

Ministry of Education and Science of Ukraine
Black Sea Universities Network

ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of
Student Scientific Works

BLACK SEA SCIENCE 2022 PROCEEDINGS



ODESA, ONUT 2022

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BLACK SEA SCIENCE 2022

Proceedings

Odesa, ONUT 2022

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INTRODUCTION

International Competition of Student Scientific Works “Black Sea Science” has been held annually since 2018 at the initiative of Odesa National University of Technology (formerly Odesa National Academy of Food Technologies) with the support of the Ministry of Education and Science of Ukraine. It has been supported by Black Sea Universities Network (the Association of 110 higher education institutions from 12 countries of the Black Sea Region) since 2019, and by Iseki-FOOD Association (European Integrating Food Science and Engineering Knowledge into the Food Chain Association) since 2020.

The goal of the competition is to expand international relations and attract students to research activities. It is held in the following fields:

- Food science and technologies
- Economics and administration
- Information technologies, automation and robotics
- Power engineering and energy efficiency
- Ecology and environmental protection

The jury includes both Ukrainian and foreign scientists. In the 4 years that the competition has been held, the jury included scientists from universities of 24 countries: Angola, Azerbaijan, Benin, Bulgaria, China, Czech Republic, France, Georgia, Germany, Greece, Israel, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Pakistan, Poland, Romania, Serbia, Slovakia, Switzerland, Turkey, USA.

At the same time, every year the geography has expanded and the number of foreign jury members has increased: from 46 jury members representing 25 universities from 12 countries in 2018, to 73 jury members of the 46 universities from 19 countries in 2022.

More than a thousand student research papers have been submitted to the competition from both Ukrainian and foreign institutions from 25 countries: China, Poland, Mexico, USA, France, Greece, Germany, Canada, Costa Rica, Brazil, India, Pakistan, Israel, Macedonia, Lithuania, Latvia, Slovakia, Romania, Kyrgyzstan, Kazakhstan, Bulgaria, Moldova, Georgia, Turkey, Serbia.

The interest of foreign students in the competition grew every year. In 2018, the students representing 15 institutions from 7 countries have submitted 33 works. In 2021 the number of submitted works increased to 73, authored by the students of 40 institutions from 18 countries.

The competition is held in two stages. In the first stage, student research papers are reviewed by members of the jury who are experts in the relevant fields. In the second stage of the competition, the winners of the first stage have the opportunity to present their work to a wide audience in person or online.

All participants of the competition and their scientific supervisors are awarded appropriate certificates, and the scientific works of the winners are included in the electronic proceedings of the competition. Every year the competition receives a large number of positive responses from Ukrainian and foreign colleagues with the desire to participate in the coming years.

1. FOOD SCIENCE AND **TECHNOLOGIES**

**RESEARCH OF INDICATORS OF QUALITY AND SAFETY OF
MAYONNAISE ON THE BASIS OF HEMP OIL AND PROTEIN ISOLATE**

Authors: Ivan Prykhodko,
Svitlana Girichenko,

Advisors: Anna Helikh,
Olha Vasylenko

Sumy National Agrarian University (Ukraine)

Annotation. *Sauces are an integral part of most dishes, which are prepared from a variety of products: meat, fish, seafood, vegetables. They give the dishes juiciness, add variety to the aesthetic appearance of the dish and complement their taste, increase calories and nutritional value. The most common sauces are culinary sauces of the emulsion type, in particular mayonnaise and their derivatives. Today, the oil and fat industry produces a whole "line" of mayonnaise products with various additives that improve the taste, structure and increase the shelf life. The oil and fat industry is at a stage when its development can no longer be carried out by traditional methods, new approaches and solutions are needed. Trends in a balanced and healthy diet are forcing producers to look for new approaches to the production of classic mayonnaise with high biological value and high quality characteristics. The problem of nutrition optimization in terms of the content of essential nutrients, such as fatty acids, can be solved by introducing into the recipe composition, as an oil-fat base, vegetable oils are rich in polyunsaturated fatty acids ω -3 and ω -6. One of the promising areas of production of emulsion products, such as mayonnaise sauce is the introduction of standard recipes for full or partial replacement of sunflower oil with hemp oil in order to improve biological value, while maintaining high organoleptic, structural and mechanical properties and safety. Among the essential nutrients needed to maintain homeostasis of the human body are polyunsaturated fatty acids, the source of which is hemp oil. Hemp oil contains natural antioxidants, which give it increased resistance to oxidation, despite the natural high content of ω -3 and ω -6 fatty acids. One of the ways to implement the innovative idea is the partial or complete replacement of the oil-fat fraction of the emulsion-type mayonnaise sauce with hemp oil with a mass fraction of introduction into the recipe (50%, 75%, and 100%) and complete replacement egg powder on protein isolate of hemp seed.*

