Research of the stability of low-calorie mayonnaises and development of their formulation

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Abstract. New formulation of mayonnaise using biologically active additives and surface-active substances have been studied. The stability features of new formulation of mayonnaise at different fat contents have been analyzed. The organoleptic indicators and physical-chemical characteristics of low-calorie mayonnaises with new types of food additives and thickeners have been established by offering optimal technological modes that ensure high quality and long-term preservation of low-calorie mayonnaises. The research results have been recommended for industrial application. When developing mayonnaise recipes with different fat phase contents and a reduced amount of egg powder, it was necessary to preserve, in addition to stability, the taste of the product. The use of milk concentrate as an emulsion thickener instead of egg powder leads to a fivefold increase in the limit of plastic strength of mayonnaise at 65% fat phase content. Dairy concentrates can be recommended for targeted regulation of the structural and rheological properties of low-calorie mayonnaises in a wide temperature range.

1 Introduction

One of the most important conditions for the production of high-quality mayonnaise is research of the properties of raw materials and products from them. The set of features of mayonnaise, which appear during development, production and consumption, determines its ability to satisfy certain needs in accordance with its purpose and constitutes its quality. These indicators of mayonnaise, characterized mainly by quantitative assessments of its properties, can be forecasted, projected, normative and actual.

The biological and nutritional value of mayonnaise is determined by its nutrient composition, i.e., the content of proteins, fats, carbohydrates, minerals, vitamins, as well as physical-chemical and organoleptic properties.

Vegetable fats are not only a medium in which biologically active substances, including vitamins, are dissolved, but they themselves influence the degree of assimilation of these substances and the effectiveness of the biological impact. Antioxidant, provitamin and radioprotective properties of biologically active lipids allow increasing the nutritional and biological value of food products [1-3].

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Natural antioxidants - tocopherol, quercetin, etc. significantly reduce oxidative processes in products, the introduction of them allows to double the shelf life of fatty products.

Technological and technical capabilities of the oil-and-fat industry allow producing specialized fat products of the required composition with different ratios of saturated and polyunsaturated fatty acids, including low-calorie products. In order to reduce the calorie content of fatty products, it is possible to use starch, cellulose, dietary fiber, proteins and other substances that have low calorie content [2-4].

When producing complete food products with the formation of specified functional properties in them, it is necessary to consider the basic provisions of the composition of fatty acids, triglyceride acids, their chain length and spatial configuration [5].

2 Methodology

Research on the preparation of mayonnaise was carried out in laboratory and pilot production conditions. Laboratory studies were carried out on the installation, which is shown in Fig. 1

Fig. 1. Laboratory installation for mayonnaise production 1- control device, 2- mixing device, 3, 5, 6- nozzles, 4- faucet, 7- tank.

The design of the unit is made entirely of food grade stainless steel. Technical characteristics of the installation are given in table 1.

Table 1. Technical characteristics of the installation.

Bath volume, not less, l	2.20
Time for heating the product to pasteurization temperature, no more than, min	60
Maximum product heating temperature, C°	95
Time for heating the product to pasteurization temperature, no more than, min	60
Mixer rotation speed, rpm	35
Diameter of the finished product supply pipeline, mm	35
Installed power, kW	34.0
Overall dimensions, no more than, mm	11.50x15.50x16.50
Weight, no more than, kg	2.30

The technological process provided the creation of optimal conditions that allow obtaining uniform (close to homogeneous) and stable system from components practically

insoluble in each other (oil-water). Factors such as the concentration of dry components and the intensity of mechanical action have been also considered.

The production of mayonnaise consisted of the following technological operations:

- Preparation of a 10% solution of acetic acid
- Preparation and dosing of bulk components.
- Preparation of paste (emulsifying and structuring base);
- Preparation of rough emulsion (homogenization).
- Prepacking and packing of the finished product.
- Transportation of finished products to the warehouse.

The quality of mayonnaise was assessed according to GOST 30004.1-93 "Mayonnaise. General technical conditions". Mayonnaises were assessed by taste and smell, consistency, color, fat content, moisture, acidity, and emulsion stability.

According to GOST 30004.1-93 "Mayonnaise. General technical conditions", appearance and consistency of mayonnaise is a homogeneous creamy product with a few air bubbles. The presence of particles of additives, pinpoint inclusions of mustard in accordance with the technical description for mayonnaise of a specific name. Taste and smell were in accordance with the technical description for mayonnaise of a specific name, the color is white or creamy yellow, uniform throughout the mass with the shades established in the technical descriptions for specific names of mayonnaise.

Defects in mayonnaise include separation of the emulsion, the presence of a large number of air bubbles, rancid taste, and uneven color.

