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Development of an Emulsion Product with a Functional Purpose Using an Emulsifier of Plant Origin.

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ABSTRACT

Emulsion products, with vegetable oil in a dispersed state, occupy a definite place among promising fatty foods, which increases their digestibility and nutritional value. In addition, food emulsions for different populations can be created by changing the ratios of different types of oil in the recipe. The presence of the aqueous phase allows one to enter into the composition of the emulsions of water-soluble physiologically functional ingredients, as well as the use of non-traditional emulsifiers of plant origin. Therefore, work in this direction is promising. The article assesses consumer motivation when choosing sauces, as one of the stages of creating functional products, in order to study the demand for new functional sauces. Theoretically, based on the study of chemical and amino acid composition, as well as the organoleptic evaluation of the powder from dried champignons, the expediency of its use is justified as an emulsifier of vegetable origin in the production of emulsion products of functional purpose. Based on experimental studies to establish the technological parameters for the production of an emulsion product, the following parameters were determined: optimum soaking temperature, soaking time, optimal hydromodule of the mushroom powder, concentration of the wet mushroom powder, and optimal emulsion emulsification modes. Optimization of the fat component in the emulsion product was conducted in the ratio of ω-3 and ω-6=10: 1 fatty acids for a healthy diet. Scientifically based technology and formulation of an emulsion product of a functional purpose using as a emulsifier powder of dried champignons with a balanced fatty acid composition (for healthy nutrition) and structural and mechanical characteristics as close as possible to the mayonnaise sauce. Comparative characteristics produced chemical composition and organoleptic evaluation of the emulsion product using as an emulsifier of vegetable origin and mayonnaise sauce. The absence of cholesterol, reduced energy value can be attributed to the developed emulsion product to products for healthy people and for people with high cholesterol. The high content of potassium and sodium allows its use in the diet of people with cardiovascular diseases.

Keywords: emulsion product, mushroom powder from dried champignons, emulsifiers, balanced fatty acid composition, functional product.

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INTRODUCTION

Currently, two major trends can be identified in the global oil and fat industry. First, the improvement of recipes and technologies for the production of combined foods with given functional and technological properties. Second, the creation and widespread use of food products with high nutritional value using vegetable non-traditional raw materials. Therefore, the objectives of this work were formulated with regard to these areas.

Raw egg yolk is used as an emulsifier in the production of a "mayonnaise sauce" according to a traditional recipe [29], 100 g of yolk contains 1085 mg of cholesterol. Moreover the use of raw egg yolk is not safe, since it can be a source of pathogens, such as salmonella [36, 37, 41, 42]. Therefore, today, the development of technology for an emulsion product without cholesterol using a plant-derived emulsifier is quite promising [38, 43, 48].

Today, a large number of scientific works on the production of emulsion products exists, in which the following raw materials are used as plant emulsifiers: products for processing seeds and roots of plants (soap root, mustard powder) [1, 9, 17, 18, 19, 27], soybean processing products (soy flour, soybean oilcake, soy protein, soy base, soy protein isolate) [8, 44, 45, 49]; algae processing products [5, 9, 20, 21, 27]; processed cereals and legumes [33]; vegetable and fruit products [3, 28]; cereal products [23, 26], as well as products of deep processing of vegetable raw materials (maltin, carboxymethylcellulose, carboxymethyl starch, methylcellulose, pumpkin pectin, polysaccharides of plant origin, keltrol, manucol, monoglycerides, food, vegetable phospholipids, as well as fat and oil phospholipid product) [2, 4, 16, 22, 24, 25, 34, 46].

Using the mushroom powder as an emulsifier of unconventional vegetable raw materials allows, along with an increase in the nutritional value of emulsions, to improve their physico-chemical characteristics, particularly structural and rheological characteristics, while ensuring the desired organoleptic properties.

In this regard, the research on developing a technology of emulsion products with a functional purpose using an emulsifier of plant origin to expand the range of functional products is highly relevant and in demand for the technology of food production.

