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## RESEARCH OF THE NUTRITIONAL VALUE OF FUNCTIONAL PURPOSE MARSHMALLOWS

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***This scientific article presents the results of studying the nutritional value (vitamins, antioxidants, organic acids) of marshmallows based on local vegetable raw materials (cranberries, currants, strawberries, apples) with the addition of powders from medicinal herbs (sea buckthorn leaves, St. John's wort, rosehip) in order to widen the assortment of immunostimulating confectionery for functional purposes. Based on the results of scientific research, the highest content of antioxidants is found in currant-apple and apple marshmallows (1.19 mg /100 and 1.15 mg/100g), most of the B vitamins: $B_1$ in apple marshmallows with the addition of sea buckthorn leaves (0.191 mg /100g); vitamins $B_2$ (0.511 mg /100g) and $B_6$ (0.099 mg / 100g) in currant-apple marshmallows with the addition of St. John's wort; $B_5$ in cranberry-apple marshmallows with the addition of sea buckthorn leaves (0.022 mg / 100g). Vitamin C content prevailed in strawberry and apple marshmallows, 0.109 mg/100g and 0.284 mg/100, respectively. All types of marshmallows with the addition of powders from medicinal herbs also distinguished themselves by a high content of organic food acids. Thus, it should be noted that the developed assortment of marshmallows has optimal indicators of nutritional value and meets the requirements for functional confectionery products.***

**Keywords: marshmallows, vitamins, antioxidants, medicinal herbs, vegetable raw materials, confectionery.**

## ФУНКЦИОНАЛДЫ МАҚСАТТАҒЫ ЗЕФИРЛЕРДІҢ ТАҒАМДЫҚ ҚҰНДЫЛЫҒЫН ЗЕРТТЕУ

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***Бұл ғылыми мақалада функционалды мақсаттағы иммундық жүйені реттейтін кондитерлік өнімдердің ассортиментін кеңейту мақсатында дәрілік шөптерден (шырғанақ жапырақтары, шайқурай, итмұрын) алынған ұнтақтар қосылған жергілікті өсімдік шикізаты (мүкжидек, қарақат, құлпынай,***

***алма) негізінде жасалған зефирлердің тағамдық құндылығын (дәрумендер, антиоксиданттар, органикалық қышқылдар) зерттеу нәтижелері келтірілген. Ғылыми зерттеулердің нәтижелері бойынша антиоксиданттардың ең көп мөлшері қарақат-алма және алма зефирлерінде (1,19 мг/100 және 1,15 мг/100г), В тобындағы дәрумендердің көп бөлігі: $B_1$ (0,191 мг/100г) шырғанақ жапырақтары қосылған алма зефирінде; $B_2$ (0,511 мг/100г) және $B_6$ (0,099 мг/100г) шайқурай қосылған қарақат-алма зефирінде; $B_5$ шырғанақ жапырақтары қосылған мүкжидек-алма зефирінде (0,022 мг/100г) болды. С дәруменінің құрамы құлпынай мен алма зефирлерінде басым болды, сәйкесінше 0,109 мг/100 г және 0,284 мг/100 құрады. Дәрілік шөптерден алынған ұнтақтар қосылған зефирлердің барлық түрлері органикалық қышқылдардың жоғары құрамымен ерекшеленді. Осылайша, зефирлердің әзірленген ассортименті тағамдық құндылықтың оңтайлы көрсеткіштеріне ие екенін және функционалды мақсаттағы кондитерлік өнімдерге қойылатын талаптарға жауап беретінін атап өткен жөн.***

