

ІННОВАЦІЙНІ ПРОЦЕСИ ХАРЧОВИХ ВИРОБНИЦТВ

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DEVELOPMENT OF TECHNOLOGY OF SAUCES WITH VEGETABLE HYDROCOLLOIDS

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Abstract. *The article analyzes modern trends in a healthy lifestyle, emphasizing the importance of a balanced diet, which stimulates the development of functional products to eliminate the deficiency of essential substances and prevent diseases. In this context, the creation of sauces with plant additives, such as gum arabic and flax meal, opens up new opportunities for increasing their nutritional value and biological activity. The study is devoted to improving the technology of red basic sauce by adding gum arabic – a natural polysaccharide from acacias, which acts as a stabilizer and source of fiber, and flax meal – a product of flax seed processing, rich in proteins, polyunsaturated acids (Omega-3, Omega-6) and trace elements. Gum arabic improves the texture and stability of the product, preserving its taste, while eggplant powder and flaxseed meal enrich the sauce with vitamins, amino acids, and fiber, promoting intestinal health and cholesterol regulation. Traditional red basic sauce is characterized by a low content of fiber, vitamins and minerals, which limits its functionality. The paper proposes to modify the recipe by adding gum arabic (2.5 g), eggplant powder (3 g), and flaxseed meal (2.5–5 g per 1000 g of product) with particles of 0.06–0.1 mm, which ensures optimal release of nutrients without compromising taste. Experiments have determined the limits of the introduction of additives: smaller doses are insufficient for enrichment, and larger doses lead to an oily aftertaste. Two recipes have been developed with sautéing vegetables, adding meal to flour and cooking with broth. Organoleptic evaluation revealed the superiority of recipe 1 (5 g of meal) in taste, aroma and consistency, with preservation of quality for 20 days at 5°C. The proposed technology increases the nutritional value of the sauce, improves its rheological properties and makes the product competitive in the healthy food segment. The use of secondary raw materials, such as flaxseed meal, supports the principles of sustainability and economic feasibility, opening up prospects for innovation in the food industry.*

Key words: *gum arabic, eggplant powder, flaxseed meal, sauces, functional products, dietary fiber, nutritional value, plant hydrocolloids, dietary supplements, technology.*

Formulation of the problem in general form.

The development of sauces with plant hydrocolloids is a challenging task at the intersection of food technology, consumer needs and sustainability. Traditional sauce production is often based on animal gelatin, starch or synthetic stabilizers, which have limitations: high calorie content, allergy risk and a significant environmental footprint. Changing dietary preferences – veganism, low-fat or gluten-free diets – require alternatives that preserve the sensory qualities of sauces (viscosity, mouthfeel, stability). Plant hydrocolloids are a promising solution, but their use in sauces is not well studied and poses certain challenges. First, the physicochemical properties of hydrocolloids – solubility, gelation, interaction with other ingredients – require precise formulation for stable results. Second, scaling is a problem: laboratory successes often cannot be transferred to industrial production due to costs, processing conditions or variability of raw materials. Third, sensory acceptability remains key to whether hydrocolloid-based sauces can compete with traditional recipes in terms of taste. In Ukraine, where sauces are part of the culinary

heritage, the problem is exacerbated. Local producers compete with imported products, but research on hydrocolloids adapted to regional tastes is lacking. The work aims to fill these gaps by investigating the functionality of hydrocolloids, optimizing sauce formulations, and taking into account practical and cultural aspects. Stagnation in sauce technologies may limit dietary inclusivity and environmental progress.

Analysis of recent research and publications.

Ukrainian and foreign scientists are actively researching food technologies, increasingly paying attention to plant-based ingredients, in particular hydrocolloids. Scientists emphasize the functional benefits of hydrocolloids – thickening, stabilization, health improvement – but often ignore the sensory profile and industrial implementation [1, 2].

Peresichny M.P. investigates functional products, focusing on natural thickeners to increase nutritional value. He emphasizes the potential of pectin in fruit sauces, noting its ability to improve texture and reduce sugar content. This is in line with healthy eating trends, but there is a lack of data on sensory evaluations [3].

Ukrainets A.I. analyzes hydrocolloids in food processing, focusing on the emulsifying properties of guar gum. His works show its suitability for creamy sauces, but the issues of scaling (costs, availability of raw materials) are not sufficiently covered [4].