The quality of mayonnaise was determined by the following indicators:

- organoleptic;
- physical and chemical;
- microbiological;

The following organoleptic indicators have been determined: appearance, consistency, taste and smell, color. Mayonnaise must be a creamy product, single air bubbles are allowed, the presence of particles of added spices, mustard seasonings is allowed in accordance with the technical description of the mayonnaise of a specific name. The color of mayonnaise should be white or creamy yellow, uniform throughout the mass with the shades indicated in the technical descriptions. Taste and smell must also correspond to the technical description for a specific type of product. [4]

Physical-chemical indicators include the mass fraction of fat, moisture, table salt, sorbic acid, acidity in terms of acetic or citric acid, emulsion stability, pH value, and effective viscosity.

The mass fraction of fat in high-calorie mayonnaise was more than 55%, medium-calorie – 40-55%, low-calorie – less than 40%. The mass fraction of moisture, common salt, sorbic acid, and acidity were determined by the technical description of a specific type of mayonnaise. The stability of the emulsion of high-calorie and medium-calorie mayonnaise should be at least 98%, and for low-calorie mayonnaise at least 97%. pH value is 4.0-4.7. Effective viscosity is 5.0-20.0 Pa*s. [6-8]

From microbiological indicators, the following are normalized: bacteria of group of colon bacillus (coliforms) are not allowed in 0.01g; pathogenic microorganisms, including salmonella, are not allowed in 25 g; yeast is no more than 1000 CFU in 1 cm, mold is no more than 10 CFU. The most important defect of mayonnaise is the separation of the emulsion, as a result of which fat is released from the mass. The separation of mayonnaise is a consequence of the destruction of the emulsion. The essence of this process is the violation of the integrity of the protein shells of the emulsifier around the dispersed droplets of fat under the influence of unfavorable factors: sudden changes in storage temperatures, non-compliance with temperature conditions, etc. In this case, individual drops of oil, not limited by the shells of the emulsifier, merge, a layer of oil is released and the mayonnaise stratifies.

In addition, mayonnaise defects include: the presence of a large number of air bubbles; rancid taste caused by spoilage of the fat base; a taste unusual for mayonnaise caused by spoilage of the fat base; tastes and odors of various origins that are unusual for mayonnaise; heterogeneity of color. The examination of mayonnaise was carried out mainly to identify falsification of the mass fraction of fat, which is one of the reasons for the unjustified increase in the price of low-calorie mayonnaise. Vegetable oil in mayonnaise was partially replaced by adding starch or starch products that increase the viscosity of mayonnaise. This increases the effective viscosity of the product. A qualitative reaction to the addition of starch is the reaction with iodine. The freshness of mayonnaise was judged by organoleptic indicators, and the pH value was also determined. As a result of hydrolytic and oxidative reactions of the fat base, free fatty acids accumulate and the pH value increases. For dietary mayonnaise, it is important to determine the mass fraction of common salt, which is due to its purpose.

3 Results and discussion

Samples of mayonnaise prepared according to the following formulation have been studied. When developing formulations for mayonnaise with different contents of the fat phase and a reduced amount of egg powder, it was necessary to preserve, in addition to stability, the taste of the product. For the preparation of mayonnaise, raw materials were used, the chemical characteristics of which are given in Table 2. When 5% natural casein concentrate is introduced into the mayonnaise recipe as a stabilizer, it can be said that mayonnaise with a fat phase content of 65% and 5% milk concentrate has a very thick consistency.

Table 2. Formulations of mayonnaise with effective additives.

Components	**Code of mayonnaise**				
	Content, %				
	"Provencal"	**2**	**3**	**4**	**5**
Vegetable oil	65.4	65.0	46.0	50.0	40.0
Egg powder	5.0	2.5	2.5	-	-
Skimmed milk powder	1.6	1.6	1.6	1.6	1.6
Granulated sugar	1.5	1.5	1.5	1.5	1.5
Salt	1.1	1.1	1.1	1.1	1.1
Soda	0.05	0.05	0.05	0.05	0.05
Mustard powder	0.75	0.75	-	0.75	0.75
Acetic acid 80%	0.6	0.6	-	0.6	0.4
Lemon acid	-	-	0.4	-	-
Dairy concentrates	-	0.1	0.5	5.0	5.0
Water	24.0	26.8	46.35	39.4	49.6

Table 3. Indicators of additives in mayonnaise recipe.

Product Name	**The name of indicators**					
	Humidity, %	**Solubility, %**	**Content of protein substances, %**	**Acidity, %**	**pH**	**Fat content, %**
Skimmed milk powder	3.56	99.0	36.0	19.0	7.15	-
Egg powder	6.6	80.3	35.8	8.0	7.94	35
Mustard powder	7.2	-	43.5	-	-	13
Vegetable oil	According to GOST 1129-73					
Granulated sugar	According to GOST 21-57					

When the content of the fat phase is reduced to 40%, the adhesion forces between the particles of the dispersed phase weaken, and a homogeneous emulsion is formed. Mayonnaise with a fat phase content of 40% and 5% milk concentrate is not inferior in its organoleptic properties to the control sample.

