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ORIGINAL RESEARCH PAPER

APPLICABILITY OF PUMPKIN PUREE IN SUGAR BISCUIT PRODUCTION

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Abstract: At present, the use of products of vegetable processing in confectionery has become quite relevant. The purpose of this research was to determine the variety of pumpkin, rich in nutrients and vitamins, to develop a technology for the production of pumpkin puree. To study physical, chemical, organoleptic parameters and nutritional value of sugar biscuits with replacement of a part of flour with pumpkin puree in the formula. Local pumpkin varieties purchased at the market were used in the research: "Rossiyanka", "Candy" and "Olga". Of all three varieties, the "Candy" variety contained more biologically active substances and can be recommended as a *β*-Carotene and pectin enricher for sugar biscuits. Test samples of biscuits were prepared by adding pumpkin puree in the amount of 5 %, 10 %, and 15 % of the wheat flour. In all physical and chemical parameters, except the mass fraction of moisture in PP15 sample, the obtained biscuit samples did not exceed the values regulated in the state standard. The organoleptic evaluation proved that the biscuits with the pumpkin puree in the amount of 5 % of the flour mass were the most acceptable in their flavor characteristics and appearance for further use.

Keywords: *pumpkin puree, sugar biscuits, nutritional value, organoleptic evaluation, pumpkin*

INTRODUCTION

High nutritional value, effectiveness in preventing cancer, obesity, cardiovascular and other diseases determine the constant interest of researchers in the biochemical composition of various types of pumpkin and the processes of its selection in order to obtain a product with a high content of biologically active compounds.
Pumpkin fruits are a most valuable food and dietary product, a rich in biologically active substances. They contain easily digestible proteins, pectin, carbohydrates, starch, organic acids, fats, vitamins, mineral salts and other substances beneficial for the human body [1 – 4]. The chemical composition of pumpkin fruits largely depends on various technological methods of cultivation, species and variety, as well as soil and climatic conditions and other factors. Pumpkin fruit contains 85 - 94 % of water. Carbohydrates (8 - 12 %) are mainly polysaccharides. Of the total sugar content (4 - 8 %), individual table varieties contain from 11 to 14 % of polysaccharides, including sucrose up to 8 %, especially after the storage during autumn and winter. Pumpkin fruits contain between 2.5 and 16 % of starch, which turns into soluble sugars during the storage. Since pumpkin is rich in sugars and contains little organic acids (its acidity is 0.8 - 2.9 %), it is widely used in confectionery for making candied fruits and pastila. The protein content in pumpkin is relatively small (0.5 - 1.1 %) but it is highly rich in pectin (2.6 - 14.0 %), which promotes the cholesterol excretion.
High content of pectin makes pumpkin a perspective raw material for obtaining gelling agents widely used in confectionery. The change in the polysaccharide composition of pumpkin fruits, like other vegetables, determines the density and texture of tissues during ripening, storage and processing of fruits. Pectins reduce cholesterol in the blood and inhibit the oxidation of vitamin C. The unique nutritional characteristics of pumpkin make it possible to classify the processed products of the latter as functional foods. The most popular product, among others based on pumpkin, is pumpkin puree, widely used in baby food.
A characteristic feature of pumpkin is a low fiber content (0.3 - 1.2 %), which is boiled soft, nonfibrous and easily digested in a pureed form. Pumpkin is the main source of carotene in the plant world. The content of carotene in pumpkin fruits is 16 - 17 mg per 100 g of raw product, and in some forms it reaches 35 - 38 mg. The more brightly colored the orange-yellow pulp is, the more carotenoids it contains. It should be noted that in mid- and late-season table varieties, this content increases in the first months of storage. Therefore, they are valuable for the food industry, the pulp being used as a raw material for the production of pumpkin concentrates [5 – 14].

MATERIAL AND METHODS

Local pumpkin varieties purchased at the market were used in the research:
1. "Rossiyanka" is a mid-season pumpkin variety. This variety is characterized by increased cold-endurance, the first fruits ripen in 90 days. A characteristic feature of the variety is a very soft rind. The pulp is thick, dry, dark orange, loose, sweet with a pleasant melon aroma.

2. "Candy" is a new early-ripening high-yielding pumpkin variety. Fruits are ready for use already three months after sowing seeds in the ground. The rind is soft, easily cut with a knife, dark red after ripening. The pulp is juicy, thick, dark orange.
3. "Olga" is a new early-ripening variety of large-fruited pumpkin. Fruits are ready for use 3 - 5 months after sowing. The rind is hard, bright pink. The pulp is juicy, very sweet, thick, orange, without a strong pumpkin smell.
Other materials for analysis such as potassium ferrocyanide, sodium hydroxide, phenolphthalein indicator, metaphosphoric acid, 2,6-Dichlorophenolindophenol sodium salt hydrate with ascorbic acid were purchased from Closed Joint-Stock Company "SoyuzChimProm" (Chelyabinsk, Russia).

