Some vegetables are indispensable for the production of a wide range of bread products, because of their chemical composition. One of the factors hindering their widespread use in the bakery is the insufficient study of their functional properties in the mentioned technological areas. The main goal of the study was a complex analysis of the food value, mineral and vitamin compositions of raw materials and bread with additives, on the example of pumpkin variety «Perekhvatka 69». This is necessary to further substantiate the development of technology for the production of new types of bakery products, expanding the range of products and satisfying various consumer preferences. The nature of changes in nutrients, mineral and vitamin compositions in the technological process has been studied, which makes it possible to determine the proportion of reduction in their content. Based on this, it is possible to adjust the content of nutrients, mineral and vitamin compositions before and after the technological process of processing raw materials and making bread with additives. It has been found that the introduction of pumpkin puree has practically no effect on the amount of washed gluten. However, at a dosage of pumpkin puree from 5 to 25 %, the compression strain of raw gluten increases from 68.5 to 94.7 units instrument. This makes it possible to regulate the desired final properties of bread and the deformation of gluten in the dough

Keywords: wheat flour, gluten, pumpkin, pumpkin puree, vitamins, minerals, dough, bread

UDC 664.66.016.8
DOI: 10.15587/1729-4061.2022.254090

INCREASING THE BIOLOGICAL VALUE OF BREAD THROUGH THE APPLICATION OF PUMPKIN PUREE

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Received date 31.01.2022
Accepted date 01.04.2022
Published date 28.04.2022

How to Cite: *Bayramov, E., Aliyev, S., Gasimova, A., Gurbanova, S., Kazimova, I. (2022). Increasing the biological value of bread through the application of pumpkin puree. Eastern-European Journal of Enterprise Technologies, 2 (11 (116)), 58–68. doi: https://doi.org/10.15587/1729-4061.2022.254090*

1. Introduction

The lack of essential nutrients in the body is the cause of diseases, and a prolonged lack leads to death. A person does not always pay attention to his health until he gets sick. In order to replenish the body with necessary nutrients, it is advisable to provide the population with such products that are included in the daily diet. One of these products is bread, which is an essential product and is in steady demand among the population. However, the main disadvantage of bread products, especially from wheat flour of the highest grade, is low nutritional value due to the high content of carbohydrates and low content of vitamins, minerals, and fiber [1]. Therefore, providing the population with bread products enriched with nutrients is one of the main directions of the socio-economic policy of any state. To solve the tasks in this area, it is innovative to add raw materials to the recipe of bread products that will enrich them mainly with proteins, vitamins, minerals and other useful substances. This will allow developing the technology of baking, increasing efficiency based on scientific and technological progress and introducing them into production [2].

Therefore, the most appropriate and effective is the additional enrichment of bread products with such types of raw materials that are rich in mono- and disaccharides, vitamins, minerals, dietary fiber, etc. Such a raw material is pumpkin, which is also the main source of carotene [3]. Pumpkin carotene has antioxidant properties, which can neutralize free radicals and prevent the development of malignant tumors.

It should be noted that many varieties of pumpkin have not yet been studied in terms of their use in existing technological processes for the production of bread.

The world of pumpkin plants is very diverse. Three species are most common: hard-barked, or ordinary (Cucurbita pepo L.), large-fruited (Cucurbita maxima Duch) and nutmeg (Cucurbita moschata Duch). They differ in morphological, biological and economic features.

The deterioration of the environmental situation in the world and the associated level of food contamination, as well as stress, lead to an increase in negative trends in the health

of the population. Improving the health of all age groups through quality, safe food is the main goal of all governments.

Modern technologies should provide the required usefulness of bread. The path of development and improvement of new technologies based on scientific and technological achievements has been chosen as the development priorities of this industry. However, the improvement of production technology and technical means, ensuring high quality, compliance with and management of technical regimes and parameters at all stages of the production process with the widespread use of local raw materials and their inclusion in technological processes remain urgent problems.

