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QUALITY AND SAFETY OF MAYONNAISE BASED ON BLENDED OIL, EGGPLAN POWDER AND GUM ARABIC

Summary. The paper theoretically and experimentally substantiates the feasibility of using gum arabic, eggplant powder, and blended oil to develop mayonnaise technology, and also creates recipes for different versions of this sauce. The results of organoleptic analysis showed that the use of gum arabic, eggplant powder and blended oil has a positive effect on the organoleptic properties of mayonnaise. The consistency, appearance, color and aroma of all samples received positive ratings, and the mayonnaise sample with 50% blended oil (M2) received the highest rating (5 points). The study of the fatty acid composition of lipids demonstrated that the mayonnaise sample (M3) has the highest results in terms of the content of fatty acids of the ω-3 and ω-6 groups. However, the ratio of fatty acids in the sample (M3) is 1:7/1:9, which is not optimal. The best ratio of fatty acids, which is 1:4, is characterized by the mayonnaise sample (M2). The analysis of the fatty acid composition also confirmed the functionality of all mayonnaise samples. It was determined that all developed samples based on blended oil meet the standards for structure (viscosity and emulsion stability) and quality (pH, acid and peroxide values), which indicate the resistance of the product to mechanical stress and stability during storage. It was found that the microbiological indicators of the control sample and experimental samples, in which the oil-fat fraction was partially or completely replaced with blended oil, during 28 days of storage show that the conditionally pathogenic and pathogenic microflora are within the permissible values. The number of bacteria of the Staphylococcus aureus group in the control and experimental samples remained constant at 2.7×10^2 throughout the entire storage period. The results obtained indicate the possibility of substantiating the technology of mayonnaise based on gum arabic, eggplant powder and blended oil with increased biological value.

Keywords: sauce, mayonnaise, oil, gum arabic, eggplant powder, polyunsaturated fatty acids (PUFA), technology, functional product, dietary supplements, technology.

Statement of the problem and its relevance. The biologically active components of vegetable oils, in particular blended ones, which normalize lipid metabolism, primarily include polyunsaturated fatty acids (PUFAs) – linoleic (ω-6) and linolenic (ω-3). PUFAs participate in the body's work as structural elements of cell biomembranes. They contribute to the regulation of metabolism in cells, normalization of blood pressure, affect cholesterol metabolism, stimulating its oxidation and excretion from the body, participate in the metabolism of B vitamins, increasing resistance to infectious diseases and other factors [1; 2].

One of the main products of the oil and fat industry, which is present in the mass daily consumption of the population, is mayonnaise sauce. The multicomponent composition of mayonnaise provides opportunities for the creation of products that prevent deficiency states in essential fatty acids, vitamins and other physiologically functional ingredients [3; 4].

One of the main components of mayonnaise emulsions is refined deodorized oil. In order to create mayonnaises with increased biological value in terms of essential fatty acid content, samples of mayonnaise sauce with partial or complete replacement of the oil-fat base with blended deodorized oil were studied, thereby ensuring the necessary balance of PUFA [5].

Gum arabic is a natural thickener and stabilizer used in the food industry, in particular in the production of mayonnaise. Gum arabic helps to achieve the desired consistency of mayonnaise, giving it a creamy texture, prevents the ingredients from separating, maintaining the homogeneity of the product. As a natural polymer, gum arabic is considered a healthier alternative to synthetic additives. The use of gum arabic can extend the shelf life of mayonnaise. Gum arabic has practically no taste, which allows you to preserve the original taste of mayonnaise and is able to improve the creaminess and visual appeal of the product. Gum arabic is usually added at the emulsification stage, when oil and water are mixed.

Analysis of recent research and publications. Many studies by domestic and foreign scientists and others have been devoted to the determination of organoleptic, microbiological, physicochemical and functional-technological properties, the study of the fatty acid composition of mayonnaise sauces, vegetable oils and the development of emulsion-type sauce technologies based on them [1–8].

A number of scientists continue to work in this direction, since the indicated problem has not lost its relevance even today. A market analysis of mayonnaise sauce consumption shows that in modern society they have become one of the most sought-after products. However, this product does not correspond to the peculiarities of physiology and biochemical processes of the human body due to the increased amount of saturated fatty acids, as well as the presence of flavoring and technological food additives that are not beneficial to health. Convenience of consumption, high organoleptic indicators contribute to the fact that emulsion-type sauces are quite popular among consumers, with the classic mayonnaise sauce "Provencal" being in the greatest demand. The analysis of the Ukrainian sauce market shows that mayonnaise production accounts for about 49% of the total number of sauces. About 80% of consumers prefer this type of sauce, and 40% of the population consumes mayonnaise sauce at least several times a week.

