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INFLUENCE OF DIETARY ADDITIVES ON THE TECHNOLOGY OF SAUCES

Today, the creation of new products that improve the nutritional status of people is a pressing problem for scientists in the food industry. Functional ingredients with increased protective and improved technological properties are increasingly used in food technologies. Such components include plant substances, in particular dietary fiber and plant phospholipids. Phospholipids are indispensable essential substances that enter the body only with food. They cannot be synthesized independently in the body, but they perform important functions: restoring cell membranes, participating in lipid metabolism and reducing the risk of cholesterol formation, and also ensuring the delivery of biologically active substances to cells. Gum arabic is a rich source of biologically active components, and its medicinal properties have already been recognized by official medicine. This study studied the effect of gum arabic and phospholipids in the recipe of red sauce on its rheological and physical properties. Samples of sauces with the replacement of 50% and 100% flour with gum arabic, as well as 30% animal fat with vegetable phospholipids, were developed. Changes in the effective viscosity and density of the resulting sauces were studied. It was found that at a shear rate of 0.3333 s-1, the viscosity of the control sample is 14.32 Pa·s, while samples with the replacement of 50% flour and 10 g of fat, as well as 100% flour and 10 g of fat showed 16.49 and 19.6 Pa·s, respectively. The replacement was accompanied by a slight increase in density. To substantiate the functional properties of sauces with vegetable additives, a study of their antioxidant activity (AOA) was conducted. It was found that the sauce with vegetable additives is able to "neutralize" 89% of radicals after 90 min in a model system. Adding such sauces to ready-made dishes, even in small quantities, increases their nutritional value and attractiveness. The influence of additives on the consumer characteristics of sauces that have a creamy and homogeneous consistency, a pronounced taste and aroma was studied. The conducted complex of studies allows us to confidently state that the use of affordable plant raw materials instead of traditional ingredients with high nutritional value can reduce energy value and expand the range of functional sauces for restaurant businesses.

Keywords: sauce, vegetable phospholipids, rheological characteristics, effective viscosity, antioxidant activity, organoleptic properties, protein-fat additive, gum arabic, dietary fiber, biotechnology

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ВПЛИВ ДІЄТИЧНИХ ДОБАВОК НА ТЕХНОЛОГІЮ СОУСІВ

Сьогодні створення нових продуктів, які покращують харчовий статус людей, є актуальною проблемою для науковців у харчовій промисловості. У харчових технологіях все частіше використовують функціональні інгредієнти з підвищеними захисними та вдосконаленими технологічними властивостями. До таких компонентів можна віднести рослинні речовини, зокрема харчові волокна та рослинні фосфоліпіди. Фосфоліпіди є незамінними есенціальними речовинами, які потрапляють ворганізм лише з їжею. Вони не можуть синтезуватися самостійно в організмі, але виконують важливі функції: відновлення клітинних мембран, участь у ліпідному обміні та зниження ризику утворення холестерину, а також забезпечують доставку біологічно активних речовин до клітин. Гуміарабік є багатим джерелом біологічно активних компонентів, а його лікувальні властивості вже визнані офіційною медициною. У цьому дослідженні вивчався вплив гуміарабіку та фосфоліпідів у рецептурі червоного соусу на його реологічні та фізичні властивості. Розроблені зразки соусів із заміною 50% та 100% борошна на гуміарабік, а також 30% тваринного жиру на рослинні фосфоліпіди. Досліджено зміни ефективної в'язкості та густини отриманих соусів. Встановлено, що при швидкості зсуву 0,3333 с-1 в'язкість контрольного зразка становить 14,32 Па·с, тоді як зразки з заміною 50% борошна і 10 г жиру, а також 100% борошна і 10 г жиру показали відповідно 16,49 і 19,6 Па·с. Заміна супроводжувалася незначним підвищенням густини. Для обґрунтування функціональних властивостей соусів з рослинними добавками проведено дослідження їх антиоксидантної активності (АОА). Встановлено, що соус з рослинними добавками здатний "нейтралізувати" 89% радикалів через 90 хв у модельній системі. Додавання таких соусів до готових страв, навіть у невеликих кількостях, підвищує їх харчову цінність і привабливість. Досліджено вплив добавок на споживчі характеристики соусів, які мають кремоподібну та однорідну консистенцію, яскраво виражений смак і аромат. Проведений комплекс досліджень дозволяє впевнено стверджувати, що використання доступної рослинної сировини замість традиційних інгредієнтів з високою харчовою цінністю може знизити енергетичну цінність і розширити асортимент функціональних соусів для підприємств ресторанного бізнесу.

