Features of flax seeds and their use in the production of "Tahini"

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Abstract. Research on the use of natural enrichment additives from vegetable raw materials is becoming increasingly important in solving the problem of providing the population with a complete and nutritionally balanced diet. The article covers a method for solving this urgent problem on the example of "Tahini" sesame paste, characterized by a reduced content of polyunsaturated fatty acids of the ω-3 family, in particular, α-linolenic acid. Authors used non-traditional raw materials for this product in order to enrich the paste. The purpose of research was to develop a recipe and technology for the production of sesame paste with the additional use of oil flax seeds to increase the nutritional value of the product. The task of research was to determine the possibility of using oil flax seeds for partial replacement of sesame seeds in the recipe of Tahini paste to enrich its chemical composition with essential fatty acids of the ω-3 family and minor biologically active nutrients. The objects of research were sesame seeds of the variety "Tashkentsky – 122" (GOST 12095-76. Sesame for processing. Specifications), flax seeds of the oilseed variety "Bakhmalsky – 2" (GOST 10582-76. Oil flax seeds. Industrial raw materials. Specifications), "Tahini" sesame paste (TS 10.39.22-2019. "Tahini" sesame paste, peanut butter, and other nut butters. Specifications). The experimental part of the work was carried out in the laboratories of the "Food technology" Department of the Bukhara Engineering-Technological Institute. The dependence of the influence of oil flax seeds on the quality and nutritional value of the finished product has been described. During the research, traditional methods for the laboratories of food production enterprises in order to study the properties of raw materials and finished products have been used. Effectiveness of the use of this additive to increase the nutritional value of the pasta has been substantiated. The authors consider it possible jointly using sesame seeds and oil flax in the production of "Tahini" sesame paste.

1 Introduction

The oil and fat industry is currently facing fundamentally new tasks that cannot be solved by a simple quantitative increase in production volume, but require qualitatively new

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approaches, including the production of vegetable fat products for healthy and safe nutrition of the population.

Fatty products traditionally belong to mass consumption products and, accordingly, they are substantially the object of enrichment of their prescription compositions in order to obtain nutritionally adequate food products. Complex innovative products obtained by changing the composition of the fatty phase in terms of the amount and ratio of polyunsaturated fatty acids (PUFA) of the ω-6 and ω-3 families by blending various oils have the greatest potential in the segment of enriched products [1]. The advantages of using vegetable oils to correct PUFA deficiency over biologically active additives (BAA) containing them and drugs are that oils are a food product to which the human body is adapted, and they are much cheaper than dietary supplements. This necessitates new innovative developments to optimize the recipes of these food products in order to bring the mass fractions of nutrients as close as possible to specialized standards. An effective technological approach to achieve the appropriate ratio of functional nutrients is the creation of 2- or multi-component systems from the most accessible regional raw materials.

One of the vegetable-fat systems that have excellent taste and physiologically beneficial properties, as well as consistently high consumer demand, is tahini or sesame paste, which in the classic version contains only one component – crushed sesame seeds [2] .

The main disadvantage of this paste is the relatively low content of fatty acids of the ω-3 family, in particular, α-linolenic acid. Therefore, research to increase the content and optimize the composition of essential fatty acids in this product is relevant, since because of a sustainable trend for a healthy lifestyle, consumption patterns are changing and innovations in the food industry are welcome. It is obvious that in the near future the global market for “healthy” food products will expand significantly and steadily.

2 Materials and methods

The purpose of research was to develop a recipe and technology for the production of sesame paste using oil flax seeds to increase the nutritional value of the product.

The task of research was to determine the possibility of using oil flax seeds for partial replacement of sesame seeds in the recipe of “Tahini” sesame paste to enrich its chemical composition with essential fatty acids and minor biologically active nutrients.

The objects of research were sesame seeds of the variety “Tashkentsky – 122” (GOST 12095-76. Sesame for processing. Specifications), flax seeds of the oilseed variety “Bakhmalsky – 2” (GOST 10582-76. Oil flax seeds. Industrial raw materials. Specifications), “Tahini” sesame paste (TU 10.39.22-2019. “Tahini” sesame paste, peanut butter, and other nut butters. Specifications).

