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VEGETARIAN SHORTBREAD ENRICHED WITH SWEET POTATO (*IPOMOEA BATATAS* VAR. *PORTU BETERRABA*)

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Abstract

Sweet potato is a dicotyledonous plant that has large, starchy, sweet-tasting tuberous roots that are used in food as a vegetable. Sweet potato (*Ipomoea batatas* var. *Portu Beterraba*) grown in Ukraine has a high content of sugars (5.25 %), protein (2.8 %), dietary fiber (3.2 %), ash (0.85 %) and starch (11.6 %). *Portu Beterraba* sweet potato has a yellow-pink color, which was formed by the combination of anthocyanin pigmentation of the skin and β -carotene of the pulp. However, *Portu Beterraba* sweet potato and its semi-finished products are not used for the production of vegetarian shortbread. Sweet potato was added to the shortbread recipe in the form of a puree in the amount of 52.5 % to completely replace sugar, butter and part of egg products. Sweet potato puree is prepared by steaming and is a technologically simple alternative to sweet potato powder. Shortbread enriched with sweet potato has a high nutritional value in terms of protein content (9.8 g/100g), dietary fiber (9.7 g/100g) and minerals (2.0 g/100g). In shortbread enriched with sweet potato, the protein content increased by 71.9 %, the dietary fiber content increased by 67.2 %, and the mineral content increased by 2 times compared to the control. Hardness of shortbread decreased by 80.2 % and fracturability decreased by 64.4 % compared to the control, making it more acceptable to consumers. The high content of bioactive components, increased nutritional value and absence of animal husbandry products in the recipe of shortbread enriched with *Portu Beterraba* sweet potato allow it to be classified as a dietary food.

Keywords: vegetables, sweet potato puree; confectionery; dietary fiber; antioxidant; food coloring; steam cooking; quality characteristics; dietary food.

ВЕГЕТАРИАНСЬКЕ ПІСОЧНЕ ПЕЧИВО ЗБАГАЧЕНЕ БАТАТОМ (*IPOMOEA BATATAS* VAR. *PORTU BETERRABA*)

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Анотація

Батат – дводольна рослина, яка має великі, крохмалисті, солодкі на смак бульбоподібні корені, що використовуються у харчуванні як овоч. Батат (*Ipomoea batatas* var. *Portu Beterraba*) вирощений в Україні має високий вміст цукрів (5.25 %), білка (2.8 %), харчових волокон (3.2 %), золи (0.85 %) та крохмалю (11.6 %). Батат сорту *Portu Beterraba* має жовто-рожевий колір, що утворився від поєднання пігментації антоціаном шкірочки та β -каротином м'якоті. Однак, батат сорту *Portu Beterraba* та напівфабрикати з нього не використовуються для виробництва вегетаріанського пісочного печива. Батат додавався до рецептури пісочного печива у вигляді пасти у кількості 52.5 % для повної заміни цукру, вершкового масла та частини яєчних продуктів. Паста з батату готується варкою на пару і є технологічно простою альтернативою порошку з батату. Пісочне печиво збагачене бататом має високу харчову цінність за вмістом білка (9.8 г/100г), харчових волокон (9.7 г/100г) та мінеральних речовин (2.0 г/100г). У пісочному печиві збагаченому бататом вміст білка збільшився на 71.9 %, вміст харчових волокон збільшився на 67.2 %, а вміст мінеральних речовин збільшився у 2 рази у порівнянні з контролем. Твердість пісочного печива зменшилась на 80.2 %, а ламкість зменшилась на 64.4 % у порівнянні з контролем, що зробило його більш прийнятним для споживачів. Високий вміст біоактивних компонентів, збільшена харчова цінність та відсутність продукції тваринництва у рецептурі пісочного печива збагаченого бататом сорту *Portu Beterraba* дозволяє віднести його до дієтичної їжі.

Ключові слова: овочі; паста батату; кондитерські вироби; харчові волокна; антиоксидант; рослинний барвник; варка паром; якісні характеристики; дієтичне харчування.