Ключові слова: соус, рослинні фосфоліпіди, реологічні характеристики, ефективна в'язкість, антиоксиданта активність, органолептичні властивості, білково-жирова добавка, гуміарабік, харчові волокна, біотехнологія,

Formulation of the problem

Nowadays, nutrition is one of the main factors that determine human health and activity, its normal growth and development, working capacity, life expectancy, the body's resistance to diseases and harmful environmental factors. The problem of rational nutrition of the population is of great social importance and plays a decisive role in ensuring the quality and duration of human life, its health. In Ukraine, the most important violations in the nutrition system are excessive consumption of animal fats, carbohydrates, against the

background of a deficiency of complete proteins of animal origin, polyunsaturated fatty acids, trace elements, vitamins and dietary fiber. Therefore, scientists are faced with the task of creating a range of new products that have a functional orientation and improve human nutritional status.

In food technology, an effective direction is the use of functional ingredients that have increased physiological and improved technological properties. From this point of view, there is a huge potential in plant raw materials, which are an inexhaustible source of natural biologically active substances with versatile functional and physiological properties [10]. Functional food products containing plant raw materials are now recognized as an effective means of preventing a wide range of diseases, an important component in their treatment [7,9-15]. The menu of modern restaurants requires dishes from plant raw materials that would be safe, natural and tasty and, very importantly, enriched with physiological ingredients. The most promising for enrichment are products and dishes that make up the daily diet. A special group among them are sauces. Sauce (from the French sauce - gravy) is a hot or cold spicy liquid of various consistencies, served with a dish to give it a special taste, as well as as an additive in the preparation of food products. Sauces are an integral part of most dishes prepared from various products. They give dishes juiciness, a special taste and aroma, and an attractive appearance. Their aroma and taste stimulate the appetite, they contribute to better absorption of the main components of the dish due to the presence of extractive, aromatic and flavoring substances that stimulate the secretion of digestive glands. Sauces are also able to enrich the main dish with deficient nutrients: macro-, microelements, vitamins, dietary fiber, PUFA and other biologically active substances. Therefore, sauces are able to show familiar dishes, products and ingredients in a new light - in short, they are an important component of dishes of any cuisine.

Today, restaurants use many varieties of sauces: hot and cold, fish, meat, spicy, dairy, cheese, dessert, low-calorie - vegetable, berry and oil. Many restaurants develop special sauce cards, which include sauces for each category of dishes. However, not enough attention is paid to the development of new recipes and technologies for culinary products for healthy eating, including sauces, which are an integral part of a person's daily diet.

Analysis of recent sources

The works of Ukrainian scientists have considered and proposed scientific approaches to the development of various types of sauces with the addition of various functional ingredients to their composition. Thus, Kublinska I. A. developed a technology for mushroom sauce using powders from champignons, reishi, shiitake and mushroom sauces with a thickener, which allows to increase the biological value of the product and expand the range of sauce products based on plant raw materials for restaurant establishments [8].

Scientists Choni I. V. and Sutkovych T. Yu. of the higher educational institution of the Ukoopspilka “Poltava University of Economics and Trade” proposed a technology for emulsion-type sauces using oat and pearl barley flour as emulsifiers and stabilizers [2].

Specialists of the Kharkiv State University of Food and Trade Pogozhykh M. I., Golovko T. M., Dyakovym O. G. [1] the introduction of powdered dietary supplements based on chelate complexes into mayonnaise “Provencal” and white sauce was investigated. Sauces enriched with essential micronutrients with traditional quality indicators were obtained.

