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ПРИМЕНЕНИЕ ПЛОДОВОГО СЫРЬЯ СИБИРСКОГО РЕГИОНА КАК ОСНОВЫ НАЧИНОК ДЛЯ ХЛЕБОБУЛОЧНЫХ ИЗДЕЛИЙ

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Представлены результаты изучения плодов и продуктов их переработки как источников веществ антиоксидантной направленности (витаминов, органических кислот и различных фенольных веществ) в рационе человека. Установлено, что существует вариативность содержащихся в плодах биологически ценных веществ в зависимости от места произрастания, условий культивирования и других. Цель исследования – дать оценку целесообразности применения традиционного для Сибирского региона плодового сырья (клюквы, брусники и аронии) как основы начинок для хлебобулочных изделий. Объект исследований – свежие дикорастущие плоды клюквы и брусники (урожай 2021 г., заготовка Томского Облпотребсоюза Центросоюза РФ) и плоды аронии (сортосмесь, выращенная на территории Кемеровской области и реализуемая на потребительском рынке). Органолептическую оценку начинок осуществляли по 5-балльной шкале, суммарную антиоксидантную активность – кулонометрическим экспресс-методом на приборе «Экспресс-006-Антиоксиданты». На основании проведенных исследований установлено, что свежие плоды по антиоксидантной активности ранжируются следующим образом: клюквы > аронии > брусники. Установлено, что на показатель «внешний вид и консистенция» начинок для хлебобулочных изделий оказывают основное влияние структурообразователи, которые ранжируются следующим образом: 1,0% агара > 2,0% пектина > 1,5% агара > 6,0% крахмала модифицированного. На запах и вкус начинок основное влияние оказывает используемое плодовое сырье, а структурообразователи – опосредованное. Суммарная антиоксидантная активность начинок для хлебобулочных изделий зависит от разрушения биологически активных веществ плодов при изготовлении, а не от используемых структурообразователей. Результаты данных исследований будут полезны при создании функциональной пищевой продукции.

Ключевые слова: плоды, антиоксидантная активность, начинки, структурообразователи, показатели качества

THE USE OF FRUIT RAW MATERIALS OF THE SIBERIAN REGION AS THE BASIS OF FILLINGS FOR BAKERY PRODUCTS

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The results of the study of fruits and their products as sources of antioxidant substances (vitamins, organic acids and various phenolic substances) in the human diet are presented. It was found that there is a variation in the biologically valuable substances contained in fruits depending on the place of growth, cultivation and other conditions. The purpose of the study is to assess the feasibility of using traditional for the Siberian region fruit raw materials (cranberry, lingonberry and chokeberry) as the basis for the filling of bakery products. The object of research was fresh wild fruits of cranberry and lingonberry (harvest of 2021, harvested by the Tomsk Regional Consumer Union of the Russian Federation) and chokeberry fruits (variety mix, grown in the Kemerovo region and sold in the consumer market). The organoleptic evaluation of the fillings was carried out on a 5-point scale, total antioxidant activity - by coulometric express method on the device "Express-006-Antioxidants". Based on the studies conducted, it was found that fresh fruits are ranked as follows in terms of antioxidant activity: cranberry > chokeberry > lingonberry. It was found that the indicator

"appearance and consistency" of fillings for bakery products is mainly influenced by structural formers, which are ranked as follows: 1.0% agar > 2.0% pectin > 1.5% agar > 6.0% modified starch. The smell and taste of fillings are mainly influenced by the fruit raw material used, and the structure-forming agents are indirectly influenced by them. Total antioxidant activity of bakery fillings depends on the destruction of biologically active substances of fruit during manufacturing, rather than on the used structure-forming agents. The results of these studies will be useful in the creation of functional food products.

Keywords: fruits, antioxidant activity, bakery fillings, structure-forming agents, quality indicators

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Conflict of interest
The authors declare no conflict of interest.

INTRODUCTION

The peculiarities of modern human nutrition, the emergence of new data on the functional properties of food ingredients, including natural origin, contribute to the development of technologies for obtaining food products with given properties having physiological value [1]. At the same time, plant raw materials are a valuable source of essential nutrients of different physiological orientation, allowing it to be used for the production of combined products in combination with the basis of animal origin [2].

Oxidative stress resulting from inadequate functioning of the antioxidant system leads to metabolic disorders. As a consequence, inflammatory processes arise in the human body, leading to chronic diseases, as well as widespread nutritional (food-related) diseases [3]. In this regard, the development and production of food products containing natural functional food ingredients are of interest in order to solve the problem of reducing oxidative stress.

