Original Article

Formulation of Mayonnaise Recipe Enriched with ω-6 and ω-3 Acids and Stabilization of its Storage Period

Shakhnozakhon Gaipova[1], Ahror Abdurakhimov[2], Akbarali Ruzibayev[3]

[1]PhD Student, Tashkent Chemical-Technological Institute, Uzbekistan, Tashkent, A. Navoiy Str. E-mail: charosgaipova@gmail.com

[2]Doctor Technical Sciences, Docent, Tashkent Chemical-Technological Institute, Uzbekistan, Tashkent, A. Navoiy Str.

[3]Candidate Technical Sciences, Docent, Tashkent Chemical-Technological Institute, Uzbekistan, Tashkent, A. Navoiy Str.

Abstract

Chemical substances are necessary for the vitality and formation of cells in the human body[1]. These substances mainly come from outside with food. Some of them enter directly from outside, some are synthesized inside the body from other substances [2]. For example, highly unsaturated essential fatty acids (olein, linoleic, linolenic) necessary for the body enter from outside with food, but arachidonic acid, which enters the lipid balance of the cell membrane, does not enter from outside with food, it is synthesized in the human body from linoleic acid [3]. All fatty acids have a regulatory limit that is necessary for the body, and their excess has a negative effect on the body. Therefore, substances balance each other [4]. For example, if arachidonic acid is synthesized from linoleic acid, linolenic acid blocks this synthesis process and provides balance. This requires keeping these acids in certain proportions. Research shows that the ratio of linoleic and linolenic acids should be 5-10:1[5]. According to the recommendations of scientists, the optimal ratio of PUFA ω-6: ω-3 in the diet of a healthy person is (9.10): 1[6]. In cases of lipid metabolism pathology, the recommended ratio of ω-6: ω-3 PUFAs is 5: 1 and even 3: 1[7]. Analysis of the results of monitoring the population's diet shows that in practice these PUFAs enter the body in a ratio of 10:1 to 30:1. For this reason, u-3 PUFA deficiency is always observed in the human body [8 14].

In order to ensure the daily norm of essential fatty acids needed by the body, it is necessary to consume oils with a large amount of essential fatty acids. In order to ensure the mutual proportions of essential fatty acids, the ways of consuming various oils in a mixture have been recommended [9]. Such mixtures can be consumed in salad oils, oil emulsion products and other forms [10]. For example, it can be made in the form of mayonnaise, the recipe of which includes oils rich in various essential fatty acids.

Keywords: Mayonnaise, Unsaturated Essential Fatty Acids, Arachidonic Acid, Linoleic Acid, Essential Fatty Acids, "Oil-water" Type Emulsions, Fat-soluble Components, Acid Number of Oils, Antioxidant, Corn Oil, Sunflower Oil, Soybean Oil, Chromatogram of Fatty Acid Composition, Peroxide Number, Anisidine Number, Organoleptic Indicators, Ratio of ω-6:ω-3 of 5-10:1.

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INTRODUCTION

Mayonnaise is a fat emulsion product, which is used as an additive to improve the digestibility and taste of food, and as an ingredient in the preparation of various foods[11].

Mayonnaises are pointment-like finely dispersed "oil-water" type emulsions, which are prepared by adding emulsifiers, stabilizers, flavoring substances, thickening agents, aroma and flavoring substances to refined, deodorized vegetable oils [12]. Mayonnaise has a long history and was originally consumed as a sauce by the inhabitants of the Mediterranean island of Monerque. The sauce is made with olive oil grown on the island, turkey egg, lemon juice and red pepper. This sauce is pronounced in French as mayonnaise (mayonnaise) with the name Maoncha, and thus it was named. Until now, mayonnaise has become very popular, and its name has become a common name for all sauces containing vegetable oil, eggs and vinegar (or lemon juice) [13].

The composition of mayonnaise consists of oily and watery phases, and the oily phase mainly contains vegetable oils and fat-soluble components. The aqueous phase contains water and substances soluble in it [14].

Liquid vegetable oils are the main component of mayonnaise, and the oils in the recipe directly determine its organoleptic, physicochemical and nutritional properties. Mayonnaise recipe can be made with one oil or a combination of several oils [15]. It takes into account the quality and cost of mayonnaise, as well as competitiveness. In order to reduce the cost of mayonnaise, relatively cheap and saturated oils are used. However, the quality indicators and healing properties of the product may decrease. Therefore, in the formulation of the mayonnaise recipe, first of all, the composition of the fatty phase is selected, and then other components are introduced accordingly.

As we mentioned above, vegetable oils containing highly unsaturated fatty acids are used to obtain mayonnaise rich in essential fatty acids and optimized ratio of acids. However, due to the low oxidation stability of highly unsaturated fatty acids, their application possibilities are limited [16]. It also has a negative effect on the shelf life of mayonnaise. The shelf life of mayonnaise directly depends on the oxidation stability of its ingredients[17].

This research work is aimed at forming a mayonnaise recipe rich in highly unsaturated essential fatty acids and with optimized ratios of acids and stabilizing its shelf life.

MATERIALS AND RESEARCH METHODS

For the fatty phase of mayonnaise, sunflower, corn and soybean oils were used. Oils were purchased over the counter and analyzed under laboratory conditions. The acid number of oils was determined by the titration method, the color using the iodine scale, the moisture content in a drying cabinet, the fatty acid content on a Shimadzu GC2030 gas chromatograph (capillary column SH-2560; 0.25 mm ID; 0.2 mm df; 105 m) and the iodine number determined by the refractometer method.

Egg powder was used as an emulsifier, corn starch, sesame seeds and mustard powder were used as thickeners. EDTA was used as an antioxidant. Sodium benzoate, vinegar and citric acid were added as preservatives. Oxidation stability of mayonnaise was evaluated by peroxide number and anisidine number. The number of peroxides and anisidine was determined by the titration method [18].