Physical and Chemical Parameters and Nutritional Value of Pumpkin Fruits

Average samples selected from the batch of fruits of these varieties were tested for the mass fraction of water-insoluble solids, sugars, titratable acidity, vitamin C, β-Carotene, and pectin substances, employing the appropriate methods.

Mass fraction of water-insoluble solids
The method consists in removing substances that dissolve in water from the product sample (by extraction and washing with water), drying the residue and determining its mass with respect to the total weight of the sample. (GOST 29031-91. Fruit and vegetable products. Method for determination of water-insoluble solids content) (GOST - standard of the Russian Federation).

Mass fraction of sugars
The method is based on the interaction of carbonyl groups of sugars in an alkaline medium with potassium ferrocyanide and the measurement of the optical density of the resulting solution on a photoelectric colorimeter KFK-2, measuring the absorption of light at λ = 440 nm. (GOST 8756.13-87. Fruit and vegetable products. Methods for determination of sugars).

Determination of titratable acidity
Titration of the solution under analysis with a titrated solution of sodium hydroxide in the presence of a phenolphthalein indicator. (GOST ISO 750-2013. Fruit and vegetable products. Determination of titratable acidity).

Determination of vitamin C
The method is based on the extraction of vitamin C with metaphosphoric acid or a mixture of acetic and metaphosphoric acids, the reduction of 2,6-Dichlorophenolindophenol sodium salt hydrate with ascorbic acid, followed by extraction with an organic solvent (amyl acetate, butyl acetate or xylene) of excess 2,6-Dichlorophenolindophenol sodium salt hydrate and photometric measurement of the organic extract at a wavelength of 500 nm. (GOST 24556-89. Products of fruits and vegetables processing. Methods for determination of vitamin C).

Determination of β-Carotene

The method is based on the photometric determination of the mass concentration of carotene in a solution obtained after extracting the carotene from the products with an organic solvent and purified from the accompanying coloring substances by liquid chromatography "Lyumakhrom". (GOST 8756.22-80. Fruit and vegetable products. Method for determination of carotene).

Determination of pectin substances

The method is based on the photometric determination of pectin at a wavelength of 525 nm. (GOST 32223-2013. Juice products. Photometric method for determination of pectin content).

Technology of Pumpkin Puree Production

Pumpkin fruits used for the preparation of puree were pre-sorted to remove the ones unsuitable for production. After sorting, the pumpkin was washed to remove dirt. After washing, the pumpkin was scalded and its rind was removed. Pumpkin pulp was scalded with steam for 5 - 7 minutes. To obtain the proper puree, pumpkin needs to be heated quickly, but heating above 100 °C is unacceptable. Scalded pumpkin was delumped using grids with a hole diameter of 1.5 - 2.0 mm. After delumping the puree was preserved by adding sodium benzoate. The estimated amount of preservative was introduced into the hot (65 - 70 °C) puree in a thin trickle while stirring continuously. Then the puree was cooled down, sealed and stored at a temperature of 2 - 4 °C. Puree in cans can be stored at 0 - 20 °C.

Technology of Production of Sugar Biscuits

Test samples of sugar biscuits were obtained using raw materials that meet the requirements of reference documentation: high quality wheat flour (GOST R 52189-2003), granulated sugar (GOST 21-94), butter (GOST R 52969-2008), table chicken eggs (GOST R 52121-2003), cooking salt (GOST R 51574-2000), baking soda (GOST 2156-76).

Test samples of biscuits were prepared by adding pumpkin puree in the amount of 5 %, 10 %, and 15 % to the wheat flour. Samples of sugar biscuits were prepared in the following way: preparation of raw materials, preparation of a recipe mixture and dough kneading, molding, baking, cooling of finished products. Preparation of raw materials consisted in sifting flour, sugar and other loose products to remove impurities. To obtain test samples, pumpkin puree was added in the amount of 5 %, 10 %, and 15 % to the weight of wheat flour. The formula of the control and test samples is given in Table 1.

The dough for the biscuits was kneaded until a uniformly mixed elastic homogeneous mass was obtained. The finished dough was rolled to obtain a 3 - 5 mm thick layer with a smooth surface. The dough was molded after rolling and baked in a heated oven at a temperature of 185 °C for 10 - 15 minutes. After baking, the finished biscuits were cooled for 15 minutes.