Scientists Slashcheva A. V., Popova S. Yu., Klymenko A. V. proposed to use pumpkin and sea buckthorn puree for the preparation of sauces and showed high organoleptic indicators of the resulting sauces, proved their safety and increased content of pectin, carotenoids, ascorbic acid and minerals. Developments of the technology for the production of low-lactose emulsion sauces using a semi-finished product from condensed milk whey and fermented pumpkin pulp puree are also known. The resulting sauces have high nutritional and biological value, increased protein content, as well as a balanced amino acid and improved vitamin and mineral composition [6].

Also, a number of works by foreign scientists [1,3-6] were devoted to solving this problem. The introduction of okra mucus in natural and freeze-dried forms into tomato sauce as a thickener and emulsifier was investigated. The developed types of sauce contain a significant amount of phenolic compounds and they have high antioxidant activity, improved consumer properties and sensory characteristics. A group of researchers [13] developed a new type of natural sauce from processed cheese seasoned with essential oils. Essential oils give the resulting sauce antioxidant and antimicrobial properties, have excellent taste and beautiful color. Scientists from Spain proposed enriching white sauces with red sweet pepper, based on its properties as a source of antioxidant compounds. The work conducted a study to study the effect of the addition of red pepper and modified starch on rheological parameters, microstructure, color. Sensory characteristics and consumer acceptability of new white sauces were determined [3,7-9].

However, there is a lack of research on the development of sauce recipes with soluble dietary fibers, which contribute to the binding and excretion of anthropogenic pollutants and metabolic products from the body. Dietary fibers belong to one of the most necessary categories of food components. They are recognized as a powerful tool in the prevention and complex treatment of numerous “diseases of the century”, in particular such formidable ones as diabetes mellitus, a number of tumor diseases, atherosclerosis, ischemic heart disease.

The work proposes to use water-soluble polysaccharides of gum arabic, which consist of two types of polysaccharides – neutral arabinoxylans and acidic pectin-like substances. The glue-like consistency of mucus

allows them to be used as food additives with various functional properties – structure-forming agents, emulsifiers, stabilizers, water-retaining hydrocolloids.

Also, in conditions of deterioration of the ecological situation and the structure of nutrition, substances with antioxidant and lipotropic action are of particular interest. Phospholipids of plant origin can serve as an important source of these substances in nutrition.

Thus, the development of red sauce technology, which has detoxifying properties, as well as lipotropic and antioxidant effects, is appropriate and relevant.

The purpose of the work is to develop a red sauce enriched on the basis of plant raw materials.

In accordance with the goal, it is necessary to solve the following tasks:

- selection and justification of functional ingredients for enriching the basic red sauce;
- study of the structural and mechanical properties of the sauce with plant additives;
- study of the antioxidant activity of the developed sauces and their components;
- study of consumer characteristics of experimental samples of the sauce.

Presenting main material

The experimental part of the work was carried out at the Odessa National Academy of Food Technologies.

The research included replacing wheat flour with gum arabic and replacing animal fat with vegetable phospholipids in the recipe of the red basic sauce.

The raw materials used for the research met the DSTU and the requirements of the regulatory documentation in force in Ukraine.

Sampling of the finished product and preparation of samples for analysis were carried out according to the standard method.

The study of rheological characteristics was carried out on a rotational viscometer "Rheotest-2" (Hernández-Carrión et al., 2015). When studying the sauces, the shear rate varied from 0.3333 to 145.8 s^{-1}.

The density of the sauces was determined using a pycnometer (Iorhachova et al., 2011).

The determination of organoleptic quality indicators of the product was carried out using profile analysis (descriptive analytical method) (Yalçınöz & Erçelebi, 2016).

Antioxidant activity (AOA) was determined by the modified thiocyanate method with a non-specific oxidation substrate (1.3% solution of olive oil in 96% ethyl alcohol) (Sal'kova & Amzashvili, 1987).