PREPARATION OF MAYONNAISE PASTE

In the experiments, mayonnaise with 60% fat content was prepared. For this purpose, the specified amount of water according to the recipe was put into the mixer. Then the water was heated and a previously prepared mustard solution, egg powder, sugar, salt, EDTA, sodium benzoate and citric acid were added to it. The mixture was stirred at 75-80 °C for 30-35 minutes. Then it was cooled to 40-45 °C, sunflower oil or a mixture of oils was added and mixed for 15-20 minutes. After the homogenization of the mayonnaise paste was completed, acetic acid was added and mixing was continued. Ready-made mayonnaise paste is packed.

RESULTS

Corn oil is a secondary product of corn flour and starch production[19]. The fatty acid composition of corn oil contains a relatively high level of linoleic acid (58-62%) [20].

In literary sources, corn oil is classified as vegetable oil rich in phytosterols and tocopherols [21,22]. The main phytosterol and tocopherol in corn oil are β-sitosterol and γ-tocopherol, respectively[23]. Many clinical studies have shown an association between the consumption of corn oil and a reduction in total cholesterol, which may be due to the high concentration of phytosterols in the oil[24,25]. Studies have shown that tocopherols in corn oil have protective properties against DNA damage, high blood pressure, and diabetes[26,27].

Taking into account the beneficial aspects of biologically active substances and essential fatty acids in corn oil for the body, it is appropriate to include it in the recipe of mayonnaise, which is calculated from fatty products consumed daily [28].

Sunflower and cottonseed oils are mainly used in the production of mayonnaise in Central Asia. There are also mayonnaises made from safflower, soybean, rapeseed and other vegetable oils, but they are also added depending on the availability of the raw material source. Today, the production of non-traditional vegetable oils, such as corn oil or oils obtained from fruit seeds, has become quite popular. Such oils should be included in the daily mayonnaise on a scientific basis.

As it was mentioned above, today, the oils in the mayonnaise, which are prepared by adding different vegetable oils, are included in the recipe based on the availability of the source of raw materials. Also, in order to improve the organoleptic parameters of mayonnaise, a mixture of different oils is used. However, a deep analysis of the fatty acid content of the used oils and determination of their mutual proportions based on the fatty acid content has not been carried out. Therefore, in this research work, it is aimed to create a scientifically based mayonnaise recipe based on local oils produced in Uzbekistan, with a balanced fatty acid composition and a ratio of the mixture of oils.

The fatty base of mayonnaise enriched with essential fatty acids was formed from corn, sunflower and soybean oils. In order to determine the mutual proportions of oils, their fatty acid content was first determined (Figures 1-3 and Table 1).

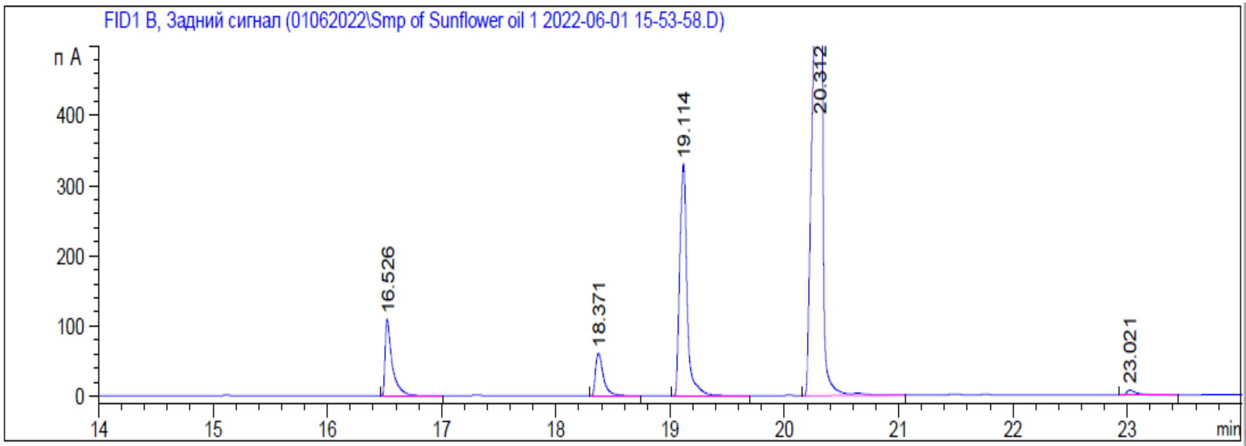

Figure 1. Chromatogram of fatty acid composition of sunflower oil obtained by gas chromatography method

Sunflower oil contains five fatty acids. This can also be seen from the peaks in Figure 1. The highest peak was observed in linoleic acid and the lowest in arachidonic acid. Peaks of oleic, palmitic and stearic acids were also detected.