Thus, the improvement of bakery technology depends on the solution of a large-scale urgent scientific problem. And this allows you to increase the nutritional value and expand the range of bread products. These issues are of worldwide importance. The deterioration of the ecological state as a result of the inclusion of products that are poor in chemical composition, especially bread made from premium wheat flour, rich only in starch, in the daily diet, leads to the appearance of adverse diseases in the body. Another reason for this is that the change in the chemical composition of pumpkin, pumpkin puree, premium wheat flour and bread with the addition of pumpkin puree has not been sufficiently studied.

2. Literature review and problem statement

The paper [4] convincingly shows the prospects of using pumpkin puree and sourdough from cereal bran. The results revealed that pumpkin puree and cereal-bran sourdoughs synergistically improved the textural and sensorial properties of the product. However, the study of the effect of pumpkin puree on the content and proportion of changes in nutrients, mineral and vitamin compositions, their growth in bread with pumpkin puree has not been carried out.

The paper [5] determined the effect of adding fresh pumpkin pulp directly to wheat flour on the physical, organoleptic and biological properties of bread. The bioavailability of the active compounds was also studied. It is shown that an increase in pumpkin pulp from 5 to 20 % (in terms of dry weight) causes a decrease in the volume of bread and an increase in the hardness and cohesion of the crumb. In the organoleptic evaluation of bread, it was found that partial replacement of wheat flour up to 10 % with pumpkin pulp gives satisfactory results. The taste, aroma and overall acceptability of the control bread and bread with 5 % or 10 % pulp were the best. However, the addition of more than 10 % pumpkin pulp caused an unpleasant aroma and taste. The highest antioxidant activity was observed in bread samples with the addition of 10 and 15 % pumpkin puree. The highest activity was determined in bread with 15 and 20 % pumpkin puree. According to the authors, angiotensin-converting enzyme (ACE) inhibitors from the tested bread were highly bioavailable in vitro. However, studies of the nature of changes in the chemical composition of pumpkin pulp and bread have not been conducted. In this work, it would be necessary to study the effect of pumpkin pulp on the gluten deformation index, as well as the increase in the content of the chemical composition in bread with the additive.

In [6], a study was made of the effect of various dosages of pumpkin puree and pumpkin powder on the organoleptic and physicochemical indicators of bread from whole wheat. The optimal dosages of introduced additives were determined: pumpkin puree – 20 %, pumpkin powder – 4 %. It is also shown that the use of pumpkin puree and powder intensifies the dough fermentation process. It has been found that adding up to 6 % pumpkin powder and up to 30 % pumpkin puree leads to an increase in the ultimate shear stress of the dough. It was also found that with the addition of up to 6 % powder and up to 30 % puree, the crumb compressibility index after 3, 16, 24, 48 hours of storage was higher compared to the control sample. However, studies on the nature of changes in the chemical composition of pumpkin, puree and powder from it, as well as bread with the addition of additives have not been conducted. In addition, the work determines the dose of pumpkin puree based on organoleptic quality indicators. However, this does not take into account the effect of pumpkin puree dosage on the adhesive properties of dough.

The paper [7] shows that bread products contain a huge amount of easily digestible carbohydrates and a small amount of macro- and microelements, vitamins, and food fibers. Excessive consumption of such bakery products causes cardiovascular diseases, obesity, diabetes, diseases of the gastrointestinal tract, etc. The paper [8] shows that this suggests the importance of the purposeful enrichment of therapeutic and prophylactic bakery products.

The paper [8] shows that garden vegetables, including pumpkin, are rich in fats, macro- and microelements, vitamins, pectin and food fibers [9], which prevent various diseases. Pumpkin is useful in the treatment of diseases related to the cardiovascular system, kidney [10], plays a protective role, causing anti-inflammatory, antioxidant and anti-fibrotic effects [11]. Pumpkin is useful in the treatment of blood circulation [12], liver, biliary tract, hypertension, obesity, prostate, oncology, etc. The paper [13] shows that pharmacological properties and the technology of using pumpkin are considered also in healthcare.