Increasing the production of biologically complete multicomponent sauces (in particular, mayonnaise) is relevant in light of the concept of balanced nutrition, according to which a person's daily diet should contain a sufficient amount of polyunsaturated fatty acids [7].

The main advantage of sauces is the potential for enriching the recipe composition with ingredients by one or more factors in order to most fully comply with their balanced nutrition formula [8].

However, despite the high nutritional value of sauces, including mayonnaise, they have their drawbacks, one of which is the low content of essential nutrients, in particular polyunsaturated fatty acids. The main oil-fat fraction of mayonnaise sauce contains a large amount of saturated fatty acids and is unstable to oxidation processes, so classic mayonnaise is not able to satisfy the human need for the necessary micronutrients and cannot maintain its quality indicators for a long time.

Partial introduction (25%, 50%) of blended oil into the composition of mayonnaises or complete replacement of refined deodorized sunflower oil with it causes high biological value. Therefore, the issue of developing mayonnaise based on blended oil, enriched with polyunsaturated fatty acids, biologically active components (cachetin, flavones and flavonoids), which will be important both for the full nutrition of the population and for ensuring high indicators of quality and safety of the sauce, is currently relevant.

Eggplant powders are an additional source of vitamins, which is especially important for regulating metabolism and improving the body's resistance to various negative environmental factors. Vitamins are part of enzymes that provide important metabolic processes in the body. Water-soluble vitamins in eggplant powders (PP, B1, B2) contribute to cellular metabolism. The mineral composition of eggplant powders increases by an average of 2.5–3.0 times, where the vast majority is, mg/100g: calcium (48.5±2.0), potassium (740.4±2.0), iron (1.7±0.5), phosphorus (98.80±1.5), magnesium (26.18±2.0). All these elements are a component of bone tissue, have radioprotective and anti-anemic properties, and therefore are vital for humans. The amount of vitamins of group B (B1 and B2), PP increases

more than 10 times and is, mg/100g: thiamine B1 – 0.40±0.01; riboflavin B2 – 0.5±0.06; nicotinic acid PP – 5.22±0.10. The increased level of mineral elements, vitamins of group B, niacin in eggplant powders will contribute to the overall strengthening of the body and the strengthening of the protective effect of the immune system. And this, in turn, increases the body's resistance to adverse environmental factors.

The purpose of the article. The purpose of the work is to study the quality indicators of mayonnaise sauce with partial or complete replacement of the oil-fat fraction with blended oil and the use of gum arabic and eggplant powder. The main attention is paid to organoleptic and physicochemical indicators (effective viscosity, emulsion stability, acidity, acid and peroxide value), analysis of the fatty acid composition of the developed sauce samples based on blended oil, as well as changes in microbiological indicators during storage.

The methodological basis of the study is the process of developing the recipe composition of mayonnaise sauce using blended oil and tracking its quality and safety indicators.

Research methods – standard organoleptic, structural-mechanical, methods for determining the fatty acid composition, microbiological methods and processing the obtained data using modern computer programs.

The information base of the study is scientific articles, materials of international congresses and symposiums, scientific and practical conferences, regulatory and technical documentation, patents.

The object of the study is mayonnaise sauce with gum arabic, eggplant powder, and partial (25%, 50%) or complete replacement of the oil-fat fraction in the recipe with blended oil.

The subject of the study is the technology of mayonnaise sauce with partial (25%, 50%) or complete replacement of the oil-fat fraction in the recipe with blended oil and the use of gum arabic and eggplant powder.

The scientific novelty of the obtained results lies in the theoretical substantiation and experimental confirmation of the feasibility of using gum arabic, eggplant powder, and blended oil in mayonnaise sauce technology and its effect on organoleptic, physicochemical, microbiological indicators, and fatty acid composition.

Presentation of the main research material. In parallel, three samples of mayonnaise based on blended oil were prepared with a mass fraction of 25%, 50%, and 100% added to the recipe (Table 1).