Table 1. *Formula of the control and test samples*

Raw materials and semi-finished products	Consumption of raw materials and semi-finished products per 1 portion, [g]			
	Control	Test sample (5 %)	Test sample (10 %)	Test sample (15 %)
High quality wheat flour	500	475	450	425
Dairy butter	330	330	330	330
Granulated sugar	200	200	200	200
Chicken eggs (yolk)	33	33	33	33
Vanillin	2	2	2	2
Baking soda	2	2	2	2
Table salt	3	3	3	3
Pumpkin puree	-	25	50	75
Yield of semi-finished products	1070			

Physical and Chemical Parameters and Nutritional Value of Sugar Biscuits

Determination of the mass fraction of moisture

The method consists in drying the sample of the product and the semi-finished product at a certain temperature to a constant dry mass and determining the weight loss with respect to the sample (GOST 5900-73. Confectionery. Methods for determination moisture and dry substances).

Determination of the mass fraction of sugar

The method is based on the reduction of alkaline solution of copper with a reducing agent and the determination of the amount of copper (I) oxide formed or unreduced copper by the iodometric method. (GOST 5903-89. Confectionery. Methods for determination of sugar).

Determination of the mass fraction of fat

The method is based on the extraction of fat from the analyzed product sample with a solvent and the determination of the mass fraction of fat after the solvent removal (GOST 31902-2012. Confectionery. Methods of determination of fat weight fraction).

Determination of alkalinity

The method is based on neutralizing the alkaline substances contained in the sample, with acid in the presence of bromthymol blue before the appearance of a yellow color. (GOST 5898-87. Confectionery. Methods for determination of acidity and alkalinity).

Determination of β-Carotene

The method is based on the extraction of micronutrients by an organic solvent after alkaline saponification of the substrate or by direct dissolution, evaporating the extract obtained and transferring the dry residue to another solvent, introducing the extract onto a liquid chromatograph "Lyumakhrom"and then detecting with fluorescence and spectrophotometric detectors [15].

Determination of pectin substances

The sample is ground, 1 - 5 g (depending on the amount of pectin in the sample) is transferred to a glass flask, poured with boiling water mixed with concentrated hydrochloric acid (0.8 cm^3 per 250 cm^3 of distilled water). The mixture is heated while stirring for 30 minutes at 95 - 100 °C. Extraction is carried out twice, the extracts and washing water are combined, the amount is measured, and 1.5 volumes of ethanol are added to the cooled pectin solution (isopropyl alcohol or acetone can also be used) containing 2 cm^3 of concentrated hydrochloric acid (1.19 g) per liter. The mixture is hand-mixed slowly and carefully and left to stand for 30 minutes so that the pectin floats to the surface. The content of pectin is determined gravimetrically.

Determination of vitamin C

Determination of vitamin C in confectionery products is based on the extraction of ascorbic acid or its salts with an acid solution (hydrochloric, oxalic, trichloroacetic, metaphosphoric or a mixture of acetic and metaphosphoric), followed by visual titration with a solution of 2,6-Dichlorophenolindophenol sodium salt hydrate until light pink coloring.

Organoleptic evaluation of sugar biscuits

The sensory evaluation of products was performed by 35 consumers in individual booths at room temperature, using white light. The samples were served in disposable white plastic cups, identified by three-digit numbers, randomly arranged.

The results were statistically analyzed by means of the table for the ordering test of Newell and Mac Farlane, which defines the value of critical differences between the total ordering at level of 5 % [16].

The biscuits were evaluated using a nine-point hedonic scale, where the extremes corresponded to 9 = liked extremely, 8 = liked very much, 7 = liked moderately, 6 = liked slightly, 5 = neither liked nor disliked, 4 = disliked slightly, 3 = disliked moderately, 2 = disliked much, and 1 = disliked extremely.

Statistic analysis

All analyses were carried out in triplicate unless otherwise stated and the average values were calculated. The results were expressed as mean value ± standard deviation. Significant differences between mean values at significance level $p < 0.05$ were established using the One way analysis of variance and Student`s test. Microsoft Excel version 2010 was used as the statistical analysis software.

RESULTS AND DISCUSSION

When choosing a dosage of the pumpkin puree, the following factors were taken into account: maximum possible enrichment of the products with pectins, vitamins and other biologically active substances, achieving the optimal concentration for purposes of therapeutic and preventive effects on the human body; obtaining ready-made confectionery products with high organoleptic properties (color, taste, smell).