The reaction mixture consisted of 0.5 ml of olive oil, 1 ml of 0.05 M Na-phosphate buffer pH 7 and the sample under study. The reaction mixture was heated in a water bath for 1.5 h. After cooling the reaction mixture, 0.1 ml of 30% ammonium rhodanate NH4(CNS) and 0.1 ml of 0.02 M FeSO4·7H2O, previously purified from Fe^{3+} ions by recrystallization from 96% alcohol, were added. The intensity of the developed red color was measured spectrophotometrically at a wavelength of 540 nm on a spectrophotometer.

The essence of the method is as follows: in the oxidation substrate, the formation of peroxide compounds is initiated, the amount of which is recorded by a reaction with the formation of a complex compound that has a maximum absorption at a wavelength of 500...540 nm. When an oxidation inhibitor is introduced into the model system (the studied sauce samples), the amount of peroxide compounds decreases, which is accompanied by a change in the intensity of the color of the complex compound: the Fe^{2+} ion is oxidized by peroxide and hydroperoxide radicals into the Fe^{3+} ion, which, when interacting with CNS-, forms a complex compound colored in red.

Sauces, along with a number of advantages, are also able to enrich the main dish with deficient nutrients: macro-, microelements, vitamins, dietary fiber, PUFA and other biologically active substances, can enhance the detoxification, antioxidant activity of the diet, and affect the functioning of the gastrointestinal tract. Therefore, it would be advisable to develop sauce recipes using plant raw materials with specified functional and technological properties. When creating new sauce compositions, it is important to select and justify the recipe ingredients, their rational combination, which will ensure the production of semi-finished products and sauces with the necessary structural, mechanical and organoleptic properties, and a specified physiological effect.

The basic red sauce recipe No. 1.365 [16] was used as the basis for the composition. Brown broth, sautéed and broth-diluted flour, sautéed vegetables (onions, carrots, parsley) with tomato puree, and rendered animal fat are used to prepare the sauce. Basic red sauce is used to prepare derived sauces and on its own. Basic red sauce is served with natural and cutlet meat dishes, ham, sausages; varieties of red coysu with fried meat dishes. Many sauces are used for stewing meat and vegetables. Onion sauce, red sauce with onions and cucumbers, red sauce with wine, sauce with onions and mushrooms, sweet and sour red sauce, and a wide range of branded sauces developed in restaurants are prepared on the basis of this sauce.

The quality of the finished sauce with the specified functional properties largely depends on the ingredients used, which are introduced into the recipe. Traditionally, when preparing sauces, high-grade wheat flour is used as a thickener (emulsifier and stabilizer). However, such flour has a low nutritional value, so it is advisable to add gum arabic to enrich the product with dietary fiber, replacing wheat flour. The work investigated the introduction of a biologically active additive (BAA) "Fibregum" from African acacia resin, the chemical composition of which is represented by hemicelluloses (80...83%), a protein component (4.0...5.2%) and minerals (1.5...2.5%). Vegetable phospholipids were also introduced to partially replace animal fat in the recipe.

The work investigated sauce samples with 50% and 100% flour replaced by gum arabic and with 10 g of animal fat replaced by vegetable phospholipids. The following sauce samples were investigated:

1. Basic red sauce - control;
2. Red sauce with 50% flour and 10 g of fat replaced;
3. Red sauce with 100% flour and 10 g of fat replaced;

To obtain a high-quality finished product, it is necessary to solve the problem of obtaining a sauce of stable and uniform consistency, which would not separate when served. Therefore, it is advisable to investigate the change in the viscosity of sauces with the introduction of additives.

One of the most important characteristics of the structural and mechanical properties of sauces, which determines their rheological state, is their viscosity. Viscosity determines the state of the material and is a measure of flow resistance (internal friction). Experimental determination of the viscosity of the studied sauces was carried out on a rotational viscometer "Rheotest-2". The tests were carried out using a measuring system of cylinders N/N. The measuring tank was filled with the studied product and tempered at a temperature of 50 °C.

The results of studies on the change in the effective viscosity of sauces from the shear rate gradient with different replacement of flour and animal fat are shown in Fig. 1.