Gulich M. P. is working on innovative sauce technologies, promoting carrageenan for low-fat formulations. Her studies demonstrate stability during heat treatment, but consumer acceptance has not been investigated [5].

Kravchenko M. F. is studying hydrocolloids in gluten-free products with potential applications in sauces. The role of xanthan gum in viscosity is well described, but the interaction with local ingredients (e.g. beetroot or sour cream) is hardly considered [6].

Snizhko O. V. is investigating sustainable food systems, linking hydrocolloids to waste reduction. Her work on alginate-based sauces indicates environmental benefits, but data on technical optimization are lacking [7].

Saha D. and Bhattacharya S. are investigating the functionality of hydrocolloids, testing xanthan and guar gum in sauces. Their rheological studies show excellent texture control, but cost-effectiveness for mass production is not addressed [8].

Gorinstein S. analyzes the antioxidant properties of pectin in sauces, linking them to health benefits. Sensory tests are included, but cultural adaptation is not considered [9].

Phillips G.O. and Williams P.A. provide a comprehensive guide to hydrocolloids, detailing the mechanics of carrageenan gelation [10].

Taylor A. investigates consumer perception of sauces with hydrocolloids, finding that acceptability is dependent on texture. This combines science and the market, but lacks specifics on formulations [11].

Mizota T. studies alginates in Asian sauces, emphasizing umami enhancement. His approach integrates the science of taste, although processing costs are a barrier [12].

International and Ukrainian scientists are strong in technical analysis (rheology, chemistry) and consumer research, creating a solid foundation for sauce innovation. However, their work often does not take into account the context of local cuisines or scaling, unlike the Ukrainian focus on regionality.

Formation of article goals. The aim of the work is to develop a technology for making red basic sauce using plant additives (gum arabic, eggplant powder, and flaxseed meal) to increase its nutritional and biological value, improve organoleptic and structural-rheological properties, and ensure functional characteristics of the product that meet the principles of healthy eating.

Object of research: technology for preparing red basic sauce by introducing plant components (gum arabic, eggplant powder and flax meal) to enrich its nutritional value.

Object of research: gum arabic, eggplant powder, flax meal, nutritional value, organoleptic indicators,

structural and rheological properties, stability of red basic sauce, production and storage.

Presentation of the main research material. The most accessible and widely used method of eliminating the deficiency of essential nutrients in the diet of the population and preventing various diseases is to expand the range of functional products.

The use of new types of functional raw materials for targeted correction of the chemical composition of food products requires new technological solutions that ensure the production of high-quality, competitive products.

Today, the topic of a healthy lifestyle, and therefore healthy nutrition, is relevant. Without touching on scientific research and without conducting scientific experiments, it is difficult to say which products contain the most important and necessary nutrients for our body.

Gum arabic (acacia gum) is widely used in the food industry as a natural emulsifier, stabilizer and thickener due to its unique properties. It is obtained from the sap of acacia trees (mainly *Acacia senegal* and *Acacia seyal*) and is a water-soluble polysaccharide. In the production of products, gum arabic is used to stabilize emulsions (e.g. in drinks, sauces, mayonnaise), prevent sugar crystallization in confectionery (candy, chewing gum) and improve the texture of dairy products and ice cream. It is a source of dietary fiber, which allows it to be used in functional products to reduce calories and maintain a healthy digestive system. Gum arabic is safe, does not affect the taste and aroma, which makes it a popular ingredient in dietary and healthy foods.

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Adding eggplant powder to the technology is an additional source of vitamins, which is especially important for regulating metabolism and improving the body's resistance to various negative environmental factors. Vitamins are part of enzymes that provide important metabolic processes in the body. Water-soluble vitamins in eggplant powder (PP, B1, B2) contribute to cellular metabolism. The mineral composition of eggplant powders contains calcium (48.5 ± 2.0), potassium (740.4 ± 2.0), iron (1.7 ± 0.5), phosphorus (98.80 ± 1.5), magnesium (26.18 ± 2.0), which are components of bone tissue, have radioprotective and anti-anemic properties, and therefore are vital for humans. The amount of vitamins is, mg/100g: thiamine B1 – 0.40 ± 0.01 ; riboflavin B2 – 0.5 ± 0.06 ; nicotinic acid PP – 5.22 ± 0.10 . The increased level of mineral elements, B vitamins, niacin in eggplant powders will contribute to the overall strengthening of the body and the strengthening of the protective effect of the immune system. And this, in turn, increases the body's resistance to adverse environmental factors.

