Biologically active substances of plant components for the enrichment of dairy products

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Abstract. The article discusses the possibility of using arabinogalactan and powder from pumpkin pulp as enriching plant components of the curd mass. To this end, the technological properties of the food additive arabinogalactan (Lavitol-arabinogalactan), the properties of the vegetable additive in the form of powder from pumpkin pulp as a functional component, the aspects of their influence on the qualitative characteristics of the curd mass, the optimal dosage of the enriching ingredients in the curd recipe were studied. The combination of raw components adopted according to the research results allows to obtain curd mass enriched with vegetable micronutrients and expand the assortment line of curd products with a functional load.

1. Introduction

In matters of ensuring economic and food security of the country, among other factors, the significance of the level of development of the agro-industrial complex stands out. The specificity of its role is determined by the production of food as the basis of human life and the reproduction of labor. After all, the health of a person as a whole and how his body will cope with adverse environmental factors depend on obtaining the components necessary for normal life activity. There are many known diseases that arise due to the lack of one or another element that must enter the human body during the meal. In this regard, the improvement and balancing of the diet to maintain the health, working capacity and longevity of the population become a topical task. Prerequisites for this are created on the basis of the development of technology for the production of new food products with functional properties.

The resource potential of the agro-industrial complex is especially important in creating enriched products of functional action. The idea of creating enriched products is proposed to be realized through the formation of a combined plant-fermented milk system. Where plant material is considered as an enriching component, and curd mass appears as a basic recipe. The advantage of such enriching components is the complexity of the composition, the mutual complement of the active ingredients.

Dairy products are presented in a wide variety on the food market and their enrichment with components of plant origin is becoming increasingly developed. Curd mass is a sweet product with delicate consistency, made mainly from pureed cottage cheese and having the taste and aroma of the ingredients introduced. The benefits of curd mass for a person are almost equal to the benefits of its main constituent component - cottage cheese, which is a concentrate of nutrients contained in milk. Cottage cheese is a source of complete protein, which is easily absorbed by the body. It is also rich in vitamins A, E, P, B2, B6, B12, folic acid, salts of calcium, iron, sodium, magnesium, copper, zinc,
fluorine and phosphorus. The use of cottage cheese contributes to the growth and restoration of all body tissues, especially bone tissue. It is useful for the functioning of the nervous system, cardiac activity and blood formation [1].

With high nutritional value, products of the dairy products group are poor in fiber content. Thus, the curd mass production technology does not provide processing with high temperatures, it allows to preserve the nutrients included in the composition of its components, which makes this product a suitable object for further modeling formulation in solving the problem of enrichment of dairy products with biologically active substances. In this case, raw materials of plant origin seem to be a particularly valuable component. In order to develop the recipe and production technology for the enriched fermented milk product, we set the task to study in detail the composition and properties of two promising plant components – pumpkin of the grade “Kroshka” and arabinogalactan, to establish the optimal dosage in the recipe and the method of application. The selected enrichment components are favorably distinguished by the specificity of nutrient composition and availability in our geographical area.

2. Materials and methods
The research work was carried out in accordance with the research plan of the FSBEI HE Far Eastern GAU on the topic "Food Products". Research on this topic was carried out at the Department of Agricultural Processing Technology of the Faculty of Technology of the FSBEI of HE Far Eastern GAU.

The objects of study at different stages of the research were: arabinogalactan produced by extraction from Daursky larch according to technical specifications (TU) 9325-008-706-921-52-08; 9 % fat cottage cheese that meets the requirements of National standart (GOST) 31453-2013; pumpkin pulp powder; samples of enriched curd products.

Powder from pumpkin pulp was prepared from pumpkin grade “Kroshka” grown in gardening enterprises of the Amur Region. Organoleptic evaluation of the obtained powder was carried out and the mass fraction of moisture was determined by the thermogravimetric method according to GOST 33977-2016.

Arabinogalactan was provided by Ametis closed joint stock company (CJSC), located in Blagoveshchensk, Amur Region. Arabinogalactan is produced and marketed as a product under the brand name “Lavitol-arabinogalactan”.