**Негізі сөздер: зефирлер, дәрумендер, антиоксиданттар, дәрілік шөптер, өсімдік тектес шикізат, кондитерлік өнімдер.**

## ИССЛЕДОВАНИЕ ПИЩЕВОЙ ЦЕННОСТИ ЗЕФИРОВ ФУНКЦИОНАЛЬНОГО НАЗНАЧЕНИЯ

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***В данной научной статье приведены результаты изучения пищевой ценности (витамины, антиоксиданты, органические кислоты) зефиров на основе местного растительного сырья (клюква, смородина, клубника, яблоки) с добавлением порошков из лекарственных трав (листья облепихи, зверобой, шиповник) в целях расширения ассортимента иммуностимулирующих кондитерских изделий функционального назначения. По результатам научных исследований, наибольшее количество антиоксидантов содержится в смородиново-яблочном и яблочном зефирах (1,19 мг/100 и 1,15 мг/100г), большая часть витаминов группы В: $B_1$ в яблочном зефире с добавлением листьев облепихи (0,191 мг/100г); витамины $B_2$ (0,511 мг/100г) и $B_6$ (0,099 мг/100г) в смородиново-яблочном зефире с добавлением зверобоя; $B_5$ в клюквенно-яблочном зефире с добавлением листьев облепихи (0,022 мг/100г). Содержание витамина С преобладало в клубничном и яблочном зефирах, 0,109 мг/100г и 0,284 мг/100 соответственно. Все виды зефиров с добавлением порошков из лекарственных трав также отличились высоким содержанием органических пищевых кислот. Таким образом, необходимо отметить, что разработанный ассортимент зефиров обладает оптимальными показателями пищевой ценности и отвечает требованиям к кондитерским изделиям функционального назначения.***

**Ключевые слова: зефиры, витамины, антиоксиданты, лекарственные травы, растительное сырье, кондитерские изделия.**

### *Introduction*

The enhancement of confectionery technology through the incorporation of functional ingredients into the formulation allows for a scientifically grounded approach to addres the challenge of expanding their assortment and ensuring widespread consumption in everyday life [1]. In this regard, researchers from Almaty Technological University conducted a scientific project to explore local plant-based raw materials and medicinal herbs. The aim was to identify optimal components for developing advanced technology for immune-boosting confectionery products [2-9]. Subsequently, this study led to the formulation of a functional marshmallow technology, accompanied by an examination of its microbiological, physicochemical, rheological parameters, and nutritional aspects, including vitamins, antioxidants, and organic food acids.

Vitamins are multifunctional and play a crucial role in the functioning of the immune system. In this regard, the study of vitamins allows us to determine their content in plant-based products, compare them with the body's daily nutritional needs, and make necessary adjustments to the diet when needed [10]. Antioxidants are substances capable of reducing the level of free radicals and protecting the macromolecules of living cells. The determination of antioxidant content in food products is based on the necessity of maintaining antioxidant balance in the body. Recent studies indicate that the use of antioxidants can reduce inflammatory processes in the body and improve organ function [11]. Organic food acids are im-

portant components for the proper functioning of the human body as they participate in metabolism and stimulate the secretion of digestive juices. Berries, fruits, vegetables, leafy greens, and others are considered natural sources of these acids. In the production of food products, food acids play a crucial role in shaping the taste and aroma of the finished goods [12,13].

***Materials and research methods***

The objects of the study were as follows: apple marshmallow (control) without the addition of medicinal herbs, cranberry-apple marshmallow with the addition of sea buckthorn leaf powder, blackcurrant-apple marshmallow with the addition of St. John's wort powder, strawberry marshmallow with the addition of rosehip powder, and apple marshmallow with the addition of sea buckthorn leaf powder.

The quantitative determination of the mass fraction of water-soluble vitamins of the B group was conducted using capillary electrophoresis. The determination methodology is based on the migration and separation of the free forms of the analyzed water-soluble vitamins under the influence of an electric field, with registration at a wavelength of 200 nm of their electrophoretic mobility. The determination of vitamins B1, B2, B3, B5 (niacin), B6, and B9 was carried out in the capillary zone electrophoresis mode [14].

Antioxidants were determined using the method of measuring the mass fraction of antioxidants by measuring the strength of the electric current arising from the oxidation of antioxidant molecules on the surface of the working electrode at a certain potential [15]. The study of organic acids was determined by the capillary electrophoresis system. This method is based on the migration and separation of anionic forms of the analyzed components under the action of an electric field due to their different electrophoretic mobility [16].

***Results and discussion***

Table 1 reflects the data on the results of determining the quantitative content of vitamins in 5 types of marshmallows, including the control sample. From this table, it can be inferred that the highest amount of Vitamin B1 (thiamine hydrochloride) among the functional products under investigation is present in the apple marshmallow with added sea buckthorn leaves - 0.191 mg/100g. This vitamin in the control sample, blackcurrant-apple, and strawberry marshmallows is found at approximately the same level within the range of 0.154-0.157 mg/100g. In comparison with the apple marshmallow, the amount of thiamine hydrochloride in the cranberry-apple marshmallow is 23% lower, at 0.148 mg/100g. Vitamin B1 is an essential water-soluble vitamin with crucial importance for carbohydrate catabolism, amino acids, and gluconeogenesis [17].

