Journal of Chemistry and Technologies, 2022, *30*(2), 253-264

Journal of Chemistry and Technologies

pISSN 2663-2934 (Print), ISSN 2663-2942 (Online).

journal homepage: http://chemistry.dnu.dp.ua

UDC 664.3

QUALITY MANAGEMENT IN THE TECHNOLOGY OF MAYONNAISE SAUCES WITH NON-TRADITIONAL RAW MATERIALS

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Received 23 May 2022; accepted 10 July 2022, Available online 25 July 2022

Abstract

In the context of the global food crisis, deepened by the global COVID-19 pandemic, the question arises of manufacturing products with specified properties of different price categories, finding new technological solutions, using unconventional raw materials that can predict and stabilize the quality of fat products, including mayonnaise sauces, mainly of natural origin. Guar and xanthan gums were used to stabilize the quality of physicochemical properties, rheological characteristics, and improve the structure. The use of hydrocolloids in mayonnaise sauces provides important indicators, such as viscosity and stability of the emulsion. In this study, we studied the effect of the Stabilex stabilization system, which is a mixture of guar gum and xanthan, on the quality indicators of mayonnaise emulsions. It was found that to obtain the stability of mayonnaise sauce at least 97 %, it is necessary to add 56 % water, 35 % refined oil, 2.6 % Stabilex stabilization system. Chia seeds, raspberry puree, smoked paprika and greens were added to the mayonnaise sauce as non-traditional raw materials, and acetic acid was replaced by citric acid. Emulsification was performed using a high-speed blender. According to the results of previous studies, the optimal emulsification conditions were selected: temperature of the aqueous and fat phases 25–27 °C, emulsification time 5 min, mixing intensity with stirrer speed – 10–20 s^{-1}. The studied indicator of stability of the developed mayonnaise sauces testifies that during their storage these values decrease, however do not reach critical ones. After 35 days of storage, the stability of mayonnaise sauce with smoked paprika (sample №2) is 100 %, while of the control sample – 94 %. The analysis of the obtained rheological flow curves of mayonnaise sauces shows that the best viscosity characteristics belong to the sample in the recipe of which the Stabilex stabilization system and dried herbs are included in quantities of 2.5 %. The rheological properties of mayonnaise sauce with raspberry puree and chia seeds have significantly deteriorated, indicating a lack of bond strength in the system. The use of ingredients according to the developed recipes with the Stabilex stabilization system allows to obtain recipes for mayonnaise sauces with preserved emulsion properties and high stability that meet the requirements of DSTU 4487:2015.

Keywords: Stabilex stabilization system; chia seeds; raspberry puree; smoked paprika; greens; mayonnaise sauces; emulsion stability; viscosity; acidity.

УПРАВЛІННЯ ЯКІСТЮ В ТЕХНОЛОГІЇ МАЙОНЕЗНИХ СОУСІВ З НЕТРАДИЦІЙНОЮ СИРОВИНОЮ

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Анотація

В умовах світової продовольчої кризи, що поглибилася світовою пандемією COVID-19 постає питання щодо виготовлення продуктів із заданими властивостями різних цінових категорій, пошук нових технологічних рішень, використання нетрадиційної сировини, здатних прогнозувати та стабілізувати якість жировмісних продуктів, зокрема майонезних соусів за рахунок дії основних біополімерів, головним чином, натурального походження. Для стабілізації якості фізико-хімічних властивостей, реологічних характеристик та покращення структури використовували камеді гуара та ксантана. Використання гідроколоїдів у майонезних соусах дозволяє забезпечити важливі показники як в'язкість та стабільність емульсії. В даній роботі вивчали вплив стабілізаційної системи «Стабілекс», що представляє собою суміш камеді гуару та ксантану, на показники якості майонезних емульсій. Встановлено, що для отримання стійкості майонезного соусу не менше 97 % необхідно внести 56 % води, 35 % рафінованої олії, 2.6 % стабілізаційної системи

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doi: 10.15421/jchemtech.v30i2.258185

«Стабілекс».До складу майонезного соусу у якості нетрадиційної сировини введено насіння чіа, пюре малини, копчену паприку та зелень, оцтову кислоту замінили на лимонну Емульгування проводили за допомогою швидкісного блендера. За результатами попередніх досліджень були обрані оптимальні умови емульгування: температура водної та жирової фаз 25–27 ˚С, час емульгування 5 хв, інтенсивність перемішування з частотою обертання мішалки – 10–20 с$^{-1}$. Досліджений показник стійкості розроблених майонезних соусів свідчить, що при їх зберіганні значення зменшуються, проте не досягають критичних. Після 35 днів зберігання стійкість майонезного соусу з копченою паприкою(зразок №2) становить 100 %, в той час як контролю – 94 %. Аналіз отриманих реологічних кривих течіння майонезних соусів свідчить, що найкращі в'язкісні характеристики має зразок, до рецептури якого входять стабілізаційна система «Стабілекс» та сушена зелень, додані у кількостях 2.5 %. Значно погіршилися реологічні властивості майонезного соусу з пюре малини та насіння чіа, що свідчить про недостатню міцність утворених зв'язків у системі. Викорстання інгредієнтів згідно розроблених рецептур з стабілізаційною системою «Стабілекс», дозволяють отримати рецептури майонезних соусів зі збереженими емульсійними властивостями та високою стабільністю, що відповідають вимогам ДСТУ 4487:2015.
Ключові слова: стабілізаційна система «Стабілекс»; насіння чіа; пюре малини; копчена паприка; зелень; майонезні соуси; стійкість емульсії; в'язкість; кислотність.

Introduction

A person's whole life is related to nutrition. Mayonnaise is one of the most widely used fatty foods. Due to its high taste and nutritional properties, the popularity of this product is very high. Mayonnaise is one of the most popular sauces, which, by the way, most consumers perceive as a completely separate product. The traditional raw materials for the production of mayonnaise are refined liquid vegetable oils: sunflower, corn, peanut, olive; egg products: dry egg powder or yolk, dairy products: milk powder, cream, whey; granulated sugar; salt; sodium bicarbonate; mustard powder; acetic acid; corn starch; ground black pepper; cumin; soy protein; citric, sorbic, benzoic acid [1].