Organoleptic, physico-chemical and microbiological indicators of the finished samples were determined in accordance with the requirements of GOST R ISO 22935-2-2011, GOST 5867-90, GOST 3624-2014, GOST R 54667-2011, GOST 3626-73.

3. Results and Discussion
The recent need for the production of therapeutic and prophylactic food products is associated with a shortage in everyday products of biologically active elements involved in the functioning of human body systems. A solution to this problem may be such a vegetable common in agriculture as pumpkin (Cucurbita pepo).

Pumpkin contains a large number of various useful substances, such as vitamins, organic acids, micro and macro elements, fiber, pectin. Therefore, it has long been used in the production of many food products both in the main role and as an additive. Pumpkin is used in food pickled, fried, stewed, in the form of mashed potatoes, juice and other types of culinary processing.

The fruit pulp of a pumpkin is a fibrous structure. It includes 70-94 % water and 6-30 % dry matter, which according to various sources includes 1.5-15 % sugars, 4-23 % fiber and hemicelluloses, 20-24 % starch, 0.3-1.4 % pectin, 1-3 % nitrogenous substances, 0.5-0.7 % crude fat, 0.1% acids, 0.4-1.4 % ash, 25-40 mg per 100 g of ascorbic acid, 2-28 mg per 100 g of carotene.

Pumpkin vegetable fiber is very beneficial for humans, especially cellulose polysaccharides, which enhance the enzymatic digestion of food, and in addition inhibit the development of pathogenic microorganisms in the intestines, and also activate the immune system. In addition to stimulating the
growth of intestinal microflora, pumpkin pulp plays the role of a natural enterosorbent that absorbs toxic substances, and then transforms them into neutral ones or accumulates harmful substances and removes them through the excretory system. Due to symbiotic bacteria, pumpkin promotes detoxification of formaldehydes, plant poisons, heavy metals and other harmful substances, the absorption of vitamins and amino acids (groups B, C), the formation and absorption of vitamin K - a blood coagulation factor, regulation of the metabolism of salts, cholesterol, bile acids.

The set of experimental data obtained by the authors (Ling Chen, Rong Long, Gangliang Huang, Hualiang Huang. 2020) in vivo showed that pumpkin polysaccharides can significantly increase the protein content, the activity of antioxidant enzymes glutathione peroxidase (GSH-Px) and superoxide dismutase (SOD) in the blood serum, liver, spleen and kidneys of mice, as well as significantly reduce the content of malonic dialdehyde (MDA) in the blood serum, liver, spleen and kidneys of mice [2, 3, 4].

The antimicrobial activity of pumpkin pectin polysaccharides was also noted. Accordingly, pumpkin can be positioned as a functional component of the formulation with many therapeutic, pharmacological and biofunctional properties [5].

Shaimaa Negm notes that the chemical composition of pumpkins is high in vitamins, minerals and carbohydrates, but low in fat, and based on studies [6], recommends pumpkin intake for patients with cirrhosis.

The fat-soluble vitamin E (tocopherol), which is part of the pumpkin, inhibits the aging process, protects the body from toxins, participates in tissue respiration. Also, pumpkin contains: vitamin C, which is an antioxidant and supports the immune system; Vitamin B1, involved in many biochemical processes; Vitamin B2, which affects the condition of the skin, nails and hair. Due to potassium salts, pumpkin is useful for kidney failure, inflammation of the genitourinary system. The iron consumed from pumpkin is involved in hematopoiesis, is part of hemoglobin, and is also part of many enzymes.

Due to the fact that arabinogalactan has unique properties, it is in a special place among polysaccharides. Arabinogalactan is characterized by a high degree of solubility, low viscosity in aqueous solutions, thermal stability, stability in an acidic environment, non-toxicity, due to which it can be successfully used as a functional additive in dairy products.