Riboflavin (Vitamin B2) exhibits significant antioxidant activity in neutralizing radicals within food products. The blackcurrant-apple marshmallow with added St. John's wort contains the highest Vitamin B2 content at 0.511 mg/100g. In comparison, the riboflavin content in the control marshmallow is 11% lower, 19% lower in cranberry-apple marshmallow, 5% lower in strawberry marshmallow, and 17% lower in apple marshmallow with added sea buckthorn leaves.

Nicotinic acid (Vitamin B3) was found at 0.074 mg/100g in cranberry-apple marshmallow, which is 48% higher than in apple marshmallow. Vitamin B3 is essential for all living cells and is effective in reducing cholesterol levels. The highest vitamin B5 content was found in cranberry-apple marshmallow 0.022 mg/100g, followed by currant-apple sample, control sample, apple sample with sea buckthorn leaf addition and strawberry marshmallow, inferior to cranberry-apple marshmallow by 23%, 27%, 32% and 50%, respectively. A group of experts on dietary products defined reference values of pantothenic acid and established adequate intake levels for different age groups, taking into account its role in energy metabolism [18].

The highest amount of pyridoxine (Vitamin B6) was identified in blackcurrant-apple marshmallow at 0.099 mg/100g. In cranberry-apple and strawberry marshmallows, its quantity was three times less compared to blackcurrant-apple marshmallow (0.030 and 0.028 mg/100g, respectively). Vitamin B6 is essential for the synthesis of blood cells and hemoglobin, and it also contributes to the efficient digestion of protein-rich foods. Scientists have proven the beneficial effects of pyridoxine on the health of women suffering from pregnancy-related nausea [19].

Table 1 – Content of vitamins and antioxidants in functional marshmallows

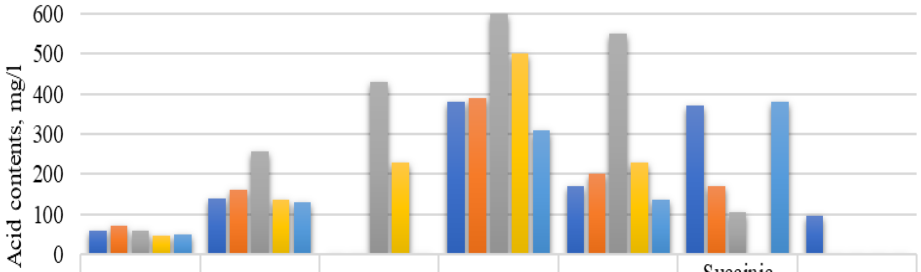
| | Apple marshmallow (control) | Cranberry-apple marshmallow with the addition of sea buckthorn leaf powder | Blackcurrant-apple marshmallow with the addition of St. John's wort powder | Strawberry marshmallow with the addition of rosehip powder | Apple marshmallow with the addition of sea buckthorn leaf powder |
|---|---|---|---|---|---|
| Vitamin B1 (thiamine hydrochloride), mg/100g | 0,157 | 0,148 | 0,156 | 0,154 | 0,191 |
| Vitamin $B_2$ (riboflavin), mg/100g | 0,453 | 0,413 | 0,511 | 0,483 | 0,424 |
| Vitamin $B_3$ (nicotinic acid), mg/100g | 0 | 0,074 | 0 | 0 | 0,142 |
| Vitamin $B_5$ (pantothenic acid), mg/100g | 0,016 | 0,022 | 0,017 | 0,011 | 0,015 |
| Vitamin $B_6$ (pyridoxine), mg/100g | 0 | 0,030 | 0,099 | 0,028 | 0 |
| Vitamin $B_9$ (folic acid), mg/100g | 0 | 0,005 | 0,009 | 0 | 0,010 |
| Vitamin C (ascorbic acid), mg/100g | 0 | 0,086 | 0,090 | 0,109 | 0,284 |
| Antioxidants, mg/g | 0,92 | 1,05 | 1,19 | 0,99 | 1,15 |

According to the research, vitamin B9 (folic acid) was found in three types of marshmallows. In cranberry-apple marshmallow, its content is 0.005 mg/100g. In blackcurrant-apple and apple marshmallows with the addition of sea buckthorn leaves, the content of folic acid was 44% and 50% higher, respectively, compared to cranberry-apple zephyr. Folic acid strengthens blood vessel walls and contributes to the normal functioning of the heart. Recent studies have explored the production of folic acid under the influence of lactic acid microorganisms in the production of dairy products [20].