Production of mayonnaise sauces on automated lines involves the following operations: dosing of components according to the recipe; dissolution and pasteurization of the aqueous phase, emulsification of fat and preparation of "coarse emulsion"; cooling; homogenization; packing and packaging.

Mayonnaise sauce has a very positive property: it promotes the assimilation of food, which is extremely important for health and well-being. Table mayonnaise sauces have a creamy consistency and are intended for consumption as seasonings or additives for cooking at home and in public and restaurant businesses. Mayonnaise sauces are universal products that reduce the caloric content of food by replacing some recipe ingredients with low-calorie ones, for instance, replacing sugar with sweeteners [2].

An important problem in the production of mayonnaise is the replacement of eggs in the recipes, as they are the main emulsifying and structuring component of mayonnaise emulsions [3]. In addition, eggs contain a high number of gram-positive heat-resistant enterococci, which can be a source of cross-bacteriological contamination of mayonnaise sauces [4]. According to Rodrigue et al., contamination of eggs with Salmonella Enteritidis microorganisms can cause outbreaks of food poisoning [5].

The recommended amount of egg intake for most healthy people is one egg per day. Egg powder, as one of the recipe components of mayonnaise sauces, is a product of high nutritional value, containing about 2% cholesterol. This makes it undesirable for patients with atherosclerosis, hypertension, obesity, and the elderly. According to American Heart, the daily intake of cholesterol is not more than 300 mg [6].

Although phospholipid substances such as lecithin contained in egg yolks increase the stability of the mayonnaise sauce system as noted in Nikzade, V. et al., the development of new recipes and technology of mayonnaise sauces using unconventional raw materials is becoming increasingly important [7].

The results of studies by Santos Alves, J. show that most emulsion products require long-term physical stability to maintain and regulate the properties of the product in order to meet their quality requirements [8]. The possibility of increasing the stability of the emulsion by adding hydrocolloids, in particular emulsifiers and stabilizers, is widely used. Information on this is given in the works of Lorenzo, G; Felix da Silva, [9; 10].

Hydrocolloids provide stability and texture of mayonnaise sauce due to aggregation and gelation [11–13]. The Stabilex stabilization system – a mixture of guar gum and xanthan - was introduced into the developed recipes of mayonnaise sauces. Egg powder was used as an emulsifier of the control mayonnaise sauce.

Due to the high content of nutrients, raspberries are used as promising raw materials in the development of functional foods. It contains up to 11.5 % sugar (glucose, fructose, sucrose and pentose), 1–2 % organic acids (citric, malic, salicylic, tartaric and others), tannins, pectin (up to 0.9 %), fiber 4–6 %), proteins, anthocyanins, flavonoids, alcohols (wine isoamyl, phenylethyl), ketones (acetoin, diacetyl, β-ionone). Raspberries are also rich in vitamins: A, B1, B2, B9 (folic acid), C, PP, beta-sitosterol, which are characterized by antisclerotic properties. They contain minerals and trace elements: Cu, K, Fe (which raspberries are especially rich in), Mg, Ca, Zn, Co. Raspberries contain coumarin, which has the ability to reduce prothrombin levels and normalize blood clotting, and anthocyanins, which have antisclerotic properties and the ability to strengthen capillaries [14].

According to Metri-Ojeda, J.C., a promising source of micronutrients in mayonnaise sauce technology is chia seeds [15]. Chia (Salvia hispanica L.) is a crop from southern Mexico and northern Guatemala. As described in Fernandes & Mellado, Julio et al., chia seeds are a source of essential fatty acids, especially α-linolenic acid, soluble and insoluble fiber and proteins, contain ω-3 polyunsaturated fatty acids, associated with numerous potential benefits for health [16; 17].

Due to the content of soluble fiber, which manifests itself in the form of mucus, chia seeds have many health benefits. In the work of Soukoulis et al., it is argued that chia seed mucus can reduce the risk of type 2 diabetes and has a prebiotic effect to enhance intestinal microbiota by increasing strains of Lactobacillus and Bifidobacteria [18].

Razavi, S. M. A. argues that mucus is a heterogeneous branched and hydrophilic polysaccharides that form a thick and viscous solution when dissolved in water. It is located in various parts of plants, such as seeds, leaves and buds, and chia seeds are recognized as a good source of it [19].

The goal of the work is to develop mayonnaise sauces using non-traditional raw materials and the Stabilex stabilization system.

To achieve this goal, the following *research objectives* were set:

- to determine the optimal content of recipe components of mayonnaise sauces based on a mathematical model,
- make a selection of non-traditional components for the development of mayonnaise sauces with assigned properties,
- study the organoleptic, physicochemical and rheological properties of the developed mayonnaise sauces,
- investigate changes in the quality of samples of mayonnaise sauces during storage.

The object is the technology of mayonnaise sauces with the use of non-traditional raw materials and the Stabilex stabilization system.

The subject is sauces using non-traditional raw materials (chia seeds, raspberry puree, smoked paprika, dried greens: parsley, dill) and the Stabilex stabilization system.

Research methods. Mayonnaise sauces were made as follows: the recipy quantity of dry components (sugar, salt) was dissolved in water, pasteurization was carried out at a temperature of 75 °C for 7–10 minutes. Egg powder was introduced into the control sample, and the Stabilex stabilization system, i.e. a mixture of guar gum and xanthan gum, was introduced into the research ones. Then sunflower oil was added to the obtained aqueous phase in small portions with constant stirring, and the next portion of oil was added only after the previous one had already been completely emulsified. Vegetable oil is added very slowly to prevent the emulsion from breaking down and reversing the phases. The acid was introduced at the end, before the final homogenization. Emulsification was performed using a high-speed blender. According to the results of previous studies, the optimal emulsification conditions were selected: temperature of the aqueous and fat phases 25–27 °C, emulsification time 5 min, mixing intensity, expressed by the stirrer speed – 10–20 s^{-1}.