The experimental part of the work was carried out in the laboratories of the “Food technology” department of the Bukhara Engineering-Technological Institute.

“Tahini” sesame paste was prepared according to the classical recipe from ground sesame seeds - 100 g and refined vegetable oil - 15 ml (prototype) in accordance with the recommendations described in the source [2]. Experimental samples of the paste were prepared from ground sesame and flax seeds in certain ratios calculated in advance, as well as refined vegetable oil in the same way.

The quality of the paste was analyzed by organoleptic and physicochemical parameters in accordance with the requirements of TS 10.39.22-2019. “Tahini sesame paste, peanut butter, and other nut butters. Specifications”. The reliability of the obtained data is confirmed by repeated experiments.

3 Results and discussion

Tahini is a paste made from sesame seeds and refined vegetable oil. According to TS 10.39.22-2019. this paste, unlike sesame paste, is prepared from raw, not roasted seeds. The result is a creamier texture and a more delicate taste with a slight hint of bitterness.

Sesame (Sesamum indicum) is an annual herbaceous plant cultivated in Uzbekistan for a long time because of its oil properties. Economic experience has shown that the dry lands of Uzbekistan with an annual rainfall of 320-350 mm or more fully ensure the yield of local varieties of sesame seeds up to 5–6 quintal/ha. The largest sown area is occupied by the "Tashkent-122" sesame variety, which is characterized by increased resistance to drought. Such a variety of sesame in the hot conditions of Uzbekistan ripens 100–110 days after germination; the growing season is from 90 to 95 days (Table 1) [3].

We used flax seeds of the oilseed variety "Bakhmalsky-2" (lat. Línum usitatíssimum L.), obtained at Zamona Rano LLC (Uzbekistan) (Table 1).

Oilseed flax is a highly profitable crop, one of the advantages of which is drought resistance, which is a very weighty argument for republics with an arid climate, in particular for Uzbekistan. In addition, this crop is distinguished by a relatively simple growing technology that does not require the use of insecticides, which increases the degree of its food safety [4].

Currently, worldwide there is an increased interest in flax culture (flax family (Linaceae), genus Linum), as a source of biologically valuable substances - essential amino acids, dietary fiber, vitamins, antioxidants, essential PUFA. Oil flax is the main raw material for oil and fat products, there are works on the use of flax seeds and products of its processing in other sectors of the food industry, in particular in the production of bakery and flour confectionery products [5-10].

Next, a comparative analysis of the vegetative characteristics and chemical composition of the studied oilseeds was carried out.

The results of the study are presented in Tables 1-5 and in Fig 1, 2.

Table 1. Vegetative characteristics of the studied species and varieties of sesame and oil flax.

Indicators	Values of indicators	
	Sesame "Tashkentskiy – 122"	**Flax "Bakhmalsky – 2"**
Standard or hybrid combination	Information is not found	Bakhmalskiy – 1056
Average yield, quintal/ha	5.0 – 6.0	5.9 – 7.8
Vegetation period, days	90 - 95	74 – 77
Drought, lodging and shedding resistance	High	High
Weight of 1000 seeds, g	2.6 – 2.8	5.7 – 6.4
Seed size, mm	2.8-3.2	3.2-4.8
Seed color	Light brown	Brown

The chemical composition of the studied seed samples is given in Table 2.

A comparative analysis of the chemical composition of sesame seeds with oil flax seeds confirmed the assumption that the latter can partially replace sesame in the paste recipe. Thus, the mass fraction of protein and carbohydrates in flax seeds differed very little from the comparison sample. At the same time, these seeds had a mass fraction of fat, on average, 1.3 times (according to DM) less than the same value in sesame seeds. An increased amount of fiber (cellulose), minerals (in terms of ash content) characterized flax seeds. Significant differences in the vitamin content of the studied seed samples were not found. Flax seeds are less nutritious than the reference sample, mainly due to the reduced

content of fats (oils). It should be noted that flax seeds assimilate selenium, which also determines their uniqueness, and are an unsurpassed source of ω-3 PUFA, which are a deficient functional food ingredient in the diet of the population.

Table 2. The chemical composition of the studied oilseed raw materials.