The use of concentrate of milk as an emulsion thickener instead of egg powder leads to a fivefold increase in the limit of plastic strength of mayonnaise at 65% fat phase content. By reducing the fat content in mayonnaise, for example, to 50% using milk concentrate, emulsions can be obtained while maintaining their standard rheological properties and degree of dispersion.

The introduction of milk concentrate instead of egg powder has a more complex effect on plastic strength. At 65% fat content, the introduction of milk concentrate has a plasticizing effect on the emulsion. However, as the oil concentration decreases, it increases sharply. Apparently, this effect is associated with an increase in the viscosity of the milk concentrate solution with a decrease in pH as a result of the ionization of amino groups in casein macromolecules.

During the storage of mayonnaise, in addition to changes of microbiological origin, physical and chemical processes occur that lead to changes in the quality of fats and their organoleptic characteristics. The degree of these changes depends on the composition, production technology, and storage conditions of the emulsions.

Therefore, in the work it was considered necessary to study the physical-chemical, structural and rheological changes occurring in mayonnaise using new types of milk concentrates as a structure former during storage at different temperature conditions. This data is necessary to establish the optimal modes and shelf life of mayonnaise.

For the research, a batch of mayonnaise of varying degrees of fat content was produced and stored at 2 temperature conditions: at room temperature 18-20 °C and cooled at 3-7 °C. The study was carried out after 0, 10, 15 and 20 days of storage. The following indicators of mayonnaise quality were determined: emulsion stability, titratable acidity in terms of the predominant acid, as well as organoleptic indicators [9].

The stability of the emulsion structure of mayonnaises during storage was determined after 0, 10, 15 and 20 days experimentally (by centrifugation) and organoleptically. During organoleptic analysis, it turned out that mayonnaise stored at room temperature on the 10^{th} day observed the release of a dispersion medium, and by the end of storage (20 days) the system liquefied. Nevertheless, mayonnaises stored at 3-7 °C remained stable throughout the entire period. During the experimental study, it was established that mayonnaise stored at a temperature of 3-7 °C during centrifugation releases only the fatty phase, the amount of which increases slightly towards the end of storage, which does not exceed the permissible value for the industrial production of mayonnaise.

Thereby, storing mayonnaise at a temperature of 3-7 °C ensures the necessary stability of the emulsion structure for 20 days of storage for all tested samples.

Table 4. Stability of mayonnaise with 65.4 % fat content during storage.

Storage, days	Temperature of the storage, °C	In the static condition		At centrifuging	
		Amount of released liquid phase, %	Amount of released liquid phase, %	Amount of released liquid phase, %	Amount of released liquid phase, %
0	18-20	0	0	0	0
10	3-7	0	0	0	0.1
15		0	0	0	0.15
20		0	0	0	0.2
10	18-20	0.1	0	0.2	0

15		0.3	0.2	0.8	1.5
20	Removed from storage				

The results of determining the stability of mayonnaises stored at room temperature 18-20 °C indicate destabilization of the systems. These data correlate well with the results of rheological studies; therefore, room temperature storage of mayonnaises does not ensure the stability of the emulsion structure.

Table 5. Stability of mayonnaise with 65.0 % fat content during storage.

Storage, days	**Temperature of the storage, °C**	**In the static condition**		**At centrifuging**	
		Amount of released liquid phase, %	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**
0	18-20	0	0	0	0
10	3-7	0	0	0	0.1
15		0	0	0	0.1
20					0.2
10	18-20	0.1	0	0.3	1.2
15		0.3	0.1	0.5	1.5
20	Removed from storage				

Table 6. Stability of mayonnaise with 65.4 % fat content during storage.

Storage, days	**Temperature of the storage, °C**	**In the static condition**		**At centrifuging**	
		Amount of released liquid phase, %	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**
0	18-20	0	0	0	0
10	3-7	0	0	0	0.15
15		0	0	0	0.20
20		0	0	0	0.25
10	18-20	0.1	0	0.2	0
15		0.3	0.2	0.8	1.5
20	Removed from storage				

Table 7. Stability of mayonnaise with 65.0 % fat content during storage.

Storage, days	**Temperature of the storage, °C**	**In the static condition**		**At centrifuging**	
		Amount of released liquid phase, %	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**
0	18-20	0	0	0	0
10	3-7	0	0	0	0.15
15		0	0	0	0.15
20					0.25
10	18-20	0.1	0	0.3	1.2
15		0.3	0.1	0.5	1.5
20	Removed from storage				

Table 8. Stability of mayonnaise with 46,0 % fat content during storage.