As experimental data show, at a temperature of 50 °C the sauce with complete replacement of flour with a polysaccharide structure-forming agent has the highest viscosity, the control sample has the lowest. Thus, at a shear rate of 0.3333 s-1, the viscosity of the control sample is 14.32 Pa·s, and the sample with a replacement of 50% flour and 10 g of fat and 100% flour and 10 g of fat is 16.49 and 19.6 Pa·s, respectively. Therefore, it can be stated that the sauce with a complete replacement of flour with plant polysaccharides has a thicker, more viscous consistency, which affects the organoleptic properties, compared to the control sample. The increase in effective viscosity in samples with flour replacement is due to the fact that soluble polysaccharides are introduced into the sauces when gum arabic is added. When decorating and serving dishes with sauces, their density is of great importance. Very thick sauces do not give juiciness, are unevenly distributed over the surface of the dish, which makes their use difficult in decoration and worsens the appearance of the finished dish. Too thin sauces can negatively affect the main dish, mainly softening it, and also spreading over the surface, while losing its original shape.

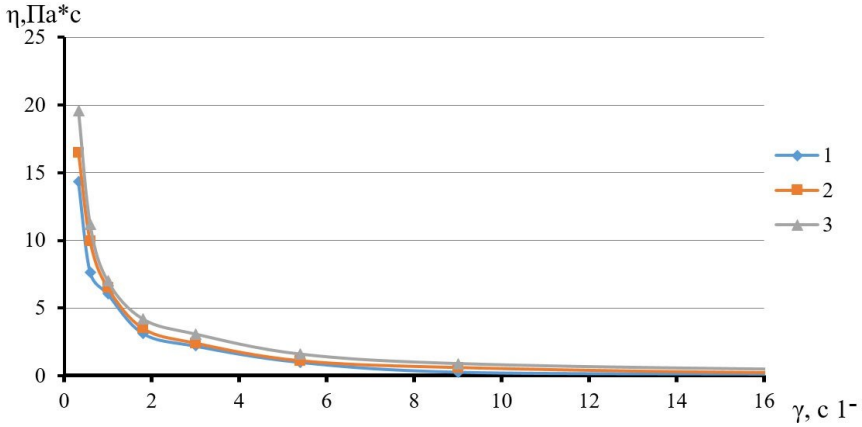

Fig. 1. Dependence of the effective viscosity of sauces on the shear rate gradient at a temperature of 50 °C: 1 – control; 2 – with replacement of 50% flour and 10 g fat; 3 – with replacement of 100% flour and 10 g fat

The analysis of experimental data showed that when replacing flour with gum arabic, there is a slight increase in the density of sauces. When replacing 50% of flour, the density is 1.25 g/cm3, when replacing 100% of flour - 1.27 g/cm3. Thus, when replacing flour with plant polysaccharides, there is a slight increase in density, which does not affect the quality of the resulting sauces. The developed sauces have excellent structural, mechanical and organoleptic indicators.

Our task was to maximize the enrichment of the finished product with functional ingredients. Therefore, in the future, a sample with 100% flour replacement with gum arabic and 40% animal fat replacement with lecithin was used as a functional sauce.

To substantiate the functional orientation of sauces with plant ingredients, it is necessary to investigate the antioxidant activity of the resulting sauces. Antioxidant activity is understood as the ability of substances to inhibit or break the formation of chains in free radical oxidation reactions. That is, the ability to resist oxidative stress in the body of a modern person, which is widespread due to frequent stress, overwork, environmental pollution, bad habits, etc.

The antioxidant activity (AOA) of the studied sauce, as well as its individual components, was determined by a modified thiocyanate method with a non-specific substrate (1.3% solution of olive oil in 96% solution of ethyl alcohol).

As experimental results show, the maximum AOA is possessed by the sauce with vegetable additives. Thus, at t = 90 °C for 90 min, its main components are able to "extinguish" 89% of the radicals formed under these conditions in the model system. The minimum AOA under the same conditions was found in samples of the traditional red basic sauce and slime.

It was found that the most significant synergistic effect on the inhibition of oxidation processes is exhibited by a functional sauce, which is probably explained by the fact that one of the inhibitors breaks oxidation chains, and the other destroys peroxides.