The study was conducted by standard methods according to DSTU 4487: 2015 ‘Mayonnaise and mayonnaise sauces. General technical conditions’. Control methods. Organoleptic parameters were determined in the following sequence: consistency, appearance, color, odor, taste at a temperature of (20 ± 2) °C, physicochemical parameters: emulsion stability and acidity were determined by known methods. The acidity and stability of the emulsion of the developed mayonnaise samples were determined in accordance with the requirements of DSTU 4487: 2005 when stored for 35 days. Acidity determines the taste properties of the product and its freshness and good quality. The method of determining the acidity is based on the neutralization of an alkali solution of aqueous extracts of acids and acid salts extracted from the samples of the test product. 50 ml of distilled water are poured into the flask and 1.9… 2.1 g of the test sample is weighed. The contents are stirred in a circular motion until completely dissolved and titrated with sodium hydroxide

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solution in the presence of phenolphthalein indicator until a pale pink color is obtained that does not disappear within 1 minute. The acidity of mayonnaise was determined in terms of acetic or citric acid. The calculation was performed according to formula (1.1):

$$X = \frac{100*V*K*N}{m} \quad (1.1)$$

where V is the volume of sodium hydroxide solution used for titration, ml;

K – correction to the titer of sodium hydroxide solution;

N = 0,0060 – conversion factor to acetic acid;

m – mass of mayonnaise taken for the research, g.

To determine the stability of the emulsion, a tube was filled up to the top division with mayonnaise, placed in a centrifuge and centrifuged for five minutes at 1500 rpm. The tube was then placed in boiling water for three minutes and centrifuged again for five minutes. The stability of emulsion X as a percentage of intact emulsion by volume was calculated by the formula (1.2):

$$X = \frac{V2*100}{V1} \quad (1.2)$$

where V_2 – volume of intact emulsion, cm^3,

V_1 – volume of mayonnaise sample, cm^3.

Rheological properties are determined on a rotary viscometer Reotest 2, which provides measurement of viscosity in the range $(1.0–1.8)\cdot 10^8$ m·Pas with a relative error of not more than (3–4)% according to the manual of the device.

Structural and mechanical properties of the model emulsions and mayonnaise sauce were studied for effective viscosity on the Reotest 2 device. The experimental viscosity at different shear stresses was determined by the method of rheological curves construction and analysis.

The tangential stress was determined at different speeds of the cylinder of the device. To do this, we measured a value that is proportional to the applied tangential stress. The value of the tangential stress is calculated by the formula:

$$\tau = z \cdot \alpha, \quad (1.3)$$

where z – constant of the cylinder of the device,

α – device readings.

The value of the dynamic viscosity of the samples is calculated by the formula:

$$\eta = \left(\frac{\tau}{Dr}\right) * 100, \quad (1.4)$$

where η - dynamic viscosity, Pa·s;

τ – tangential stress, Pa;

D_r – strain rate, s^{-1}.

Ryograms dynamic viscosity – tangential stress were constructed to characterize the structure of the system. The analysis of rheograms was performed by graphical methods based on the analysis of curves.

Experimental part

Refined sunflower oil is a traditional raw material for mayonnaise sauce; egg products; acetic acid, table salt; sugar. In Ukraine, the concept of 'mayonnaise' is interpreted very broadly, and our favorite classic 'Provencal' in European countries could not be called a mayonnaise at all because of the relatively low caloric content and limited egg content. In European countries, there are clear requirements to ensure that the consumer is not misled by the name of the product. Depending on the fat content, the sauce can be called mayonnaise with a fat content of 80 %, salad mayonnaise – at 70–50 %, and salad dressing - at 49–30 % [20].

According to the recipe and purpose of mayonnaise is divided into: table mayonnaise; mayonnaise with spices; mayonnaise with flavoring and gelling additives; dietary mayonnaise.

A wide range of classic mayonnaises and sauces is presented on the Ukrainian market. Mayonnaise manufacturers in the domestic market are divided into three groups: large-scale production, medium-capacity companies with aggressive marketing policies and small regional firms.

In the first group we can note such large companies as: PJSC "Volynholding" (TM "Torchin"), PJSC "Chumak" (TM "Chumak"), PJSC "Lviv Fat Plant" (TM "Generous"), PE "Victor and K "(TM" Royal Taste "), which occupy about 40 % of the Ukrainian market. The second group includes "LTD Olis" (TM "Olis"), PJSC "Kyiv Margarine Plant" (TM "Olkom"), LLC "Prime-Product" (TM "McMay"), LLC "Delta", TM "Gulyay -pole "), LLC" Fores "(TM" Fores "). The third group holds 18 % of the mayonnaise market, they include: LLC "Best", LLC "Vista" and others [21]. In addition, PJSC "Volynholding" occupies 97 % in the market of dressings for soups and borscht, 63.4 % – in the market of ketchup, 51.9 % – in the market of sauces, 48.5 % – in the market of mustard, 23 % – in the market of mayonnaise.

In total, more than 100 enterprises produce mayonnaise in Ukraine. At the same time, there are no more than 10 large manufacturers (production volumes over 1 thousand tons per year). During the last 2010–2020 there has been a decrease in consumption of mayonnaise per capita. One of the factors in reducing the demand for it is that consumers are looking for ways to change their diet. For example, they choose mayonnaise products with lower calories and light sauces, or refuse to consume them altogether more and more often [21]. Therefore, the issue of developing low-calorie mayonnaise sauces enriched in chemical composition with high biological value, which is fully consistent with the concept of healthy eating, is becoming increasingly important.

Based on the data of Rahbari et al. [22], the main trends in expanding the range and developing new mayonnaise sauces are reducing calories by reducing the amount of fat and sugar in the recipe, and increasing the biological value by fully or partially replacing traditional ingredients with natural substances. Some of these promising non-traditional ingredients are chia seeds, raspberry puree, smoked paprika, onions, and greens. Mayonnaise sauces, which are intended for direct consumption as a seasoning, have certain requirements: bacterial purity, fairly viscous consistency and the ability not to stratify during manufacture and storage [23].

