

## *Research and development of production technology for mayonnaise sauce of functional purpose*

**Keywords:** mayonnaise sauce, pine nut oil cake, protein concentrate, functional food product,  $\beta$ -carotene

### **1. SUMMARY**

We studied functional properties of pine nut oil cake, used as a protein concentrate, and those of  $\beta$ -carotene, used as a natural antioxidant, and their effect on organoleptic, physical, chemical, and rheological properties of mayonnaise sauces. The aim of the work was to develop a functional mayonnaise sauce and to study the quality indicators of the finished product where egg powder was partially replaced with a protein concentrate, namely, pine nut oil cake.

The use of  $\beta$ -carotene in the sauce formula allowed not only to enhance the color of natural egg products, but also to increase the oxidation stability of the fatty phase of the sauce and to extend its shelf life. A reference sample and samples with 1%, 2%, and 3% pine nut oil cake instead of egg powder were subject to study. The dosage of 3% pine nut oil cake instead of egg powder was considered the most preferable to be introduced into the formula.

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## 2. Introduction

Mayonnaise sauces, like all mayonnaise products, are among the most popular everyday consumer goods. Main components for mayonnaise sauces involve natural products with high biological value and health-promoting properties. In this regard, the development of mayonnaise product formulas can be viewed as a promising line of research [1, 2].

Hydrocolloids and protein-polysaccharide complexes, plant extracts, vitamin and mineral complexes, dietary fiber, polyunsaturated fatty acids and protein concentrates are the most valuable functional ingredients in the production of emulsion foods for particular nutritional uses. These biologically active components allow you to structure a person's diet in order to improve metabolism, immunity, nervous and endocrine systems, functioning of individual organs and body systems [3, 4].

Currently, protein concentrates are widely used in production of various sauces, pastes, dairy, and confectionery products. Such popularity of protein concentrates is due to the protein deficiency that more than 60% of people suffer from to a varying degree [5].

At the same time, every year scientists all over the world come up with new sources and methods of protein isolation to create new functional foods enriched with protein concentrates. It has been established that regular consumption of such products helps to increase body's resistance to harmful factors, strengthen immunity, and improve metabolism [6].

Pine nut oil cake, obtained by extracting oil from pine nut kernels, is a secondary raw material, but it is of great importance as an additional source of complete protein, easily digestible carbohydrates, vitamins, and minerals. With the right choice of the method of its extraction and purification, it is possible to obtain a protein-rich concentrate that can be added to various foods in order to give them functional properties.

The composition of the protein of pine nut oil cake is determined by the composition of the protein of the kernels of pine nuts.

The content of essential amino acids in the protein composition of pine nut kernels ranges from 36 to 40%.

The content of some individual essential amino acids in pine nut protein is specific, which is characteristic of all types of plant materials. It should be noted that in terms of amino acid composition, namely, the content of phenylalanine, tyrosine, histidine, tryptophan, arginine, pine nut oil cake protein is as good as the protein of the major grain and oilseed crops. It is close to dairy protein in terms of tryptophan content, surpassing it in terms of arginine and histidine content.

The composition of the lipid fraction of pine nut oil cake is characterized by a quantitative predominance of polyunsaturated fatty acids – linoleic and  $\gamma$ -linolenic –, belonging to the  $\omega$ -6 family.

The vitamin and mineral value of pine nut oil cake depends both on the initial chemical composition of the processed nut and on the residual oil content in the oil cake after pressing.

Pine nut oil cake has a high content of tocopherols (11.8 mg/100 g of product), thiamine (0.6 mg/100 g of product), and riboflavin (1.83 mg/100 g of product).

Pine nut oil cake is a concentrate of biologically valuable food substances like proteins, lipids, carbohydrates [7].

## 3. Materials and methods

The following was used as the material for research:

- ground cake of pine nut kernels, produced in accordance with TU 9146-001-53163736-06 (by "Siberian Product", supplied by "Altai Dar LLC", Altai Territory, Barnaul, Russia) [14];
- Beta-carotene 30% os, plant-based, liquid, oil-soluble (by "NATEC", Moscow);
- reference and test samples of mayonnaise sauces.

Organoleptic characteristics of mayonnaises and mayonnaise sauces must comply with the requirements of GOST 31761-2012 "Mayonnaises and mayonnaise sauces. General specifications" [8]. Testing of organoleptic characteristics was carried out at  $(20 \pm 2)$  °C after at least 12 hours after production.

Organoleptic indicators were determined in the following sequence: texture, appearance, colour, smell, taste.

The mass fraction of protein was determined by the Kjeldahl titration method.

The stability of the emulsion was determined by centrifugation.

The intact emulsion stability was determined by centrifuging the emulsion for 5 minutes at 1500 rpm.

The dynamic viscosity of the samples was determined using “Reostat-2” rotational viscometer (Germany) at 20 °C.

The degree of oxidative deterioration was determined by the peroxide number of the oil phase using the iodometric method and calculating the degree of oxidative deterioration of the product [9-11].