The aim of the work is to study the quality of mayonnaise sauce with partial or complete substitution of oil and fat fraction for hemp oil and protein isolate of hemp seed, namely their organoleptic, physicochemical (effective viscosity, emulsion stability, acidity, acid and peroxide value) indicators, to investigate the fatty acid composition developed samples of mayonnaise sauce based on hemp oil and investigate the change in microbiological parameters during storage. This will expand the range of quality foods enriched with essential nutrients. The following research methods were used in writing the article: standard methods of organoleptic profile analysis, structural-mechanical, standard methods of research of fatty acid composition and methods of determining microbiological parameters. The results of these studies were processed using modern computer programs. Results. The expediency of using mayonnaise-based

mayonnaise sauce technology during the development of hemp oil sauce technology has been theoretically and experimentally substantiated and formulations of these mayonnaises have been developed. Based on the organoleptic analysis, it was determined that the use of hemp oil in the technology of mayonnaise sauce has a positive effect on its organoleptic characteristics. A study of the fatty acid composition showed that the optimal ratio of fatty acids of the groups ω -3: ω -6, as 1: 4, has a sample of mayonnaise sauce (M2), containing 75% hemp oil in its composition. Analysis of the fatty acid composition also confirmed the functionality of all developed samples of mayonnaise. It was found that all developed samples of mayonnaise based on hemp oil, fully comply with the normative indicators of structure (effective viscosity and stability of the emulsion) and quality indicators (pH, acid number and peroxide value). It was investigated that the microbiological parameters of the control sample of mayonnaise and experimental samples with partial or complete replacement of the oil and fat fraction with hemp oil during storage (28 days) indicate that opportunistic and pathogenic microflora are within acceptable values.

Conclusions and discussions. *The studied quality indicators make it possible to substantiate the technology of mayonnaise sauce based on hemp oil and protein isolate of hemp seed with increased biological value.*

Key words: *emulsion type sauce, mayonnaise, hemp oil, fatty acids, oil and fat fraction*

I. INTRODUCTION

The biologically active components of vegetable oils, in particular hemp oil, which normalizes lipid metabolism, primarily include polyunsaturated fatty acids (PUFA) - linoleic (ω -6) and linolenic (ω -3) PUFA are involved in the body as structural elements cell biomembranes [1-3]. They help regulate metabolism in cells, normalize blood pressure, affect cholesterol metabolism, stimulate its oxidation and excretion from the body, participate in the metabolism of B vitamins, increasing resistance to infectious diseases and other factors [4].

Mayonnaise sauce is one of the main products of the oil and fat industry, which is present in the mass daily consumption of the population [5, 6].

The multi-component composition of mayonnaise provides opportunities to create products that prevent deficient conditions in essential fatty acids, vitamins and other physiologically functional ingredients [7].

One of the main components of mayonnaise emulsions is refined deodorized oil. In order to create mayonnaises with high biological value in terms of essential fatty acids, samples of mayonnaise sauce with partial or complete replacement of oil-fat base with deodorized hemp oil were investigated, thus providing the necessary balance of PUFA and emulsifier. [8-10].

The idea of adding hemp seed protein isolate to mayonnaise sauce technology is due to several factors. One of them is the desire to reduce the fat content by replacing the egg yolk in the recipe, which will allow you to get a product perfectly balanced for daily nutrition. On the other hand, protein isolate obtained from waste oils (cakes) is a valuable source of protein, the use of which in turn solves the problem of food conservation and waste-free production [11-12].

The positive point of using the protein isolate is that it, along with significant biological value, has high functional properties - emulsifying, structuring, moisture-retaining. It enhances the structure-forming properties, which exhibits each component separately, which improves the technological characteristics of mayonnaise emulsions [13].