Flax seeds and their processed products (flax cake) differ in their technological and functional indicators. In this regard, scientific and practical research is needed on their implementation in food technologies. Flaxseed meal is a secondary raw material resource. It is obtained by squeezing oil on screw presses, by cold pressing from pre-treated and cleaned flax seeds. Flaxseed meal is a full-fledged source of nutrients. It contains complete proteins, easily digestible carbohydrates, lipids, vitamins, minerals. Flaxseed meal is also low in cost compared to flax seeds. Also, the fiber found in flaxseed meal enhances intestinal peristalsis. It absorbs harmful substances and toxins and removes them from the body. Fiber slows down the absorption of fats and carbohydrates and reduces cholesterol levels. Polyunsaturated acids (Omega-3 and Omega-6) have been found in flaxseed meal. They force saturated fats from animal food to leave the body. At the same time, cholesterol is reduced and excess weight goes away. From this we can conclude that it is in tandem with food that flaxseed meal will have a beneficial effect on the human body. Flaxseed meal has high dietary properties. When steamed, flaxseed meal forms mucus, the same as when boiling flax seeds and with the same properties. Moreover, to obtain mucus, the meal does not need to be boiled, it is enough to simply steam it in a sufficient amount of water, since extruded flax meal does not contain anti-nutritional substances. Flaxseed meal has a high energy value: 1 kg of meal contains 1.27 k.u., 13.73 MJ (as in 1.3–1.4 kg of oats) and 287 g of digestible protein; as well as a rich composition of microelements and vitamins.

The chemical composition, organoleptic and physicochemical indicators of flaxseed meal will depend on the quality of flax seeds, methods and modes of kernel pressing. The chemical composition of flaxseed meal is presented in Tables 1 and 2.

Table 1
Organoleptic and physicochemical properties of flaxseed meal

Name of the indicator	Characteristic
Color	From grey to light brown
Smell	Characteristic of flaxseed meal, without foreign odor
Metallomagnetic impurity, mg per 1 kg of meal	None
Other foreign impurities	None

Table 2
Chemical composition of flaxseed meal

Components	Weight g per 100 g of edible part
Water	15
Protein	26
Fat	10
Carbohydrates	12
Dietary fiber	30
Fiber	9,3

The mineral composition of flaxseed meal is presented in Table 3. The amount of minerals and vitamins in flaxseed meal depends on the chemical composition of flaxseed and the residual oil content in the meal after pressing.

Table 3
Mineral composition of flaxseed meal

Macronutrients	Contents, g
K	12,4
Ca	3,4
Mg	4,3
Na	3,9
P	10
Mn	38
Fe	197
Cu	26,4
Zn	69

When separating oil, the content of essential substances, minerals, and vitamins in flaxseed meal changes. The content of vitamins in flaxseed meal is presented in Table 4.

Table 4
Vitamin content in flaxseed meal

Name	Contents, g
Tocopherols (E)	5,8
Thiamine (B ₁)	10,2
Riboflavin (B ₂)	4,8
Pantothenic acid (B ₃)	9,5
Nicotinic acid (B ₃)	44

Flaxseed meal is unique in that after the oil has been distilled, the fats remaining in the flaxseed meal have beneficial properties, and flaxseed meal is rich in valine and threonine, their value is close to the maximum. And lysine, methionine, leucine are acids that limit the biological value of flaxseed proteins. The content of essential amino acids in flaxseed meal is presented in Table 5.

Table 5
Content of essential amino acids in flaxseed meal

Name	Content of essential amino acids, g per 1 kg of meal
Valin	16,7
Isoleucine	15,8
Leucine	19,6
Lysine	11,1
Methionine	5,1
Threonine	12,3
Tryptophan	4,4
Phenylalanine	13,3

Currently, a method and recipe for preparing a basic red sauce is widely known, characterized by the fact that chopped onions and carrots are sautéed with fat, tomato puree is added and sautéing is continued for another 10-15 minutes; sifted wheat flour is sautéed at

a temperature of 150-160°C; the flour sauté cooled to 70-80°C is diluted with warm broth in a ratio of 1:4, thoroughly mixed and vegetables sautéed with tomato puree are added and cooked at a low boil for 45-60 minutes; at the end of cooking, salt, sugar, black peppercorns are added; the sauce is filtered, rubbing the finished vegetables into it, and brought to a boil. In this case, the following ratio of components in grams per 1000 grams of the finished product is used (Table 6).