The process of designing the ingredient composition of a food product with functional properties consists in a multivariate selection of valuable raw ingredients for all product systems under the condition of a complex structure. Products with fillings consisting of two ingredient systems with different properties can be used as an example [4].

Oxygen is the main guarantor of the vital activity of living organisms, but as a result of normal metabolic processes free radicals are formed in the cell, damaging the cell membranes. Therefore, the lack of timely neutralization of active oxygen leads to irreversible damage to the body. Humans exist under constant stress, the situation is exacerbated by emotional stress, environmental conditions, air pollution, and the prevalence of smoking. In this regard, free radical damage is due to their excessive amount. Antioxidant protection of the body is necessary for humans to level the consequences of destructive oxidative processes [5].

The main sources of antioxidants are fruits, especially those with a pronounced sour and sour-sweet taste, blue, red, and orange. Various groups of substances show antioxidant properties: vitamins E, C, carotenoids, flavonoids, polyphenols, trace elements (such as selenium) and others. Especially rich in antioxidants are rosehips, cranberries, blueberries, black currant, wild strawberries, blackberries, goji, sea buckthorn, cranberries, etc. Fruit flavonoids are mainly anthocyanins, proanthocyanides, flavonols, and catechins [6, 7]. A number of authors have shown that significant variation in the content of biologically valuable substances in fruits is associated with the variety, cultivation conditions, and place of growth [8-10]. At the same time, there are not enough studies of the variability of antioxidant activity of the ingredient composition of fruit processing products.

The purpose of the research is to assess the feasibility of using traditional for the Siberian region fruit raw materials (cranberries, lingonberries and chokeberries) as the basis for the filling of bakery products.

The following tasks were solved within the framework of the stated goal:

- the total antioxidant activity of cranberry, lingonberry and chokeberry fruits was determined;

- evaluation of organoleptic characteristics and total antioxidant activity of the toppings for bakery products from the studied fruit raw materials depending on the used structure-forming agent was carried out.

MATERIAL AND METHODS

Studies were conducted in October 2021 in the laboratories of the departments of technology and organization of public catering and technology of processing of raw materials of plant origin of Kemerovo State University.

The object of research is fruit raw material (cranberry, lingonberry and chokeberry), which has antioxidant activity, and semi-finished products (stuffing for bakery products) based on it.

Fresh wild fruits of cranberry and lingonberry of 2021 harvested by Tomsk Regional Consumer Union of the Central Union of Consumer Cooperatives of the Russian Federation, fresh fruits of chokeberry, mixed varieties grown in the Kemerovo region and sold on the consumer market were studied in the work.

For the structuring (thickening) of the fillings we used:

– pectin according to GOST 29186-91 "Pectin. Technical conditions";

– agar according to GOST 16280-2002 "Agar food. Technical Conditions";

– corn starch modified with cold swelling GLETEL BAW E1422.

Stuffing was prepared as follows: fresh chopped fruits (particle size 1-4 mm) were mixed with sugar in the ratio fruit: sugar - 80: 20, heated and brought to a boil; then thickener was added in various amounts, brought to a boil and boiled for 4 minutes. Then it was cooled at room temperature until formation of gelled structure. The amount of structure agents was introduced according to the manufacturers' recommendations for the fillings as percentage of the mass of fruit and sugar mixture: 1.0% and 1.5% agar, 2.0% pectin, 6.0% corn starch (GLETEL BAW-23).

Organoleptic evaluation of the fillings was carried out on a hedonic 5-point scale: 5 points - excellent quality; 4 - good; 3 - satisfactory; 2 - poor (unacceptable); 1 point - very poor (unacceptable). When examining the indicator "appearance and consistency" of the products, descriptive characteristics and scoring were carried out in terms of the behavior of fruit filling during baking, its uniform distribution inside the baked product, including after cooling.

Total antioxidant activity (AOA) was determined by the coulometric express method on the device "Express-006-Antioxidants". AOA was measured by preparing an aqueous-alcoholic extract of fruits or fillings: solid portions of crushed fruits or fillings were poured into aqueous-alcoholic mixture (40%) in the ratio 1: 4 (portions to mixture) and incubated in a cabinet without light at 20 ± 2 ° C for 2 hours. The duration of infusion was determined by experiment - after 2 h the AOA parameters were stabilized and did not change essentially. The use of water-alcohol mixture allowed maximum extraction of water- and alcohol-soluble substances exhibiting antioxidant activity.

When evaluating the antioxidant activity of the filling, it was preheated to 98 ° C and incubated for 10 minutes, simulating the heating of a bakery product during baking, then cooled and measured.