Nutrients	The value of the indicator in seeds			
	sesame		flax	
	100 g product	100 g DM*	100 g product	100 g DM
Nutrients, g:				
water	4.3	-	6.5	-
proteins	21.0	22.0	19.2	20.6
carbohydrates	18.3	19.1	17.4	18.6
fats	49.0	51.2	36.2	38.7
cellulose	5.1	5.3	16.2	17.3
ash	2.3	2.4	4.5	4.8
Minerals, mg:				
calcium	360	376	248	265
magnesium	345	360	372	398
phosphorus	667	697	625	648
iron	6.4	6.7	5.8	6.2
Vitamins, mg:				
thiamine, B_1	0.75	0.78	1.57	1.70
riboflavin, B_2	0.28	0.29	0.15	0.16
niacin, PP	4.50	4.70	2.84	3.04
tocopherols, E	19.17	20.03	18.65	19.95
Energy value, kcal	593.6	-	467.8	-
Distinctive minor components	Sesamin, sesamolin, sesamol, tocopherol, tocotrienols, phytosterol		Tocopherols (beta+gamma), beta-sitosterol, carotene and carotenoids, phosphatidylcholine	

Note: *DM – dried matters

Research [11, 12] have proven that the biological role of ω-3 and ω-6 fatty acids is involved in the synthesis of hormones – prostaglandins, which regulate inflammatory processes in the body, regulate the activity of the cardiovascular and nervous systems. The high content of α-linolenic acid in the diet has an anti-stress and adaptogenic effect, stimulates mental activity and human performance (Fig. 1).

The value of linseed oil is determined by the high content of PUFA, especially essential α-linolenic (ALA) and low saturates. This acid, together with linoleic (ω-6), are the precursors of long-chain PUFA in the human body and are part of almost all cell membranes, while α-linolenic acid is metabolized into docosahexanoic acid (DHA) (ω-3) and eicosapentaenoic acid (EPA) (ω-3). The health benefits of all ω-3 (ALA, DHA, and EPA) fatty acids are well known, including cardiovascular disease, hypertension, atherosclerosis, diabetes, cancer, arthritis, osteoporosis, autoimmune disorders, and neurological disorders. Flaxseed ALA has anticancer activity, reduces blood triglycerols, lowers cholesterol, has antithrombotic and anti-inflammatory effects.

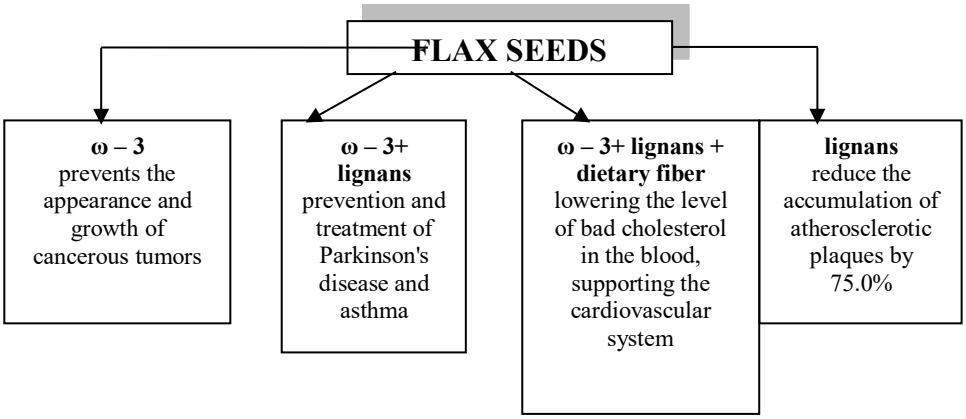

Fig. 1. Flax seed substances of functional purpose.

Linolenic acid in combination with linoleic and other polyenoic acids affect the absorption of fat-soluble vitamins A, D, E and K. In addition, ω-3 PUFA are considered as a component of a therapeutic diet for obesity [1].

The fatty acid composition of sesame and flax lipids was studied (Table 3).

Table 3. Fatty acid composition of lipids of the studied oilseed raw materials.