Table 6

Layout of ingredients for red base sauce

Ingredients	Gross	Net
Cooking fat	20	20
Wheat flour	50	50
Tomato puree	100	100
Carrot	100	80
Onion	24	20
Sugar	15	15
Salt	6-10	6-10
Black peppercorns	0,1	0,1
Brown broth	1000	1000
Total	-	1000

The disadvantage of this sauce is that it is poor in minerals, vitamins and dietary fiber.

Gum arabic and flaxseed meal, pre-crushed to a particle size of 0.06-0.1 mm, are used as a filler. The use of this particle size is due to the maximum yield of essential amino acids in the sauce, its enrichment. If the particle size is less than 0.06 mm, the appearance of the sauce is lost (it does not meet aesthetic requirements). If the particle size is more than 0.1 mm, then in this case there will be a smaller amount of essential amino acids in the sauce and, thus, the enrichment of the sauce will be insignificant.

When adding red basic gum arabic and flaxseed meal to the sauce, the structural, rheological, organoleptic properties of the finished product are improved, its nutritional and biological value increases.

When developing the technology, the limits of the introduction of gum arabic and flaxseed meal were identified, which can be justified as follows. Addition of gum arabic and flaxseed meal in the amount of 2.5 g of the wheat flour weight does not provide the product with a sufficient amount of dietary fiber and essential amino acids. Addition of gum arabic and flaxseed meal in the amount of more than 2.5 and 5 g of the wheat flour weight worsens the organoleptic properties of the finished product, an obvious oily taste appears. The method for preparing the red base sauce is as follows.

Recipe 1. To prepare the sauce with flaxseed meal, carrots and onions were chopped, sautéed with fat and mixed with tomato puree. The resulting mixture was sautéed for 10 minutes. Wheat flour was sautéed at

150°C for 5 minutes, then flaxseed meal, particle size 0.06 mm, was added without heat treatment, cooled to 70°C. Then, gum arabic and broth were added to the resulting flour sauté with flaxseed meal to a flour sauté: broth ratio of 1:4 at a broth temperature of 30°C and a mixture of vegetables sautéed with fat and tomato puree. Then, all components were cooked together at 90°C for 45 minutes, salt, sugar and black peppercorns were added. The resulting mixture was filtered with the finished vegetables rubbed into it, and brought to a boil. The initial components were taken in the following quantities in grams per 1000 grams of the finished product (Table 7).

Table 7

Layout of ingredients according to recipe 1

Ingredients	Gross	Net
Carrot	100	80
Onion	24	20
Cooking fat	20	20
Tomato puree	100	100
Wheat flour	45	45
Flax meal	5	5
Gum arabic	2,5	2,5
Eggplant powder	3	3
Salt	6	6
Sugar	15	15
Black peppercorns	0,1	0,1
Brown broth	1000	1000
Total	-	1000

Recipe 2. To prepare the sauce with flaxseed meal, carrots and onions were chopped, sautéed with fat and mixed with tomato puree. The resulting mixture was sautéed for 10 minutes. Wheat flour was sautéed at 150°C for 5 minutes, then flaxseed meal, 0.05 mm in particle size, was added without heat treatment and cooled to 70°C. Then, gum arabic and broth were added to the resulting flour sauté with flaxseed meal until the ratio of flour sauté: broth was 1:4 at a broth temperature of 30°C and a mixture of vegetables sautéed with fat and tomato puree. Then, all components were cooked together at 90°C for 45 minutes, salt, sugar and black peppercorns were added. The resulting mixture was filtered with the finished vegetables rubbed into it, and brought to a boil. The initial components were taken in the following quantities in g per 1000 g of the finished product (Table 8).

The result of the study is the enrichment of the sauce with dietary fiber and the increase in the nutritional and biological value of the finished product. The nutritional value of flaxseed meal indicates the possibility of using flaxseed meal when choosing sauces of maximum use. Flaxseed meal has a high energy value, which allows enriching the sauce with dietary fiber, nutritional and biological value (Table 9).