Vitamin C is an essential micronutrient for human health since its biochemical mechanism is related to its antioxidant capacity [21]. This acid was detected in all marshmallows except the control sample: in apple marshmallow with sea buckthorn leaves (0.284 mg/100g), then 2.6 times less in strawberry marshmallow (0.109 mg/100g), 3.3 times less in cranberry-apple (0.086 mg/100g) and currant-apple marshmallows (0.090 mg/100g) compared to apple marshmallow with sea buckthorn leaves.

Antioxidants play an important role in the immune system [22]. They protect the body's cells from damage caused by reactive oxygen species and the aggressive behavior of free radicals. The most antioxidants were found in blackcurrant apple marshmallow (1.19 mg/g), followed by apple marshmallow with sea buckthorn leaves, cranberry apple marshmallow, strawberry marshmallow, and apple marshmallow (control), which were inferior to blackcurrant apple marshmallow by 3.4%, 11.8%, 16.8%, and 22.6% respectively.

The results of the study on the content of organic food acids in functional marshmallows are presented in Figure 1. The cranberry-apple marshmallow has a predominance of oxalic acid (70 mg/l), while the currant-apple marshmallow has the highest content of formic acid (255 mg/l). The levels of tartaric acid were found to be 1.5 times lower in cranberry-apple marshmallow (160 mg/l), 1.8 times lower in apple (control) (140 mg/l), 1.9 times lower in strawberry (135 mg/l), and almost 2 times lower in apple marshmallow with sea buckthorn leaves (130 mg/l) compared to currant-apple marshmallow. Additionally, tartaric acid was found to be 230 mg/l higher in strawberry marshmallow and 200 mg/l higher in currant-apple marshmallow.




| | Oxalic acid | Formic acid | Tartaric acid | Malic acid | Citric acid | Succinic acid | Lactic acid |
|---|---|---|---|---|---|---|---|
| №1 | 60 | 140 | 0 | 380 | 170 | 370 | 95 |
| №2 | 70 | 160 | 0 | 390 | 200 | 170 | 0 |
| №3 | 60 | 255 | 430 | 600 | 550 | 105 | 0 |
| №4 | 45,5 | 135 | 230 | 500 | 230 | 0 | 0 |
| №5 | 50 | 130 | 0 | 310 | 135 | 380 | 0 |

Figure 1 – The content of organic acids in functional marshmallows: №1 (apple marshmallow (control)), №2 (cranberry-apple marshmallow with sea buckthorn leaves), №3 (currant-apple marshmallow with St. John's wort), №4 (strawberry marshmallow with rosehip), №5 (apple marshmallow with sea buckthorn leaves).

The currant-apple marshmallow had the highest amount of malic acid at 600 mg/l, followed by strawberry at 500 mg/l, cranberry-apple at 390 mg/l, control at 380 mg/l, and apple marshmallows at 310 mg/l. Additionally, the currant-apple marshmallow was found to have a high citric acid content of 550 mg/L. The strawberry marshmallow contained 58% of the content, while the cranberry-apple marshmallow contained 63%. The control marshmallow sample had 69% of the citric acid content and the apple marshmallow with sea buckthorn leaves contained 75% less of the citric acid than the currant-apple marshmallow. The control marshmallow and the apple marshmallow with sea buckthorn leaves contained similar amounts of amber acid (370 and 380 mg/l, respectively), while the cranberry-apple marshmallow contained 170 mg/l and the currant-apple marshmallow contained 65 mg/l less (105 mg/l). Lactic acid was only detected in the control sample of marshmallow, at a concentration of 95 mg/l. The determination of organic acid content enables the monitoring of sensory properties and quality control of food products [23]. The acids present in marshmallows contribute to slowing down oxidative processes, maintaining the conditioned alkaline pH of the environment, and preventing the development of pathogenic fungi, molds, and bacteria, resulting in the preservation and microbiological safety of finished products.

***Conclusion***

The presented assortment of marshmallows, made from fruit and berry raw materials with the addition of medicinal herbs, has higher nutritional value compared to the control sample, as shown by the results of the scientific research. This confirms the validity of the selected plant raw materials.

As a result, the implemented marshmallow technologies incorporating local plant raw materials contribute to enhancing the quality of end products and broadening the variety of immunostimulant confectionery items with functional benefits.

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