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Introduction

Sweet potato (*Ipomoea batatas* L.) is a perennial herbaceous plant of the birch family (Convolvulaceae). Sweet potato as a tuberous root belongs to the Convolvulaceae family, is seventh in the world's crop statistics [1]. Sweet potato (*Ipomoea batatas* (L) Lam.) has acquired wide popularity in recent years as a health food. It is recognized as the sixth most essential crop in the world after wheat, maize, rice, cassava and potato [2]. As a main food crop, sweet potatoes have become an important part of the human diet [3]. Sweet potato is highly rich in starch, dietary fiber, minerals, vitamins, and phytochemicals with antioxidant activities, such as ascorbic acid, carotenoids, flavonoids, and other phenolic compounds [4–5]. The low protein content of sweet potato can be a problem for its use in vegetarian and dietetic food technology, but this problem can be solved by using plant-based protein isolates with better gelling properties [6–7]. Sweet potato is considered to be a highly nutritive vegetable that is rich in vitamins, minerals and various biologically active phytochemicals like polyphenols, dietary fiber, ascorbic acid and α -carotene [8]. Although a rich source of carbohydrate, it has low glycemic index (< 55) thereby indicating its utilization in the diets [9]. Increased consumption of diet rich in resistant starch, non-starch polysaccharides with low glycemic index has been recommended by FAO-WHO experts [10]. Significant variation in nutrient composition, such as protein, α -carotene, calcium, magnesium, phosphorus, and potassium, was found among the sweet potato varieties [11]. Different sweet potato cultivars differed in their amylose, amylopectin, ash and phosphorus contents, starch granule size, water absorption and solubility, retrogradation, crystallinity, and their thermal and pasting properties [12]. White-fleshed sweet potato had a high percentage of carbohydrate and reduced sugar and phenolics, and purple-fleshed sweet potato had high anthocyanin contents and antioxidant capacities, while yellow- and orange- fleshed ones had high levels of total protein, flavonoids, anthocyanins, and carotenoids [13]. Despite the fact that sweet potato is a non-traditional raw material for Ukraine, it can be integrated into its system after a detailed analysis of its nutritional properties in various culinary products, like other non-traditional raw materials [14].

Consumers' concern about their choice of food, and their possible health and environmental implications has led to noticeable changes in

dietary patterns and a growing shift to the consumption of Plant Base Foods, mostly for the purpose of promoting healthful living, conserving animal life and enhancing environmental sustainability [15–18]. Vegetarian diet does not allow the use of seafood and freshwater hydrobionts, but ordinary diets can necessarily include them and the formulation of such food products must be optimized for the various requirements of nutritionists [19]. Several studies have shown that Plant Base Foods help to delay the onset, reduce the risk of and even prevent certain disease conditions [20–22]. Plant-based diets have been associated with a reduced risk of a wide range of non-communicable diseases [23–26]. Plant-based diets are often deficient in microelements (iodine, selenium) and food products should be enriched with them [27].

Especially, baking is the most common and popular cooking method for sweet potatoes as a flavor snack [28]. Conventional baking methods include charcoal baking and oven baking. However, these methods have many drawbacks, including long processing time, food surface overheating and nutrients losses [29–30]. Orange-fleshed sweet potato is one of the unique varieties of sweet potatoes tuber that has attracted food professionals due to its great health benefits (α -carotene and antioxidant properties) in technology of bakery products [31]. Sweet potatoes can be used in the technology of hydrobiont pastes as a source of dietary fiber, natural sugars and other bioactive substances [32]. Sweet potato flours can be used for imparting desired properties, nutritional value, antioxidants and natural color to processed foods [33]. High fructose syrup is a highly valued liquid sweetener for beverage, confectionery and processed food industry can be made from sweet potato [34]. Sweet potatoes have been used as food and non-food raw materials in developed countries i.e. noodles, fried sweet potatoes, desserts, confectionery, soy sauce, flour, wine, vinegar, nata de coco, bioethanol and others [35]. Confectionery products can be enriched with a variety of concentrated food ingredients to increase their nutritional and biological value, such as beetroot powder and kiwi pomace [36–37]. Shortbread recipes are adapted to various diets using food waste [38–40]. Sweet potato can be used in confectionery technology instead of butter, which cannot be used in vegetarian diets and reduces the shelf life of food products [41].

The purpose of the research is to determine the effectiveness of using Portu Beterraba sweet potato puree in the shortbread recipe, to create a

new confectionery recipe with new food ingredients that are of plant origin, which allows the use of shortbread for vegetarian and dietary food. For this, it is necessary to investigate the chemical analysis of Portu Beterraba sweet potato, sweet potato puree and its production technology, and the quality characteristics of shortbread enriched with sweet potato puree.