All measurements were carried out in three replications. Statistical analysis was performed using Microsoft Excel XP and Statistica 8.0 software package. The statistical error of the data did not exceed 5% (at 95% confidence level).

#### 4. Results and Discussion

Mayonnaise sauce is a finely dispersed emulsion product with a fat content of not less than 15%, produced from refined deodorized oil, water, with or without dairy by-products, food additives and other food ingredients (GOST 31761-2012 “Mayonnaises and mayonnaise sauces. General specifications”) [8].

The ingredients of the obtained mayonnaise sauce included refined deodorized cooking oil, egg powder, mustard flour, granulated sugar, table salt, 80% acetic acid, as well as a protein concentrate made of pine nut oil cake, natural  $\beta$ -carotene and water. Introducing  $\beta$ -carotene to the formula of the mayonnaise sauce increased the stability of its fatty phase to oxidation and extended its shelf life [12].

The production technology of the functional mayonnaise sauce was based on the “classic” mayonnaise sauce production technology.

The specified amount of water of 35–40 °C (not taking into account the water used to prepare the acetic acid solution) was poured into the mixer with a steam-water jacket. The mixer was turned on, and dry components – granulated sugar, salt, pine nut oil cake – were heated and added to the mixer. The mass was mixed intensively at 70-80 rpm and heated to 80-85 °C for 25-30 minutes. Then, the resulting suspension was cooled to 35-40 °C, egg powder and mustard flour were added, after which the emulsion was heated to 55-60 °C during 15-20 minutes.

After heating, the emulsion was again cooled to 25-30 °C, the number of revolutions was reduced to 30-40 rpm, and oil with pre-dissolved  $\beta$ -carotene was introduced. Following that, after adding acetic acid solution into the sauce, it was subject to stirring for another 3-5 minutes and subsequently homogenized at a pressure of 0.9-2.5 MPa.

The use of pine nut oil cake made it possible to reduce the content of egg products in the sauce formula, to lower the cholesterol, and to increase the protein content in the finished product.

The use of  $\beta$ -carotene in the sauce formula enhanced the color of natural egg products.

The use of pine nut oil cake not only simplified the mayonnaise sauce production process, but also allowed to obtain a colloidal system consisting of finely dispersed particles of cell walls. Intensive mixing ensured a complete interaction of proteins, fats and carbohydrates with other components, which facilitated emulsion stability, as finely dispersed cell walls of pine nut oil cake formed a solid three-dimensional structure, enhancing the emulsifying and stabilizing effect.

Reducing the mass fraction of egg powder in the formula to less than 1% made it difficult to obtain a stable emulsion, which led to a decrease in the viscosity of the finished product. The consistency of the finished product became watery, its organoleptic characteristics were low [13]. Therefore, we chose 1%, 2% and 3% dosages of pine nut oil cake to be introduced instead of egg powder.

Formulas of mayonnaise sauces are given in **Table 1**.

Test samples of mayonnaise sauces with pine nut oil cake were tested for organoleptic characteristics (**Table 2**).

The appearance of mayonnaise sauces is shown in **Figure 1**.

Physical and chemical indicators are given in **Table 3**.

The use of pine nut oil cake increased the overall protein content in the finished product. Pine nut oil cake is an effective emulsifier, and in combination with a conventional emulsifier – egg powder – ensured a good, smooth consistency of the sauce and high stability of the emulsion. It allowed to obtain a finished product with a viscosity that meets consumer requirements for compatibility with other ingredients of a dish or food systems.

Table 1. Formulas of Mayonnaise Sauces

Component	Content, %			
	Reference Sample	Sample No.1	Sample No.2	Sample No.3
Refined deodorized oil	45	44	43	42
Egg powder	4,0	3,0	2,0	1,0
Mustard flour	0,4	0,4	0,4	0,4
Granulated sugar	1,3	1,3	1,3	1,3
Salt	1,2	1,2	1,2	1,2
80 % acetic acid	0,5	0,5	0,5	0,5
Pine nut oil cake	-	1,0	2,0	3,0
β-carotene	-	0,2	0,2	0,2
Water	47,6	48,4	49,4	50,4

Table 2. Organoleptic Characteristics of Mayonnaise Sauces

Characteristics	Reference Sample	Sample No.1	Sample No.2	Sample No.3
Texture	Creamy			Creamy, a little watery
Appearance	Homogeneous, without layering			
Colour	White, homogeneous	White, slightly yellowish, characteristic of natural egg products, uniform throughout the mass		
Smell	Typical of the product	Typical of the product, with the smell of pine nut oil cake		
Taste	Slightly spicy, sour	Slightly spicy, sour, with the smell of pine nut oil cake		

Table 3. Physical and Chemical Indicators of Mayonnaise Sauces

Indicator	Reference Sample	Sample No.1	Sample No.2	Sample No.3
Mass fraction of protein, %	2.13±0.03	2.59±0.07	3.02±0.08	3.64±0.05
Emulsion stability, %	83	91	92	91
Intact emulsion stability, %	94	95	95	93
Dynamic viscosity at 20 °C, Pa·s	13	14	16	16



Figure 1. The appearance of mayonnaise sauces

In the next stage of research we studied how the quality of the mayonnaise sauce changed during storage.

