stomach. Thus, the feeling of fullness is prolonged, the level of sugar in the blood is not subjected to sharp jumps, digestion returns to normal. Phosphorus and zinc in the composition of the seeds stabilizes the activity of the nervous and immune systems. Fatty acids and vitamins facilitate the hormonal restructuring of the female body during menopause, and calcium strengthens bones, joints and tendons, which is relevant for athletes, both for men and
women. Moreover, the active substances in this product contribute to the accelerated restoration of damaged tissues in the event of sports injuries or ordinary sprains. Cheese is easily absorbed in the body, while saturating it with a huge amount of nutrients. Of the minerals in the cheese, calcium, potassium, iron, magnesium, phosphorus, zinc and others predominate. The vitamin composition is very diverse, including vitamin A and group B vitamins, vitamins C, PP, E, etc. There are amino acids in cheese, such as lysine, tryptophan, methionine [2]. One of the tasks of the work is to increase the shelf life of cheeses. There are various ways to increase the shelf life of cheeses. This is the addition of preservatives, the use of special types of packaging, freezing and storage at low temperatures, drying.

Freeze-drying is based on the ability of ice to evaporate under certain conditions, bypassing the liquid phase. Freeze-drying occurs at a residual pressure below the pressure of the triple boiling point of water. Moisture removal is carried out by the ice-vapor phase transition. The main amount of moisture (75-90%) is removed by sublimation of ice at a temperature below 0°C, and only the removal of residual moisture occurs when the material is heated to 40-60°C. Freeze-drying has the following advantages compared to traditional preservation methods: the need for refrigerated storage is excluded, since dry products can be stored at positive temperatures for a long time; the mass of products after drying is significantly reduced, therefore, the cost of loading and unloading and transportation is reduced; the implementation system is simplified and the terms for their implementation are lengthened; palatability vary slightly. Freeze-drying is one of the best quality preservation methods for most foods [3, 4, 5, 6].

Freeze-dried products are of high quality, retain nutrients, have slight shrinkage, retain color, have a porous structure. In many developed countries (USA, France, Canada, Germany, etc.) specialized enterprises have been established that produce a wide range of freeze-dried foods. The experience of industrial application of freeze-dried canning of many food products has shown the technical and economic feasibility of its implementation. Therefore, for drying cheese, the method of freeze-drying was chosen [5, 7, 8].

2. Purpose of work
The aim of our work is to design the formulation of superhard (dry) cheese with a vegetable component and to study the effect of drying on the quality of the finished product. Studies were conducted at the department of the faculty of food production technology VolgSTU (Russia). It is highly advisable to use chia seeds as a plant component in dry cheeses. The relevance of this work lies in expanding the assortment of cheeses, developing a method for the production of dry cheese with an innovative additive - chia seeds and high nutritional value.

3. Materials and research methods
The research work consisted of the following stages: selection and preparation of raw materials, development of control and test samples and assessing the quality of the products obtained according to their organoleptic and physicochemical properties. The scheme of the experimental study is shown in Figure 1.
Dry cheese is produced from pasteurized cow’s milk by fermentation with lactic acid bacteria using the method of acid coagulation of proteins and subsequent removal of whey by extrusion, with the addition of salt and fillers. The main stages of cheese production are ripening, mixing the cheese mass with chia seeds, molding the product and drying. Samples were dried using a sublimation unit manufacturer Reutov, Russia (Figure 2). Drying modes - pressure in the system is 0.5-1.0 mm Hg. Art., the temperature in the process of sublimation is not higher - 100°C, the temperature in the product during the removal of residual moisture is not higher than 400°C. The vacuum in the installation was violated by introducing nitrogen gas into the system.

Figure 1. Scheme of experimental studies

Figure 2. Sublimation installation
Studies of quality indicators of samples indicators (organoleptic content, physico-chemical) were carried out according to generally accepted methods for the analysis of cheese.

4. Results and discussion
The formulation of dry cheese with chia seeds was carried out using preliminary laboratory experiments on the production of cheese, which, according to the results of organoleptic analysis, showed that the optimal content of chia seeds in the product in an amount of from 5.0 to 8.0%. To solve the problem of optimizing the formulation, three prototypes were produced in the laboratory (Table 1): sample 1 - control sample produced without chia seeds; sample 2 – with chia seeds in the amount of 5.0%; sample 3 - with chia seeds in an amount of 8.0%.

Table 1. Dry cheese experimental formulations

|            | Sample 1 | Sample 2 | Sample 2 |
|------------|----------|----------|----------|
| Normalized milk, 3,2% fat content, kg | 1000     | 1000     | 1000     |
| Leaven DVS, kg | 0.1      | 0.1      | 0.1      |
| Salt, kg   | 2.0      | 2.0      | 2.0      |
| Chia seeds, kg | 0.0      | 5.0      | 8.0      |

An organoleptic evaluation of the product was carried out for each of the samples, the results of which are presented in Figure 3 and Table 2.