Table 1

Production of mayonnaise based on blended oil with a mass fraction of 25%, 50% and 100% in the recipe

Name of ingredients	**CONTROL**	**Mayonnaise samples**		
		Test sample 1 (25%) M1	**Test sample 2 (50%) M2**	**Test sample 3 (100%) M3**
Refined deodorized sunflower oil	65,40	49,05	32,7	–
Blended oil	–	16,35	32,7	65,40
Egg powder	5,0	5,0	5,0	5,0
Skimmed milk powder	1,6	1,6	1,6	1,6
Gum Arabic	–	5	5	5
Eggplant powder	–	3	3	3
Mustard powder	0,75	0,75	0,75	0,75
Sodium bicarbonate	0,05	0,05	0,05	0,05
Sugar	1,5	1,5	1,5	1,5
Salt	1,0	1,0	1,0	1,0
Acetic acid	0,55	0,55	0,55	0,55
Water	24,15	24,15	24,15	24,15

The mayonnaise recipe in Table 1 was selected in accordance with the requirements of DSTU 4487-2015 "Mayonnaise and mayonnaise sauces" (Technical Committee "Oils, fats and products of their processing" (TC 86), 2015). The recipe for mayonnaise sauce "Provencal" with a mass fraction of fat of 67% was chosen as the control sample.

The next stage of the study was the determination of the organoleptic indicators of the developed mayonnaise samples.

The organoleptic characteristics of mayonnaise must meet the requirements of DSTU 4487-2015 "Mayonnaise and mayonnaise sauces" (Technical Committee "Oils, fats and products of their processing" (TC 86), 2015), which are presented in Table 2.

Table 2

Characterization of organoleptic parameters of mayonnaise based on blended oil and gum arabic

Indicator name	Characteristic
Consistency and appearance	Homogeneous creamy product
Taste and smell	The taste is slightly sharp, sour.
Color	White with a yellowish tint, uniform throughout the mass

The results of the obtained organoleptic indicators, given in Table 2, were carried out on a 5-point scale. The obtained data indicate that the use of blended oil in the technology of mayonnaise sauce has a positive effect on its organoleptic indicators. The consistency, appearance, color and smell of all samples (M1 and M2), which contained 25% and 50% of blended oil, respectively, were marked with the highest score (5 points), except for the mayonnaise sample with a complete replacement (100%) of the oil-fat fraction with blended oil. The sample (M3) was marked with the lowest taste score (4.6), since it had some deviations from the norm. To confirm the enrichment of the biological value of mayonnaise sauce based on blended oil, a study of the fatty acid composition of lipids of the developed samples with the control – mayonnaise "Provencal" (Table 3). The fatty acid composition of lipids was determined by the method of gas-liquid chromatography of fatty acid methyl esters. The studies were carried out on a gas-liquid chromatograph.

From the obtained data presented in Table 3, it can be seen that the ratio of fatty acids of the ω-3:ω-6 groups for lipids of the mayonnaise sauce sample (M2) was 1:4 (Table 3), which is the recommended ratio for functional food products. α-linolenic fatty acid belongs to the ω-3 fatty acids listed above. Linoleic and γ-linolenic acids belong to the ω-6. The optimal overall ratio of ω-3 to ω-6 in the diet for the age group 18–45 years is 1:3/1:6, respectively, and it must be maintained. It is undesirable to exceed the value of 1:10. This stimulates the development of inflammatory processes in the body. The lipids of the control sample of mayonnaise "Provansal" do not contain ω-6 and ω-3 fatty acids. Monounsaturated fatty acids are contained in the lipids of the control sauce sample twice as much as in the mayonnaise sauce sample (M2), and 2.2 times more than in the lipids of the mayonnaise sauce sample (M3). The presented data on the qualitative characteristics of the developed mayonnaise sauce samples based on blended oil indicate that the best indicators in terms of the ratio of fatty acids of the ω-3:ω-6 groups were obtained by the sauce sample (M2). It should be noted that the highest indicators in terms of the content of fatty acids of the ω-3 and ω-6 groups in lipids were obtained by the mayonnaise sample (M3). However, the ratio of fatty acids of the ω-3:ω-6 groups in the lipids of the mayonnaise sample (M3) is 1:7/1:9, which does not correspond to the optimal one. Important for emulsion-type sauces are the structure indicators (effective viscosity and emulsion stability) and quality indicators (pH, acid number and peroxide number), which characterize the resistance of the product to mechanical influences and storage stability.