In the domestic concept of healthy eating an important place is occupied by the use of plant proteins in food production. In general, foods using plant proteins are healthy foods with an improved balance of nutrients compared to traditional foods [14].

Products derived from hemp seeds are divided into three groups that differ in protein content: protein-fat flour (45-50% protein content), protein concentrate 65-70% protein, protein isolate (more than 90% protein content). The most high-protein products - isolates - are the most purified from non-protein components product. They have a neutral taste, smell and color, ranging from light cream to white. Isolates are well soluble in water. When heating solutions and concentrated suspensions, hemp isolates form non-synergistic storage-resistant gels, which in turn have high moisture-retaining properties. Isolates well stabilize fat emulsions in water, which is technologically necessary in the manufacture of mayonnaise sauces [15].

The use of protein isolates as emulsifiers in the industrial production of mayonnaise does not involve changes in technology. The protein isolate forms a suspension in water, is sterilized and, after cooling, enters the emulsifier together with other prescription ingredients. The use of protein isolates in the production of mayonnaise instead of egg powder provides the required consistency of the low-fat product through the ability of hemp protein isolates to form high-viscosity solutions [16-18].

II. LITERATURE ANALYSIS

2.1 The state of study of the problem

Many studies of domestic and foreign scientists have been devoted to the determination of organoleptic, microbiological, physicochemical and functional-technological properties, research of fatty acid composition of mayonnaise sauces, vegetable oils and development of emulsion-type sauces based on them [11,12].

A number of scientists continue to work in this direction, as this problem has not lost its relevance today.

2.2 Unresolved issues

Analysis of the market for mayonnaise sauces shows that in modern society they have become one of the most popular products. However, these products do not meet the characteristics of physiology and biochemical processes of the human body due to the increased amount of saturated fatty acids, as well as the presence of flavoring and technological food additives that are not safe for health [13]. Ease of consumption, high organoleptic characteristics contribute to the fact that emulsion-type sauces are quite popular among consumers, with the greatest demand for mayonnaise sauce classic "Provençal". The analysis of the sauce market in Ukraine shows that the share of mayonnaise production is about 49% of the total number of sauces. About 80% of consumers prefer this type of sauce, and 40% of the population use mayonnaise sauce at least two or three times a week [14].

Increasing the production of biologically complete multicomponent sauces (including mayonnaise) is relevant in light of the concept of a balanced diet, according to which the daily diet should be sufficient polyunsaturated fatty acids [15]. The main advantage of sauces is the potential to enrich the recipe with ingredients for one or more factors in order to most fully comply with their formula for a balanced diet [16].

However, despite the high nutritional value of sauces, including mayonnaise, they have their drawbacks, one of which is the low content of essential nutrients, including polyunsaturated fatty acids, essential amino acids. The main fat fraction of mayonnaise sauce contains a large amount of saturated fatty acids and is not resistant to oxidation, so the classic mayonnaise is not able to meet human needs for essential micronutrients and cannot maintain its quality for a long time [17].

Partial introduction (50%, 75%) of hemp oil mayonnaise or complete replacement of refined deodorized sunflower oil causes high biological value [15]. Therefore, the development of mayonnaise based on hemp oil, enriched with polyunsaturated fatty acids, biologically active components (cachtin, flavones and flavonoids), which will be important both for proper nutrition and to ensure high quality and safety of the sauce [18].

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The aim of the article is to study the quality of mayonnaise sauce with partial or complete substitution of oil and fat fraction for hemp oil and replacement of egg powder with protein isolate, namely their organoleptic, physicochemical (effective viscosity, emulsion stability, acidity, acid and peroxide value) indicators, study of the fatty acid composition of the developed samples of mayonnaise sauce based on hemp oil and study of changes in microbiological parameters during storage.

The methodological basis of the study is the process of developing the recipe for mayonnaise sauce using hemp oil and protein isolate and the study of its quality and safety.

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

Information base of the research - scientific articles, materials of international congresses and symposiums, scientific-practical conferences, normative and technical documentation, patents.

The object of the study is mayonnaise sauce with partial (50%, 75%) or complete substitution in the recipe of the oil-fat fraction for hemp oil and replacement in the recipe of egg powder for protein isolate.