The required viscosity and stability of mayonnaise emulsions can be ensured only if all the recipe components are evenly distributed in the volume of the mayonnaise emulsion.

The stability of the emulsion is affected by the content (%) of: sunflower oil, aqueous phase, the Stabilex stabilization system. The expediency of using the Stabilex stabilization system in the production of mayonnaise sauces was determined by conducting a full three-factor experiment.

We selected such factors of the optimization of the mayonnaise sauce recipe composition: x_1 – content of vegetable oil, x_2 -content of water by recipy, x_3 – Stabilex content.

The equation of the polynomial function has the general form:

$$y=f(x_1, x_2, x_3)$$

Regression equation:

$$y= B_0 + B_1 \cdot x_1+ B_2 \cdot x_2 + B_3 \cdot x_3+ B_{12} \cdot x_1 \cdot x_2+B_{13} \cdot x_1 \cdot x_3+B_{23} \cdot x_2 \cdot x_3+B_{123} \cdot x_1 \cdot x_2 \cdot x_3$$

The required number of experiments is 8. The normalized initial regression equation is:

$$y= B_0 + B_1 \cdot z_1+ B_2 \cdot z_2 + B_3 \cdot z_3+ B_{12} \cdot z_1 \cdot z_2+B_{13} \cdot z_1 \cdot z_3+B_{23} \cdot z_2 \cdot z_3+B_{123} \cdot z_1 \cdot z_2 \cdot z_3$$

Table 1 shows the range of changes in the selected optimization factors.

Table 1

Table of changes in the range of optimization factors

Levels of factor variation	Denotation	Factors		
		x_1,%	x_2,%	x_3,%
Upper	+	40	60	3.0
Middle	0	35	65	2.5
Lower	-	30	70	2.0
Step	Δ	5	5	0.5

Number of parallel experiments: m=3

According to the plan of the experiment, the determined composition of the model samples is given in Table. 2

Table 2

Composition of model samples

№ sample	Oil content	Water content	Stabilex content
1	40	60	3.0
2	40	60	2.0
3	40	70	3.0
4	40	70	2.0
5	30	60	3.0
6	30	60	2.0
7	30	70	3.0
8	30	70	2.0

The model samples were made as follows: Stabilex was introduced into the required amount of water with stirring, and oil was introduced in small portions after dissolution. A matrix of the complete three-factor experiment is compiled, which is given in Table. 3:

Table 3

Matrix of three-factor experiment

№ Experiment	Variable factors X_1	X_2	X_3	Value of experiment y_1	y_2	y_3	y_i average	Value of variance
1	+	+	+	100	100	100	100	0
2	+	+	-	100	100	100	100	0
3	+	-	+	100	100	100	100	0
4	+	-	-	98	99	99	98.6	0.34
5	-	+	+	97	97	98	97.6	0.34
6	-	+	-	97	98	99	97.6	0.34
7	-	-	+	96	96	97	96.3	0.135
8	-	-	-	94	95	96	95	1.0

As optimization factors: X1-vegetable oil content, X2 -water content, X3-Stabilex content, B-emulsion stability index. The given matrix of the full-factor experiment allows to determine the value of the optimization parameter (U) for all possible variations of the levels of variables (Xi) factors. The obtained values of optimization parameters (UI) for each experiment allow to determine the type of function and calculate the coefficients of the regression equation.

The obtained data were further processed using statistical analysis to obtain a regression equation that could be used to model sauce recipes.

Decoding of input and output parameters.

$$y= 98.75+1.075\cdot x_1+0.6\cdot x_2+ 0.5\cdot x_3-0.425\cdot x_1\cdot x_2$$

The required stability of the mayonnaise emulsion is set at 97 %, (according to the requirements of DSTU 4487) the amount of vegetable oil by the recipy – 35 %, the amount of water by the recipy – 56 %. Then the required amount of the Stabilex stabilization system is calculated, which is:

$$97 = 98.75 +1.075\cdot x_1+0.6\cdot x_2 + 0.5\cdot x_3 -0.425\cdot x_1\cdot x_2$$

$$97=98.75 +1.075\cdot 35+0.6\cdot 56+ 0.5\cdot x_3 - 0.425\cdot 35\cdot 56$$

$$X_3 = 2.6\ \%$$

Given the results of research, for the production of mayonnaise sauce with stability (B) at least 97 %, (X1) 56 % water, (X2) 35 % refined oil, (X3) 2.6 % the Stabilex stabilization system should be added.

The calculated content of recipe components was selected for the research samples of mayonnaise sauces. This calculated ratio provides the necessary organoleptic characteristics and viscosity of the mayonnaise emulsion.

The recipe composition of mayonnaise sauces is shown in Table. 4.

Table 4

Recipe composition of mayonnaise sauces

Name of recipe components	Content of recipe components, %			
	Control (Salade)	Sample № 1 (with chia and raspberries)	Sample № 2 (with smoked paprika)	Sample № 3 (with dried greens)
Refined sunflower oil	35	35	35	35
Stabilex stabilization system	-	2.6	2.6	2.5
Skimmed milk powder	2.5	-	-	-
Egg powder	6.0	-	-	-
Mustard powder	0.75	-	-	-
Chia seeds	-	1.25	-	-
Raspberry puree	-	1.25	-	-
Smoked paprika	-	-	2.5	-
Dried greens	-	-	-	2.5
Sugar	2.5	2.2	2.2	2.2
Salt	2.0	1.1	1.1	1.1
Baking soda	0.05	-	-	-
Optic acid (80 %)	1.25	-	-	-
Citric acid	-	0.3	0.3	0.3
Water	49.95	56.3	56.3	56.4
Total	100	100	100	100

One of the important indicators of the quality of mayonnaise sauces is the stability of the emulsion, namely the sedimentation resistance, which is determined by the dispersion of the emulsion particles, the homogeneity of the obtained phases, as well as the viscosity of the medium.

The research results are shown in Table 5.