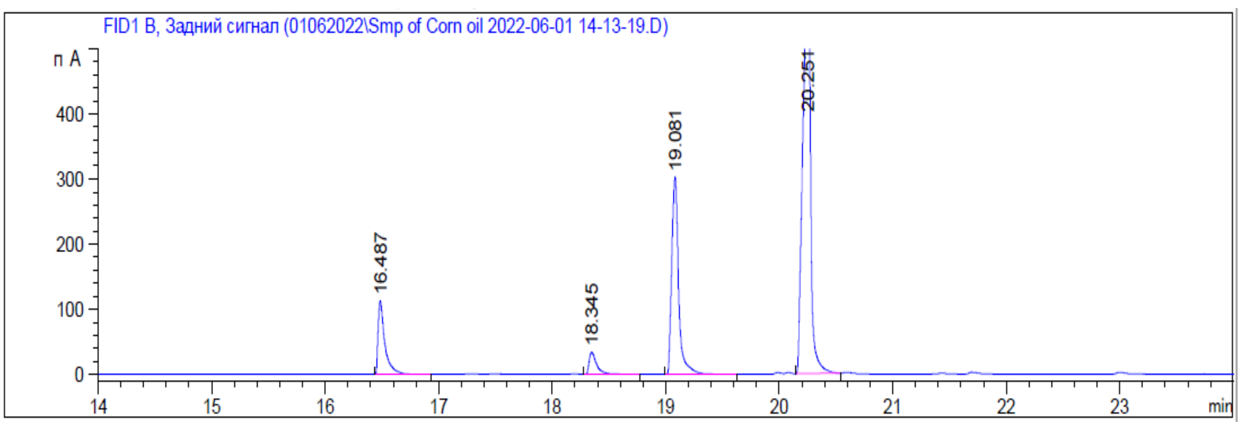

Figure 2. Chromatogram of fatty acid composition of corn oil obtained by gas chromatography method

Corn oil contains four fatty acids. This can also be seen from the peaks in Figure 2. The highest peak was observed in linoleic acid and the lowest in stearic acid. Peaks of oleic and palmitic acids were also detected.

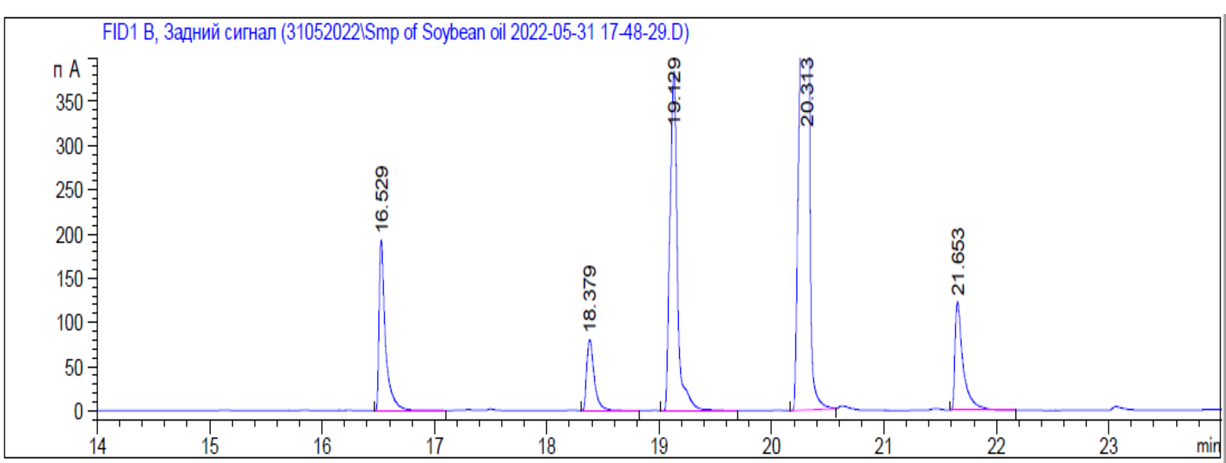

Figure 3. Chromatogram of fatty acid composition of soybean oil obtained by gas chromatography method

Soybean oil also contains five fatty acids. This can also be seen from the peaks in Figure 3. The highest peak was observed in linoleic acid and the lowest in stearic acid. Peaks of oleic, palmitic and linolenic acids were also detected.

Table 1: Fatty acid composition of the oils used in the study.

Fatty acids %	Sunflower oil	Corn oil	Soybean oil
C16:0+ C16:1	6,65	9,51	9,81
C18:0	4,05	3,07	4,85
C18:1	20,74	25,71	22,69
C18:2	67,85	61,51	54,7
C18:3	0,1	0,2	7,95
Another fatty acids	0,61	ND	ND
ω-6 : ω-3	678,5	307	6,88

From the data in Table 1, it can be seen that the total amount of saturated fatty acids in oils was 10.7%-14.66% due to palmitic (C16:0) and stearic (C18:0) acids. The content of unsaturated fatty acids ranged from 85.34 to 89.3%, of which oleic acid was the most in corn oil (25.71%) and linoleic acid was the most in sunflower oil (67.85%) was determined. Linolenic acid is the most in soybean oil (7.95%), and in other oils it does not exceed 0.2%. Considering the ratio of ω-6: ω-3, its value was the largest (678.5) in sunflower oil and the smallest (6.88) in soybean oil. From this, it follows that in order to ensure the ratio of ω-6:ω-3 to be 5-10:1, the mass percentage of soybean oil should be high in the mixture of oils. Therefore, the mass fractions of sunflower and corn oils were conditionally equal, and the mass fraction of soybean oil was taken in the range of 10-70% (Fig. 4).