Arabinogalactan is contained in gum angiosperms and some gymnosperms [7]. A large amount of it is found in larch gum - in some species up to 35 %. On the territory of the Amur region in the city of Blagoveshchensk, there is the Ametis enterprise, which processes Daursky larch with the extraction of dihydroquercetin and arabinogalactan. The composition of the arabinogalactan molecule depends not only on the source of processing, but also on the methods of its isolation. There are various methods for extracting arabinogalactan. A simple method of its extraction is the extraction of crushed larch wood at low temperatures, followed by evaporation of the separated extract. Further precipitation of arabinogalactan is done with acetone in the presence of sodium chloride or ethanol.

The macromolecule of arabinogalactan from larch wood has a highly branched structure; its main chain consists of galactose units connected by $\beta$- (1 \(\rightarrow\) 3) glycosidic bonds, and side chains with $\beta$- (1 \(\rightarrow\) 6) bonds consist of galactose and arabinose units, from single units of arabinose, as well as uronic acids, mainly glucuronic. There is evidence that arabinose links are also present in the main chain of a macromolecule. The ratio of galactose to arabinose units is approximately 6:1, with 1/3 of the units of arabinose in pyranose form, and 2/3 in the furanose form. These ratios, as well as the molecular weight of arabinogalactan, can fluctuate not only depending on the species of larch, but can also vary within the same species [8].

The properties of arabinogalactan are presented in table 1.

| Indicator     | Standard values                                      |
|---------------|------------------------------------------------------|
| Colour        | Yellowish white                                      |
| Composition   | Polysaccharide, consisting of 6 parts of D-galactose and 1 part of L-arabinose, impurities: resins, glucuronic acids, dihydroquercetin; |
Arabinogalactan is a food supplement registered in JECFA (Joint FAO / WHO Expert Committee on Food Additives, JECFA)), which has an index of E 409.

Arabinogalactan is used as a source of soluble dietary fiber. It stimulates the growth of beneficial intestinal bacteria, such as bifidobacteria and lactobacilli, improves food absorption and, in general, the functioning of the gastrointestinal tract and maintains its healthy functioning [9, 10].

It enhances the synthesis of short chain fatty acids (SCFA), mainly butyrates and propionates. These specific fatty acids are extremely important for intestinal health, and their sufficient number makes the colon cells more resistant to tumor growth, as well as to other intestinal diseases [11].

Due to its immunostimulating properties, arabinogalactan can prevent colds infections. A clinical study in humans has shown that larch arabinogalactan increases the body's ability to protect itself from colds. Larch arabinogalactan reduced the incidence of colds by 23 % [12, 13].

Arabinogalactan, without affecting the taste of the products, mixes well with different types of food, which makes its use as an additive more universal. The main quality indicators of arabinogalactan (Lavitol-arabinogalactan) are presented in table 2.

Table 2. Quality indicators of the dietary supplement Arabinogalactan (Lavitol-arabinogalactan).

| Indicator                      | Valid Values                      | Analysis results |
|--------------------------------|-----------------------------------|------------------|
| Appearance                     | White to pale yellow powder       | Pale yellow powder |
| Humidity, %                    | 10.0                              | 3.05             |
| Mass fraction of AG, %         | He < 88                           | 91.8             |
| Molecular Weight, Daltons      | -                                 | -6000            |
| DDT, mg / kg                   | He > 0.1                          | Not detected     |
| Mercury mg / kg                | He > 0.1                          | < 0.01           |
| Arsenic, mg / kg               | He > 0.5                          | 0.002            |
| Lead, mg / kg                  | He > 6.0                          | < 0.01           |
| Cadmium, mg / kg               | He > 1.0                          | 0.0015           |
| Cesium-137, Bq / kg            | 200                               | < 2.5            |
| Strontium-90, Bq / kg          | 100                               | < 2.4            |
| QMAFA nm, CFU / g              | He > 5 • 10^4                     | < 1 • 10^2       |
| Pathogenic microflora, including Salmonella, in 0.1 g | Not allowed | Not detected |
| Yeast CFU / g                  | 100                               | Not detected     |
| Mold CFU / g                   | 100                               | Not detected     |
| E. coli in 1.0 g               | Not allowed                       | Not detected     |
The technological process for the production of cottage cheese consists of preparing the components and preparing the mixture. To obtain products of delicate consistency, the cottage cheese is ground using a rolling machine or a colloid mill. Sugar and other similar components are sieved before being added to the mixture. Prepared components are loaded into a kneading machine in a certain sequence: first, cottage cheese, then flavoring fillers are added and mixed again. Then the mass is cooled to a temperature of 6 ° C, packaged and stored in chambers at a temperature not exceeding 8 ° C.