According to the results of the research, for a number of parameters "Rossiyanka" and "Candy" varieties prove to be the most valuable in terms of the content of biologically active substances - 1.04 and 1.14 g/100 g pectin and 27.0 and 27.1 mg/100 g β-carotene respectively (Table 2). According to the obtained data, the "Candy" variety contains a greater amount of biologically active substances, which makes it possible to recommend this variety as *β*-carotene and pectin enrichment for sugar biscuits. Moreover, considering that the "Candy" variety has a stable high yield (50-60 $t \cdot ha^{-1}$) and considerably exceeds other varieties for the content of *β*-carotene and pectin substances, it was selected for further research.

Table 2. *Physical and Chemical Parameters and Nutritional Value of Pumpkin Fruits*

Variety	Weight fraction, [g/100 g]			Weight fraction, [mg/100 g]		Titratable acidity, [%]
	water-insoluble solids	sugar	pectin substances	vitamin C	*β*-Carotene	
Rossiyanka	11.2±0.09	10.1±0.21	1.04± 0.10	13.9±0.21	27.0±0.04	0.06± 0.02
Candy	11.4±0.12	12.8±0.18	1.14± 0.15	12.9±0.16	27.1±0.03	0.11± 0.04
Olga	13.1±0.17	12.5±0.05	1.01± 0.11	12.2±0.09	24.7±0.18	0.08± 0.05

The "Candy" variety was further used to obtain pumpkin puree.

An experimental laboratory baking was carried out to determine the influence of the pumpkin puree ("Candy" variety) on the quality, nutritional and biological value of sugar biscuits. The traditional sugar biscuits recipe was used to get the formula for sugar biscuits with the addition of pumpkin puree ("Candy" variety).

The experiment was carried out in four variations:

1. Control sample - according to the standard recipe for sugar biscuits (CS)
2. Adding 5 % pumpkin puree ("Candy" variety) of flour mass when kneading the dough (PP5).
3. Adding 10 % pumpkin puree ("Candy" variety) of flour mass when kneading the dough (PP10).
4. Adding 15 % of pumpkin puree ("Candy" variety) of the mass of flour when kneading the dough (PP15).

Physical and chemical parameters of sugar biscuits are given in the Table 3.

Table 3. *Physical and Chemical Parameters of Sugar Biscuits*

Parameter	CS	PP5	PP10	PP15
Mass fraction of moisture, [%]	7.6±0.07*	8.1±0.08*	9.6±0.07*	10.1±0.12*
Mass fraction of sugar, [%]	26.3±0.11*	28.4±0.18*	28.8±0.15*	29.1±0.15*
Mass fraction of fat, [%]	24.5±0.13*	24.4±0.10*	24.4±0.15*	24.1±0.19*
Alkalinity, deg.	1.8±0.11*	1.7±0.08*	1.7±0.03*	1.6±0.14*

* denotes statistically significant difference at $p < 0.05$ level

In all physical and chemical parameters, except the mass fraction of moisture in PP15 sample (not more than 10 % according to GOST 24901-2014 Biscuits. General specifications), the obtained samples of sugar biscuits do not exceed the values regulated in the state standard. Small deviations in the moisture content can be explained by the fact that pectin substances in pumpkin puree possess gelling properties.

Pectins interact with various functional proteins and flour starches, form heat-resistant protein-polysaccharide complexes with an increased hydrophilic capacity. This leads to an increased proportion of tightly bound moisture in the finished products. As a result, less moisture is lost during baking and storage. The increase in the mass fraction of sugar in biscuits directly depends on the concentration of pumpkin puree, which contains a large amount of natural sugars in raw materials. Alkalinity is an important quality indicator that affects the organoleptic characteristics and shelf life of the product. When testing the samples for alkalinity, it was found that its value decreased with the increase in the amount of pumpkin puree, which positively influenced the organoleptic characteristics of the samples. The amount of fat also decreased during baking, which is explained by the release of fat in the dough as a result of its weak adsorption on the surface of micelles. Nutritional value of sugar biscuits is given in Table 4.