Table 5

Stability of emulsion of developed mayonnaise sauces during storage

Expiration date	Stability of mayonnaise sauce emulsion, %			
	Control (Salade)	Sample № 1 (with chia and raspberries)	Sample № 2 (with smoked paprika)	Sample № 3 (with dried greens)
1 day	99	99	100	100
7 days	97	99	100	100
14 days	96	99	100	99
21 days	94	99	100	99
28 days	94	99	100	98
35 days	94	98	100	97

Table 5 shows that the value of the developed mayonnaise sauces emulsion stability decreases during storage for 35 days, but does not reach the critical values set in the regulatory and technical documentation [24].

Such research results were expected, as the research samples included the Stabilex stabilization system. After 35 days of storage, the stability of the mayonnaise sauce emulsion of №2 was 100%, while of the control one was 94 %. This is due to the better structure formation for low-fat mayonnaise sauces with the introduction of Stabilex.

It is believed that the structure formation in emulsion systems occurs within a day from the date of manufacture, and the deadline for research is related to the shelf life of the product, so the time interval chosen for research was 24 hours after making samples and after 35 days of storage.

The obtained rheological flow curves of mayonnaise sauces are shown in Fig. 1.

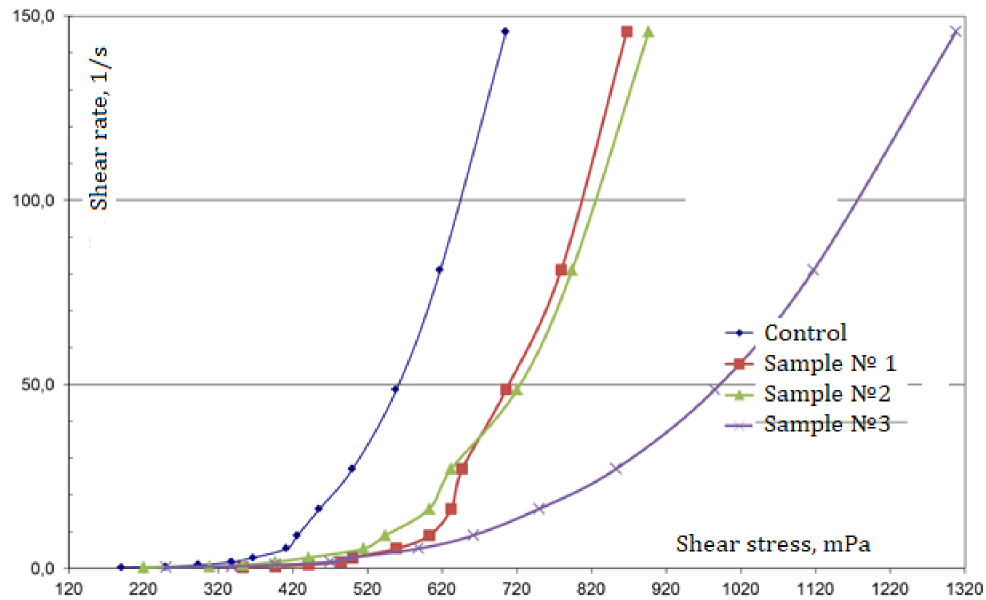

Fig.1. Rheological curves of mayonnaise sauce flow, 24 hours after manufacture

Analysis of the rheological flow curves of mayonnaise sauces samples shows that all test samples belong to non-Newtonian fluids with a pseudoplastic flow model, i.e. the viscosity decreases with increasing shear stress.

For the mayonnaise sauces developed, the experimental values are the flow index, the stress of the virtually intact and completely destroyed system, and the corresponding viscosities. The results of determining these indicators are presented in Table 6.

Table 6

Characteristic values of developed fresh mayonnaise sauces rheological indicators (24 hours after manufacture)

Indicator	Control (Salad)	Sample № 1 (with chia and raspberries)	Sample № 2 (with smoked paprika)	Sample № 3 (with dried greens)
Stress of practically intact system, N / m²	170	420	440	430
Viscosity of practically intact system, mPa·s	4.4	7.2	8.1	6.9
Stress of practically destroyed system, N / m²	350	580	610	590
Viscosity of practically destroyed system, mPa·s	0.58	0.53	0.56	0.55

The obtained data show that the best rheological indicators belong to sample №1 (mayonnaise sauce with chia seeds and raspberry puree), while samples № 2 (with smoked paprika) and №3 (with dried greens) have close values, and the control sample has the worst values.

The obtained rheological flow curves of the developed mayonnaise sauces samples after 35 days of storage are presented in Fig. 2.

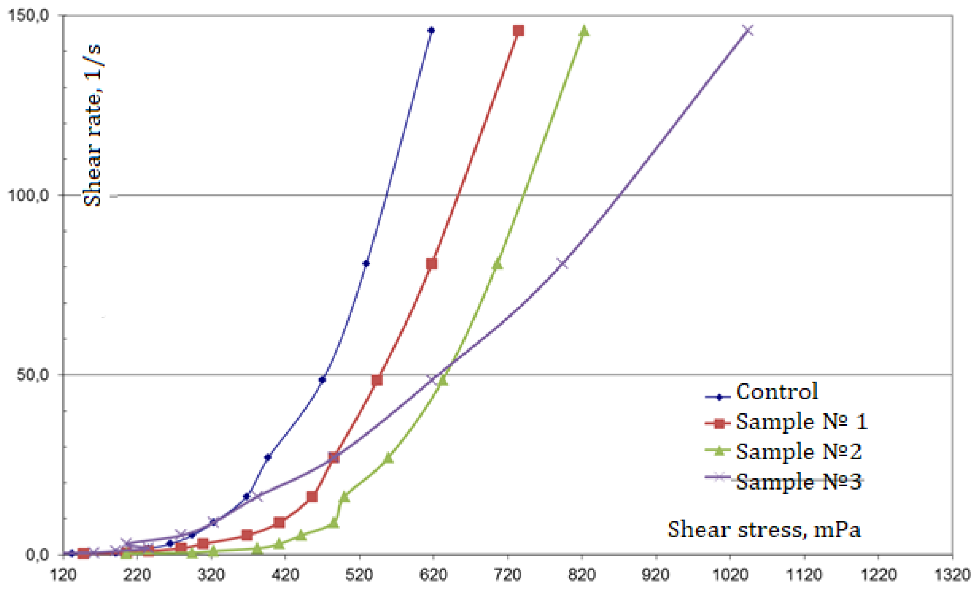

Fig. 2. Rheological flow curves of mayonnaise sauces samples after 35 days of storage

After analyzing the results of research, it was found that during storage the viscosity of mayonnaise sauces decreased. This is due to the negative impact of gravitational forces over time on the emulsion system. For these samples of mayonnaise sauces, characteristic rheological values were determined, such as the flow index, the stress of the virtually intact and completely destroyed system, and the corresponding viscosities.

