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USE OF CHIA SEEDS IN NON-ALCOHOLIC BEVERAGE TECHNOLOGY

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Abstract

The article contains the results of research on the development of recipes for biologically active soft drinks with a healthy effect with original organoleptic properties. Prepared drinking water, concentrated lemon juice, natural honey, sugar, citric acid, aromatizers and unconventional raw materials - chia seeds were used. Xanthan gum was used to give the drink the required viscosity. Raw materials, intermediates and finished products were analyzed by chromatographic and spectrophotometric research methods conventional for beer and non-alcoholic food industry. The studies used prepared water with a total hardness of 0.3 mmol/dm³, a total alkalinity of 1.0 mmol/dm³, a dryresidue of 450 mg/dm³, a pHof 6.5 and a sulfate contentof 25 mg/dm³. Organoleptic and microbiological parameters of chia seeds were studied. The number of mesophilic aerobic and optionally anaerobic microorganisms did not exceed the maximum allowable values, no pathogenic microorganisms were detected. The high nutritional and biological value of chia seeds has been established. The content of carbohydrates, fats and fatty acids, amino acids, vitamins and minerals was determined. The content of fatty acids in polyunsaturated, saturated and monounsaturated forms was about 30 %. Of the polyunsaturated fatty acids, the content of linolenic (ω-3 acid) was 59.51 %, linoleic (ω-6 acid) – 18.83 %. To give the beverage the required viscosity and provide chia seeds in a suspended state for a long time, it is proposed to use xanthan gum in the amount of 3.0...3.2 g per 1 dm ³ of beverage, which corresponds to the kinematic viscosity of 5.04...5.51 mm²/s. Formulations of six experimental samples of beverages have been developed. Their organoleptic parameters are given. Drinks «Strawberry», «Lemon-mint» and «Honey» are recommended for industrial production. Their organoleptic profile is characterized, and the results of sensory analysis by color, transparency, appearance, aroma and taste are given. The drinks received excellent tasting marks. The obtained research results ensure the production of original non-alcoholic beverages with high taste and aromatic properties and the content of biologically active substances with immunomodulatory and antioxidant action.

*Keywords:*chiaseeds;softdrinks; xanthangum;organolepticcharacteristics.

ВИКОРИСТАННЯ НАСІННЯ ЧІА У ТЕХНОЛОГІЇ БЕЗАЛКОГОЛЬНИХ НАПОЇВ

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Анотація

Стаття містить результати досліджень розробки рецептур біологічно активних безалкогольних напоїв оздоровчої дії з оригінальними органолептичними властивостями. Сировину, напівпродукти та готову продукцію аналізували загальноприйнятими у пиво-безалкогольній галузі харчової промисловості хроматографічним та спектрофотометричним методами. В дослідженнях використовували підготовлену воду із загальною жорсткістю 0.3 ммоль/дм³, загальною лужністю 1.0 ммоль/дм³, сухим залишком 450 мг/дм³, pH 6.5 та вмістом сульфатів 25 мг/дм³.Досліджено органолептичні та мікробіологічні показники насіння чіа. Кількість мезофільних аеробних і факультативно анаеробних мікроорганізмів не перевищувала гранично допустимих значень, патогенних мікроорганізмів не виявлено. Встановлена висока поживна та біологічна цінність насіння чіа. Вміст жирних кислот, які представлені поліненасиченими, насиченими і моно-ненасиченими формами становила близько 30 %. З поліненасичених жирних кислот вміст ліноленової (ω-3 кислота) становила 59.51 %, лінолевої (ω-6 кислота) – 18.83 %. Для надання напою необхідної в'язкості і забезпечення насіння чіа у зваженому стані не менше 30 діб запропоновано використання ксантанової камеді у кількості 3.0...3.2 г на 1 дм³ напою, що відповідало кінематичній в'язкості 5.04...5.51 мм²/с. Розроблено рецептури шести дослідних зразків напоїв. Наведено їх органолептичні показники.

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Для промислового виробництва рекомендовано напої «Полуничний», «Лимон-м'ята» та «Медовий». Охарактеризовано їх органолептичний профіль, наведено результати сенсорного аналізу за кольором, прозорістю, зовнішнім виглядом, ароматом та смаком. Напої отримали відмінні дегустаційні оцінки. Результати досліджень забезпечують отримання оригінальних безалкогольних напоїв з викокимисмако-ароматичними властивостями та вмістомбіологічноактивнихречовинімуномоделюючої, антиоксидантноїдії.
Ключові слова: насіння чіа, безалкогольні напої, ксантановакамідь, органолептичні показники.