Table 3

Fatty acid composition of lipids of mayonnaise based on blended oil

Indicator name	Content g per 100 g of product			
	CONTROL	Test sample 1 (25%) M1	Test sample 2 (50%) M2	Test sample 3 (100%) M3
Saturated fatty acids	7,96	8,337	13,895	16,674
14:0 Myristic acid	0,01	0,050	0,084	0,101
16:0 Palmitic acid	4,48	4,774	7,956	9,547
17:0 Heptadecanoic acid		0,036	0,060	0,072
18:0 Stearic acid	2,79	2,521	4,201	5,041
20:0 Arachidonic acid	0,2	0,696	1,160	1,392
22:0 Behenic acid	0,46	0,166	0,277	0,332
24:0 Lignoceric acid	–	0,094	0,157	0,188
Monounsaturated fatty acids	16,88	18,636	31,06	37,272
16:1 Palmitoleic acid	0,08	0,175	0,291	0,349
17:1 Octadecenoic acid	–	0,019	0,032	0,038
18:1 Oleic acid	16,8	16,876	28,127	33,752
20:1 Gadoleic acid	–	0,059	0,099	0,119
22:1 Erucic acid	–	1,507	2,511	3,013
Polyunsaturated fatty acids	39,27	33,027	55,045	66,054
18:2 Linoleic acid	39,24	14,473	24,122	28,946
18:3 Linolenic acid	0,03	18,554	30,923	37,108
18:3 γ-linolenic acid	–	6,517	10,862	13,034
18:3 α-linolenic acid	–	12,037	20,061	24,073

The stability of the mayonnaise emulsion depends on the composition of the oil-fat base, the recipe components used as emulsifiers of powdered milk, egg, mustard, and eggplant powder, which participate in creating the structure of mayonnaise, as well as on compliance with the optimal parameters of the technological process, primarily homogenization. The study of the change in emulsion stability was carried out by the method of centrifugal force. For this, the control and experimental samples of mayonnaise were centrifuged for 5 minutes at a rotation speed of 3000^{-1} s. The results of the study of these indicators are presented in Table 4.

Table 4

Physico-chemical parameters of mayonnaise based on blended oil and gumarabic

Indicator name	Mayonnaise samples			
	CONTROL	Test sample 1 (25%)	Test sample 2 (50%)	Test sample 3 (100%)
Effective viscosity, Pa×s^{-1} (at a shear rate of 3 s^{-1})	9,5	9,5	9,5	9,3
Emulsion stability, %	99	100	100	99
pH	4,5	4,5	4,5	4,6
Acid value, ml KOH/kg	0,2	0,2	0,2	0,2
Peroxide number, ½O2, mol/kg	2,3	2,5	2,6	2,9

The results of the conducted studies (Table 4) confirm the possibility of producing all mayonnaise samples based on blended oil, since their physical and chemical indicators fully comply with the established requirements of regulatory documentation. The percentage of unbroken emulsion for the experimental samples of mayonnaise (M1) and (M2) with a mass fraction of blended oil of 25% and 50% was 100%, which is 1% less than for the control and experimental sample of mayonnaise (M3).

As a result of the conducted studies, the emulsion stability indicator corresponds to the norm for all mayonnaise samples. The effective viscosity for the control and experimental samples of mayonnaise (M1, M2 and M3) was within the norm. However, the effective viscosity index for the experimental mayonnaise sample (M3) with complete replacement of the oil-fat fraction with blended oil was 0.2 $Pa \times s^{-1}$ less than for other experimental mayonnaise samples (M1 and M2). The results obtained for the active acidity indices indicate, however, that the pH for all developed mayonnaise samples was within normal limits. The acid number indices did not differ for the control and experimental mayonnaise samples (M1, M2, M3). The peroxide number indices for the mayonnaise sample (M3) almost reach the limit value for this type of product – 3.1 mmol of active oxygen/kg.

In order to control the safety indices for the developed mayonnaise samples, the change in microbiological indices during storage (28 days) was determined (Table 5).

Studies of microbiological indicators (Table 5) of the control sample of mayonnaise and experimental samples with partial or complete replacement of the oil-fat fraction with blended oil during storage (28 days) indicate that the conditionally pathogenic and pathogenic microflora are within acceptable values.

Table 5

Microbiological indicators of mayonnaise based on blended oil and gum arabic during storage

Indicator name	Permissible level	Sample	Shelf life, days			
			0	10	14	28
Escherichia coli (coliform) bacteria, in 0.01g of mayonnaise	Not allowed According to DSTU 6003:2008	CONTROL	–	–	–	–
		Experimental samples	–	–	–	–
Pathogenic microorganisms, including Salmonella bacteria, in 25g of mayonnaise	Not allowed	CONTROL	–	–	–	–
		Experimental samples	–	–	–	–
Staphylococcus aureus, in 1g of mayonnaise, no more than	5,0×102	CONTROL	$2,7\times10^2$	$2,7\times10^2$	$2,7\times10^2$	$2,7\times10^2$
		Experimental samples	$2,7\times10^2$	$2,7\times10^2$	$2,7\times10^2$	$2,7\times10^2$
Listeria monocytogenes, in 25g of mayonnaise	Not allowed	CONTROL	–	–	–	–
		Experimental samples	–	–	–	–

Determination of BGCP in 0.01 g of experimental and control samples of mayonnaise indicate their absence in the studied products. The number of bacteria of the Staphylococcus aureus group in the control sample of mayonnaise and experimental samples throughout the entire storage period is the same and is 2.7×10^2.