A comparative analysis of the properties of the sauce with chia seeds and the Stabilex stabilization system included into the recipy showed that chia seeds in contact with water form mucus which together with the hydrocolloids of the stabilization system protected the emulsion oil droplets from coalescence. This provides better resistance of the mayonnaise emulsion to gravity, so the viscosity for sample №1 better than the control one, but slightly inferior to samples №2 and №3 (Table 7).

The viscosity of the practically intact emulsion (initial) of the sample №1 is 260 MPa·s. This may be due to the deformation and destruction of the drops of vegetable oil to which the stress was applied during the structure formation, which in turn leads to a decrease in viscosity.

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Table 7

Characteristic values of rheological indicators of developed mayonnaise sauces after 35 days of storage

Показник	Control (Salad)	Sample № 1 (with chia and raspberry)	Sample № 2 (with smoked paprika)	Sample № 3 (with dried greens)
Stress of practically intact system, N / m²	110	6.1	8.1	9.1
Viscosity of practically intact system, mPa·s	3.1	260	430	340
Stress of practically destroyed system, N / m²	200	0.41	0.45	0.48
Viscosity of practically destroyed system, mPa·s	0.32	0.53	0.45	0.40

The obtained research results coincide with the studies of McClements, 2015 [25] and Fernandes & Mellado 2017 [26]. They found that partial replacement of egg yolk with chia seed mucus reduced the viscosity of the sauce. However, the cc of the Stabilex stabilization system and these types of non-traditional raw materials in the recipes of mayonnaise sauces can improve the viscosity of the product. This is due to better structuring, increased molecular bonds, and the formation of a surface film. The results of our research coincide with the research of Mun, S.; 2009 [27].

The acidity index is one of the important physicochemical indicators that characterize the quality of mayonnaise sauces, so the influence of the recipe composition on this factor has been studied.

Mayonnaise sauce, due to the content of 35% emulsified oil and a significant amount of prescription water, is prone to spoilage due to auto-oxidation, and its stability depends on the type of oil used [28; 29]. The use of ingredients according to the developed recipes with the Stabilex stabilization system allows to obtain mayonnaise sauces with high rheological characteristics and stability of the emulsion [30–32].

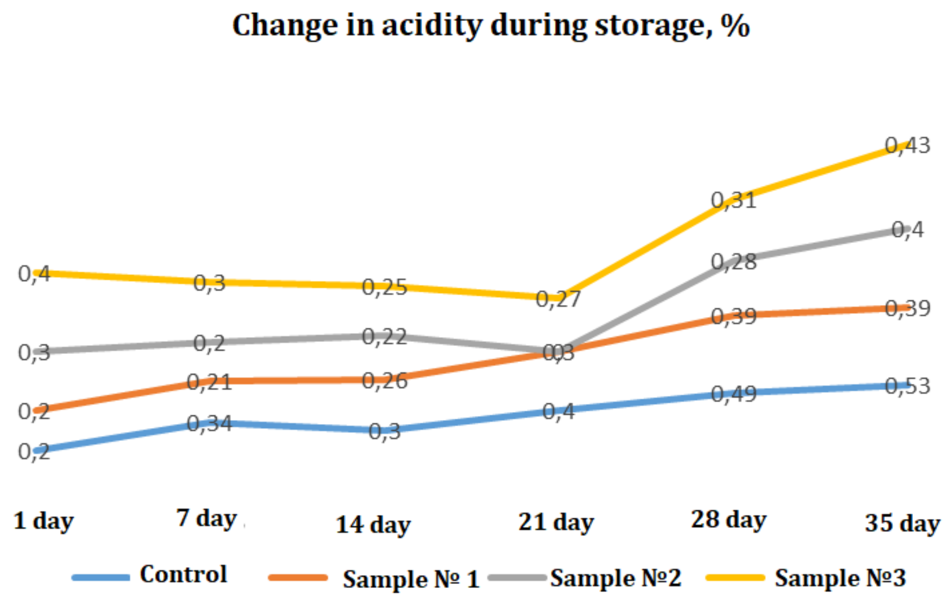

Fig.3. Mayonnaise sauces acidity changing

Analyzing the data on changes in the acidity of mayonnaise sauces during storage, it was found that the increase in acidity during storage of mayonnaise sauces can occur for several reasons, first due to possible oxidation of vegetable oil included in the recipe, and to hydrolysis of fat phase under the influence of prescription water (Fig. 3). Therefore, it can be concluded that the highest acidity values of mayonnaise sauces do not exceed the permissible levels according to the requirements of DSTU 4487-2005.

An organoleptic assessment of the quality of mayonnaise sauces was also performed in accordance with the requirements of DSTU 4487-

2005 for developed mayonnaise sauces. The research results are shown in table 8.

Table 8

Organoleptic characteristics of mayonnaise sauces

Name of indicator	Characteristic
Control (Salad)	
Appearance, consistence	Homogeneous sour cream-like product with single powder puffs
Taste and smell	The taste is a little sour, without pronounced bitterness. The flavor characteristic of egg products is felt.
Color	Light yellow, throughout the mass
Sample № 1 (with chia and raspberries)	
Appearance, consistence	Homogeneous product of the consistency of thick sour cream, without air bubbles
Taste and smell	The taste is a little sour without bitterness. No extraneous flavors.
Color	With a pinkish tinge, uniform throughout the mass
Sample № 2 (with smoked paprika)	
Appearance, consistence	Homogeneous product of the consistency of thick sour cream
Taste and smell	The taste is pleasant, without pronounced bitterness. No extraneous flavors.
Color	White, uniform, orange color is present.
Sample № 3 (with greens)	
Appearance, consistence	Homogeneous product of the consistency of thick sour cream, without air bubbles
Taste and smell	The taste is a little sour, without bitterness. No extraneous flavors.
Color	With a green tinge, homogeneous.