The paper [14] shows that pumpkin is resistant to patulin agents having a mutagenic effect, and the paper [15] shows that the useful properties of pumpkin do not change under high temperatures.

The paper [5] shows that food fibers are considered as an index of indigestion and determined using an enzymatic method. When the amount of pumpkin fibers increased from 0 to 20 % in the total flour mass, the consistence (R=0.995) and chewing time (R=0.983) of bread increased, volume, elasticity (R=0.710) and cohesion (R=0.665) decreased, bad smell and taste appeared. Sensor assessment showed that when 10 % of wheat flour was replaced with pumpkin fiber, the general consumption characteristics of bread were satisfactory.

In [16], the mechanical composition of nutmeg pumpkin varieties «Palov-Kodu-268» and «Perehvatka-69» was determined. It has been shown that the pumpkin varieties Bykov, Biryuchekutskaya, Bashkirskaya, Cherkesskaya, Altaiskaya, etc. are also the most valuable. The paper [17] shows that to solve the problem of food safety, the production of various ranges of environmentally friendly and healthy food products from pumpkin is essential.

Thus, bread products are not only nutrients for humans, they also enrich the organism with vitamins, macro- and microelements.

The possibilities of using pumpkin products in baking have been studied, but changes in the nutritional value, mineral and vitamin composition of these products and bread with additives in the technological process have not been presented correctly.

Therefore, a comprehensive analysis of changes in the technological process, nutritional value, mineral and vitamin

compositions of raw materials, i.e. pumpkin, pumpkin puree, wheat flour, and finished products – bread with the addition of pumpkin puree is needed to further justify the development of technology for the production of new types of bakery products, expanding the range of products and satisfying various consumer preferences.

3. The aim and objectives of the study

The aim of the study is to analyze the food value, mineral and vitamin substances of raw materials to increase the biological value of bread, taking into account their changes in the technological process and the nature of changes in the deformation index of raw gluten of wheat flour as a result of using pumpkin puree. This is necessary to further substantiate the development of technology for the production of new types of bakery products, expanding the range of products produced and satisfying various consumer preferences.

To achieve the aim, the following objectives are accomplished:

– to conduct an analysis of the food value of raw materials and bread with additives;

– to conduct an analysis of the mineral substances of raw materials and bread with additives;

– to conduct an analysis of the vitamin substances of raw materials and bread with additives;

– to conduct an analysis of the effect of pumpkin puree on gluten compression deformation.

4. Materials and methods

The methods of the research: theoretical studies-comparative analysis of the literature resources, experimental studies-experiments based on the GOST standards.

The research was carried out at the «Food Engineering and Expertise» department of the Azerbaijan Technological University, «Ganja-Deyirman», Ganja «NEON» enterprises, and at the laboratories of the Georgian Research Institute.

The high grade wheat flour with the «Mehriban» trademark was purchased from the wholesale network, the dry yeast having 8 % moisture with the «Pakmaya» trademark and «Azeriduz» iodinated salt were purchased from the «Hyper Gold Amina» market in Ganja.

Total protein in the studied objects was determined using the Kjeldahl method. Protein indices for flour, bread and pumpkin were found to be 5.83, 5.7 and 6.25, respectively. Vitamin contents were studied using a highly effective liquid chromatograph – Shimadzu LC-20 Prominence (Germany). The ash amount was defined in the muffle furnace. The Soxhlet apparatus was used for the determination of fats. The mineral substances were quantified using the atomic absorption spectrometer – AAnalyst 400 (Perkin Elmer, USA).

The gluten amount in the «Mehriban» high grade wheat flour was defined according to the GOST standards, extensibility was measured on a ruler, gluten deformation index (GDI) in the «İDK-1M» device (Russia), moisture in the flour using the Pfeuffer HE-50 device (Germany), its color in the «R3-TBMS-M» device (Russia), the falling number was found using the Hagberg-Perten device (Switzerland). The following indices were determined for the wheat flour: fresh gluten amount – 30.1 %, extensibility – 9 cm, GDI – 60 units, moisture in the flour – 13.7 %, color – 57.1 units, FN – 365 sec, index – 98.