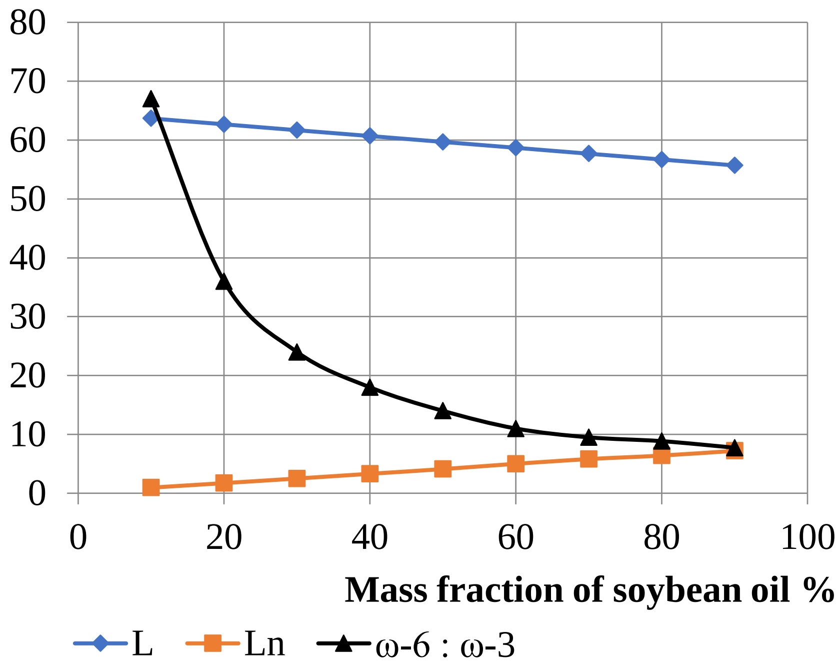

Figure 4. The influence of the mass fraction of soybean oil in the mixture of oils on the amount of linoleic and linolenic acids and their ratios

From the data in Figure 4, it can be seen that as the mass fraction of soybean oil in the mixture of oils increases, the amount of linoleic acid in the mixture decreases and the amount of linolenic acid increases. However, the ω-6:ω-3 ratio also decreased. It can be seen that the value of ω-6:ω-3 ratio is higher than 10 but lower than 15 when the mass fraction of unmixed soybean oil exceeds 50%. Especially when the mass fraction of soybean oil reached 90%, the ω-6:ω-3 ratio was equal to 7.7:1. This shows that for the fat base of mayonnaise with normalized essential fatty acids, the mass fraction of soybean oil should be more than 50% in the mixture of oils.

In subsequent experiments, the mass fraction of soybean oil was taken in the amount of 50%, and the mass fraction of corn oil was taken in the range of 10-50% (Fig. 5).

From the data in Figure 5, it can be seen that when the mass fraction of corn oil in the mixture increases from 10% to 40%, the amount of linolenic acid increases and the ratio of ω-6:ω-3 decreases. When the mass fraction of corn oil exceeds 40%, we can see that the amount of linolenic acid decreases sharply and, accordingly, the ω-6:ω-3 ratio increases. This is explained by the decreasing mass fraction of soybean oil in the mixture of oils.

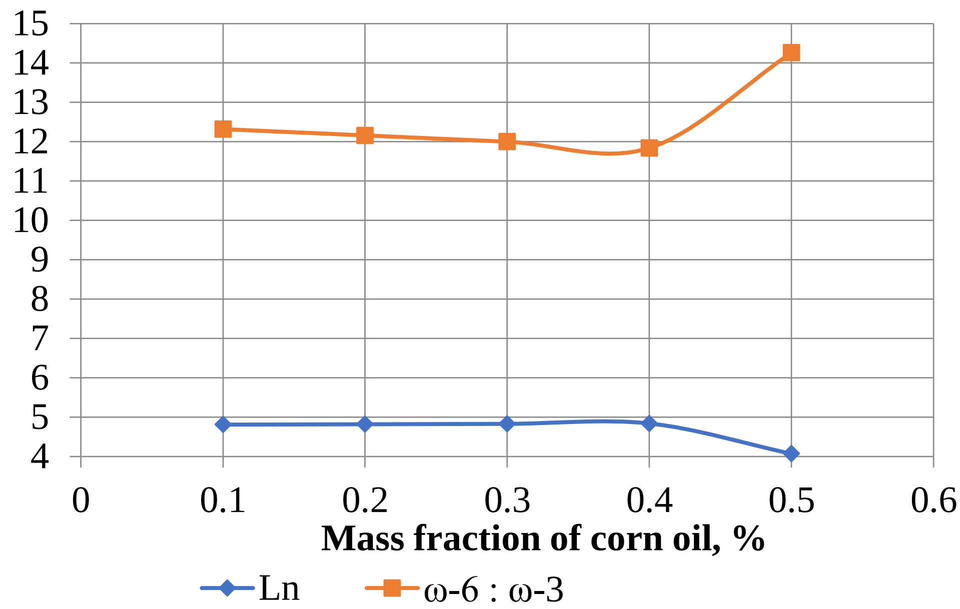

Figure 5. The effect of changes in the mass fraction of corn oil in the mixture of oils on the content of linolenic acid and the ω-6:ω-3 ratio

Based on the data in Figures 4 and 5, it can be concluded that to obtain a mixture of oils with a ratio of ω-6:ω-3 less than 10:1, the mass fraction of soybean oil is more than 60%, and the mass fraction of corn oil is It should be more than 20%.

The fatty acid composition of mixtures of sunflower, corn and soybean oils in the ratio of 20:20:60 is presented in Figure 6 and Table 2.