Introduction

The health of modern person is largely determined by the nature, level and structure of nutrition. Disruption of the food structure is a factor that causes more damage to human health than environmental pollution.

The concept of healthy nutrition for the population involves the creation of qualitatively new products that not only satisfy the physiological needs of the human body and supply energy, but also perform preventive and curative functions. To do this, it is necessary to develop measures to change the nutrition structure, create innovative product technologies that meet the needs of the body, and increase the share of mass consumption products with high nutritional and biological value. World and domestic experience shows that in modern conditions the most effective and expedient way to provide the population of all age groups with micronutrients is the development, production and systematic consumption of functional food products [1].

Drinks made from natural raw materials, which include biologically active substances (vitamins, mineral compounds, amino acids, organic acids, etc.), are able not only to satisfy the body's need for water, but also to provide the finished product with healthy properties [2]. Chia seeds (Spanish sage), a traditional food product for Central and South America, have a wide range of such substances, but are practically not used in the production of soft drinks. An important feature of the chemical composition of chia is the absence of gluten, which allows its use in food products intended for people with celiac disease. Therefore, it is promising to develop new original preventive drinks using chia seeds.

One of the components of nutrition that affects human health are drinks, which not only prevent water deficit in the body, but also provide it with energy. Drinks based on natural raw materials contain biologically active substances and can give the finished product health-promoting properties [2].

Functional drinks are in high demand and tend to increase in consumption. The results of the latest research by doctors, physiologists, biologists, and nutritionists revealed a correlation between the content of certain nutrients in products and the state of human health, which made it possible to form a new perspective on drinks as a means of prevention and treatment of many diseases [3].

The first scientific developments of functional food products were proposed at the end of the 9th century in Japan. Nowadays, their share in the entire volume of food products is no more than 10 %. In developed countries, products with certain health-promoting properties are spreading quite rapidly. According to forecasts, in the coming years their share will reach 30 %. Today, the leading countries in the production and sale of functional products are the USA, Japan and EU countries. The European market is led by Germany (36.3 %), Great Britain (21.9 %) and France (15.0 %) [4].

The Ukrainian market of functional drinks is gradually being filled not only with products of imported, but also domestic production. These are probiotic fermented milk products and drinks enriched with vitamins, minerals, soluble dietary fibers and other components [5].

Recently, non-alcoholic drinks on an emulsion basis, enriched with vitamins, minerals, dietary fibers, and pectin substances, have been developed. At the same time, nutraceutical drinks with an emulsion structure, with high nutritional and biological value are presented on the market in very limited quantities.

The technology of emulsion products with new consumer properties is one of the innovative directions of development of food technologies, which are based on the use of additives with emulsifying and stabilizing properties. Due to the increase in global production of products, in addition to traditional food stabilizers, such as starch, stabilizers of animal (gelatin) and plant (gums, pectin's, carrageenan's) origin have come into use to prevent the delamination of emulsion systems.

Xanthan gum is an extracellular hetero-polysaccharide obtained as a result of a specific fermentation process of bacteria of the genus Xanthomonas campestris [6]. Xanthan gum remains one of the most effective and versatile modifiers and stabilizers on the market. The use of xanthan gum in the food industry is due to its unique physical and chemical properties. The special pseudo-plastic rheology, heat and acid

stability, high viscosity and high solubility in the aqueous environment ensure the wide use of xanthan gum as a multi-purpose stabilizer, thickener and auxiliary material in the production process. Along with high aggregative stability in the form of colloidal solution, this product is characterized by unusual resistance to intense mechanical and thermal effects and enzyme action. Xanthan gum is characterized by long-term stability even in conditions of high acidity of the environment and with a high concentration of salts.

Despite the wide use of polysaccharides in the food industry, their role as stabilizers and thickeners has not yet been sufficiently studied. Knowledge of the mechanism of the structuring action of these substances, the nature of interaction with other components of complex mixtures of substances will make it possible to purposefully influence the quality of finished products and create modern ecologically safe and highly effective food technologies [7; 8].