Developing a technology for the production of an emulsion product of a functional purpose using a vegetable emulsifier with specified technological and structural-mechanical properties is the goal of the current paper.

To achieve this goal, the following tasks were solved:

1. To study the technological properties of the powder of dried champignons and to establish the influence of prescription ingredients and emulsification modes on the properties of the emulsion product with champignon powder;
2. To develop the technology and composition of an emulsion product of functional purpose using a vegetable emulsifier.
3. To study the quality indicators of the developed emulsion product with a functional purpose using the vegetable emulsifier.

In the work, the expediency and efficiency of the use of champignon powder is experimentally justified, providing the specified technological and structural-mechanical characteristics of the emulsion product.

The dependence of the technological preparation of the powder of dried champignons, the number of prescription ingredients, as well as the mode of emulsification on the properties of emulsion products is established for the first time.

We also designed a blend of vegetable oils for healthy nutrition.

MATERIALS AND METHODS

Common, standard, and special methods of researching the quality of raw materials, semi-finished and

finished products are used in the work. The following research methods have been applied: moisture content [6], sedimentation stability [7], emulsifying capacity, emulsion stability [7], indicators of the biological value of the protein (by calculating the amino acid score [10, 11]), an ultimate shear stress on the device "Strukturometor ST-1" (in accordance with the instructions).

RESULTS AND DISCUSSION

In order to study the demand for new functional sauces, a sociological study was conducted on a selective basis with the help of a survey of students and the teaching staff of the Orel State University of Economics and Trade, Orel.

According to the survey, tomato (41% of respondents) and emulsion sauces (mayonnaise) (47% of respondents) are the most popular among sauces. Fruit (5% of respondents) and vegetable (7% of respondents) are the least used as sauces.

In the course of the research it was revealed that 53% of respondents were interested in the composition of sauces, 22% of them were sometimes interested in the composition, and 25% were never interested in the composition of sauces. The data presented suggests that the majority is interested in what they eat; therefore, they are concerned about maintaining a healthy lifestyle and preventing possible diseases.

Also, 61% of respondents were ready to use functional sauces on a vegetable basis, 39% were not ready. Such a ratio suggests the existing of public awareness of functional foods and the readiness to consume them.

At the next stage of our research, the feasibility of using mushroom powder in the technology of emulsion-type products was substantiated.

The value of mushrooms as a food product is associated with the peculiarity of their chemical composition. The Fungi contain substances characteristic of both animal and plant products. In particular, the main part of carbohydrates is contained in them in the form of glycogen – the animal starch, which is similar to what is deposited in the liver of animals.

The vitamin row contained in mushrooms is also rich: A, B (B1, B2, B3, B6, B9), D, E, PP. Such a set in the most favorable way affects the nervous system, blood formation processes, blood vessels. The use of mushrooms allows keeping one's hair, skin, and nails in good condition. The benefits of mushrooms in terms of the content of B vitamins are much higher than those of some vegetables and cereals.

The trace elements contained in the mushrooms (potassium, calcium, zinc, copper, phosphorus, sulfur, manganese) replenish the supply of trace elements in the body and beneficially affect many functions. More than that, mushrooms have a positive effect on the work of the cardiovascular system, strengthening the myocardium, are a prophylactic agent for the development of heart diseases, and remove harmful cholesterol from the blood. Zinc and copper, which are part of the fungi. They are actively involved in metabolism, improve blood formation, participate in the processes of hormone production by the pituitary gland.

Also, useful components of fungi include the beta-glucans, which support the immune system and have a high anti-cancer effect. Drying mushrooms can significantly increase the protein content. Dried mushrooms are almost ¾ composed of protein compounds. In an airtight container, powders can last for a long time without losing its quality.

Among the fatty components, lecithin, fatty acid glycerides, and unsaturated fatty acids (butyric, stearic, palmitic) are the most valuable. Lipids, phosphatides, and essential oils in mushrooms give them a specific smell.