The fragrant and early-ripening «Perechvatka-69» variety of the Cucurbita moschata species was used. Because it is widely cultivated in Azerbaijan and cost-effective. The «Perekhvatka-69» pumpkin was medium-sized and cylindrical, the fleshy part was granular, crunchy and pink, with a mass of 3.6 kg. Pumpkin was purchased from the «Ganja sabati» market. The quantities of dry matter of pumpkin and its puree were determined by the IFX-22 refractometer and were found to be 11 and 7 %, respectively.

We believe that it is more advisable to use a puree of pumpkin than its core, powder and juice. Because pumpkin juice contains much water, the amounts of dry substances are small. About 50 % of the ascorbic acid is oxidized and lost for 15 min in the pumpkin juice.

Preparing pumpkin powder requires much time and a considerable number of operations.

When juice is squeezed from the pumpkin core, the amounts of useful substances in its composition decrease. Pumpkin puree is quickly processed, losses in the technological process are negligible, and the amounts of beneficial substances in its composition are relatively high.

Pumpkin puree was prepared as follows. Pumpkin was washed and cleaned and cut into small pieces, with approximately the same size, separated from the inedible parts, placed in an enameled saucepan. A small amount of water was added and cooked stirring over low heat until a viscous mass is formed. Then it was cooled at room temperature, a homogeneous mass using a blender was obtained and filtered through a sieve with a 0.1 mm diameter of holes.

The suitability of bread for baking is determined based on GOST 27669-88 according to the bread sample made in the laboratory [18].

Main quality indices, minerals and vitamins of the pumpkin variety «Perekhvatka-69», pumpkin puree, high grade wheat flour, control bread made from the high grade wheat flour, bread prepared from the high grade wheat flour by adding pumpkin puree (10 % of the total content) were studied comparatively.

5. Discussion of the results of the research experiment on the possibilities of using pumpkin puree to increase the food value of bread

5. 1. Analysis of the food value of raw materials and bread with additives

Table 1 presents a comparative analysis of the nutritional value of pumpkin variety «Perechtka-69» and puree made from this pumpkin, wheat flour of the highest grade and bread made from wheat flour of the highest grade with the addition of pumpkin puree.

As seen in Table 1, pumpkin puree contains more water, fats, saturated fatty acids, ash, mono- and disaccharides and smaller amounts of proteins, starch, organic acids and food fibers compared to the high grade wheat flour.

Pumpkin and pumpkin puree contain fewer proteins than the high grade wheat flour and the control bread. Protein is the most complex substance among other nutrients. Its consumption and use are quite difficult. Protein-rich nutrients require more energy than other foods. Any food, except fruits, passes through the gastrointestinal tract within 25–30 hours. The more protein a human consumes, the less energy remains in the organism for other important processes, including the disposal of toxic waste.

Table 1

Food value of raw materials and bread samples, g/100 g

Indices	Pumpkin	Pumpkin puree	Highgrade wheatflour	Changes in indices during the technological process, %	Bread made from the high grade wheat flour	
					Control bread	Bread containing 10 % pumpkin puree
Water	89.0	93.0	13.7	+24...+29	37.8	43.0
Proteins	1.03	1.68	10.3	–26.2	7.6	7.73
Fats	0.11	6.1	1.1	–30.0	0.8	1.197
Saturated fatty acids	0	3.42	0.2	0	0.2	0.54
Carbohydrates:	4.39	6.29	70.6	–30.3	49.2	49.65
Mono-and disaccharides	4.19	3.6	1.6	–56.2	0.7	0.86
Starch	0.2	2.69	68.5	–29.19	48.5	48.70
Food fibers	2.03	1.21	3.5	–25.7	2.6	2.69
Pectin	0.31	0.3	0	0	0	0.03
Organic acids	0.1	0.1	0.5	+340	1.7	1.734
Ash	0.62	1.12	0.5	+340	1.7	2.074

Protein amounts in pumpkin and pumpkin puree were found to be 1.03 and 1.68 g/100 g, respectively, whereas in the high grade wheat flour and the control bread this parameter was equal to 1.03 and 1.68 g/100 g, respectively. In the bread made from the high grade wheat flour and containing 10 % pumpkin puree of the total mass, the protein amount was 7.73 g/100 g, which is more than 0.13 g/100 g compared to that in the control bread.