To expand the assortment and increase the biological value of drinks, it is proposed to use chia seeds. A study was conducted, and the biological value and safety of consuming chia seeds was determined. The amount of protein in it varies between 19...23 %, fats 32...39 %, carbohydrates 38 %, of which 30 % is insoluble dietary fibers, 3 % soluble and almost 5 % sugars. In terms of antioxidant content, 25 g of chia seeds can replace 900 g of oranges or 150 g of blueberries, which are used as traditional raw materials in the production of beverages [9].

In the technologies of soft drinks, it is not typical to use ingredients that contain fatty acids. Chia seeds contain several times more oil than cereals and a high content of ω-3 and ω-6 fatty acids, including 41...59% α-linolenic (ω-3) and 18...25 % linoleic (ω- 6) acids [10-12]. Compared to other products rich in these acids, chia seeds contain more of them. Almost 2 times more than in salmon caviar, 3 times more than in cod liver and 42 times more than in olive oil. At the same time, ω-3 and ω-6 fatty acids in chia seeds are in a ratio of 1:4...1:6, which is favorable for absorption by the human body [13-15]. ω-3 Fatty acids improve the functioning of the cardiovascular system, reduce the risk of heart attacks, normalize blood pressure, and ω-6 acids improve blood coagulation, reduce cholesterol levels, and ensure healthy skin [16].

Chia seeds as a food ingredient were initially approved for use in Great Britain [17-19]. Since 2005, the European Food Safety Authority (EFSA) has adopted a decision on the possibility of using chia seeds as a component in baking bread, according to which about 5 % of flour can be replaced with chia seed flour. Since 2013, the use of chia seeds in mass consumption products has been permitted, including bakery products, breakfast cereal, and fruit-nut-cereal mixes in amounts from 5 to 10%. In its pure form, as an independent product, chia seeds are recommended to consume no more than 15 g per day [19–21].

The purpose of the work is to develop recipes for new biologically active non-alcoholic drinks with high organoleptic and consumer properties and original appearance using chia seeds.

To achieve the goal, the microbiological indicators of the studied samples of chia seeds, its chemical composition, particularly the content of biologically active substances, were determined. The influence of xanthan gum on the viscosity and resistance to settling of chia seeds was also studied. To increase the biological value of the drink, it is proposed to use lemon juice and natural honey.

Materials and methods

Chia seeds were used in the research according to TU 9164-002-24003345-2014, drinking water according to DSanPiN 2.2.4-171-10, honey according to DSTU 4497:2005, sugar according to DSTU 4623:2006, citric acid according to GOST 908:2006, lemon juice according to DSTU 7159:2010, xanthan gum according to GOST 33333-2015.

The work used generally accepted methods of research in the beer-non-alcoholic branch of the food industry. The relative viscosity was determined with an Oswald viscometer. The chemical composition of chia seeds was determined by chromatographic and spectrophotometric methods.

Mixing syrup and drinks were prepared according to the requirements of TI-10-04-06-144-87 using prepared drinking water. Linden honey with a dry matter content of 81% and sugar syrup prepared by a hot method were used in the research. Organoleptic and physicochemical indicators were determined in the finished drink.

Sensory evaluation of the developed drinks was carried out in accordance with international ISO standards. To create profiles, the DSTU ISO 6564:2005 method "Sensory research. Methodology. Methods of creating a flavor spectrum".

The organoleptic indicators were determined by the tasting committee consisting of 8 people. Consumer-relevant descriptors included in the complex taste profile of a hypothetical standard were assessed. Respondents used 6 descriptors to evaluate drinks, which were presented in order of decreasing importance.

The main raw material for the production of beverages is water, which is contained in the finished product up to 90 % or more. The quality of the drink largely depends on its physical and chemical parameters.

The studies used prepared water [22-24] with the indicators listed in Table 1.

Results and discussion

Table 1

Physical and chemical indicators of prepared water

Indicator	Requirements of DSanPin 2.2.4-171-10	Requirements for technological water	Actual value
Total hardness, mmol/dm^3	≤ 7.0	0.2…0.7	0.3
Total alkalinity, mmol/dm^3	not determined	1.7	1.0
Dry residue, mg/dm^3	≤ 1000	≤ 500	450
Hydrogen index, pH units	6.5…8.5	≤ 7.0	6,5
Total iron, mg/dm^3	≤ 0.2	0	0
Sulfates, mg/dm^3	≤ 250	20…50	25

According to the data provided, the prepared water met the technological requirements for the production of soft drinks.