Storage, days	**Temperature of the storage, °C**	**In the static condition**		**At centrifuging**	
		Amount of released liquid phase, %	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**
0	18-20	0	0	0	0
10	3-7	0	0	0	0.1
15		0	0	0	0.2
20					0.3
10	18-20	0.1	0	0.2	1.0
15		0.5	0.5	0.8	1.6
20	Removed from storage				

Table 9. Stability of mayonnaise with 46,0 % fat content with milk concentrate during storage.

Storage, days	**Temperature of the storage, °C**	**In the static condition**		**At centrifuging**	
		Amount of released liquid phase, %	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**	**Amount of released liquid phase, %**
0	18-20	0	0	0	0
10	3-7	0	0	0	0.15
15		0	0	0	0.25
20					0.3
10	18-20	0.2	0	0.3	0
15		0.4	0.4	0.8	1.5
20	Removed from storage				

Table 10. Stability of mayonnaise with 50,0 % fat content with milk concentrate during storage.

Storage, days	Temperature of the storage, °C	In the static condition		At centrifuging	
		Amount of released liquid phase, %	Amount of released liquid phase, %	Amount of released liquid phase, %	Amount of released liquid phase, %
0	18-20	0	0	0	0
10	3-7	0	0	0	0.15
15		0	0	0	0.25
20		0			0.3
10	18-20	0.3	0.2	0.4	1.2
15		0.5	0.5	0.8	1.7
20	Removed from storage				

Thereby, storing mayonnaise at a temperature of 3-7 °C ensures the necessary stability of the emulsion structure for 20 days of storage for all tested samples.

Organoleptic evaluation is one of the decisive factors in the quality of food products. Freshly prepared mayonnaise samples were subjected to organoleptic evaluation. The introduction of 5% milk concentrates into the mayonnaise recipe affected the taste, color, smell, consistency and appearance of the product. Mayonnaises with the introduction of milk concentrates acquire a light cream color, have a delicate taste without the smell of egg powder and bitterness, and resemble sour cream in consistency. The samples of mayonnaise with a milk concentrate thickener were practically no different in their organoleptic characteristics from the standard “Provencal” mayonnaise. These mayonnaises had a light-yellow color, a

uniform consistency, like sour cream, the combination of taste and smell was due to the addition of egg and mustard powders.

Organoleptic assessment of the quality of mayonnaise during storage at 2 temperature conditions of 3-7 °C showed the following. At a storage temperature of 3-7 °C, the mayonnaise remained virtually unchanged over the entire storage period in all respects. When mayonnaise was stored at room temperature, changes occurred on the 10th day; traces of mold appeared, the consistency became liquid, and the mayonnaise took on the appearance of a spoiled product. By the end of storage (20 days), these changes became even more pronounced. Mayonnaises have been removed from storage.

4 Conclusion

Based on research of the effect of thickener additives and milk concentrates on the structural and rheological properties of mayonnaise, the following conclusions can be drawn:

The possibility of reducing the fat phase of the emulsion from 65% to 40% has been established.

The effectiveness of the stabilizing effect of the thickener and its complexes in real mayonnaise emulsions has been demonstrated. The results of the experiments allowed identifying the optimal concentrations of food proteins (egg powder, skimmed milk powder) and thickener for obtaining mayonnaise emulsions of a given stability.

The optimal condition for storing mayonnaise is a temperature of 3-7 °C for up to 20 days.

Concentrates of milk can be recommended for targeted regulation of the structural and rheological properties of low-calorie mayonnaises in a wide temperature range.

References

1. N. Sabirova, M. Sadikova, E3S Web of Conferences **390**, 02013 (2023). https://doi.org/10.1051/e3sconf/202339002013
2. C.-Y. Li et al., Food Chemistry **152**, 592-596 (2014)
3. S.G. Gorji et al., Trends in Food Science & Technology **56**, 88-102 (2016)
4. V.K. Gamov, L.V. Lentsova, T.K. Kalenik, *Examination of food fats*. Textbook. (Vladivostok, Publishing House of Far Eastern State University, 2001), p 244
5. V.P. Gulkov, Yu.A. Makhichin et al., *Rheology of food masses* (M., Food industry, 2000), p 207
6. E.P. Kornena, S.A. Kalmanovich, E.V. Martovshchuk et al., *Examination of oils, fats and products of their processing.* Edited by Pozdnyakovsky V.M (Novosibirsk, 2007), p 272
7. V.M. Poznyakovsky, *Food and biologically active additives* (Novosibirsk, 2005), p 522
8. Nargiza Majidova, E3S Web of Conferences **390**, 02028 (2023)
9. K.Kh. Majidov, D.Kh. Bozorov, M.N. Rakhimov, *Perfecting the quality of oil using biological active additions*, 3rd International Symposium on Edible Plant Resources and the Bioactive Ingridients (Urumqi China, 2012), p 74