Materials and methods

Materials and raw materials for research. Sweet potatoes (*Ipomoea batatas* var. Portu Beterraba) of the 2022 harvest were purchased from a farm in Kryvyi Rih, Ukraine. Other components of the shortbread recipe were purchased at the local market in Kyiv, Ukraine. All reagents used in the experiment were of analytical quality.

Shortbread manufacturing technology.

Preparation of dough. Put butter in a dough mixer, add granulated sugar, melange, salt, and mix for 20–30 minutes. to obtain a homogeneous mass. Then pour in the flour and continue kneading the dough for 1–2 minutes. Shortbread should have a smooth surface without lumps and traces of poor kneading.

Formation. The dough is cut into pieces of 3-4 kg each and rolled into layers on the table. Then the layers are cut and transferred to pastry sheets using a rolling pin. The excess dough is cut off at the edges of the sheet. Before baking, the surface of the dough is pricked in several places to prevent swelling. Sheets for baking shortcrust pastry are not greased. The dough for the rings is rolled out to a thickness of 6–10 mm.

Baking. The duration of baking the rings at a temperature of 200–225 °C is 10–15 minutes.

Physico-chemical composition of the Portu Beterraba sweet potato and sweet potato puree, and analysis of the nutritional value of shortbread

cookies. The chemical composition of the Portu Beterraba sweet potato and sweet potato puree and shortbread samples with their addition was analyzed, including measurements of moisture, starch, sugars and ash [42]. The fat content was analyzed using the Soxhlet extraction method, the protein content using the Kjeldahl method, and the total dietary fiber content using the enzymatic-gravimetric method [42]. The energy value of shortbread in kcal per 100 g was determined by the calculation method.

Structural analysis of shortbread. Texture characteristics analysis: Texture analyzer fitted with a cylindrical probe (P2) was used to determine the hardness and fracturability of shortbread. The parameters were as follows: Test force using puncture mode; pre-speed and test speed of 1 mm/s; post-speed of 5 mm/s and test distance of 10 mm; trigger force of 5.0 g. Six measurements were performed for each sample and the average value was calculated.

Organoleptic characteristics. Ten experts evaluated shortbread using the Score Card method to assess sensory parameters, namely: color, consistency, aroma, taste, and overall acceptability [43]. The obtained values from the participants were evaluated using a one-way analysis of variance and expressed as a mean value.

Statistical analysis. Research results were expressed as the average value with the number of experiments $n=6$ and standard error $\alpha < 0.05$.

Results and Discussion

The chemical composition of the Portu Beterraba sweet potato, grown in Ukraine, was studied to determine its potential in confectionery technology. The general chemical composition of sweet potato is given in Table. 1.

Table 1

The chemical composition of the Portu Beterraba sweet potato $n = 6, \alpha < 0.05$	
Nutritional value, g/100g	Sweet potato (<i>Ipomoea batatas</i> var. Portu Beterraba)
Water	76.2
Starch	11.6
Sugars	5.25
Dietary fiber	3.2
Proteins	2.8
Fats	0.1
Ash	0.85

The results of the chemical composition study showed that the Portu Beterraba sweet potatoes has high nutritional and biological value. Portu Beterraba sweet potatoes are particularly rich in dietary fiber (3.2 %), protein (2.8 %) and ash (0.85 %), which are of crucial importance in the

nutrition of the population, especially vegetarians and dietetics.

In confectionery technology, sweet potato is used in the form of puree and powder. Sweet potato puree is a technologically simple alternative to powder, but has a short shelf life and is used fresh. Sweet potato puree can also be

obtained by reducing sweet potato powder. Sweet potato puree is suitable for use in food enterprises, which will allow obtaining culinary products of higher quality, avoiding losses during

drying and grinding the root crop into flour. The developed puree production technology is shown in Fig. 1.