Fatty acids	Mass fraction of fatty acids of seed lipids, %	
	sesame	flax
Palmitic (16:0)	5.7	6.5
Stearic (18:0)	9.4	4.8
Oleic (18:1)	39.1	24.4
Linoleic (18:2)	43.1	16.7
Linolenic (18:3)	1.3	47.0
Other	1.4	0.6

In terms of oil content, flax seeds are very close to sesame, and in terms of the content of α-linolenic acid, flax seed lipids are champions among oil seeds of plants. To provide the necessary ratio of PUFA families ω-6 : ω-3, it is necessary to solve the system of equations (1. 2):

$$\left.\frac{m_1 * c_1^{\omega_6} * M_1 + m_2 * c_2^{\omega_6} * M_2}{m_1 * c_1^{\omega_3} * M_1 + m_2 * c_2^{\omega_3} * M_2} = y\right\} \quad (1)$$

$$m_1 + m_2 = 1 \quad (2)$$

where, m1 is weight of sesame seeds, g or kg;
m2 is weight of flax seeds, g or kg
$c_1^{\omega_6}$ - is content of linoleic acid in sesame seed oil, %;
$c_1^{\omega_3}$ - is content of α-linolenic acid in sesame seed oil, %;
$c_2^{\omega_6}$ - is content of linoleic acid in the oil of selected linseed, % ;
$c_2^{\omega_3}$ - is content of α-linolenic acid in the oil of selected linseeds, % ;
M_1- is oil content of selected sesame seeds, %
M_2- is oil content of selected flax seeds, %
y - is required ratio of PUFA of ω-6 : ω-3 families

In this case, it is advisable to use the following calculation algorithm to create a program that allows you to calculate various recipe options (Fig. 2).

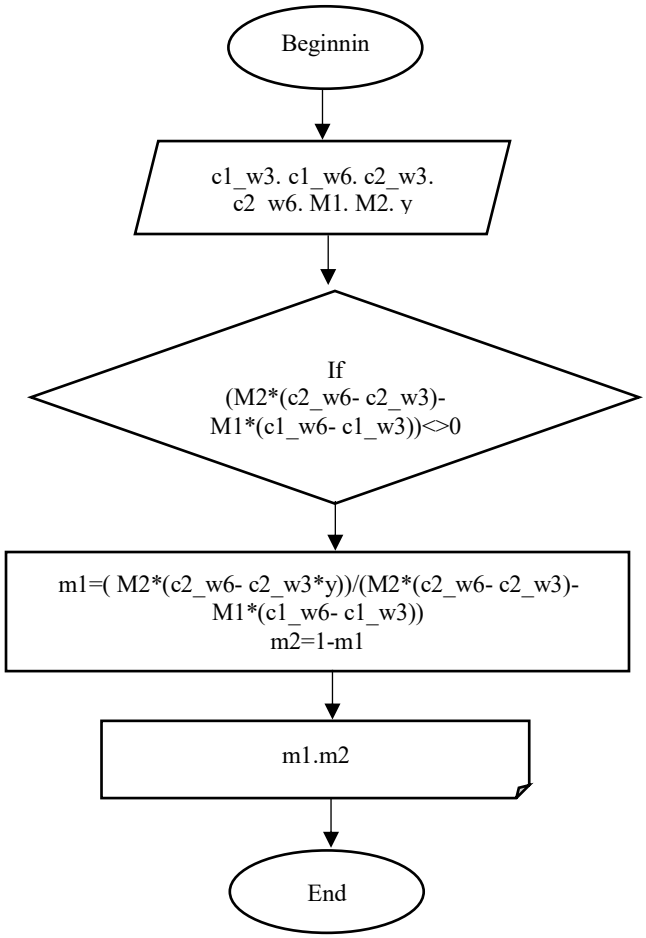

Fig. 2. Algorithm for solving the problem of balancing the ratio of ω-6 and ω-3 fatty acids in "Tahini" paste.

For preventive purposes for healthy people, the recommended ratio of ω-6 : ω-3 PUFA in fatty foods is 10:1. In addition, in cases of lipid metabolism pathology, this ratio should be equal to 5: 1 and even 3: 1. According to Japanese scientists, this ratio should ideally be 2.5: 1. Analysis of the results of monitoring the actual nutrition of the population indicates that these PUFA actually enter the body in a ratio of 30 or more to 1 (30:1 or more). Thus, we are constantly experiencing a shortage of ω-3 PUFA.