Since sauces significantly affect the organoleptic characteristics of dishes, an important task is to determine the effect of additives on the consumer properties of the developed sauces.

Sauces according to organoleptic characteristics must meet the requirements of relevant standards. When assessing organoleptic characteristics, sauces are evaluated according to the following indicators: appearance (including color), consistency, smell and taste.

The appearance of sauces is a general visual impression, which in practice has a decisive physiological and psychological significance. Sauces should have the appearance of a homogeneous mass, without films and fatty substances on the surface. A heterogeneous consistency worsens the appearance of dishes and reduces the taste of food, and the appearance of films and fat on the surface negatively affects the taste of the dish. The organoleptic characteristics of the developed sauce recipes are given in Table 1.

Table 1

Organoleptic characteristics of sauce samples

Indicators	CONTROL	Sauce with 50% flour replacement	Sauce with 100% flour replacement
Appearance	Homogeneous mass, without films, slight separation of fat droplets on the surface, with individual lumps of sautéed flour	Homogeneous mass without films and fat on the surface	Homogeneous mass without films and fat on the surface
Consistence	Pasty, slightly viscous	Thick consistency, creamy product, uniform in consistency	Thick consistency, creamy product, uniform in consistency
Color	Crimson	Crimson	Crimson
Taste, smell	Typical for this type of semi-finished product, the smell and taste of tomatoes and broth are not clearly expressed.	Typical for this type of semi-finished product, without foreign taste or smell	Typical for this type of semi-finished product, without foreign taste and smell, the taste and aroma are well pronounced

The organoleptic evaluation of the sauce samples (control and experimental) was carried out by the tasting commission using a scoring system. Scores were given for appearance, consistency, color, taste, and smell, with 5 points corresponding to the highest score and 2 points to the lowest. The results of the organoleptic evaluation of the sauce samples are shown in Fig. 2.

For the control sample of red sauce, the scores were reduced for appearance, since the presence of lumps of brewed flour was detected, and some separation of fat droplets on the surface was observed.

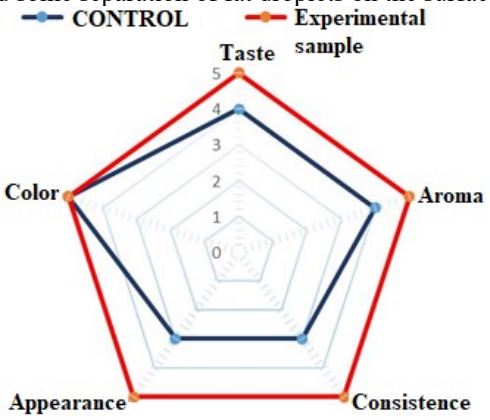

Fig. 2. Sauce profile

The consistency of the control was inferior to the experimental samples, it was characterized as somewhat viscous, sticky. This is due to the use of flour as a thickener, the peculiarities of its functional and technological properties. The use of a composition of gum arabic and lecithin, which exhibit the properties of a thickener and emulsifier, leads to the formation of a thick, creamy mass.

Conclusions

The results of the conducted research indicate that the functional ingredients – gum arabic and vegetable phospholipids – are promising and advisable to use in the recipe of red sauce. The work established that the introduction of gum arabic allows to exclude 100% of wheat flour from the recipe, and vegetable phospholipids – 40% of animal fat. At the same time, a sauce was obtained that has not only excellent organoleptic characteristics: a characteristic structure, a pronounced tasteand aroma, a creamy consistency, but also functional properties – the content of dietary fiber and phospholipids of plant origin has increased, and the developed type

of sauce is also able to positively influence the physiological processes of the human body. Namely: it has detoxifying properties and has antioxidant and lipotropic activity. Thus, the introduction of dietary fiber and plant phospholipids into the red sauce will significantly expand the range of sauces and dishes with functional properties at restaurant enterprises, and will be interesting for manufacturers of gluten-free products, as well as for visitors with intolerance to wheat flour components.

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