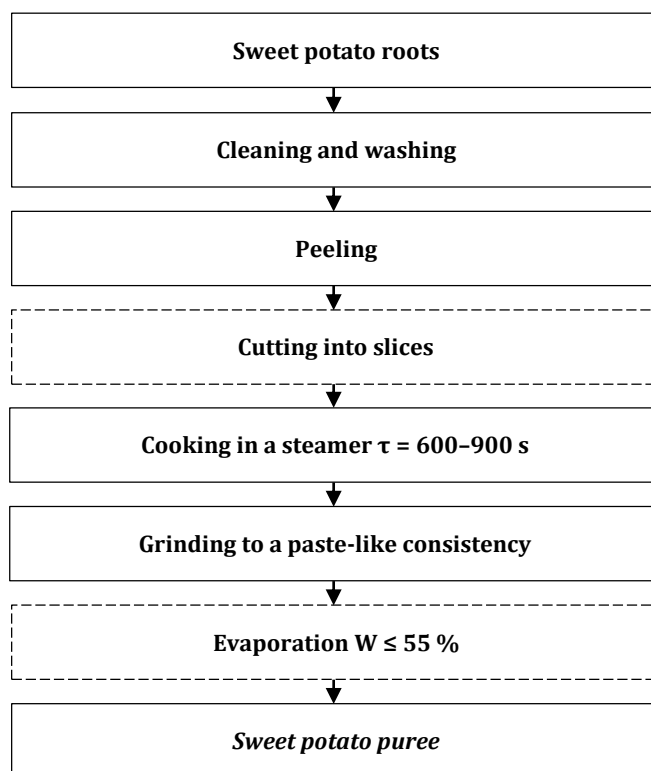


Fig. 1. Sweet potato puree production technology

Sweet potato puree is very easy to make and does not require additional equipment costs, which is standard for food production. Evaporation is used only when the moisture content of the puree does not meet the requirements of the confectionery recipe.

The chemical composition of the puree will allow to calculate the optimal cookie recipe and determine amount of sweet potato for various confectionery products. The general chemical composition of sweet potato puree is given in Table 2.

Table 2

The chemical composition of the Portu Beterraba sweet potato puree $n = 6$, $\alpha < 0.05$

Nutritional value, g/100g	Sweet potato puree (Ipomoea batatas var. Portu Beterraba)
Water	55
Starch	22.0
Sugars	9.8
Dietary fiber	6.1
Proteins	5.3
Fats	0.2
Ash	1.6

Portu Beterraba sweet potato puree has high indicators of biological value and is suitable for replacing the components of animal origin recipes. Sweet potato powder is more suitable for the industrial production of confectionery products and allows you to store sweet potatoes for a long time and increase its export potential. Since the main part of the world production of sweet potatoes is in agrarian countries, its drying is carried out by conventional methods that are

energy-consuming and long-term, they also reduce the yield and worsen the chemical composition and food safety of the flour. Although sweet potato puree can be obtained by reconstituting sweet potato powder, fresh sweet potato is the best alternative to powder if it can be grown and stored in the country where the food processing plant is located.

The effectiveness of adding Portu Beterraba sweet potato puree to the cookie recipe was

investigated. Standard shortbread recipes contain allergens such as wheat flour and egg products and animal ingredients such as butter. Unfortunately, sweet potato puree does not have the necessary properties to replace gluten in wheat flour, so the wheat flour in the cookie recipe

remained unchanged. Portu Beterraba sweet potato puree is suitable for replacing a part of egg products (30 % in the recipe), butter and sugar, which greatly simplifies and improves the shortbread recipe given in the Table 3.

Table 3

Recipe for shortbread cookies enriched with Portu Beterraba sweet potato puree			
Control sample recipe	Raw materials g/kg of shortbread	Experimental sample recipe	Raw materials g/kg of shortbread
Shortbread		Shortbread enriched with sweet potato puree	
Wheat flour	560	Wheat flour	560
Sugar	200	Sweet potato puree	200
Butter	300		300
Melange	25		25
	60	Soybean flour	60
Salt	20	Salt	20
In total	1165	In total	1165
Shortbread yield, %	76,2	Shortbread yield, %	85.8

Part of the egg products (70 % in the recipe), which was not replaced by sweet potato puree, is replaced with soy flour, which goes well with the yellow-pink color of the sweet potato. The yellow shades of the color of egg substitutes and their chemical composition are well combined in the recipe of shortbread cookies enriched with of the Portu Beterraba sweet potato puree. The total amount of Portu Beterraba sweet potato puree in

the recipe was 525.5 g, which significantly affected the chemical composition and organoleptic parameters of the shortbread.

In order to analyze the quality characteristics of shortbread enriched with Portu Beterraba sweet potato, its chemical and textural analysis was carried out. The chemical composition of shortbread is shown in Fig. 2.