The research has shown that mushroom powder is absorbed better than dry mushrooms. Human digestibility of protein substances is up to 89%, fat and carbohydrates – up to 94.6%, fiber – up to 75%

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At the next stage of our research, they justified the expediency of using champignon powder as an emulsifier in the production of emulsions (Table 1).

Table 1: Comparative chemical composition of mushroom powders

Main components, g / 100 g	Champignon	Shiitake	P*leurotus*	White mushroom
Protein	21,0-40,0	10,0-17,0	10,5-30,0	25,0-35,0
Carbohydrates	24,0-62,0	54,0-82,0	60,0-82,0	8,0-15,0
Fat	1,0-6,8	0,6-8,0	1,0-7,2	6,0-12,0
Energy value	175,0-337,0	296,0-375,0	317,0-367,0	209,0-286,0
Cellulose	6,0-7,7	6,5-8,5	7,0-8,0	15,0-17,0

As can be seen from the tabular data, mushroom powder from champignons is in the first place in terms of protein content. Therefore, this powder will have the maximum emulsifying properties. In addition, up to 13% of urea is included in the composition of champignons; urea, in the presence of carbohydrates, can be synthesized into amino acids.

In table 2, a comparative amino acid composition of mushroom powder and egg yolk is presented, traditionally used as an emulsifier in the production of emulsion products. As can be seen from the presented data, the protein of mushroom powder from champignons contains all the essential amino acids. In addition, the protein of mushroom powder is close to the "ideal" one.

The organoleptic characteristics of mushroom powder from champignons TU 9146-005-25646217-07 are given in Table. 3.

Table 2: Amino acid powder composition of champignons and egg yolk

Amino acids	Champignon mushroom powder	Egg yolk	Content (mg) in 1 g of "ideal protein"
Protein g / 100 g	49,1	16,2	
Leucine	70,6	85	70
Isoleucine	54	56	40
Lysine	74	71	55
Threonine	45	51	40
Valin	50	58	50
Phenylalanine + tyrosine	104	86	60
Methionine + cysteine	53	42	35
Tryptophan	8,5	14,8	10

Table 3: Organoleptic indicators of mushroom powder made of champignons

Taste and smell	The expressed mushroom smell, without foreign tastes and smells.
Consistency	Fine dry powder.
Colour	Brown, uniform throughout the mass.

Thus, we can conclude that the powder of dried champignons can be used as an emulsifier of plant origin in the production of edible functional emulsions, due to the high content of protein, lecithin, dietary fiber, minerals, and vitamins.

Further, we experimentally substantiated the technological parameters of the production of food emulsion. To do this, we studied the effect of preliminary preparation of champignon powder on the quality indicators of model food emulsions. We also researched the emulsifying properties of champignon powder, depending on the technological modes of its preliminary preparation.

ISSN: 0975-8585

At the first stage of our research, the dependence of the emulsifying ability of champignon powder on soaking temperature was established. The results of the study are shown in Fig. 1.

As can be seen from the presented data, the maximum emulsifying ability (100%) is observed at 60 ° C. This is due to a more complete dissolution of the polymer component of the champignon powder insoluble in cold water.

To determine the optimal hydromodule for mushroom powder, the sedimentation stability index was studied, which showed the degree of floating or subsidence of the dispersed phase depending on the density difference between the phases and the size of the droplets.

As a result of the research, it was established that with hydromodules, champignon powder has: water=1:2÷6 an indicator of sedimentation stability (SS) was 100% regardless of the duration of swelling. An increase in the hydromodule to 1:8 resulted in a decrease in SS with a swelling duration of 15 min by 5%, with 90 min – by 20%. The smallest indicator of SS is noted in samples of champignon powder with a hydromodule: water = 1:10.

This is due to the fact that, due to its functional properties, the protein of the fungi, instead of forming an aqueous solution, absorbs moisture until it absorbs the maximum amount of liquid, and then it forms a suspension in the remaining water.

Thus, as a result of studying the SS, samples were used for further research with the following ratios of champignon powder: “water = 1: 2-6”.