The subject of the research is the technology of mayonnaise sauce with partial (50%, 75%) or complete substitution in the recipe of the oil-fat fraction for hemp oil and replacement in the recipe of egg powder for protein isolate.

The scientific novelty of the obtained results lies in the theoretical substantiation and experimental confirmation of the expediency of using hemp oil and protein isolate in mayonnaise sauce technology and its effect on organoleptic, physicochemical, microbiological parameters and fatty acid composition.

IV. RESULTS

The recipe of mayonnaise is selected in accordance with the requirements: DSTU 4487-2015 "Mayonnaise". The recipe of Provencal mayonnaise sauce with a mass fraction of 67% fat was chosen as a control sample. In parallel, three samples of mayonnaise were prepared on the basis of hemp oil with a mass fraction of 50%, 75% and 100%. (Table 1).

Table 1 - Mayonnaise recipes based on hemp oil with a mass fraction of 25%, 50% and 100% in the recipe (in kg per 1000 kg of product excluding losses)

Name of ingredients	Control	Samples of mayonnaise		
		Prototype 1 (50%)M1	Prototype 2 (75%)M2	Prototype 3 (100%)M3
Refined deodorized sunflower oil	65.40	49.05	32.7	-
Refined deodorized hemp oil	-	16.35	32.7	65.40
Egg powder	5.0	-	-	-
Protein isolate	-	5.0	5.0	5.0
Skimmed milk powder	1.6	1.6	1.6	1.6
Mustard powder	0.75	0.75	0.75	0.75
Sodium bicarbonate	0.05	0.05	0.05	0.05
Sugar sand	1.5	1.5	1.5	1.5
Cooking salt	1.0	1.0	1.0	1.0
Viniger acid	0.55	0.55	0.55	0.55
Water	24.15	24.15	24.15	24.15

The next stage of the study was to determine the organoleptic characteristics of the developed samples of mayonnaise.

Organoleptic characteristics of mayonnaise must meet the requirements (DSTU 4487-2015 "Mayonnaise"), which are presented in table 2.

Table 2 - Characteristics of organoleptic characteristics of mayonnaise based on hemp oil and protein isolate

Indicators	Characteristic
Consistency and appearance	Homogeneous creamy product
Taste and smell	The taste is slightly sharp, sour
Colour	White with a yellowish tinge, uniform throughout the mass

Organoleptic evaluation was performed on a 5-point scale. The results of organoleptic evaluation of experimental samples are presented in the form of a profilogram (Fig. 1).

The use of hemp oil and protein isolate in the technology of mayonnaise sauce has a positive effect on its organoleptic characteristics. The consistency, appearance, color and odor of all samples (M1 and M2) were marked with the highest score (5 points), except for the mayonnaise sample with complete replacement (100%) of the oil-fat fraction with hemp oil. Sample (M3) was marked with the lowest taste score (4.8) because it had some deviations from the norm. The highest score (5 points) was a sample of mayonnaise, which contained 75% (M2) of hemp oil.