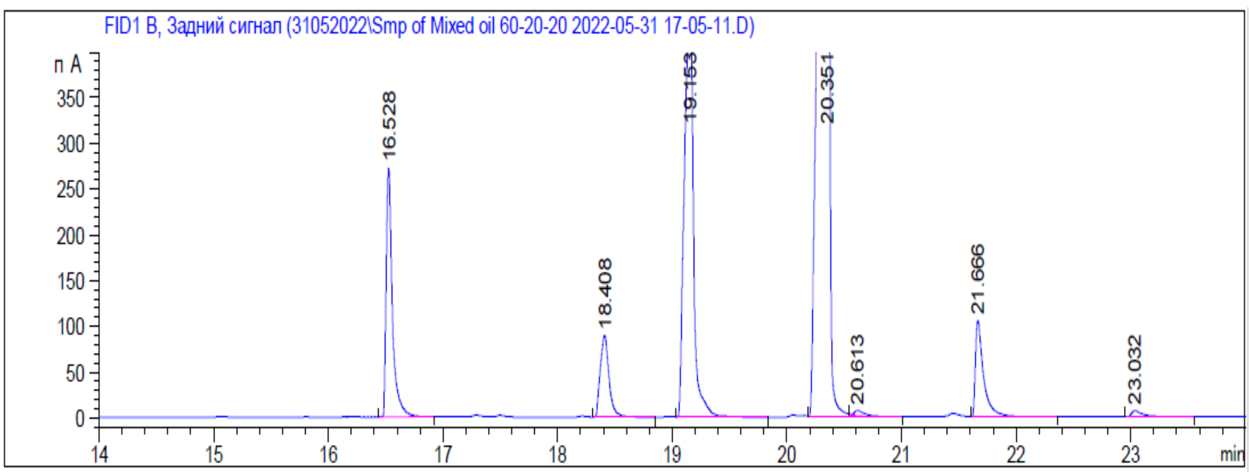

Figure 6: Chromatogram of the fatty acid composition of a mixture of sunflower, corn and soybean oils obtained by gas chromatography

It can be seen from the chromatogram in Figure 6 that the amount of 7 fatty acids is high in the mixture of sunflower, corn and soybean oils. These are palmitic, stearic, oleic, linoleic, linolenic and arachidonic acids (Table 2).

Table 2: Fatty acid composition of a mixture of sunflower, corn and soybean oils

The composition and ratio of the mixture of oils	Fatty acids %						ω-6 : ω-3
	C16:0 + C16:1	C18:0	C18:1	C18:2	C18:3	Another fatty acids	
Sunflower oil(20) : Corn oil(20) : Soybean oil(60)	9,3	4,2	22,7	58,4	4,7	0,7	12,4:1

However, due to its linolenic acid content, the stability of soybean oil to oxidation is very low. Therefore, in order to determine the optimal proportions of the mixture of oils and to determine the stability of mayonnaise to oxidation, its peroxide and anisidine numbers were analyzed. For this, mayonnaise was prepared according to the usual recipe. Fat base of mayonnaise Table 3 and the recipe are presented in Table 4.

Table 3: Fat base of mayonnaise

Oil name	Samples of mayonnaise						
	1	2	3	4	5	6	7
Sunflower	20	10	0	10	0	0	0
Corn	20	30	40	20	30	20	10
Soybean	60	60	60	70	70	80	90

7 mixtures of oils in different proportions were prepared from sunflower, corn and soybean oils (Table 3). All mixtures contain soybean and corn oils, while 4 mixtures (samples 3, 5, 6, 7) do not contain sunflower oil.

Mayonnaise recipe with corn oil

№	Components, %	Mayonnaise samples	
		Control	1-7
1	Sunflower oil	60	-
2	Mixture of oils	-	60
3	Acetic acid	4	4
4	Egg powder	5	5
5	Sugar	1	1
6	Salt	1	1
7	Mustard powder	0.3	0.3
8	EDTA	0.15	0.15
9	Sodium benzonate	0.03	0.03
10	Citric acid	0.03	0.03
12	Corn starch	5	5
13	Water	23.49	23.49

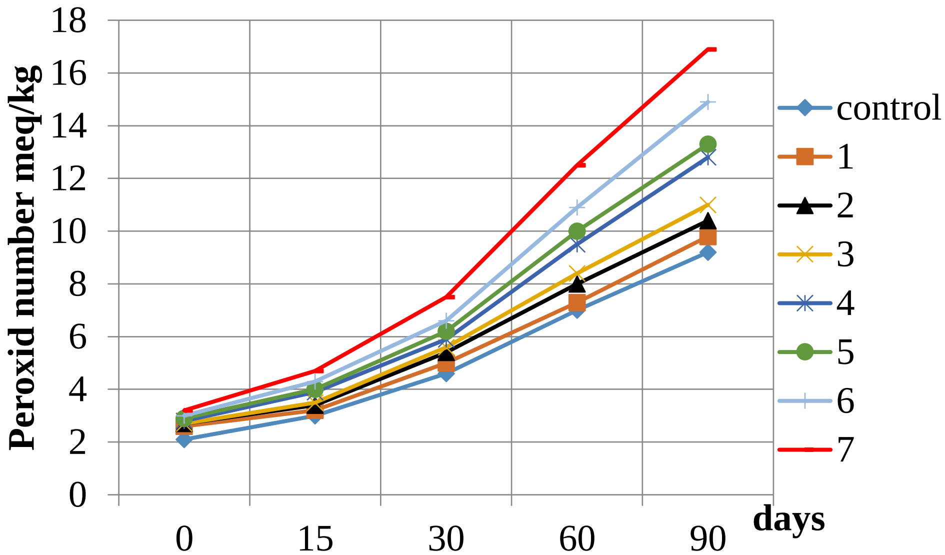

Figure 7. Changes in the number of peroxide during the 90-day storage period of mayonnaise

A total of 8 mayonnaise recipes were developed (Table 4), all of which differ from each other in the composition of the fatty phase. In the recipe of the control mayonnaise, only sunflower oil was taken as a fatty base, while in other recipes, the fatty base was taken according to Table 3. Mayonnaise fat content was chosen based on the most popular mayonnaise recipe in the markets of Uzbekistan today and was set at 60%. Also, other components in the recipe were selected on the basis of raw materials widely used in production.

Mayonnaises were prepared in laboratory conditions according to the given recipes. The resulting mayonnaises were stored for 90 days and their peroxide and anisidine numbers were determined (Figures 7 and 8).