To determine the optimal swelling time, the powder from champignons was mixed with drinking water at different hydromodules and allowed to swell for 5 to 55 minutes. Then, we cooked the model edible emulsions. In the prepared samples, the ultimate shear stress (USS) was determined. The research results are shown in Fig. 2.

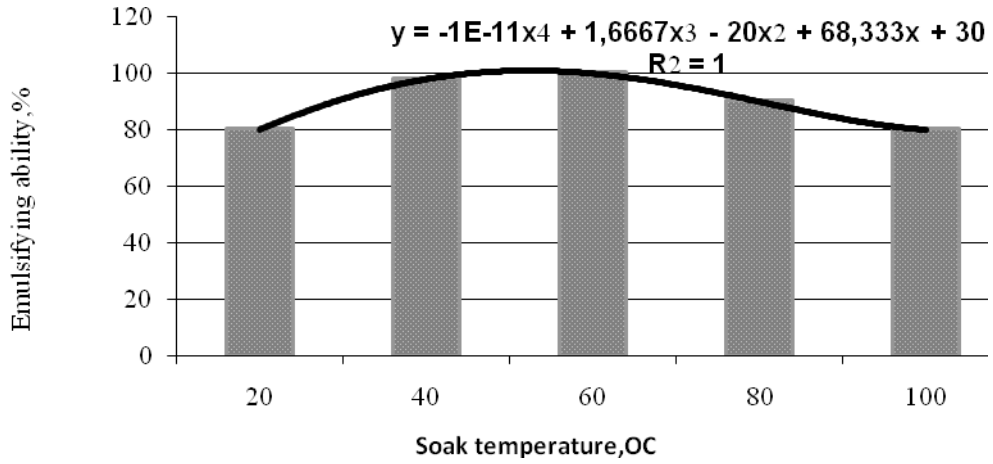

Fig 1: Dependence of emulsifying capacity on soaking temperature of champignon powder

The optimal swelling time for the powder of champignons was chosen to be the one at which the maximum value of the shear stress is observed:

1) With a hydromodule of champignon powder: water = 1: 2 and 1: 4, the swelling time is 25 minutes;
2) With the hydraulics powder made from champignons: water = 1: 6, swelling time 15 minutes.

At the next stage of research, the amount of flooded champignon powder in the emulsion was determined with the help of an indicator of the ultimate shear stress (USS). For this purpose, samples of swollen champignon powder were emulsified with vegetable oil at various ratios of champignon powder:

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vegetable oil. Emulsification was carried out at a speed of 520 rev / min for 15 min at 20 ° C. The characteristics of the studied samples and the ultimate shear stress are given in Table 4. As a control, the recipe No. 564 “mayonnaise sauce” from the collection of recipes was used [29].

Studies have shown that in terms of USS, the sample No. 3 is the closest to the control, which was used in further studies.

To clarify the duration of emulsification, technological parameters of edible emulsions were determined. Emulsification was carried out at a speed of 520 rev/min; the duration of emulsification was 5-25 minutes.

The research results are presented in Table 5. Experiments show that the maximum stability of the food emulsion (100%) is achieved at 10 minutes of emulsification. An increase in the emulsification time to 25 minutes leads to the destruction of the structure of the food emulsion, as indicated by the decline in the stability of the food emulsion.