Cottage cheese contains a large amount of calcium, but vitamin D, which is fat-soluble, is required for assimilation by its body. Also, in addition to vitamin D, cottage cheese contains other fat-soluble vitamins: A, E, K. Based on this, it can be concluded that the use of nonfat curd as a raw material for the production of enriched curd mass is less rational. The use of cottage cheese of 9 % fat content will in turn provide a delicate texture and a pleasant taste for the curd mass.

Table 3 presents a unified recipe for curd mass, which we used for enrichment.

| Name of raw materials                          | Recipe 1 |
|------------------------------------------------|----------|
| Low-fat cottage cheese with a mass fraction of moisture not more than 80 % | 899.3    |
| Sugar                                          | 100.7    |
| Total                                          | 1000.0   |

The most rational way is to use a pumpkin in the form of a powder from its pulp, since it is a concentrate of substances that make up a pumpkin.

To prepare the powder from the pulp of a pumpkin, a pumpkin of local origin was used. Figure 1 shows a method of preparing powder from pumpkin pulp, which includes: washing fruits, separating pumpkin pulp from the peel and seeds, chopping the pulp to a size of 0.5 cm, drying in an oven in a gentle mode at a temperature of 50-55 °С for 180 minutes, cooling, grinding in a roller mill to a powder state, storage.

**Table 3. Curd mass recipes.**

**Figure 1. Scheme of preparation of powder from pumpkin pulp.**

At the initial stage of research, the organoleptic and physico-chemical parameters of the obtained additive in the form of a powder from pumpkin pulp were studied. The results of the analysis are shown in table 4.

According to the manufacturer's recommendation, 1-3 % of arabinogalactan by weight of the product should be added to food products. In order to study the effect of the dietary supplement arabinogalactan (Lavitol-arabinogalactan) on the properties of the curd mass, preliminary experiments were carried out with a dosage of arabinogalactan from 1 to 3 % in increments of 0.5 %. A dosage of 2.5 % had a more favorable effect on the consistency of the curd mass, and also prolonged the shelf life by 1.5 times. The next step was to determine the optimal amount of powder from the pulp of pumpkin in the curd with arabinogalactan.
Table 4. Organoleptic and physico-chemical characteristics of pumpkin powder.

| Indicator       | Result                                      |
|-----------------|---------------------------------------------|
| Taste           | Peculiar to a pumpkin, without extraneous flavors |
| Odor            | Peculiar to a pumpkin, without foreign odors |
| Colour          | Yellow with a touch of orange               |
| Moisture content, % | 9.8                                         |
| Ash content, %  | 0.7                                         |

As part of experimental studies, a series of curd samples were prepared with a fixed dosage of arabinogalactan and a different ratio of powder from pumpkin pulp. The additives were mixed together with sugar and added to the mashed curd mass. For further studies, samples were selected with the following number of additives: sample No. 1 – control, sample No. 2 – 3 % powder from pumpkin and 2.5 % arabinogalactan, sample No. 3 – 5 % powder from pumpkin and 2.5 % arabinogalactan, sample No. 4 – 7 % pumpkin powder and 2.5 % arabinogalactan.

One of the main features of the obtained product with an unconventional herbal supplement is its effect on the senses, therefore, we further analyzed the organoleptic characteristics of the obtained samples. The results are shown in table 5.