Concentrations of fats in the pumpkin puree were found to be 6.1 g/100 g, whereas in the high grade wheat flour and the control bread this parameter was equal to 1.1 g/100 g and 0.8 g/100 g, respectively. The studies show that the amount of fats in the bread made from the high grade wheat flour and pumpkin puree (10 % of the total content) was 1.197 g/100 g, i.e. 0.397 g/100 g more than that in the control bread. Fats play an important role in forming the rheological properties of dough. When fats are added (3 % of the total content) to the dough, during kneading and fermentation gluten interacts with proteins and starch, which results in the improvement of rheological properties and gas holding capacity of dough, bread volume and elasticity of the bread inner part.

Fats are distributed in the form of thin layers between structural elements of gluten and facilitate their relative displacement (sliding relative to each other). Gluten provides «lubrication» of gluten proteins and starch granules. Due to the formation of hydrophobic layers, the amount of free water increases, leading to a decrease in the hydration ability of starch and proteins. As a result, the dough becomes soft.

The fatty acids of lipids, polyunsaturated fatty acids represented by linoleic acid are very important for the strength of the flour. The strength of flour containing lipase and lipoxygenase enzymes is related to the presence of polyunsaturated fatty acids. Small amounts of lipids are in flour, and great amounts are in bran, especially in the embryo (compared to the initial grains). Moreover, the less yield and ash are in the wheat flour, the fewer amounts of lipids are in its content.

It was found that saturated and unsaturated fatty acids strengthened gluten, as the carbon chain length decreased, their gluten-strengthening effect increased.

As seen in Table 1, there are no saturated fatty acids in pumpkin. Whereas, the amounts of saturated fatty acids are 3.42 g/100 g, 0.2 g/100 g and 0.2 g/100 g in pumpkin puree, high grade wheat flour, control bread, respectively. During the technological process, the amount of fatty acids did not change, however, in the control bread it was equal to 0.2 g/100 g, and in the bread made by adding the high grade wheat flour to pumpkin puree (10 % of the total content) – 0.54 g/100 g, which is 0.34 g/100 g more than that in the control bread.

Very small amounts of carbohydrates were in pumpkin and pumpkin puree. The amounts of carbohydrates were 70.6 g/100 g in the high grade wheat flour, 49.2 g/100 g in the control bread made from the high grade wheat flour, 4.39 g/100 g in pumpkin, 6.29 g/100 g in pumpkin puree.

It should be noted that in the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content), the amounts of carbohydrates were 49.65 g/100 g, which is 0.45 g/100 g more than those in the control bread.

Mono- and disaccharides were found to be 1.6 g/100 g, 3.6 g/100 g and 4.19 g/100 g in the high grade wheat flour, in pumpkin and pumpkin puree, respectively. The same parameter in the control bread was equal to 0.7 g/100 g and in the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content) – 0.86 g/100 g, which exceeded the control by 0.16 g/100 g.

Pumpkin and pumpkin puree are low in starch. So in the high grade wheat flour and in the control bread, it was equal to 68.5 g/100 g and 48.5 g/100 g, respectively. Whereas, in pumpkin and pumpkin puree this parameter was estimated to be 0.2 g/100 g and 2.69 g/100 g, respectively. In the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content), the starch amount increased to 48.7 g/100 g, which was 0.2 g/100 g more than that in the control bread.

Pumpkin and pumpkin puree have relatively small amounts of food fibers. Thus, in the high grade wheat flour, control bread, pumpkin and pumpkin puree, 3.5 g/100 g, 2.6 g/100 g, 2.03 g/100 g and 1.21 g/100 g food fibers were detected, respectively.