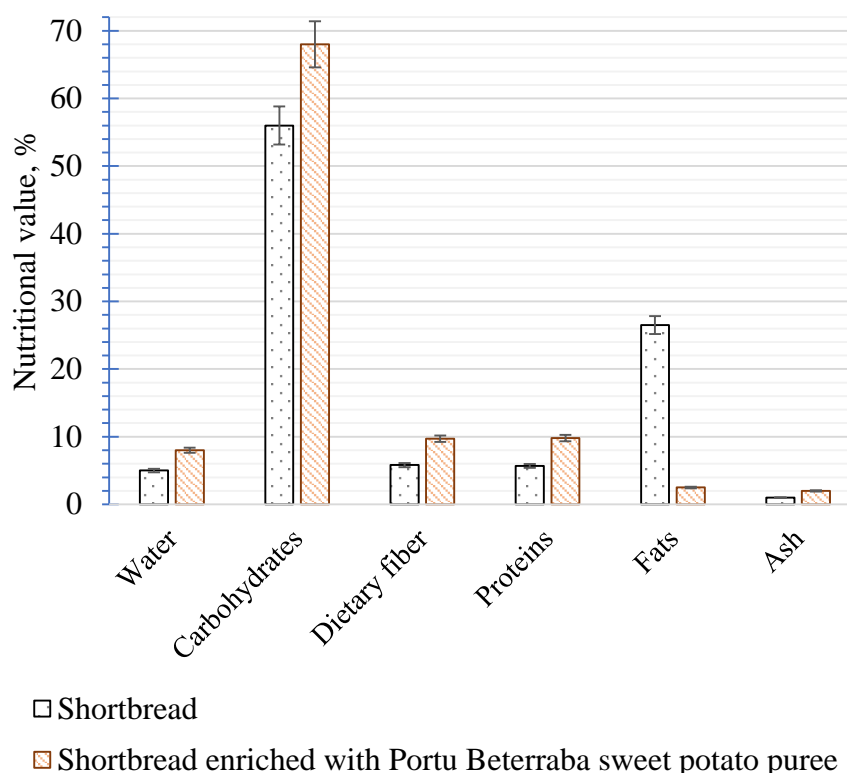


Fig. 2. Chemical composition of shortbread enriched with sweet potato puree n=6 $\alpha < 0.05$

The influence of the introduction of sweet potato puree on the chemical composition of

biscuits. Data from Fig. 2 indicate that after adding sweet potato puree to the shortbread recipe, its

chemical composition changed significantly. Compared to ordinary shortbread, the protein content increased by 71.9 % to 9.8 g/100 g of product. The content of dietary fiber increased by 67.2 % to 9.7 g/100g of product, carbohydrates by 21.4 % to 68 g/100g of product and ash by 2 times compared to ordinary shortbread. Eating 100 g of shortbread enriched with sweet potato puree provides 39.2 % of the daily norm of dietary fiber according to WHO recommendations that the daily need for the consumption of dietary fiber is 25 g. The addition of a large number of vegetable raw materials led to an increase in moisture in shortbread cookies to 8 %, which is 25 % more

than ordinary cookies with animal raw materials. The fat content of shortbread cookies with the addition of sweet potato puree decreased by 9.6 times to 2.5 g/100g compared to the usual recipe, which significantly affected the energy value of the cookies under study and it decreased by 45.4 % to 333.7 kcal/100g of product. Such a tendency to change the chemical composition is positive for the use of shortbread enriched with sweet potato puree for vegetarian and diet food.

A large amount of sweet potato puree in the shortbread recipe softened its structure, which is shown in the Table 4. The hardness and fracturability of shortbread were determined.

Table 4

Texture analysis of shortbread enriched with sweet potato puree n = 6, $\alpha < 0.05$

Texture indicator	Shortbread	Shortbread enriched Portu Beterraba sweet potato puree
Hardness, g	328	182
Fracturability, g	355	216

After adding sweet potato puree and soy flour to the shortbread recipe to replace raw materials of animal origin, the texture of the cookies improved. Its hardness is reduced by 80.2 %, compared to ordinary shortbread, due to the presence of a large amount of vegetable raw materials. Fracturability was also reduced by 64.4 % compared to ordinary shortbread, which improved the texture of the shortbread and is

associated with a reduction in hardness and the presence of a large amount of dietary fiber, vegetable protein and starch in the Portu Beterraba sweet potato puree. The addition of soy flour did not significantly affect the texture, as its amount was insignificant (Table 3).

Organoleptic indicators for the consumer based on color, taste, texture, taste and general appearance of the samples are shown in Fig. 3.