Table 5. Organoleptic characteristics of finished samples.

| Name of indicator | Sample No. 1 | Sample No. 2 | Sample No. 3 | Sample No. 4 |
|-------------------|--------------|--------------|--------------|--------------|
| Consistency and appearance | Homogeneous, moderately dense | Homogeneous, moderately dense, with the presence of single particles of pumpkin powder | Homogeneous, moderately dense, with the presence of pumpkin powder | Homogeneous, moderately dense, with a significant predominance of powder particles from pumpkin |
| Taste and odor    | Pure, sour-milk, sweet, without extraneous smacks | Sour-milk, sweet, with insufficient taste of pumpkin | Sour-milk, sweet, with taste of pumpkin | Sour-milk, sweet, with a pronounced taste of pumpkin |
| Colour            | Creamy white | Yellowish    | Yellowish with a touch of orange | Yellow orange |

Sample No. 4 turned out to be less attractive in terms of organoleptic indicators, and No. 3 was more suitable, so further studies were conducted with samples No. 1 and No. 3. Figure 2 shows photographs of samples No. 1, No. 3 and No. 4.

Figure 2. Samples: a - No. 1; b - No. 3; c - No. 4.
Physico-chemical parameters of the control sample and sample No. 3 are presented in table 6. It can be seen that in sample No. 3, the moisture index compared to the control sample decreased by 3.7%, and the acidity increased by 7 ° T. Both indicators remained within the normal range.

**Table 6.** Physico-chemical characteristics of the samples.

| Indicator                  | Sample No. 1 (control) | Sample No. 3 |
|----------------------------|------------------------|--------------|
| Mass fraction of fat, %    | 8.1                    | 7.8          |
| Mass fraction of sugars, % | 9.1                    | 8.9          |
| Mass fraction of moisture, % | 73.0                  | 69.3         |
| Acidity, ° T               | 161                    | 168          |

Table 7 shows the results of microbiological analysis showing that no mold fungi, coliform bacteria, and _S. Aureus staphylococci_ were detected in the test samples. The main microflora of curd with additives consists of lactic acid bacteria of the genera _Lactococcus_ and _Streptococcus_. Over the shelf life, the number of microorganisms was within normal limits, in accordance with the requirements of TR TS 033/2013.

**Table 7.** Indicators of finished products during the shelf life.

| Indicators                  | Norm for cottage cheese with a shelf life of more than 72 hours | The duration of the storage time, h |
|-----------------------------|------------------------------------------------------------------|-----------------------------------|
|                             | Control | Sample No. 3 | Control | Sample No. 3 | Control | Sample No. 3 | Control | Sample No. 3 |
| Lactic acid microorganisms, not less, CFU / g | 1 · 10⁶       | 20.1       | 22       | 15.2       | 16.3       | 12       | 12.9       | 10.9       | 11.2       |
| Yeast, CFU / g no more     | 100     | 78          | 63       | 65         | 31         | 37       | 20         | 19         | 15         |
| Mold mushrooms, CFU / g, not more than | 50     | -           | -        | -          | -          | -        | -          | -          | -          |
| Coliform bacteria S. aureus | Not allowed | -           | -        | -          | -          | -        | -          | -          | -          |

4. **Conclusions**

The technological, organoleptic and physico-chemical properties of the food additive arabinogalactan (Lavitol-arabinogalactan) were studied. Safety indicators are analyzed. The effectiveness of using arabinogalactan in the production of fermented milk products has been proven.

The possibility of introducing a complex additive in the form of arabinogalactan and powder from pumpkin pulp into the curd mass formulation was investigated. The dosage of enriching components was determined in the amount of 5 % powder from pumpkin and 2.5 % arabinogalactan (Lavitol-arabinogalactan), acceptable by organoleptic and physico-chemical parameters.

The microbiological analysis of enriched curd mass was studied, confirming the absence of pathogenic microflora and a favorable. The resulting curd mass, enriched with powder components from pumpkin pulp and arabinogalactan, is able to supply the body with carotenoids, vitamins A, D, E, K, PP, C, potassium, phosphorus, magnesium, dietary fiber. The product will be useful for diseases of
the gastrointestinal tract, genitourinary system, cardiovascular diseases, as well as for nervous disorders.

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