When creating a new non-alcoholic drink, along with the need to obtain excellent taste and aroma properties, it is necessary to ensure its high biological value, which is determined by the physiological and nutritional impact on the human body. Only natural raw materials were used in the research.

Chia seeds are a non-traditional raw material for the Ukrainian market. Therefore, it was important to determine its indicators. Organoleptic and microbiological indicators of chia seeds are given in tables 2, 3.

Table 2

Organoleptic indicators of chia seeds

Indicator	Characteristic
Appearance	Small grains, uniform in size, with a matte surface, like poppy seeds
Taste and smell	Clean, without extraneous flavors, characteristic of this seed, with a pleasant nutty aroma
Color	Brown with different shades

Table 3

Microbiological indicators of chia seeds

Indicator	Limit values	The studied sample
Total coliform count, CFU/g	≤ 10^3	450
Yeast and moulds, CFU/g	≤ 10	2

The organoleptic parameters of the studied samples of chia seeds were determined. When studying microbiological indicators, it was established that the number of mesophilic aerobic and facultatively anaerobic microorganisms did not exceed the maximum permissible values. No pathogenic microorganisms, including Salmonella, E. coli and S. aureus, were detected in chia seeds, which indicates safe microbiological characteristics of the seeds, and, accordingly, of the finished drink.

To justify the feasibility of using chia seeds in the technology of soft drinks, its biological value was investigated (Fig. 1).

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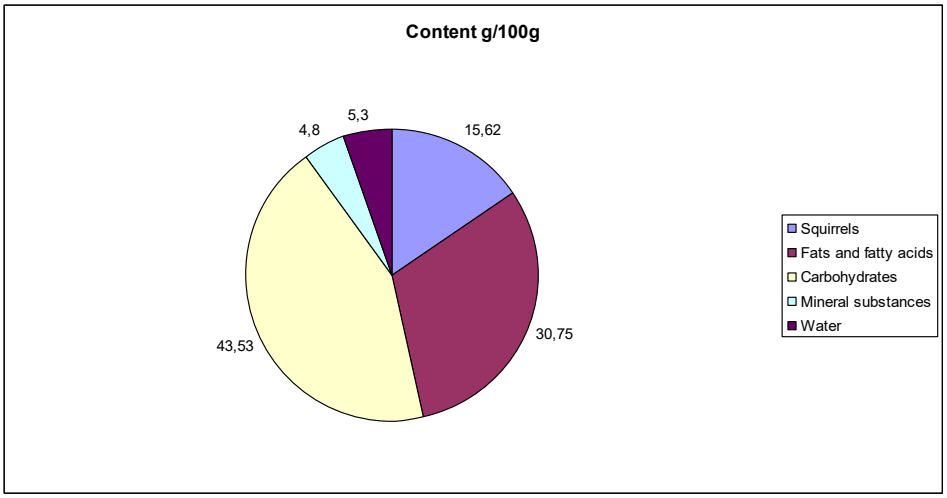

Fig. 1. Chemical composition of chia seeds

According to the data provided, chia seeds have high nutritional and biological value and they are a source of carbohydrates, fats and fatty acids, proteins, and minerals.

The content of amino acids, vitamins, minerals, fatty acids is given in tables 4, 5.

Table 4

The content of biologically active substances in chia seeds

Indicator	Contents
Amino acids, mg/g of protein	
Isoleucine	44.814
Leucine	80.666
Lysine	58.899
Methionine + Cysteine	28.809
Phenylalanine + Tyrosine	97.951
Threonine	42.894
Tryptophan	14.085
Valin	67.222
Vitamins, mg/100 g of product	
Vitamin E	1.16
Vitamin C	5.5
Vitamin B_1	0.45
Vitamin PP	6.73
Vitamin B_9	0.11
Mineral substances, mg/100 g of product	
Calcium	536
Phosphorus	760
Potassium	565
Iron	6.7
Selenium	0.055
Copper	1.4

Table 5

The content of fatty acids in chia seeds

Fatty acids	Mass fraction	
	Content, g/100 g of seeds	On dry matter, %
Saturated fatty acids	3.12	10.15
Monounsaturated fatty acids	2.23	7.25
Polyunsaturated fatty acids	23.3	78.34

The obtained data indicate that chia seeds are a source of carbohydrates, proteins, minerals. The content of fatty acids, which are not typical for soft drinks, is about 30 %. They are represented by polyunsaturated (linoleic and linolenic), saturated (palmitic), monounsaturated (oleic) forms. Among polyunsaturated fatty acids, the content of acids that perform plastic and regulatory functions in the body is: linoleic (ω-3 acid) – 59.51 %, linoleic (ω-6 acid) – 18.83 %.