Table 4. *Nutritional Value of Sugar Biscuits*

Parameter	**CS**	**PP5**	**PP10**	**PP15**
Mass fraction of pectin substances, [g/100 g]	-	0.54±0.02*	0.62±0.07*	0.69±0.05*
Mass fraction of vitamin C, [mg/100 g]	-	4.4±0.09*	4.9±0.01*	5.6±0.11*
Mass fraction of β-Carotene, [mg/100 g]	-	11.6±0.17*	12.7±0.10*	14.0±0.16*

* denotes statistically significant difference at $p < 0.05$ level

In production of sugar biscuits, the loss of vitamins is possible when obtaining pumpkin puree, during preparation of the dough (when the mixture is saturated with air bubbles during kneading), and during baking. When exposed to the air oxygen and high temperature, vitamin C and β-carotene are destroyed [17]. According to vitamin C content we established that it was best preserved in the sample with the maximum content of pumpkin puree, and it was 5.6 mg/100g in PP15 sample, which 1.2 mg/100g more compared to PP5. Despite the fact that carotenoids are stable during heat treatment, there were insignificant losses of β-carotene, the content of which was 14.0 mg/100 g in PP15, 12.7 mg/100 g in PP10, and 11.6 mg/100 g in PP5.

The pumpkin puree added to the sugar biscuit dough influenced the structure and consistency of the finished product (Figure 1). The use of pumpkin puree led to a change in the product color from light straw to orange, which is explained by the presence of β-Carotene. The taste and smell was more pronounced in PP10 and PP15.

Organoleptic method was used to test the biscuits for shape, surface, color, appearance upon fracture, taste and smell. The profilogram of control and test samples is shown in Figure 1.

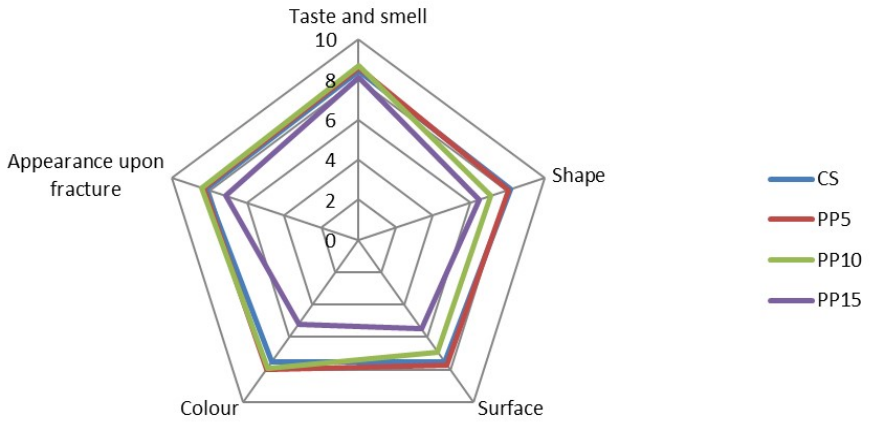

Figure 1. *The profilogram of control and test samples*

According to the received data, an increase in the amount of pumpkin puree added to the sugar biscuit formula made the taste of pumpkin more pronounced, the structure of the biscuit became less porous and denser. Due to the large amount of sugars in the pumpkin, the increase in its dosage caused caramelization, which made the edges of the biscuit samples (PP10 and PP15) dark brown, characteristic of the burnt ones [18]. (Figure 2).

Figure 2. *Photos of the control and test samples*

The surface of the biscuit also changed depending on the amount of pumpkin puree: at 10 % it was slightly rough, at 15 % dosage it was rough, swollen, with visible pumpkin particles. This occurs due to the increase in the mass fraction of moisture in the samples, and its incomplete evaporation during the baking process, resulting in the surface of the biscuit becoming rough and swollen, the shape of the biscuit was deformed.

Thus, the organoleptic evaluation of the quality of biscuits with the addition of pumpkin puree in various dosages proved that the biscuits with 5 % pumpkin puree were the most acceptable in flavor characteristics and appearance for further use.

CONCLUSIONS

Local pumpkin varieties purchased at the market were used in the research: "Rossiyanka", "Candy" and "Olga". Of all three varieties, the "Candy" variety contained more biologically active substances and can be recommended as a β-Carotene and pectin enricher for sugar biscuits. Test samples of biscuits were prepared by adding pumpkin puree in the amount of 5 %, 10 %, and 15 % of the wheat flour. In all physical and chemical parameters, except the mass fraction of moisture in PP15 sample, the obtained biscuit samples did not exceed the values regulated in the state standard. According to vitamin C content we established that it was best preserved in the sample with the maximum content of pumpkin puree, and it was 5.6 mg/100g in PP15 sample, which 1.2 mg/100g more compared to PP5. Despite the fact that carotenoids are stable during heat treatment, there were insignificant losses of β-carotene, the content of which was 14.0 mg/100 g in PP15, 12.7 mg/100 g in PP10, and 11.6 mg/100 g in PP5.
The organoleptic evaluation of the quality of biscuits with the addition of pumpkin puree in various dosages proved that the biscuits with 5 % pumpkin puree were the most acceptable in flavor characteristics and appearance for further use.

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