Food fibers have a positive effect on the metabolism of carbohydrates in the gastrointestinal tract, prevent the development of oncological diseases, stimulate the functioning of the cardiovascular and digestive tract, play an important role in the functioning of the human organism. The feature of pumpkin is that it contains a small amount of food fibers (0.3–1.2 %), so it is easily cooked and pumpkin puree is easily digested by the organism.

The amount of food fibers increased slightly (by 0.09 g/100 g) in the bread made by mixing high grade wheat flour with pumpkin puree (10 % of the total content).

Food fibers decrease the energetic value, but increase the nutritional value of flour and bread. Because they accelerate the peristalsis of the intestines, normalize lipid and carbohydrate metabolisms in the body, and allow heavy metals to be removed from the body.

The high grade wheat flour and the control bread do not contain pectin. Whereas, in pumpkin and pumpkin puree, 0.31 g/100 g and 0.3 g/100 g pectin were detected, respectively. The amount of pectin became 0.03 g/100 g in the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content).

Pumpkin and pumpkin puree contain 0.1 g/100 g organic acids. In the high grade wheat flour, control bread and bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content), the amounts of organic acids were found to be 0.5 g/100 g, 1.7 g/100 g and 1.734 g/100 g, respectively. This is 0.034 g/100 g more than that in the control bread.

Organic acids improve digestion, reduce the pH of the environment, and enrich the microflora (reduces decomposition).

There is a small amount of ash in pumpkin (0.62 g/100 g) and in the high grade wheat flour (0.5 g/100 g). Whereas, in pumpkin puree, control bread and bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content), the amount of ash was 1.12 g/100 g, 1.7 g/100 g, and 2.074 g/100 g, respectively. This is 0.374 g/100 g more than that in the control bread.

The change in nutrients in the technological process and the difference in their content in bread (control and with the additive) samples are presented in Table 2.

Table 2

Changes in nutrients in the technological process and the difference in their content in bread samples

Indices	Abbreviated	Reduction in the content of nutrients in the technological process, %	Increase in the content of nutrients in bread with the additive, g/100 g
Proteins	Pro	26.2	0.13
Fats	Fts	30.0	0.397
Saturated fatty acids	Stfacd	0	0.34
Carbohydrates:	Carbs	30.3	0.45
– mono-and disaccharides	M-disch	56.2	0.16
– starch	Strch	29.19	0.2
Food fibers	FdFib	25.7	0.09
Pectin	Pec	0	0.03

The content of nutrients in raw materials and the character of their changes in the technological process of making bread with the addition of pumpkin puree to wheat flour are clearly shown in Fig. 1.

As can be seen from Table 2 and Fig. 1, in the technological process of bread production, mono- and disaccharides are changed from food substances to a greater extent (56.2 %), and to a lesser extent – food fibers (25.7 %). Saturated fatty acids and pectins do not change at all.