Chia seeds in aqueous solutions swell, which gives the drink an original appearance and makes it attractive to the consumer. Figure 2 shows chia seeds in the finished drink and after soaking in

water. Photos of the appearance of the chia seed shells were taken using attachment lenses to reduce the focusing distance to 80 mm.

a) **b)**

Fig. 2. Chia seeds in the finished drink (a) and after soaking in water (b)

When soaking, an elastic gel shell is formed on the surface of the seeds, which prevents them from sticking together. The ability of chia seeds to form mucus and form a gel shell can be explained by the presence of water-soluble polysaccharides, particularly pentosans, the content of which reaches 8 %. Pentosans are high-molecular polysaccharides and, as products of pentoses polymerization, are considered the most common component of plant hemicelluloses [8]. They are characterized by the ability to form viscous and gel solutions.

In chia seeds, gummy substances are concentrated mainly on the surface and do not pass into the entire volume of the aqueous solution, therefore they are not able to ensure its necessary viscosity and stability of the system.

To give the drink the necessary viscosity and to ensure that chia seeds are suspended, it has long been proposed to use xanthan gum. It was added at the rate of 2.6...3.8 g per 1 dm^3 of sugar solution with a concentration of 10 % (Table 6). The research was carried out at a temperature of 20 °C and a duration of 24 hours.

Table 6

Effect of xanthan gum on viscosity and settling resistance of chia seeds

Amount of xanthan gum, g/dm^3	Kinematic viscosity, mm^2/s	Resistance to settling, c. u.
2.6	3.12	+
2.8	3.42	++
3.0	5.04	+++
3.2	5.51	+++
3.6	6.02	+++
3.8	6.65	+++

It was established that when 3.0...3.8 g of xanthan gum was added, chia seeds were resistant to settling for at least 30 days. At the same time, the kinematic viscosity ranged from 5.04 to 6.65 mm^2/s. However, beverages with viscosities greater than 5.51 mm^2/s had a vein-like appearance. Therefore, the optimal amount of xanthan gum was chosen to be 3.0...3.2 g/dm^3.

To give the drink high organoleptic properties and increase its biological value, it is proposed to use concentrated lemon juice, natural honey, strawberry, lemon, and mint flavorings. Recipes of the most acceptable drink samples are given in Table 7.

Table 7

Recipes of experimental drink samples

Component	Sample №					
	1	2	3	4	5	6
Sugar, g/dm^3	110	100	90	110	-	-
Aromatizer "Strawberry", cm^3/dm^3	0.40	0.30	-	-	-	-
Aromatizer "Lemon", cm^3/dm^3	-	-	0.24	0.20	-	-
Aromatizer "Mint", cm^3/dm^3	-	-	0.12	0.15	-	-
Citric acid, cm^3/dm^3	0.40	0.30	0.50	0.45	0.80	0.90
Concentrated lemon juice, cm^3/dm^3	-	-	0.12	0.15	0.80	0.90
Natural honey		-	-	-	120	110
Chia seeds, cm^3/dm^3	7.50	7.50	7.50	7.50	7.50	7.50
Xanthan gum, cm^3/dm^3	3.0	3.0	3.0	3.0	3.0	3.0
Water, dm^3	to 1	to 1	to 1	to 1	to 1	to 1

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The organoleptic indicators of experimental drink samples are listed in Table 8.

Table 8

Organoleptic indicators of drinks

Indicator	Sample №					
	1	2	3	4	5	6
Transparency, color, appearance	Pink-red, cloudy	Red-pink, cloudy	Light gray, opaque	Gray, opaque	Yellow, cloudy	Yellow, cloudy
Aroma	Strawberry	Strawberry	Mint and lemon	Preferably mint	honey	Honey-lemon
Taste	Sweet with a taste of strawberries	Sweet with a slight acidity	Harmonious sweet and sour with a mint-lemon flavor	Sweet, with a mint flavor	Sweet and sour with a honey-lemon taste	Sweet and sour indistinct

It was established that samples 1, 3 and 5 had the most acceptable indicators and differed significantly.