The analysis of the obtained data shows that all the samples had organoleptic properties characteristic of this type of product. It should be noted that for samples №2 and №3 the taste characteristics were better and more liked by tasters. For the developed samples of mayonnaise sauces, tasting was performed to determine the tasting score in points (Table 9).

Table 9

Organoleptic evaluation of developed mayonnaise sauces (in points)

Name of indicator	Control (Salad)	Sample № 1 (with chia and raspberry)	Sample № 2 (with smoked paprika)	Sample № 3 (with dried greens)
Appearance	5	5	5	4
Color	4	5	5	5
Smell	5	5	4	4
Consistence	5	5	5	5
Taste	4	5	5	5

The Tasting Commission of ten members noted that all developed mayonnaise sauces had the appearance, color, consistence, smell and taste characteristic of mayonnaise products and met the requirements of DSTU 4487: 2015 'Mayonnaise and mayonnaise sauces. General technical conditions' [24] for this product.

Conclusions

1. The expediency of using the Stabilex stabilization system in the recipe compositions of mayonnaise sauces is substantiated by the method of mathematical modeling. To obtain the stability of the mayonnaise emulsion (not less than 97 %) in accordance with the regulations, it is necessary to add 56% water, 35 % refined oil, 2.6 % Stabilex stabilization system.

2. It was found that the introduction of non-traditional components (chia seeds 1.25 % and raspberry puree 1.25 %, smoked paprika 2.5 %, and dried greens 2.5 %) to mayonnaise sauces recipes improved the quality of sauces and expanded the range of products.

3. The studies have shown that the organoleptic, physicochemical and rheological properties of the developed mayonnaise sauces are better than the control sample and meet the requirements of regulatory documentation for this type of product.

4. The obtained data on changes in quality indicators during storage of developed sauces for 35 days are important in the technology of mayonnaise sauces, as they characterize structural changes, and therefore allow to predict the quality of the finished product.

References

[1] Orgulloso-Bautista, S., Ortega-Toro, R., Alberto, L., Zapateiro, G. (2021). Design and Application of Hydrocolloids from Butternut Squash (Cucurbita moschata) Epidermis as a Food Additive in Mayonnaisetype Sauces. *ACS Omega,* 6, 5499–5508. doi/ 10.1021/acsomega.0c05852.

[2] Muhialdin, B. J., Mohammed, N. K., Cheok, H. J., Farouk, A. E. A., Meor Hussin, A. S. (2021). Reducing microbial contamination risk and improving physical properties of plant-based mayonnaise produced using chickpea aquafaba. *International Food Research Journal,* 28(3), 547 – 553.

[3] Ma, Z., Boye, J. I. (2013). Advances in the design and production of reduced-fat and reduced-cholesterol salad dressing and mayonnaise: a review. *Food and Bioprocess Technology*, *6*(3), 648–670. doi.org/10/007/s11947-012-1000-9.

[4] Techer, C., Daoud, A., Madec, M. N., Gautier, M., Jan, S. and Baron, F. (2015). Microbial quality of industrial liquid egg white: assumptions on spoiling issues in egg-based chilled desserts*. J Food Sci, 80*(2), 389-39. doi: 10.1111/1750-3841.12764.

[5] Rodrigue, D. C., Tauxe, R. V. and Rowe, B. (1990). International increase in Salmonella enteritidis: a new pandemic? *Epidemiology and Infection,* 105(1), 21-27. DOI.org/10.1016/0168-1605(94)90207-0.

[6] Pizzolante, C. C. (2012). O ovo e o mito do colesterol*. Pesquisa & Tecnologia*, 9, 1. [Elektronnyi resurs]. – Rezhym dostupu: http://www. ovosrs.com.br/_files/view.php/load/pasta/9/579a105 6adbfd.pdf>

[7] Nikzade, V., Tehrani, M.M., Saadatmand-Tarzjan M. (2012). Optimization of low-cholesterol-low-fat mayonnaise formulation: effect of using soy milk and some stabilizer by a mixture design approach. *Food Hydrocolloids*, *28*(2), 344-352. doi: 10.1016/j.foodhyd.2011.12.023.

[8] Santos Alves, J. dos, Souza, A., Karine, R., Bolson Moro, I., Pagnossim Boeira, C., Tasch Holkem, A., Roggia, I., Grigoletto Londero, P. M., Severo da Rosa, C. (2021). Elaboration of mayonnaises containing landrace common bean flour as a partial egg yolk substitute. *Ciência Rural, Santa Maria*, 51:9, 20200543. doi.org/10.1590/0103-8478cr2020054.

[9] Lorenzo, G., Zaritzky, N., Califano, A. (2008). Modeling rheological properties of low-in-fat o/w emulsions stabilized with xanthan/guar mixtures. *Food Res. Int.,* 41, 487–494. doi:10.1016/j.foodres.2008.02.005.

[10] Felix da Silva, D., Vlachvei, K., Geng, X., Ahrné, L., Ipsen, R., Hougaard, A. B. (2020). Effect of cheese maturation on physical stability, flow properties and microstructure of oil-in-water emulsions stabilised with cheese powders. *Int. Dairy J.*, 103, 104630. doi.org/10.1016/j.idairyj.2019.104630.

[11] Bajaj, R. Singh, N. Kaur, A. (2019). Properties of octenyl succinic anhydride (OSA) modified starches and their application in low fat mayonnaise. *Int. J. Biol. Macromol*, 131, 147–157. doi: 10.1016/j.ijbiomac.2019.03.054.

[12] Khan, W. A. Butt, M. S. Pasha, I. Saeed, M. Yasmin, I. Ali, M. Khan, M. S. (2020). Bioavailability, rheology, and sensory evaluation of mayonnaise fortified with vitamin D encapsulated in protein-based carriers. *J. Texture Stud.*, 51, 955. doi: 10.1111/jtxs.12555.