Calculations show that in order to obtain a paste with a ratio of ω-6:ω-3=10 (i.e. y=10) from the presented sesame and flax seeds, it is necessary to observe the mass ratio of sesame and flax seeds, equal to 0.917: 0.083 (in g, kg or %). And to obtain a paste for medicinal purposes, for example, with a ratio of ω-6: ω-3 = 3 or 5, it is necessary to observe the mass ratio of the selected sesame and flax seeds, equal to 0.7: 0.3 or 0.815: 0.185, respectively.

Thereby, it is possible to obtain a functional vegetable fat paste balanced in composition (ratio) of ω-6 and ω-3 fatty acids.

According to the organoleptic and physical-chemical parameters, the Tahini paste from sesame seeds (control) and a model mixture of sesame and flax seeds in a ratio of 0.7: 0.3 (experiment) must meet the requirements specified in TS 10.39.22-2019 (Table 4).

Table 4. The main quality indicators of the "Tahini" paste from sesame seeds and a model mixture of sesame seeds and flax.

Name of indicator	**Requirements of TS 10.39.22-2019**	**The value of pasta quality indicators**	
		Control	***Experiment***
Appearance	Thick oily paste, may have inclusions depending on the recipe	Thick oily paste with a creamy texture without visible inclusions	
Taste	Corresponding to the natural taste of the raw materials used in the preparation, the taste of additions is possible in accordance with the recipe composition. Side taste not allowed	Corresponding sesame seeds delicate taste with a slight hint of bitterness without side aftertastes	Corresponding sesame seeds delicate taste with a slight hint of bitterness without side aftertastes
Smell	Peculiar to this paste, without side smell	Peculiar to this paste, without side smell	Peculiar to this paste, without side smell
Colour	From light yellow to brown. Inclusions of additives are allowed in accordance with the recipe	Cream	Light brown
Presence of damaged seeds, no more than, %	3.0	Not found	Not found
Presence of insects or their larvae	Not allowed	Not found	Not found
Mass fraction of moisture, no more than, %	20.0	3.4±0.3	3.8±0.2
Mass fraction of fat, not less than, %	20.0	48.2±0.1	44.3±0.2

Analysis of the data in Table 4 showed that, according to the main organoleptic and physical-chemical parameters, the paste from the model mixture of sesame and flax seeds meets the requirements of TS 10.39.22-2019.

According to the content of toxic elements, pesticides, mycotoxins and microbiological indicators, the paste must comply with the requirements of TR CU 021/2011, given in Table 5.

An analysis of experimental data on the food safety of the studied paste showed that in terms of the content of toxicological elements and the presence of pathogenic microflora, it meets the requirements of TU 10.39.22-2019, TR TS 021/2011 and Sanitary rules and regulations No. 0366-19 Hygienic standards for food safety of the Republic of Uzbekistan. [13-16]

The data in Table 5 indicate the required degree of food safety of the product under study, namely, paste from sesame seeds and oil flax.

Table 5. Indicators of the level of toxicological and microbiological safety of paste from a model mixture of sesame and flax seeds.

Name of indicator	Requirements of TP TC 021/2011, no more	Indicator value
Toxic elements, mg/kg		
Lead	0.50	traces
Arsenic	0.30	0,00
Cadmium	0.10	0,04
Mercury	0.05	0,00
Pesticides, mg/kg		
Hexachlorocyclohexane (α-, β- and γ-isomers)	0.50	0,12
DDT and its metabolites	0.15	0,03
Mycotoxins, mg/kg:		
Aflatoxin B_1	0.005	0,001
Microbiological indicators		
Coliform bacteria (coliforms) not allowed in the mass of the product, g ($см^3$)	0.10	0,01
The mass of the product, in which pathogenic microorganisms are not allowed, incl. salmonella, g	25	Not found
Molds, KOE/g, no more	500	115

4 Conclusion

Thereby, the involvement of non-traditional types of vegetable raw materials in the production of sesame and nut pastes is a promising and relevant scientific area of research, which is of practical importance from the point of view of providing the population with enriched products. This determines the implementation of the priority directions of the state development strategy in the field of healthy nutrition of the population and food security. Most food producers do not use enough reserves of local raw materials, the use of which in the production of this type of food will reduce production costs and expand the range of products enriched with essential and minor nutrients.

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