RESULTS AND DISCUSSION

At the first stage of the experiment, the total antioxidant activity of fruit samples was determined: cranberry, lingonberry and chokeberry. The choice of these fruits is explained by their local origin (within Siberia), as well as by the content of the nutrient composition of a significant number of physiologically valuable substances. According to the literature data [11-16], the fruits selected for the study contain the following biologically active substances that determine the antioxidant orientation:

– cranberry: citric, benzoic, quinic, ursolic, chlorogenic, apple, oleic, γ-oxy-α-ketobutyric, α-ketoglutaric acids; in trace amounts - oxalic and succinic acids; betaine and bioflavonoids: anthocyanins, leucoanthocyanins, catechins, flavonols and phenolic acids;

– lingonberry: citric, apple, oxalic, benzoic, acetic, glyoxylic, pyruvic, oxypyruvic, α-ketoglutaric acids, etc.;

– black chokeberry: rutin, anthocyanins, catechins, flavonols, organic acids: citric, malic, tartaric, salicylic, tartronic.

The results of AOA studies of cranberry, lingonberry and chokeberry fruits are presented in Table 1.

The studied fruits differ from each other by AOA, they can be ranked as follows: cranberry> chokeberry> lingonberry (see Table 1). It was noted that the AOA of chokeberry fruit is insignificantly inferior to cranberry fruit, on average, by 7%, but superior to lingonberry fruit, on average, by 20%.

Stuffings were prepared from cranberry, lingonberry and chokeberry fruits. The results of the evaluation of organoleptic characteristics of the fillings are presented in Tables 2, 3.

The data in Table 2 indicate that the best appearance and consistency were the fillings made from cranberry, lingonberry and chokeberry fruits, made with 1.0% agar as a structural agent, the average score being 4.7 (the mass is thick, jelly-like, and spreadable). Fruit fillings made with pectin were slightly inferior in appearance and consistency to products made with 1% agar, with a score only 5% lower (a thick, viscous, smeary mass). Stuffings made from cranberries, lingonberries and chokeberries containing 1.5% agar were inferior to the products containing 1.0% agar by an average of 7%, as the mass became excessively dense. Samples of stuffing from cranberry, lingonberry and chokeberry fruits with 6.0% modified cold swelling starch as a texture formulator, as recommended by the manufacturer, obtained low

Табл. 1. Суммарная антиоксидантная активность плодового сырья (n = 3)

Table 1. Total antioxidant activity of fruit raw materials (n = 3)

Fruit	Total antioxidant activity, mg/100 g rutin
Cranberry	219,24 ± 3,74
Lingonberry	162,33 ± 2,49
Chokeberry	204,12 ± 3,74

Табл. 2. Органолептическая оценка показателя «внешний вид и консистенция» плодовых начинок (n = 5)

Table 2. Organoleptic evaluation of the fruit fillings indicator "appearance and consistency" (n = 5)

Sample	Descriptive characteristics of the stuffing	Integral estimation, point
Cranberry + 1,5% agar	Thick, jelly-like mass that does not spread on the surface	4,5 ± 0,4
Lingonberry + 1,5% agar		4,4 ± 0,1
Chokeberry + 1,5% agar		4,1 ± 0,1
Cranberry + 1,0% agar	Thick, jelly-like, smearing mass	4,9 ± 0,1
Lingonberry + 1,0% agar		4,6 ± 0,3
Chokeberry + 1,0% agar		4,5 ± 0,2
Cranberry + 2,0% pectin	Thick, viscous, smearing mass	4,7 ± 0,2
Lingonberry + 2,0% pectin		4,5 ± 0,4
Chokeberry + 2,0% pectin		4,1 ± 0,3
Cranberry + 6,0% starch	Dense, kisselike mass	2,9 ± 0,7
Lingonberry + 6,0% starch		3,5 ± 0,5
Chokeberry + 6,0% starch		3,1 ± 0,5

organoleptic scores for the studied index (3.2 points on average), because the mass became too dense, jellylike. The results of organoleptic evaluations of the studied organoleptic indicator did not depend on the type of fruits used.