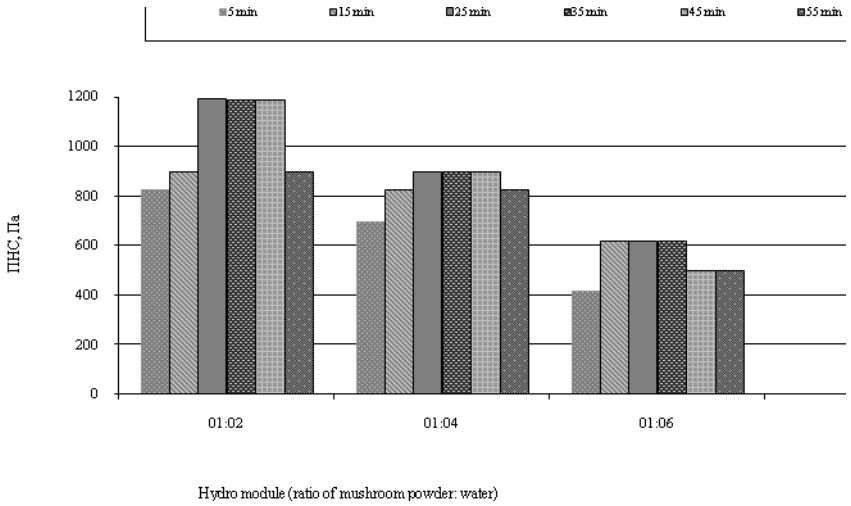

Fig 2: Influence of hydronic module and time of swelling of mushroom powder on the ultimate shear stress (USS) of model emulsion products.

Table 4: The ultimate shear stress of food emulsions

Sample	Sample Characteristics			USS, Pa
	Hydromodule powder from champignons: water	Swelling time of champignon powder, min	The amount of swollen champignon powder, % by weight of oil	
Control (No. 564 “mayonnaise sauce”)				610
Sample № 1	1:2	25	50	1190
Sample №2	1:4	25	50	990
Sample №3	1:6	15	35	650

Table 5: The effect of the duration of emulsification on the stability of the food emulsion

Sample	Emulsification time, min	The stability of the emulsion, %
Sample №1	5	91
Sample №2	10	100
Sample №3	15	99

Sample №4	20	95
Sample №5	25	93

The initial increase in the stability is due to the change in the dispersion composition of the food emulsion in the direction of reducing the particle size. With further increase in the intensity of mechanical processing, a decrease in the stability of the food emulsion occurs, being associated with the destruction of the adsorption layers of micellar structures.

Thus, the optimal time of emulsification is 10 minutes at a frequency of rotation of the working body of the machine: 520 rev / min.

At the next stage of our research, the fatty component of the food emulsion was optimized for ω-3 and ω-6 fatty acids.

The content of linoleic acid, the main representative of the family ω-6, and linolenic, the main representative of the family ω-3 of plant origin, and their ratio determine the nutritional value of vegetable oils.

To maintain optimal health, according to methodological recommendations MR 2.3.1. 19150-04 "Recommended levels of consumption of food and biologically active substances", a balance of ω-3 and ω-6 in the body, that is the ratio of linoleic and linolenic acids should be 10: 1 [12]. Practically, all vegetable oils traditionally used in nutrition do not meet the required ω-6: ω-3 fatty acid ratios.

Analysis of the nutrition of the Russian population showed that this ratio reaches 30: 1. The effects of Omega-6 and Omega-3 PFA are very similar, but their effects may be completely opposite. For example, in cancer, joint disease or asthma, Omega-3 relieves the condition, and Omega-6 provokes worsening [30, 31, 32, 35, 39, 40, 47].

Currently, active work is being done on blending vegetable oils in order to develop products designed to nourish a healthy person [13, 14, 15, 30, 31, 32].

In Table 6, the comparative characteristic is given of the fatty acid composition of the blended oils and sunflower oil, which is used as a fatty basis in the control.

Table 6: Characteristics of the fatty acid composition of oils

Name	Code	Blend (ω-6 / ω-3= 10:1)	Sunflower oil
Polyunsaturated			
linoleic	18:2	26,2	31,8
linolenic	18:3	2,9	0,5

As can be seen from the tabular data, the ω-6 / ω-3 ratio of sunflower oil is significantly inferior to the blend and does not correspond to healthy nutrition: the ω-6 / ω-3 ratio in the blend is 10: 1, in sunflower oil – 63: 1.

Thus, the resulting new emulsion products, in which the fat base is represented by blended oil balanced in fatty acid composition, have a functional orientation and provide the human body with unsaturated fatty acids.

On the basis of the conducted research, the formulation for making an emulsion product of a functional purpose has been developed using a plant-derived emulsifier (Table 7).