Table 8

Layout of ingredients according to recipe 2

Ingredients	Gross	Net
Carrot	100	80
Onion	24	20
Cooking fat	20	20
Tomato puree	100	100
Wheat flour	47,5	47,5
Flax meal	2,5	2,5
Gum arabic	2,5	2,5
Eggplant powder	3	3
Salt	6	6
Sugar	15	15
Black peppercorns	0,1	0,1
Brown broth	1000	1000
Total	–	1000

Table 9

Organoleptic characteristics of model samples of sauces with food additives of plant origin

Name of indicators	Characteristics of the sauce sample	
	Recipe 1	Recipe 2
Shelf life at 5°C for 10 days		
Color	Homogeneous throughout, caramel	Homogeneous throughout, light brown
Taste	Balanced, rich, pleasant	Balanced, pleasant
Smell	Harmonious, vegetable, with plant component	Harmonious, vegetable
Consistency	Homogeneous product, moderately thick, fluid	
When storing sauces for 20 days, no changes in organoleptic properties occur.		

The tasting assessment established that the red basic sauce obtained according to example 1 has a more pleasant taste and aroma, and has become richer in the content of minerals, vitamins and dietary fiber.

Conclusions on the above problems and prospects for further research in the given direction.

The analysis of the literature and the materials provided confirmed the relevance of developing functional sauces using plant hydrocolloids and secondary raw materials, such as gum arabic and flax meal. Gum arabic is an effective stabilizer and source of fiber, and flax meal enriches the product with proteins, amino acids, vitamins and Omega-3 acids. The proposed technology of introducing gum arabic (2.5 g), eggplant powder (3 g), and flaxseed meal (2.5–5 g per 1000 g) with a particle size of 0.06–0.1 mm into the red base sauce optimizes the production process. It was determined that the particle size of the meal affects the release of nutrients, and exceeding the dosage worsens the taste. The study showed that the addition of plant components increases the content of dietary fiber, vitamins (E, B1, B2, B3, B5), minerals (K, Ca, Mg, P, Fe) and essential amino acids (valine, threonine), improves the consistency and stability of the sauce. Recipe 1 (5 g of meal) turned out to be better in terms of organoleptic indicators: rich taste, harmonious aroma, uniform texture. The modified sauce meets the requirements of healthy nutrition, has high nutritional and biological value and retains quality for 20 days at 5°C. The use of gum arabic and flax meal as secondary raw materials contributes to economic efficiency and sustainable development.

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Анотація. У статті проаналізовано сучасні тенденції здорового способу життя, що підкреслюють важливість збалансованого харчування, що стимулює розробку функціональних продуктів для усунення дефіциту незамінних речовин і профілактики захворювань. У цьому контексті створення соусів із рослинними добавками, такими як гуміарабік і льняний шрот, відкриває нові можливості для підвищення їхньої поживної цінності та біологічної активності. Дослідження присвячене вдосконаленню технології соусу червоного основного шляхом додавання гуміарабіку – натурального полісахариду з акацій, що діє як стабілізатор і джерело клітковини, та льняного шроту – продукту переробки насіння льону, багатого на білки, поліненасичені кислоти (Омега-3, Омега-6) і мікроелементи. Гуміарабік покращує текстуру й стабільність продукту, зберігаючи його смакові якості, порошок з баклажанів та льняний шрот збагачують соус вітамінами, амінокислотами та клітковиною, сприяючи здоров'ю кишківника й регуляції холестерину. Традиційний соус червоний основний характеризується низьким вмістом клітковини, вітамінів і мінералів, що обмежує його функціональність. У роботі запропоновано модифікувати рецептуру, додаючи гуміарабік (2,5 г), порошок з баклажанів (3 г) і льняний шрот (2,5–5 г на 1000 г продукту) із частинками 0,06–0,1 мм, що забезпечує оптимальне вивільнення поживних речовин без шкоди для смаку. Експерименти визначили межі введення добавок: менші дози недостатні для збагачення, а більші призводять до масляного присмаку. Розроблено дві рецептури з пасеруванням овочів, додаванням шроту до борошна та варкою з бульйоном. Органолептична оцінка виявила перевагу рецептури 1 (5 г шроту) за смаком, ароматом і консистенцією, із збереженням якості протягом 20 діб при 5 °С. Запропонована технологія підвищує поживну цінність соусу, покращує його реологічні властивості та робить продукт конкурентним у сегменті здорового харчування. Використання вторинної сировини, як-от льняний шрот, підтримує принципи сталості й економічної доцільності, відкриваючи перспективи для інновацій у харчовій промисловості.

Ключові слова: гуміарабік, порошок з баклажанів, льняний шрот, соуси, функціональні продукти, харчові волокна, поживна цінність, рослинні гідроколоїди, дієтичні добавки, технологія.

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