The smell and taste of the fillings depended primarily on the individual characteristics of cranberry, lingonberry and chokeberry fruits (see Table 3). The use of agar as a structuring agent in fruit fillings, regardless of its concentration, had no effect on product smell, but allowed creating a more pronounced bright taste of fruits used as a base, compared with pectin - the average score was 4.6 and 4.1, respectively. The smell of the fillings was characteristic of the fruit from which they were made; there were no extraneous tones. It should be noted that the products made with 1.0% agar had a more pronounced smell than those with 1.5% agar, and the products with 2.0% pectin had more softness. The taste was sour for fillings made from cranberry and lingonberry fruits, the latter had a slight pleasant bitterness in the aftertaste; sweet and astringent - from chokeberry. Cranberry

Табл. 3. Органолептическая оценка показателя «запах и вкус» плодовых начинок (n = 5)
Table 3. Organoleptic evaluation of the fruit fillings indicator "smell and taste" (n = 5)

Sample	Descriptive characteristics		Integral estimation, point
	Taste	Flavor	
Cranberry + 1,5% agar	A pronounced, sour-sweet characteristic of cranberries, with no off-flavor	Harmonious, characteristic of cranberries, odorless	4,5 ± 0,2
Lingonberry + 1,5% agar	Expressed, sour-sweet, peculiar to the lingonberry, with a slight bitterness in the aftertaste, with no off-flavor	Harmonious, characteristic of lingonberries, odorless	4,9 ± 0,1
Chokeberry + 1,5% agar	A pronounced, sweet and astringent characteristic of chokeberry, with no off-flavor	Harmonious, characteristic of chokeberry, odorless	4,1 ± 0,2
Cranberry + 1,0% agar	A pronounced, sour-sweet characteristic of cranberries, with no off-flavor	Harmonious, pronounced, characteristic of cranberries, odorless	4,6 ± 0,1
Lingonberry + 1,0% agar	Expressed, sour-sweet, peculiar to the lingonberry, with a slight bitterness in the aftertaste, with no off-flavor	Harmonious, pronounced, characteristic of lingonberries, odorless	4,9 ± 0,1
Chokeberry +1,0% agar	A pronounced, sweet and astringent characteristic of chokeberry, with no off-flavor	Harmonious, pronounced, characteristic of chokeberry, odorless	4,3 ± 0,2
Cranberry + 2,0% pectin	Sour-sweet, typical of cranberries, with no off-flavor	Harmonious, soft, characteristic of cranberries, odorless	4,0 ± 0,2
Lingonberry + 2,0% pectin	Sour-sweet, peculiar to the lingonberry, with a slight bitterness in the aftertaste, with no off-flavor	Harmonious, soft, characteristic of lingonberries, odorless	4,3 ± 0,4
Chokeberry + 2,0% pectin	A pronounced, sweet and astringent characteristic of chokeberry, with no off-flavor	Harmonious, soft, characteristic of chokeberry, odorless	3,9 ± 0,3
Cranberry + 6,0% starch	Sour-sweet, typical of cranberries, with an extraneous flavor	Characteristic of cranberries, with extraneous tones	2,7 ± 0,5
Lingonberry + 6,0% starch	Sour-sweet, typical of lingonberries, with an extraneous flavor	Characteristic of lingonberries, with extraneous tones	2,5 ± 0,4
Chokeberry + 6,0% starch	A pronounced, sweet and astringent flavor typical of chokeberry, with an extraneous flavor	Characteristic of chokeberry, with extraneous tones	2,5 ± 0,7

and lingonberry fillings made with agar regardless of its concentration had a more pronounced taste than products made with pectin. The indicator of "expressiveness" of taste of products made from chokeberry, the structure-forming agent (agar or pectin) did not have a significant effect, but only on its overall impression. The smell and taste of cranberry, lingonberry and chokeberry fillings are most influenced by modified starch, the organoleptic evaluation of the best samples showed that this occurs on average by 44% - there appeared "floury" tones and aftertaste (see Table 3). Figures 1-3 show the research data on the total antioxidant activity of fruit fillings.

The data in Table 1 and Fig. 1-3 indicate that temperature exposure first during preparation of the filling and then during the simulated baking process reduced the antioxidant activity by more than 2-fold. At the same time, the strongest destruction of antioxidant substances was observed in chokeberry. The antioxidant activity of the toppings was influenced by the type of fruit rather than by the structural agent used (see Figs. 1-3). For example, cranberry fruit toppings, depending on the structure-forming agent used, ranked as follows in terms of antioxidant activity: 1.0% agar> 2.0% pectin> 1.5% agar> 6.0% starch. Stuffings from chokeberry fruit had almost the opposite ranking: 6.0% starch> 2.0% pectin> 1.0% agar> 1.5% agar. Stuffings from lingonberry fruits were ranked as follows in terms of antioxidant activity, depending on