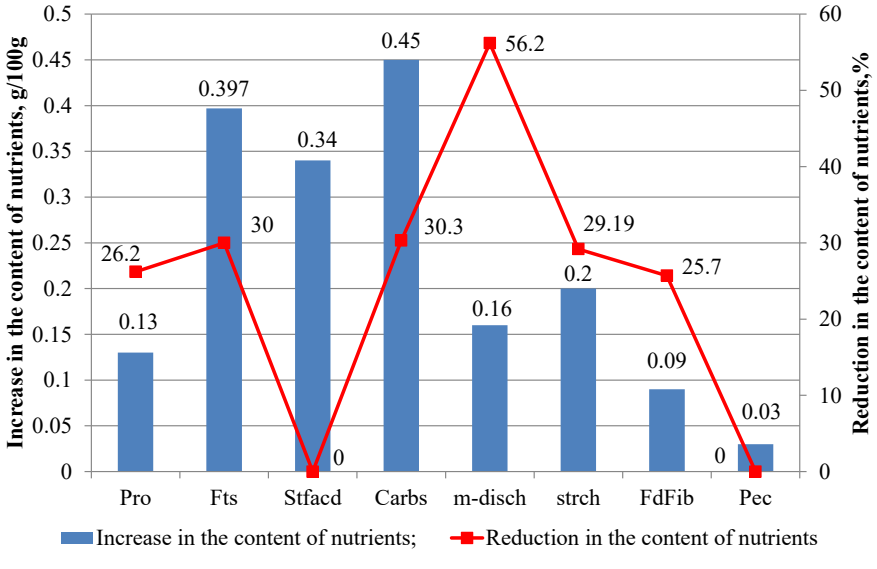

Fig. 1. Character of changes in nutrients in the technological process of making bread with pumpkin puree

5. 2. Analysis of the mineral substances of raw materials and bread with additives

The contents of mineral elements in the «Perekhvatka-69» variety of pumpkin, its puree, high grade wheat flour and bread samples made from the high grade wheat flour were compared.

As seen in Table 3, pumpkin is rich in sodium. Thus, the high grade wheat flour contains 3.0 mg/100 g, the control bread – 499 mg/100 g, pumpkin – 4.0 mg/100 g and pumpkin puree – 190 mg/100 g. According to literature data, sodium content was found to be 4.0–14.0 mg/100 g.

The increased amount of sodium in the control bread is attributed to the presence of sodium in water, salt and yeast. The sodium concentration in the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content) was found to be 521.0 mg/100 g, which is 22.0 mg/100 g more than that in the control bread.

By adding pumpkin puree, the amount of sodium in the composition of bread can be increased. Sodium salts have a positive effect on the cardiovascular system. The normal growth and state of the organism are important for the normal functioning of the neuromuscular system.

Pumpkin is very rich in potassium salts. Thus, in the high grade wheat flour – 120 mg/100 g, in the control bread – 91.44 mg/100 g, in pumpkin – 202 mg/100 g and in pumpkin puree – 170 mg/100 g potassium salts were detected. The concentration of potassium in the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content) was 104.39 mg/100 g, which is 12.95 mg/100 g more than that in the control bread. By adding pumpkin puree, the amount of potassium in the composition of bread can

be increased. Potassium has a positive effect on the cardiovascular system, it increases the permeability of the membranes to salts. Potassium is also essential for normal brain functioning, cleansing organism from slags and treatment of allergies.

Table 3

Mineral substances of raw materials and bread samples, mg/100 g

Indices	Pumpkin	Pumpkin puree	High grade wheat flour	Changes in indices during the technological process, %	Bread made from the high grade wheat flour	
					Control bread	Bread containing 10 % pumpkin puree
Sodium	4.0	190	3.0	×166.3	499.00	521.00
Potassium	202	170	120	–23.80	91.44	104.39
Calcium	24	60	18	+11.11	20.00	26.67
Phosphorus	24	54	86	–24.42	64.24	68.32
Magnesium	13.0	13.0	15	–12.50	13.13	14.26
Iron	0.39	2.25	1.2	–8.33	1.10	1.31
Copper	0.18	0.17	0.1	–20.00	0.08	0.09
Zink	0.23	0.22	0.70	–24.86	0.526	0.543

Pumpkin is also rich in calcium salts. In the high grade wheat flour, the amounts of calcium salts was 18 mg/100 g, in the control bread – 20 mg/100 g, in pumpkin – 24 mg/100 g and in pumpkin puree – 60 mg/100 g. In the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content), the calcium amount was found to be 26.67 mg/100 g, which is 6.67 mg/100 g more than that in the control bread. Thus, the calcium content in bread can be increased by adding pumpkin puree. Calcium is involved in all vital processes of the human body. Normal coagulation of blood occurs only with the participation of calcium salts. Calcium plays an important role in the nervous-muscular irritability of tissues. Nervous-muscular irritability decreases with increasing concentration of calcium and magnesium ions in blood and vice versa.