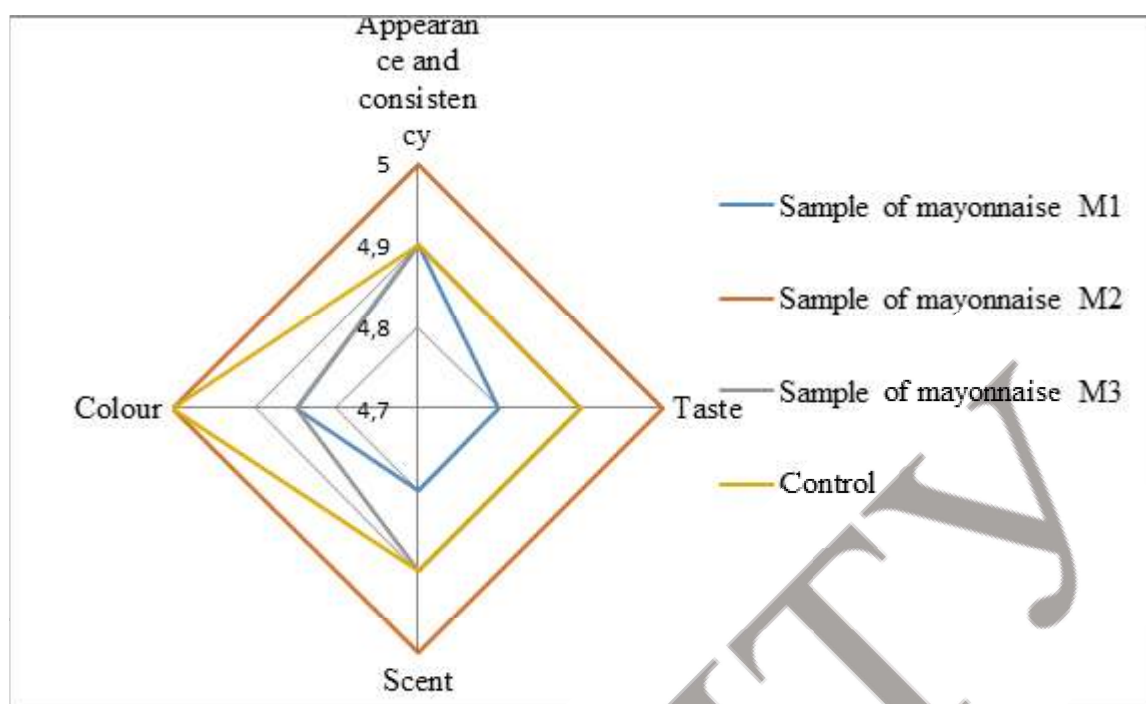


Fig. 1 - Profilograms of organoleptic characteristics of mayonnaise based on hemp oil and protein isolate

To confirm the enrichment of the biological value of mayonnaise sauce based on hemp oil and protein isolate, a study of the fatty acid composition of the developed samples with control - mayonnaise "Provençal" (Table 3).

Table 3 - Fatty acid composition of mayonnaise based on hemp oil and protein isolate

Indicator	Content g per 100 g of product			
	Control	Prototype 1 (50%)M1	Prototype 2 (75%)M2	Prototype 3 (100%)M3
Saturated fatty acids	7.96	8.337	13.895	16.674
14:0 Myristic	0.01	0.050	0.084	0.101
16:0 Palmitic	4.48	4.774	7.956	9.547
17:0 Heptadecanoic		0.036	0.060	0.072
18:0 Stearic	2.79	2.521	4.201	5.041
20:0 Arachinic	0.2	0.696	1.160	1.392
22:0 Behenic	0.46	0.166	0.277	0.332
24:0 Lignoceric	-	0.094	0.157	0.188
Monounsaturated fatty acids	16.88	18.636	31.06	37.272
16:1 Palmitoleic	0.08	0.175	0.291	0.349
17:1 Heptadecenoic	-	0.019	0.032	0.038
18:1 Oleic	16.8	16.876	28.127	33.752
20:1 Gadoleic	-	0.059	0.099	0.119
22:1 Erucic	-	1.507	2.511	3.013
Polyunsaturated fatty acids	39.27	33.027	55.045	66.054
18:2 Linoleic	39.24	14.473	24.122	28.946
18:3 Linolenic	0.03	18.554	30.923	37.108
18:3 γ -linolenic	-	6.517	10.862	13.034
18:3 α -linolenic	-	12.037	20.061	24.073

The ratio of fatty acids of the ω -3: ω -6 groups for the sample of mayonnaise sauce (M2) was 1: 4 (Table 3), which is the recommended ratio for functional nutrition. The ω -3 fatty acids include α -linolenic fatty acid. To ω -6 - linoleic and γ -linolenic. The optimal overall ratio of ω -3 to ω -6 in the diet is 1: 3/1: 6, and it must be maintained. It is undesirable to exceed the value of 1:10. It stimulates the development of inflammatory processes in the body. The control sample of Provençal mayonnaise contains ω -6 and ω -3 fatty acids. Monounsaturated fatty acids are contained in the control sample of the sauce twice as much as in the sample of mayonnaise sauce (M2) and 2.2 times more than in the sample of mayonnaise sauce (M3). The data on the qualitative characteristics of the developed samples of mayonnaise sauce based on hemp oil, show that the best indicators for the ratio of fatty acids of groups ω -3: ω -6, received a sample of sauce (M2). It should be noted that the highest levels of fatty acids of groups ω -3 and ω -6 received a sample of mayonnaise (M3). However, the ratio of fatty acids of the ω -3: ω -6 groups in the mayonnaise sample (M3) is 1: 7/1: 9, which does not correspond to the optimal one. Analysis of the fatty acid composition also confirmed the functionality of all developed samples of mayonnaise.