It can be seen from Figure 7 that during the storage period, the number of peroxides of all mayonnaises increases. However, the rate of increase varies from sample to sample. The peroxide value of mayonnaise in the control sample increased to 6.2 during the 90-day storage period, while the value of the peroxide value was higher than 10 in all other samples. It can be seen that this value was equal to 9.8 and 10.4 in 90 days of storage only in samples 1 and 2. During the 90-day storage period, only the control and 1st samples met the standard requirement (10).

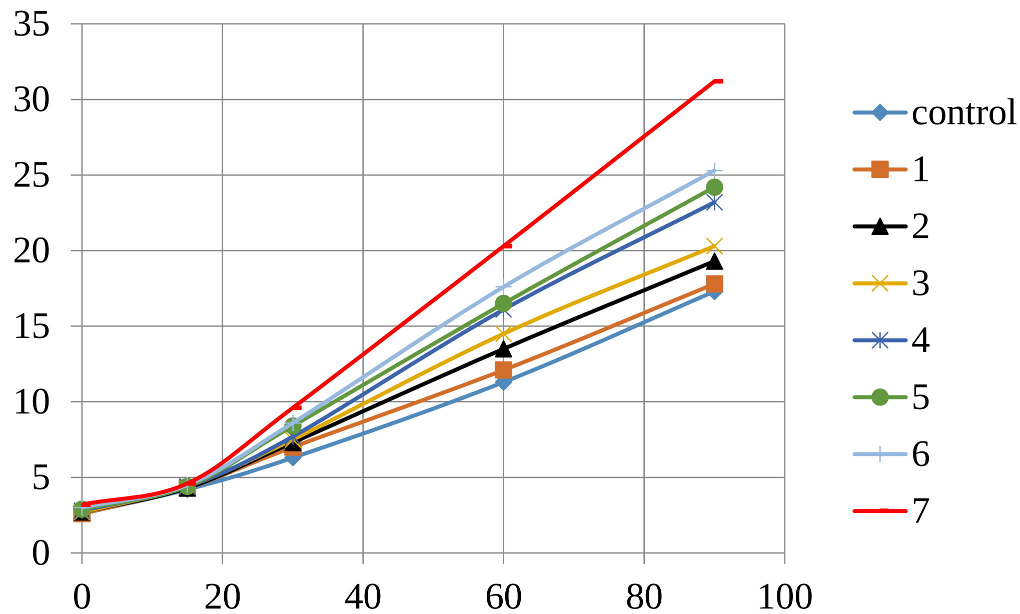

Figure 8. Changes in the amount of anisidine during the 90-day storage period of mayonnaise

In the change of anisidine numbers during the 90-day storage period of mayonnaise (Fig. 8), it was observed that the values of the control sample were significantly lower than those of the other samples. This is explained by the presence of soybean oil in other samples and its high tendency to oxidation.

From the data in Table 2, it can be seen that the ratio of ω-6:ω-3 in the ratio of 20:20:60 of the mixture of oils was 12:1. Mayonnaise obtained from a mixture of oils obtained in these proportions meets the established requirements for oxidation stability (Figures 7 and 8). However, this does not correspond to the purpose of the research work. That is, the ratio of ω-6:ω-3 in the fatty phase of mayonnaise should not exceed 10:1. Therefore, based on the data in Figure 4, we take a mixture of sunflower, corn and soybean oils in the proportions of 10:20:70, respectively. In this ratio, the ratio of ω-6:ω-3 is ensured to be 10:1. But according to the information in pictures 7 and 8, the oxidation stability of mayonnaise made from a mixture of oils in the ratio 10:20:70 is unbearable. To eliminate this deficiency, it is necessary to add additional antioxidants to the mayonnaise recipe.

The shelf life of mayonnaise directly depends on the oxidation resistance of the oils included in the recipe, and various antioxidants are used to extend it. Antioxidants limit the exposure of unsaturated fatty acids of the oils contained in mayonnaise to oxygen in the air and prevent an increase in the amount of oxidized products.

Synthetic and natural antioxidants can be used in the production of mayonnaise. According to the Codex standard, the use of certain chemical antioxidants such as BHT, BHA, TBHQ and EDTA is allowed in the mayonnaise recipe in certain concentrations. Although these synthetic antioxidants are more economical than natural antioxidants, they give a negative impression that they are synthetic products[29].

Due to the chemical stability, cheapness and availability of synthetic antioxidants, they are used universally. However, some studies have questioned their safety due to potential risks. Nowadays, consumers are more concerned about the safety of preservatives and additives. Therefore, consumers' preference for natural products is increasing. All this is driving the food industry to search for natural sources of antioxidants.

Gallic acid [30], ascorbic acid [31], tocopherol [32], rosemary [33], lactoferrin [34], phytic acid [35], mustard [36], fenugreek extract [37] for use in mayonnaise by scientists.], natural antioxidants such as black glutinous rice[38], ginger powder[39], grape seed extract[40], and chitosan[41] have been proposed[42]. Many of them are used in mayonnaise recipes today.

Synthetic antioxidant (EDTA) is also used in the mayonnaise we offer. However, the amount of EDTA included in the recipe was not enough due to the increased amount of highly unsaturated fatty acid oils in the recipe. Therefore, it was decided to add a natural antioxidant to mayonnaise. For this purpose, we aimed to use sesame seed powder, which contains a lot of polyphenols. Our previous research works on the introduction of sesame seed powder into the mayonnaise recipe [article scopus Gaipova]. In this research work, adding up to 10% of sesame seed powder to the mayonnaise recipe has a positive effect on the organoleptic properties of mayonnaise. For this reason, instead of 5% corn starch in the proposed recipe (mayonnaise sample 4), experiments were conducted to partially or completely introduce sesame seed powder and thereby increase the oxidation stability of mayonnaise. In the experiments, the mayonnaise recipe of the 4th sample was used as a basis, and new recipes were formed by changing the nature of the thickening component (corn starch) in its content (Table 5).