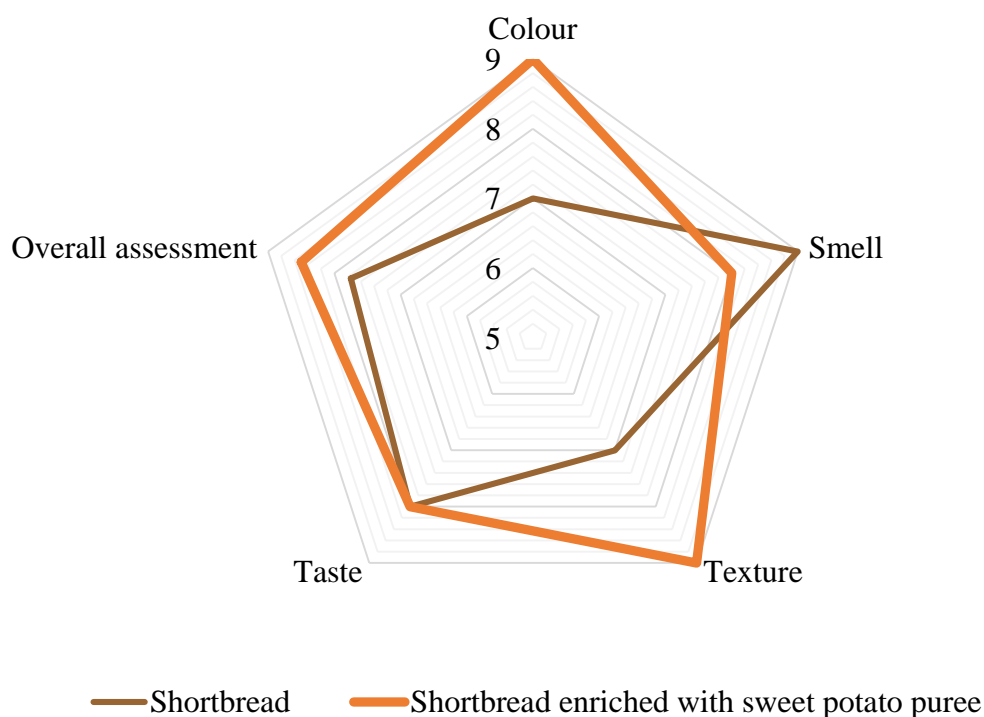


Fig. 3. Organoleptic evaluation of shortbread enriched with sweet potato puree

Data in Fig. 3 are given as average, after tasting by ten experts. Shortbread enriched with sweet potato pyree had higher scores for texture, color and taste compared to ordinary shortbread. Smell indicators were lower than in the counter, which is due to the high content of vegetable raw materials and soy flour. Although soy flour did not affect the taste, its specific smell reduced this organoleptic index in shortbread enriched with sweet potato puree. Perhaps in recipes of this type, additional flavorings in the form of essences should be used. The cookies received high marks from experts for their natural color, which is related to the rich yellow-pink color of the Portu Beterraba sweet potato, which was formed by combining the anthocyanin pigmentation of the peel (red or dark red) and the β -carotene of the pulp (yellow). The overall acceptability of the cookies was at a maximum level, considering that they will be used for feeding vegetarians and other related diets.

Conclusions

Portu Beterraba sweet potato has a high content of natural sugars (5.25 %), a significant amount of protein (2.8 %), fiber (3.2 %) and starch (11.6 %), and has a yellow-pink color according to organoleptic indicators the color formed by the combination of anthocyanin

pigmentation of the peel (red or dark red) and β -carotene of the pulp (yellow). Portu Beterraba sweet potato has a significant content of ash (0.85 %) and vitamin A. Portu Beterraba sweet potato was added to the cookie recipe in the form of a puree in the amount of 52.5 % to completely replace sugar, butter and part of egg products. Shortbread with sweet potato has a high nutritional and biological value in terms of protein (9.8 %), dietary fiber (9.7 %) and mineral substances (2.0 %), which increased compared to the control sample for protein by 71.9 %, for dietary fiber by 67.2 % and for minerals by 2 times. The fat content decreased by 9.6 times, which significantly affected the decrease in energy value by 45.4 %. Texture performance improved, making the cookie less hard, hardness reduced by 80.2 %, and brittle, fracturability reduced by 64.4 %, compared to regular shortbread, making it more acceptable to consumers. The obtained results allow the use of sweet potato puree not only in the shortbread recipe, but also in other confectionery products. Further research should be directed to a more detailed assessment of the chemical composition of the Portu Beterraba sweet potato grown in Ukraine, such as the mineral, amino acid and vitamin composition of the root crop, and its use in the other food products recipes.

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