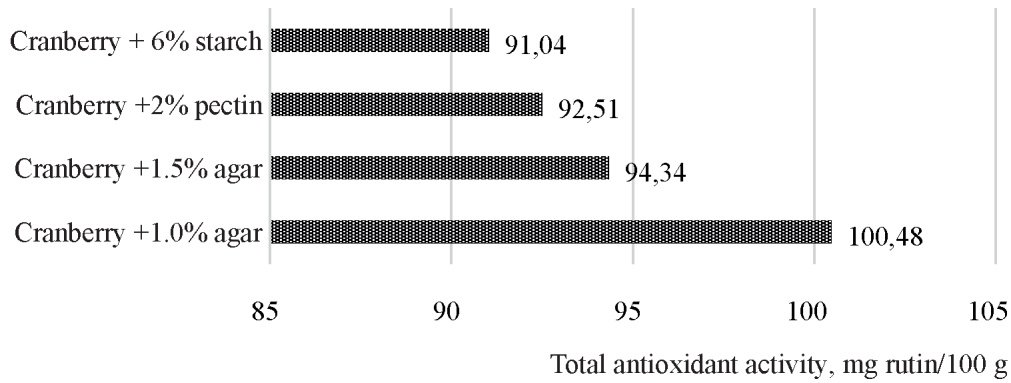

Рис. 1. Суммарная антиоксидантная активность клюквенных начинок (*n*=3)
Fig. 1. Total antioxidant activity of cranberry fillings (*n* = 3)

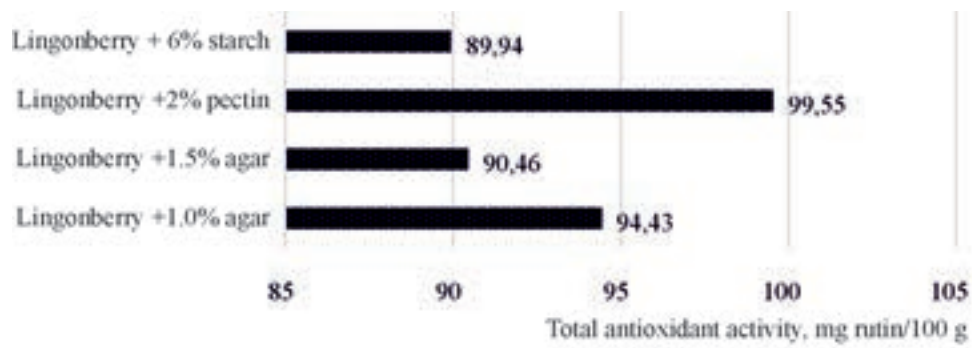

Рис. 2. Суммарная антиоксидантная активность брусничных начинок (*n* = 3)
Fig. 2. Total antioxidant activity of lingonberry fillings (*n* = 3)

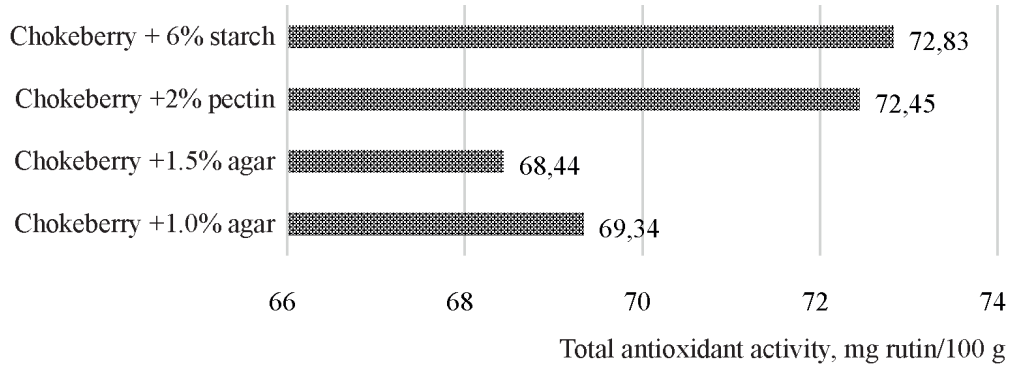

Рис. 3. Суммарная антиоксидантная активность арониевых начинок (n = 3)
Fig. 3. Total antioxidant activity of chokeberry fillings (n = 3)

the structural agent used: 2% pectin> 1% agar> 1.5% agar> 6% starch.

CONCLUSION

The paper presents data on the antioxidant status of wild cranberry, lingonberry and chokeberry cultivated in households. It was shown that according to the total antioxidant activity, the studied plant raw materials were distributed as follows: cranberry> chokeberry> lingonberry. Sensory characteristics of fillings for bakery products were significantly influenced not only by the type of fruit raw material, but also by the type of structure-forming agent used in their manufacture. Model samples with 1% agar and 2% pectin had the best indicators. It was revealed that during the preparation of the fillings there was a destruction of biologically active substances, depending on the type of fruit (ranking by antioxidant activity as follows: cranberry> lingonberry> chokeberry), but not on the used structure formers.

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