ISSN: 0975-8585

Table 7: Formulation of a vegetable-based emulsion product

Product Name	Emulsion ω-6: ω-3 = 10 :1
Bulked champignon powder, g / 100 g emulsion, incl.:	35
Powder from champignons, g	*5*
Water, g	*30*
Blend of vegetable oils, g, incl.:	63,6
sunflower oil	*44*
rapeseed oil	*19,78*
Sugar, g / 100 g emulsion	*0,71*
Salt, g / 100 g emulsion	0,5
Ascorbic acid, g / 100 g emulsion	0,01
OUTPUT:	100

The organoleptic evaluation of the developed plant-based emulsion product of functional purpose and control (No. 564 “mayonnaise sauce”) was carried out in accordance with the GOST R 50173-92. The results of the evaluation are presented in Table 8.

As can be seen from the data presented, the developed food emulsion based on the powder of champignons has high organoleptic characteristics.

Given that the intended direction of the use of the emulsion product is the replacement of the “mayonnaise sauce,” a comparative assessment of their chemical composition was carried out (Table 9).

It was established that the protein content in the emulsion product of functional purpose is 1.4 times more, and the fat content is 1.3 times less than in the control. The emulsion product contains 5 times more sodium, a large amount of sodium, 2.2 times more magnesium, 1.3 times more phosphorus. The developed emulsion product is completely free of cholesterol.

The energy value of the functional food emulsion is 21% less than in the “mayonnaise sauce”.

Table 8: Organoleptic characteristics of emulsion products

Indicators	Control No. 564 “mayonnaise sauce”	An emulsion product with a functional purpose on a plant-based
Colour	Cream-yellow, uniform throughout the mass.	Light brown, uniform throughout the mass.
Taste and smell	The taste is delicate, sour, without a trace of bitterness and smack of vinegar.	Taste is gentle, without traces of bitterness, pronounced mushroom smell.
Consistency and appearance	Homogeneous creamy product with dotted inclusions from mustard.	Homogeneous thick creamy product, with small patches of mushroom powder particles.

Table 9: The chemical composition of fatty products (100g)

Indicator	Control “mayonnaise sauce”	An emulsion product with a functional purpose on a plant-based
Water, g	0	30
Protein, g	1,81	2,5
Fat, g	78,05	62,98
Carbohydrates, g	2,77	2,66
Ratio ω-6 / ω-3	63:1	10:1
Mineral substances, mg		

Sodium, mg	36,58	196,95
Potassium, mg	0	238,1
Calcium, mg	15,81	3,84
Magnesium mg	4,49	10,11
Phosphorus, mg	57,36	73,59
Iron mg	0,89	0,31
Vitamins:		
Beta carotene	0	0
B1	0,02	0,005
B2	0,03	0,1
PP	0,384	1,9
C	0	6,51
Cholesterol mg / 100g	42	0
The energy value	714,23	588,96

This content of minerals, vitamins, the absence of cholesterol, reduced energy value allow us to attribute the developed emulsion product to products for healthy people and for people with high cholesterol. The high content of potassium and sodium allows its use in the diet of people with cardiovascular diseases.

CONCLUSIONS

1. The assessment was carried out on the basis of consumer motivations when choosing sauces, as one of the stages of creating functional products.
2. Based on the analysis of the chemical composition, the expediency of using champignon powder was justified as an emulsifier in the production of an emulsion product with a functional purpose.
3. Technological regimes of preliminary preparation of mushroom powder were established, used as an emulsifier in the manufacture of an emulsion product.
4. The effect of prescription ingredients and emulsification regimes on the properties of an emulsion product was studied.
5. The scientifically grounded technology and formulation of an emulsion product with a functional purpose was developed using a plant-derived emulsifier, with a balanced fatty acid composition (for healthy nutrition) and structural and mechanical characteristics as close as possible to that for sauce-mayonnaise.
6. A comprehensive assessment was carried out on the quality of a plant-based emulsion product.

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