Table 5: Recipes of mayonnaise formed in the mayonnaise recipe of sample 4

Components name	Mayonnaise recipes and the mass percentage of the component in them, %						
	4-0	4-1	4-2	4-3	4-4	4-5	4-6
Mixture of oil	60	60	60	60	60	60	59
Corn starch	5	4	3	2	1	0	3
Sesame cake powder	0	1	2	3	4	5	3
Another components	35	35	35	35	35	35	35

The mass fractions of oil and other components (acetic acid, egg powder, sugar, salt, mustard powder, edta, sodium benzoate, citric acid, water) have not changed in the newly formulated recipes. Only the mass fractions of thickening components (corn starch and sesame seed powder) have changed.

Based on recipes (Table 5), mayonnaises were prepared in laboratory conditions and their peroxide number, anisidine number and organoleptic indicators were analyzed (Figures 9 and 10, Table 6).

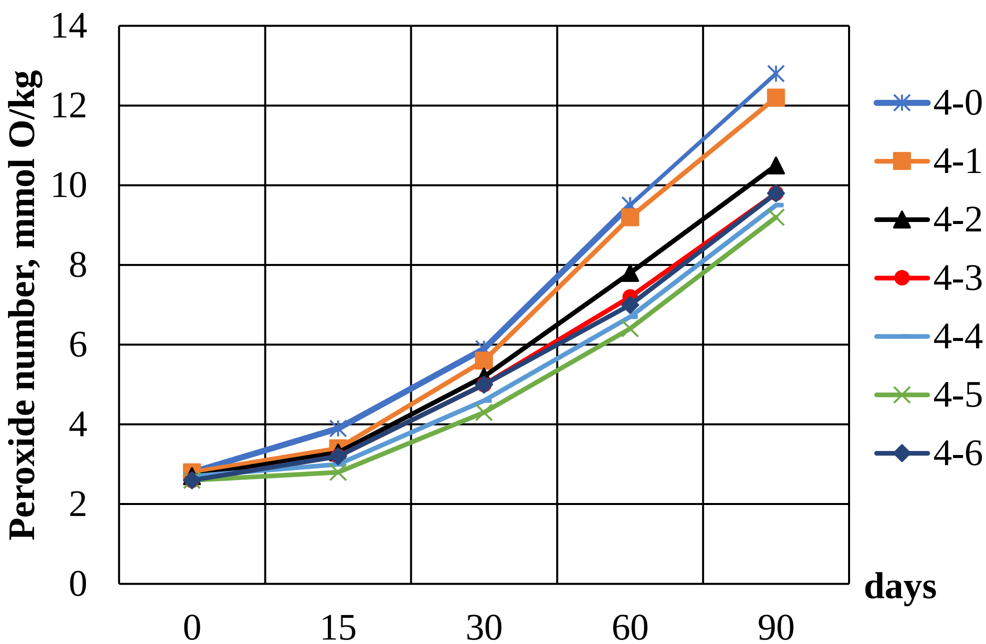

Figure 9. Changes in the number of peroxide during the 90-day storage period of mayonnaise with sesame seed powder

It turned out that the addition of sesame seeds to mayonnaise has a positive effect on the change in its peroxide number (Figure 9). In mayonnaise sample 4, after 90 days of curing, its peroxide value did not meet the standard requirement (10). Replacing the 5% cornstarch in the recipe with 1% sesame seeds slightly reduced the peroxide value. In mayonnaises (4-3,4-4,4-5) with more than 3% of sesame seeds, the number of peroxides corresponded to the standard requirement (10). This is explained by the reduction of the oxidation of highly unsaturated fatty acids and the formation of less amount of primary oxidation products due to the antioxidant properties of the polyphenols in the sesame seed contained in mayonnaise. The same pattern was observed in the formation of secondary oxidation products (Fig. 10).

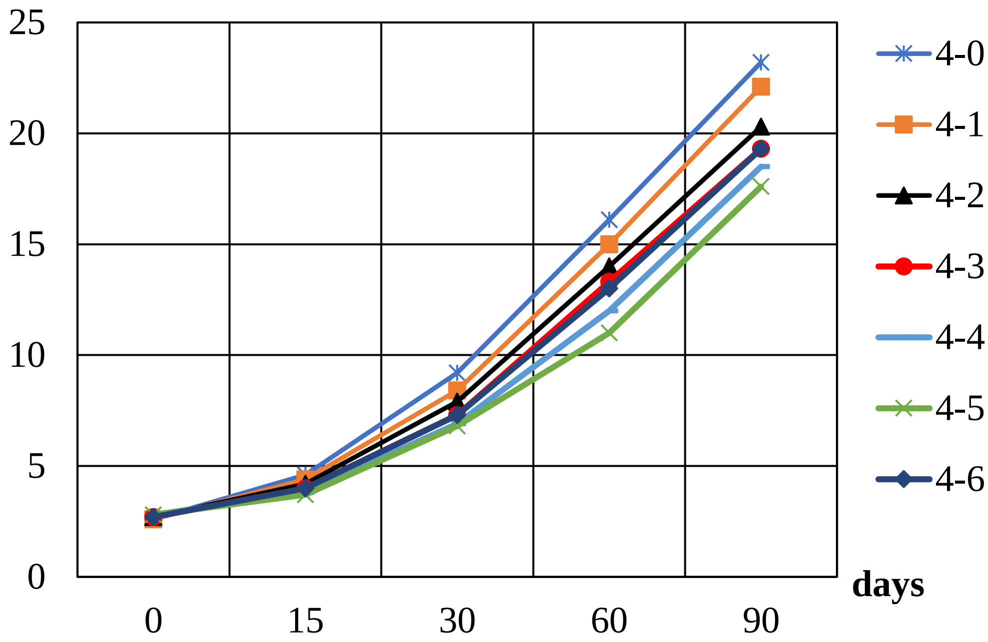

Figure 10. Changes in the amount of anisidine number during the 90-day storage period of mayonnaise with sesame seed powder

It can be seen from Figure 10 that, except for mayonnaise samples 4-0, 4-1 and 4-2, the anisidine number after 90 days of storage corresponds to the standard requirement. From this, it can be concluded that the mass fraction of sesame seeds included in the mayonnaise recipe should be higher than 3%.