The stability of mayonnaise emulsion depends on the composition of the oil-fat base and emulsifying ability of the protein used as emulsifier: hemp seed protein isolate, milk powder, egg and mustard powder involved in creating the structure of mayonnaise, as well as compliance with optimal process parameters. all - homogenization.

Important quality indicators for emulsion-type sauces are structure indicators (effective viscosity and stability of the emulsion) and quality indicators (pH, acid number and peroxide value), which characterize the product's resistance to mechanical impact and storage stability. The results of the study of these indicators are presented in table 4.

Table 4 - Physico-chemical parameters of mayonnaise based on hemp oil and protein isolate

Indicator	Samples of mayonnaise			
	Control	Prototype 1 (50%)	Prototype 2 (75%)	Prototype 3 (100%)
Effective viscosity, Pa \times s ⁻¹ (at a shear rate of 3 s ⁻¹)	9.5	9.5	9.5	9.3
Emulsion stability, %	99	100	100	99
pH	4.5	4.5	4.5	4.6
Acid number, ml KOH/kg	0.2	0.2	0.2	0.2
Peroxide number, ½O ₂ , mmol / kg	2.3	2.5	2.6	2.9

The results of the research (Table 4) confirm the possibility of producing all samples of mayonnaise based on hemp oil and protein isolate, as they fully meet the physico-chemical parameters established by the requirements of regulatory documentation.

The percentage of undamaged emulsion for test samples of mayonnaise (M1) and (M2), with a mass fraction of hemp oil of 50% and 75% was 100%, which is 1% less than the control and experimental sample of mayonnaise (M3). As a result of the research, the stability of the emulsion corresponds to the norm for all samples of

mayonnaise. The effective viscosity for the control and test samples of mayonnaise (M1, M2 and M3) is within normal limits. However, the effective viscosity of the mayonnaise test sample (M3) with complete replacement of the oil-fat fraction with hemp oil was $0.2 \text{ Pa} \times \text{s}^{-1}$ less than that of the other mayonnaise test samples (M1 and M2). The results obtained on the indicators of active acidity, however, indicate that the pH for all developed samples of mayonnaise was within normal limits. Acid values did not differ for control and experimental samples of mayonnaise (M1, M2, M3). The peroxide value for the mayonnaise sample (M3) almost reaches the limit value for this type of product 3.1 mmol of active oxygen / kg.

To control the safety indicators for the developed samples of mayonnaise was determined by the change in microbiological parameters during storage (28 days) (table 5).

Table 5 - Change in microbiological parameters of mayonnaise based on hemp oil and protein isolate during storage

Indicator	Permissible level	Prototype	Shelf life, days			
			0	10	14	28
Bacteria of the Escherichia coli group (coliforms), 0.01 g of mayonnaise	Not allowed According to DSTU 6003: 2008	Control	–	–	–	–
		Prototypes	–	–	–	–
Pathogenic microorganisms, including bacteria of the genus Salmonella, in 25 g of mayonnaise	Not allowed	Control	–	–	–	–
		Prototypes	–	–	–	–
Staphylococcus aureus, in 1 g of mayonnaise, no more than	$5,0 \times 10^2$	Control	2.7×10^2	2.7×10^2	2.7×10^2	2.7×10^2
		Prototypes	2.7×10^2	2.7×10^2	2.7×10^2	2.7×10^2
Listeria monocytogenes, in 25 g of mayonnaise	Not allowed	Control	–	–	–	–
		Prototypes	–	–	–	–

Studies of microbiological parameters of the control sample of mayonnaise and test samples with partial or complete replacement of the oil-fat fraction with hemp oil during storage (28 days), indicate that opportunistic and pathogenic microflora are within acceptable values. Determination of Bacteria of the Escherichia coli group (coliforms) in 0.01 g of experimental and control samples of mayonnaise indicate their absence in the studied products. The number of bacteria of the Staphylococcus aureus group in the control sample of mayonnaise and experimental samples during the entire shelf life is the same and is 2.7×10^2 .