![Figure 3](image)

Figure 3. Appearance of experimental samples: (a) - sample 1 - control sample produced without chia seeds; (b) - sample 2 - with the addition of chia seeds in an amount of 5.0%; (C) - sample 3 - with the addition of chia seeds in an amount of 8.0%.

Table 2. Characterization of organoleptic indicators of dry cheese

|            | Control sample | Sample 1 | Sample 2 |
|------------|----------------|----------|----------|
| Consistency| dense          | dense    | dense    |
| Colour     | white          | dark white with black speckles | dark white with black speckles |
|            | sour milk      | sour-milk, salty, with a slight non-fermented sour milk, salty, | sour milk |
| Taste      | salty          | sourness | salty, sour milk |
| Smell      | sour milk      | sour milk | sour milk |

As a result of this work, several factors were identified that affect the process of freeze-drying cheese and its properties. One of the first significant factors is the duration of cheese freezing,
depending on the geometric size of the portion. The duration of freezing is due to the geometric dimensions of the sample. The smaller the thickness of the product and the greater the ratio of its surface to volume, the faster freezing occurs. Hard cheese made from pressed and dried curdled milk with the addition of salt should have a rounded shape with a diameter of 2 to 4 cm, since it will be easier to transport, it will not crumble and the logistics of this type of product will be simplified. The use of such a diameter for dry cheese is very rational. If you make a cheese diameter more than 4 cm, the product will freeze unevenly, and therefore moisture will be worse removed. If the diameter is less than 2 cm, after drying, the size of the cheese will greatly decrease and will crumble (Table 3). The optimum temperature for pre-freezing the product, taking into account the moisture content in the final product, was -15°C (Table 4).

Table 3. The quality characteristic of cheese depending on the diameter of the sample

| Indicator   | Cheese Diameter |
|-------------|-----------------|
|             | 2 cm            | 4 cm            | 6 cm            |
| Consistency | Tiny consistency, lots of cracks on the surface | Dense consistency, without cracking on the surface | The surface is dense consistence, in the middle soft |
| Moisture, % | 5.6             | 9.8             | 18.9            |
| Acidity, °T | 61.5            | 62.0            | 68.5            |

Table 4. The quality characteristic of cheese depending on the diameter of the sample

| Indicator   | Cheese Freezing Temperature |
|-------------|-----------------------------|
|             | -20°C | -15°C | -10°C |
| Consistency | Tiny consistency, lots of cracks on the surface | Dense consistency, without cracking on the surface | The surface is dense consistence, in the middle soft |
| Moisture, % | 25.3   | 10.6   | 16.4   |
| Acidity, °T | 69.5   | 65.0   | 68.0   |

The next factor is the freeze-drying modes. After loading the frozen product into the sublimator, the period of creating a vacuum in the system begins. The duration of this period depends on the factors previously considered, as well as on whether evaporation of moisture from the product occurs. If the temperature of the loaded product is low enough so that the corresponding vapor pressure is less than the pressure in the sublimator by the end of the evacuation period, then practically no moisture from the product will evaporate. So, at a product temperature of 18°C, the vapor pressure above it \( p_{\text{sample}} \) will be 0.9 mm Hg. If the residual pressure in the sublimator is \( p = 1 \) mm Hg. Then during the entire period of evacuation \( p_{\text{sample}} < p \) and evaporation will not be. In this case, the air contained in its volume and the gases adsorbed by the surfaces of the sublimator and the product must be removed from the sublimator. If the temperature of the product is high enough so that \( p_{\text{sample}} \) is greater than \( p \) during the period of creating the vacuum, the evacuation will be accompanied by evaporation and removal of the generated vapor. The duration of the evacuation of the second case will be longer. In fact, usually at the beginning of evacuation \( p_{\text{sample}} < p \) and evaporation does not occur (the product receives heat from the environment); at the end of the period \( p_{\text{sample}} > p \) and partial sublimation of ice occurs from the surface of the product. As a result of studies of these factors in the production of dry cheese, we can conclude that this type of cheese drying has a positive effect on the quality of the product, which is confirmed by organoleptic and physico-chemical studies.
5. Conclusion
The production of dry cheeses based on vacuum freeze-drying using chia seeds will significantly expand the range of dairy products. The selected method and drying modes allow for a long time to maintain the quality and useful properties of cheeses. The developed dry cheeses are an indispensable product for dietary nutrition, supplying inaccessible areas, the army, and expeditions.

The optimal content of chia seeds in the formulation of dry cheeses is 5.0-8.0%. Cheeses are recommended to produce a round shape with a diameter of 2 to 4 centimeters. The optimum temperature for pre-freezing the product, taking into account the moisture content in the final product, was -15°C.

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