The marketability and consumption of mayonnaise products depends on their organoleptic indicators. If a mayonnaise recipe enriched with the best biologically active substances or with the best indicators in terms of shelf life and food safety is developed, but its taste, color, consistency, appearance and other organoleptic parameters are required such mayonnaise is economically unusable. Although such a mayonnaise recipe has scientific value, it has no practical value. It was investigated how the proposed recipe of mayonnaise enriched with essential fatty acids affects the organoleptic parameters of sesame kunjara, which is introduced, while increasing its stability to oxidation. Organoleptic indicators were evaluated in a 10-point system by the tasting method (Fig. 11).

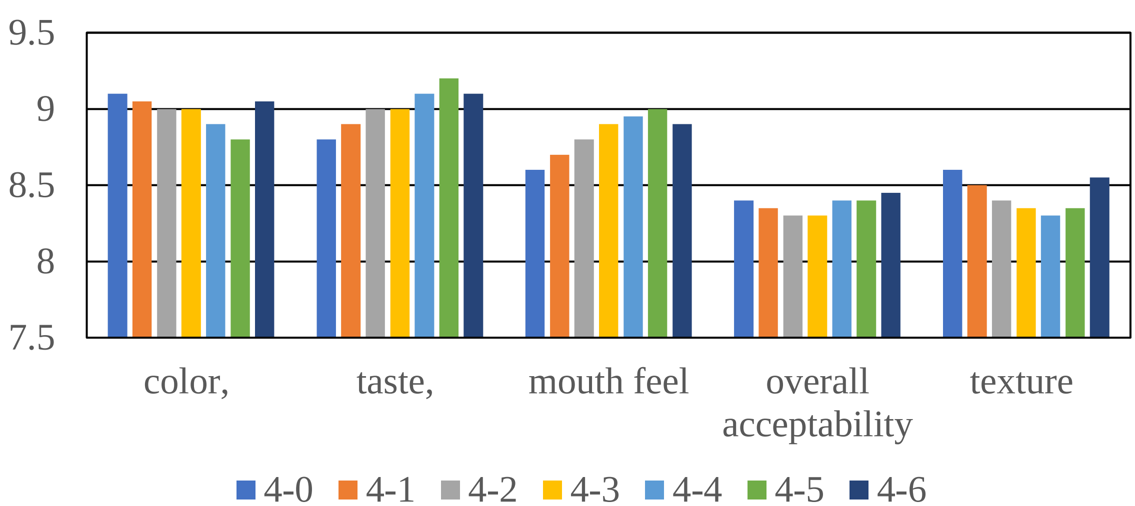

Figure 11. Organoleptic indicators of mayonnaises prepared with the addition of sesame seeds and corn starch

Sesame seed included in mayonnaise affects its organoleptic indicators such as color, taste, mouthfeel, general acceptability and structure (Fig. 11). Mayonnaises (all samples except 4-0) with sesame seeds instead of corn starch have improved taste and mouthfeel. These characteristics increased as the mass fraction of sesame seeds increased. The color and structure, on the contrary, decreased as the amount of sesame seeds increased. The overall acceptability index decreased initially when the amount of sesame seeds was 3% and then increased.

In general, when the mass fraction of sesame seeds in the recipe exceeds 3%, the parameters such as peroxide number, anisidine number, taste, mouthfeel and overall acceptability of mayonnaise are improved. On the contrary, the color and structure have deteriorated. Therefore, it is necessary to determine the optimal mass fraction of sesame seeds, which positively affects all the indicators of mayonnaise. To do this, it was decided to increase the amount of corn starch, while the mass fraction of sesame seeds in the recipe did not exceed 3%. Because the color and structure of mayonnaise with corn starch has a direct positive effect. As a result, by reducing the mass fraction of the oil in the recipe, the mass fraction of thickeners (corn starch and sesame seed) was increased (Table 5). Optimum values of perekis and anizidine numbers were observed in mayonnaise of samples 4-6. In this case, the ratio of corn starch and sesame seeds is optimized (3:3). This had a positive effect on the organoleptic indicators of directly obtained mayonnaise (Figure 11, sample 4-6).

Summary

Mayonnaise recipe enriched with omega-3 and omega-6 fatty acids and with a ratio of these acids normalized to 5-10:1 can be made on the basis of sunflower, corn and soybean oils. Having studied the fatty acid base of oils (Table 1) and their effect on the oxidation stability of the product (Figures 7 and 8), it was determined that the ratio of oils in mutual mixtures should be 60:20:20, respectively. And in mixtures of oils with other proportions, the oxidation stability of the obtained mayonnaise was not at the required level. However, the value of ω-6:ω-3 ratio of 5-10:1 was not provided. The ratio of ω-6:ω-3 of 5-10:1 was achieved when the ratio of the oil mixture was 70:20:10 (Fig. 4). However, due to the low oxidation stability of this mixture of oils, instead of corn starch in the recipe (5% mass fraction in the recipe), its mixture with sesame powder (50:50 ratio, 6% mass fraction) was added (Table 6).. As a result, it was possible to obtain mayonnaise with improved oxidation stability and organoleptic indicators and enriched with essential fatty acids.

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