[13] Jafari, S. M., Beheshti, P., Assadpoor, E. (2012). Rheological behavior and stability of d-limonene emulsions made by a novel hydrocolloid (Angum gum) compared with Arabic gum. *J. Food Eng*., 109, 1–8. doi:10.1016/j.jfoodeng.2011.10.016.

[14] Zhbanova E. (2018). Fruit of raspberry Rubus Idaeus L. as a source of functional ingredients (review). *Tekhnyka y tekhnolohyia pyshchevykh proyzvodstv, 48*(1), 5–14. doi.org/10.21603/2074-9414-2018-1-5-14.

[15] Metri-Ojeda, J.C., Pérez-Alva, A., Recio-Cazares, S.L., Baigts-Allende, D.K. (2020). Physicochemical and sensorial characterization of vegan mayonnaise using chia seed oil and mucilage (Salvia hipanica L.). *Investigación y Desarrollo en Ciencia y Tecnología de Alimentos,* 5, 485–489.

[16] Fernandes, S. S., Mellado, M. de las M. S. (2017). Development of Mayonnaise with Substitution of Oil or Egg Yolk by the Addition of Chia (Salvia Hispânica L.) Mucilage. *Journal of Food Science*, 83(1), 74–83. doi:10.1111/1750-3841.13984.

[17] Julio, L. M., Copado, C. N., Diehl, B. W. K., Ixtaina, V. Y., & Tomás, M. C. (2018). Chia bilayer emulsions with modified sunflower lecithins and chitosan as delivery systems of omega-3 fatty acids. *LWT - Food Science and Technology*, 89, 581–590. doi:10.1016/j.lwt.2017.11.044.

[18] Soukoulis, C., Gaiani, C., Hoffmann, L. (2018). Plant seed mucilage as emerging biopolymer in food industry applications. *Current Opinion in Food Science*, 22, 28–42. doi:10.1016/j.cofs.2018.01.00.

[19] Razavi, S. M. A. (2019). Introduction to Emerging Natural Hydrocolloids. *Emerging Natural Hydrocolloids*, 1–52. DOI:10.1002/9781119418511.ch1.

[20] Bozhko, T., Danchevska, R., Shapovalova, N. (2019). Rynok sousnoi produktsii: determinanty rozvytku v Ukraini. *Tovary i rynky,* 4, 26–39. doi.org/10.31617/tr.knute.2019(32)03).

[21] [Rating mayonnaise in Ukraine 2021/2022: what mayonnaise is the best and healthiest for health]. (2020). https://fdlx.com/all/society/114923-rejting-majoneza-v-ukraine-2019-2020-kakoj-majonez-samyj-luchshij-i-poleznyj-dlya-zdorovya.html**.**

[22] Rahbari, M. Aalami, M., Kashaninejad, M., Maghsoudlou Y., Ameri Ashdaei, S.S. (2014). A mixture design approach to optimizing low cholesterol mayonnaise formulation prepared with wheat germ protein isolate*. Journal of Food Science and Technology*, *52*(6), 3383–3393, doi: 10.1007/ s13197-014-1389-4.

[23] Peshuk L., Simonova I., Halukh B. (2020). Quality management and safety control of semi-finished production in the context of the haccp system. *Specialized and multidisciplinary scientific researches: Collection of scientific papers «ΛΌΓΟΣ» with Proceedings of the International Scientific and Practical Conference, 2*(1), 35–38. doi 10.36074/11.12.2020.v2.09

[24] DSTU 4487:2015 «Maionezy ta maionezni sousy. Zahalni tekhnichni umovy».

[25] McClements, D. J. (2015). Food emulsions: Principles, practices, and techniques. *CRC Press*, 2, 714. doi.org/10.1201/b18868.

[26] Fernandes, S. S., Mellado, M. de las M. S. (2017). Development of Mayonnaise with Substitution of Oil or Egg Yolk by the Addition of Chia (Salvia Hispânica L.) Mucilage*. Journal of Food Science*, 83(1), 74–83. doi:10.1111/1750-3841.13984.

[27] Mun, S., Kim, Y.-L., Kang, C.-G., Park, K.-H.,Shim, J.-Y., Kim, Y.-R. (2009). Development of reduced-fat mayonnaise using 4αGTasemodified rice starch and xanthan gum. *Int. J. Biol. Macromol*, 44, 400–407. doi: 10.1016/j.ijbiomac.2009.02.008.

Journal of Chemistry and Technologies, 2022, *30*(2), 253-264

[28] Peshuk, L.V., Nosenko, T.T. (2008).*Biokhimiia ta tekhnolohiiai oliie-zhyrovoi syrovyny: Navch.posib*. K.: NUKhT.

[29] Depree, J. A., Savage, G. P. (2001). Physical and flavour stability of mayonnaise. *Trends Food Sci. Technol*, 12, 157–163. doi.org/10.1016/s0924-2244(01)00079-6.

[30] Nikzade, V., Tehrani, M. M., Saadatmand-Tarzjan, M. (2012). Optimization of low-cholesterol–low-fat mayonnaise formulation: Effect of using soy milk and some stabilizer by a mixture design approach. *Food Hydrocolloids*, 28, 344–352. doi:10.1016/j.foodhyd.2011.12.023.

[31] Peshuk, L.V., Bakhmach, V.O., Horbach, O. Ia. (2017). Perspektyvy vykorystannia roslynnykh i tvarynnykh bilkiv v tekhnolohii miasnykh produktiv. *Naukovyi visnyk Lvivskoho natsionalnoho universytetu veterynarnoi medytsyny ta biotekhnolohii im. S.Z. Gzhytskoho*, *19*(80), 68–73. doi:10.15421/nvlvet8014

[32] Bakhmach, V.O., Peshuk, L.V. (2015). Udoskonalennia tekhnolohii maioneziv z vykorystanniam roslynnoi syrovyny. Kharchova promyslovist: - K.: NUKhT, 18, 27–31.