V. CONCLUSIONS

Thus, the following conclusions can be drawn:

The expediency of using mayonnaise sauce based on hemp oil and protein isolate during the development of the technology of mayonnaise sauce was theoretically and experimentally substantiated, and formulations of these mayonnaises were developed.

Based on organoleptic analysis, it was determined that the use of hemp oil and protein isolate in the technology of mayonnaise sauce has a positive effect on its organoleptic characteristics. The consistency, appearance, color and odor of all samples were positively evaluated. The highest score (5 points) was a sample of mayonnaise, which contained 75% (M2) of hemp oil.

The study of fatty acid composition showed that the highest indicators of fatty acid content of groups ω -3 and ω -6 received a sample of mayonnaise (M3). However, the ratio of fatty acids of the ω -3: ω -6 groups in the mayonnaise sample (M3) is 1: 7/1: 9, which does not correspond to the optimal one. The sample of mayonnaise sauce (M2) has the optimal ratio of fatty acids of the ω -3: ω -6 groups, as 1: 4. Analysis of the fatty acid composition also confirmed the functionality of all developed samples of mayonnaise.

It was found that all developed samples of mayonnaise based on hemp oil and protein isolate, fully meet the regulatory structure (effective viscosity and stability of the emulsion) and quality indicators (pH, acid number and peroxide value), which characterize the resistance of the product to mechanical influences and storage stability for emulsion-type sauces.

It was studied that the microbiological parameters of the control sample of mayonnaise and test samples with partial or complete replacement of the oil and fat fraction with hemp oil during storage (28 days), indicate that opportunistic and pathogenic microflora are within acceptable values. The number of bacteria of the *Staphylococcus aureus* group in the control sample of mayonnaise and test samples throughout the shelf life is the same and is 2.7×10^2 .

The studied quality indicators make it possible to substantiate the technology of mayonnaise sauce based on hemp oil and protein isolate with high biological value.

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TABLE OF CONTENTS

INTRODUCTION.....	4
1. FOOD SCIENCE AND TECHNOLOGIES.....	5
DEVELOPMENT OF TECHNOLOGY FOR THE PRODUCTION OF NON-ALCOHOLIC BEVERAGE WITH NATURAL VINEGAR AS A NATURAL CONSERVANT Authors: Pavel Andronic, Margarita Bem Advisor: Alina Boistean Technical University of Moldova (Republic of Moldova).....	6
MONITORING OF DIFFERENT PUMPKIN VARIETIES FOR PECTIN PRODUCTION Authors: Aibike Berik, Bayan Sovetzhanova Advisor: Sanavar Azimova Almaty Technological University (Kazakhstan).....	16
PSYLLIUM GEL AS A SUBSTITUTE FOR FAT IN THE COOKIES TECHNOLOGY Author: Maryna Bozhko Advisor: Kateryna Khvostenko Odessa National Academy of Food Technologies (Ukraine).....	27
IMPROVING THE EFFICIENCY OF THE FUNCTIONAL MECHATRONIC MODULE FOR LIQUID FOODSTUFFS Author: Denys Kozik Advisor: Lyudmila Krivoplyas-Volodina National University of Food Technologies (Ukraine).....	37
ISOLATION OF BIOACTIVE COMPOUNDS FROM HEMP (<i>Cannabis sativa</i> L.) BY CONVENTIONAL AND NOVEL EXTRACTION TECHNIQUES Author: Sanja Milošević Advisor: Branimir Pavlič Faculty of Technology, University of Novi Sad (Serbia).....	51
RESEARCH OF INDICATORS OF QUALITY AND SAFETY OF MAYONNAISE ON THE BASIS OF HEMP OIL AND PROTEIN ISOLATE Authors: Ivan Prykhodko, Svitlana Girichenko Advisors: Anna Helikh, Olha Vasylenko Sumy National Agrarian University (Ukraine).....	65
FUNCTIONAL FOOD INGREDIENTS BASED ON ORGANIC COMPLEXES OF BIOMETALS WITH COMPOUNDS OF POSTBIOTIC ORIGIN Author: Alexander Sirotyuk Advisor: Antonina Kapustian Odessa National Technological University (Ukraine).....	75