To assess the quality of drink samples, a 19-point tasting score was used without considering carbon dioxide saturation (Table 9).

Table 9

Tasting evaluation of non-alcoholic beverages

Indicator	"Strawberry" drink (Sample 1)	Drink "Lemon-mint" (Sample 3)	"Honey" drink (Sample 5)
Transparency, color, appearance	6.8	6.6	6.4
Taste, aroma	11.7	11.5	11.4
Amount	18.5	18.1	17.8

The organoleptic profile of drinks is presented in Figure 3.

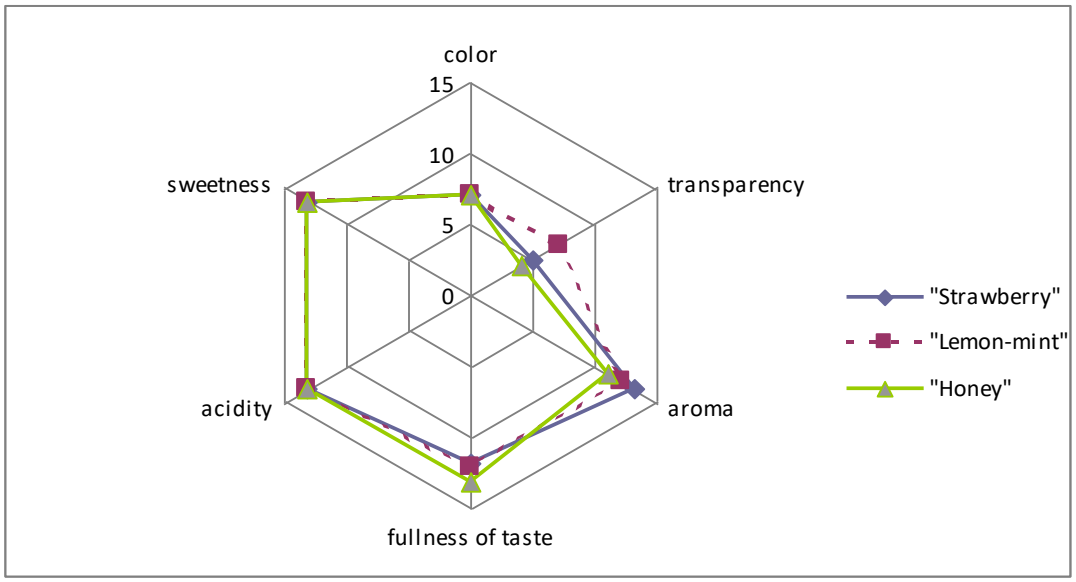

Fig. 3. Organoleptic profile of drinks

It was established that all drinks had high organoleptic indicators. There was no significant difference in the descriptors of sweetness, acidity, color. Drinks with the use of "Strawberry" and "Lemon-mint" flavorings had a more pronounced aroma, and "Honey" had a full taste.

Conclusions

1. The organoleptic and microbiological indicators of the studied samples of chia seeds were determined. The number of mesophilic aerobic and facultatively anaerobic microorganisms did not exceed the maximum permissible values, no pathogenic microorganisms were detected.

2. It has been established that chia seeds have high nutritional and biological value and contain carbohydrates, fats, fatty acids, proteins, and minerals. The content of fatty acids, which are represented by polyunsaturated, saturated, monounsaturated forms, was about 30 %. Of polyunsaturated fatty acids, the content of linoleic (ω-3 acid) was 59.51 %, linoleic (ω-6 acid) – 18.83 %.

3. To give the drink the necessary viscosity and ensure the chia seeds in a suspension, the use of xanthan gum has long been proposed in an amount of 3.0...3.2 g per 1 dm^3 of the drink, which corresponds to a kinematic viscosity of 5.04...5.51 mm^2/s.

4. Formulations of "Strawberry", "Lemon-mint" and "Honey" drinks have been developed, providing high taste-aromatic properties and the content of biologically active substances with immunomodulating and antioxidant action.

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