Storing the samples at 20 °C provoked the oxidation without changing the mechanism of the process and violating the colloidal stability of the product. The dynamics of the peroxide number of the oil phase of mayonnaise sauce samples during the storage at 20 °C is shown in **Figure 2**.

The oxidation of the samples during storage was caused by exposure to light. When stored for more than four weeks, the peroxide number of the reference sample exceeded the level of 11 mmol of active oxygen/kg, and as for the test samples, it did not reach the level of 6 mmol of active oxygen/kg.

The use of  $\beta$ -carotene (0.2%) in the mayonnaise sauce can significantly increase the oxidation stability of the product without adding a preservative, as well as enrich the mayonnaise with biologically active substances of plant origin.

Based on all types of studies, it can be concluded that 3% was the most preferable dosage of pine nut oil cake in the formula of the mayonnaise sauce.

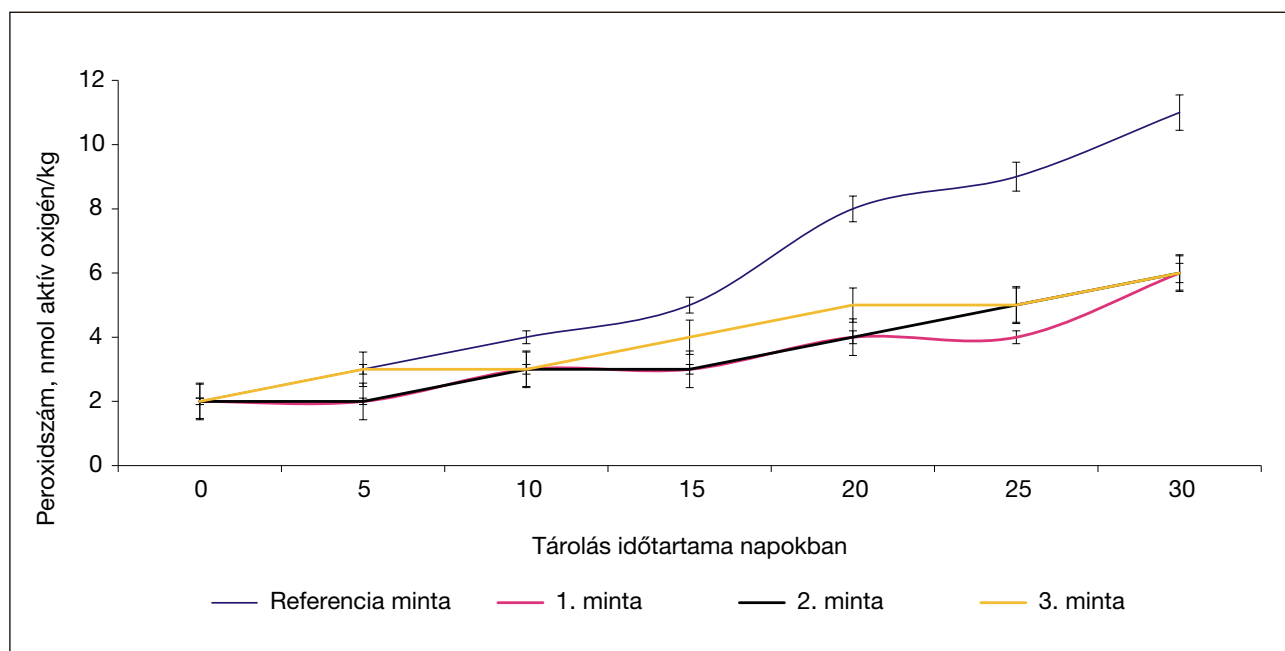


Figure 2. Dynamics of Peroxide Number of Oil Phase of Mayonnaise Sauce Samples during Storage at 20 °C

## 5. Conclusions

Using pine nut oil cake, which possesses good emulsifying properties, in the amount of 3%, alongside a conventional egg powder emulsifier, increased the viscosity of the finished product, ensured a smooth texture of the sauce and high stability of the emulsion. The use of pine nut oil cake made it possible to reduce the content of egg products in the sauce formula and lower the amount of cholesterol in the finished product. Besides, the introduction of pine nut oil cake to the sauce formula increased its protein content. The use of  $\beta$ -carotene (0.2%) in the mayonnaise sauce can significantly increase the oxidation stability of the product without adding a preservative and enrich the mayonnaise with biologically active substances of plant origin.

Thus, pine nut oil cake obtained by processing kernels of pine nuts is a promising functional additive. This material is a suitable to produce fat emulsions, including the reduced fat content products, due to the protein and carbohydrate content of oil cake, thus can provide the necessary rheological structure for low-fat products too.

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