Conclusions. The paper theoretically and experimentally substantiates the feasibility of using blended oil in the development of mayonnaise sauce technology and develops recipes for these mayonnaises. Based on organoleptic analysis, it was determined that the use of blended oil in mayonnaise sauce technology has a positive effect on its organoleptic indicators. The consistency, appearance, color and smell of all samples received a positive assessment. The highest score (5 points) was given to the mayonnaise sample containing 50% blended oil (M2). The study of the fatty acid composition of lipids showed that the highest indicators in terms of the content of fatty acids of the ω-3 and ω-6 groups were obtained by the lipids of the mayonnaise sample (M3). However, the ratio of fatty acids in lipids of the ω-3:ω-6 groups in the mayonnaise sample (M3) is 1:7/1:9, which does not correspond to the optimal one. The optimal ratio of fatty acids in lipids of the ω-3:ω-6 groups as 1:4 is possessed by the mayonnaise sauce sample (M2). The analysis of the fatty acid composition also confirmed the functionality of all developed mayonnaise samples.

The article establishes that all developed samples of mayonnaise based on blended oil, gum arabic, and eggplant powder fully comply with the regulatory indicators of structure (effective viscosity and emulsion stability) and quality (pH, acid number, and peroxide number), which characterize the product's resistance to mechanical stress and storage stability for emulsion-type sauces.

It was investigated that the microbiological indicators of the control mayonnaise sample and experimental samples with partial or complete replacement of the oil-fat fraction with blended oil during storage (28 days) indicate that the opportunistic and pathogenic microflora are within the permissible values. The number of Staphylococcus aureus bacteria in the control sample of mayonnaise and the experimental samples throughout the entire storage period is the same and is 2.7×10^2. The studied quality indicators make it possible to substantiate the technology of mayonnaise sauce based on blended oil, gum arabic, and eggplant powder with increased biological value. The implementation of this technology will expand the range and contribute to obtaining a high-quality and safe food product.

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ЯКІСТЬ ТА БЕЗПЕЧНІСТЬ МАЙОНЕЗУ НА ОСНОВІ КУПАЖОВАНОЇ ОЛІЇ, ПОРОШКА З БАКЛАЖАНІВ ТА ГУМІАРАБІКА

Анотація

У роботі обґрунтовано теоретично і експериментально доцільність використання гуміарабіка, порошка з баклажанів та купажованої олії для розроблення технології майонезу, а також створено рецептури різних варіантів цього соусу. Результати органолептичного аналізу показали, що застосування гуміарабіку, порошка з баклажанів та купажованої олії позитивно впливає на органолептичні властивості майонезу. Консистенція, зовнішній вигляд, колір і аромат усіх зразків отримали позитивні оцінки, причому зразок майонезу з 50% купажованої олії (М2) отримав найвищу оцінку (5 балів). Дослідження жирно-кислотного складу ліпідів продемонструвало, що зразок майонезу (М3) має найвищі результати за вмістом жирних кислот груп ω-3 та

ω-6. Проте співвідношення жирних кислот у зразку (М3) становить 1:7/1:9, що не є оптимальним. Найкращим співвідношенням жирних кислот, яке дорівнює 1:4, характеризується зразок майонезу (М2). Аналіз жирнокислотного складу також підтвердив функціональність усіх зразків майонезу. Визначено, що всі розроблені зразки на основі купажованої олії відповідають нормативам за показниками структури (в'язкість і стійкість емульсії) і якості (pH, кислотне і перекисне числа), які свідчать про стійкість продукту до механічного впливу та стабільність під час зберігання. Було з'ясовано, що мікробіологічні показники контрольного зразка та дослідних зразків, в яких частково або повністю замінено олієжирову фракцію на купажовану олію, протягом 28 днів зберігання показують, що умовно патогенна та патогенна мікрофлора знаходиться в межах допустимих значень. Кількість бактерій групи Staphylococcus aureus у контрольному та дослідних зразках залишалася сталою на рівні $2,7 \times 10^2$ протягом усього терміну зберігання. Отримані результати свідчать про можливість обґрунтування технології майонезу на основі гуміарабіка, порошка з баклажанів та купажованої олії з підвищеною біологічною цінністю.

Ключові слова: соуси, майонез, олія, гуміарабік, порошок із баклажанів, поліненасичені жирні кислоти (ПНЖК), функціональний продукт, дієтичні добавки, технологія майонезу.