The amount of phosphorus in pumpkin and pumpkin puree is relatively small. In the high grade wheat flour, the phosphorus amount was found to be 86 mg/100 g, in the control bread – 64.24 mg/100 g, in pumpkin – 24 mg/100 g and in pumpkin puree – 54 mg/100 g. In the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content), phosphorus amount was found to be 68.32 mg/100 g, which is 4.08 mg/100 g more than that in the control bread. Thus, by adding pumpkin puree to the high grade wheat flour, bakery products can be enriched with phosphorus. Phosphorus compounds play an important role in all processes occurring in the human organism: phosphoric acid is involved in the construction of numerous enzymes (phosphatases) that perform chemical reactions in tissues. The human skeletal tissue is formed from salts of phosphoric acid.

The magnesium amount was almost the same – 13, 13, 15 and 13.13 mg/100 g in pumpkin, pumpkin puree, high grade wheat flour and control bread, respectively. In the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content), magnesium amount was found to be 14.26 mg/100 g, which is 1.13 mg/100 g more than that in the control bread.

Magnesium is mainly found in bones and muscles, it is an important constituent of all cells and tissues; with ions of other elements, maintains the ionic balance of liquid mediums of the organism; is included in the composition of the enzymes related to the metabolism of phosphorus and carbohydrates; activates plasma and bone phosphatase and participates in nervous-muscular irritation.

Pumpkin puree is relatively rich in iron. Thus, pumpkin contains 0.39 mg/100 g, the high grade wheat flour – 1.2 mg/100 g and the control bread – 1.1 mg/100 g iron. Whereas, the concentration of iron in pumpkin puree is 2.25 mg/100 g. The bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content) contains 1.31 mg/100 g iron, which is 0.21 mg/100 g more than that in the control bread. Iron is contained in hemoglobin, iron-protein complexes and some enzymes intensifying the respiration process in tissues. Iron stimulates blood formation. Iron amounts are relatively small in fruits, vegetables and berries, but it is easily digested by the human organism. Lemon and ascorbic acids in fruits and berries as well as fructose in their juice facilitate the iron absorption from food products.

Zinc is found in small amounts in pumpkin and pumpkin puree. Thus, 0.7 mg/100 g, 0.526 mg/100 g, 0.23 mg/100 g and 0.22 mg/100 g concentrations of zinc were detected in the high grade wheat flour, control bread, pumpkin and pumpkin puree, respectively. The bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content) contains 0.543 mg/100 g zinc, which is 0.017 mg/100 g more than that in the control bread. By adding pumpkin puree, it is possible to increase the amount of zinc in bread. Zinc is included in the insulin hormone. Zinc deficiency occurs mainly in children. The growth and sexual development can be delayed in children and adolescents due to zinc deficiency.

There are relatively larger amounts of copper in pumpkin and pumpkin puree. The high grade wheat flour contains 0.1 mg/100 g, the control bread – 0.08 mg/100 g, pumpkin – 0.18 mg/100 g and pumpkin puree – 0.17 mg/100 g copper. The bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content) contains 0.09 mg/100 g copper. That is 0.01 mg/100 g more than that in the control bread. Adding pumpkin puree can increase the amount of copper in bread. Copper facilitates the absorption of iron, it is essential for the proper development of blood vessels and connective tissues. Copper is involved in the synthesis of red blood pellets, collagen, skin enzymes, height growth and pigmentation.

Changes in mineral substances in the technological process and the difference in their content in bread (control and with additive) samples are presented in Table 4.

Table 4

Changes in mineral substances in the technological process and the difference in their content in bread samples

Indices	Designation	Changes in the content of minerals in the technological process, %	Difference in the content of minerals in bread with pumpkin puree and control sample, mg/100g
Sodium	Na	×166.3	22.0
Potassium	K	–23.80	12.95
Calcium	Ca	+11.11	6.67
Phosphorus	P	–24.42	4.08
Magnesium	Mg	–12.50	1.13
Iron	Fe	–8.33	0.21
Copper	Cu	–20.00	0.01
Zinc	Zn	–24.86	0.017

For clarity, Fig. 2 shows the difference in the content of mineral substances in bread with pumpkin puree and control sample, mg/100 g.

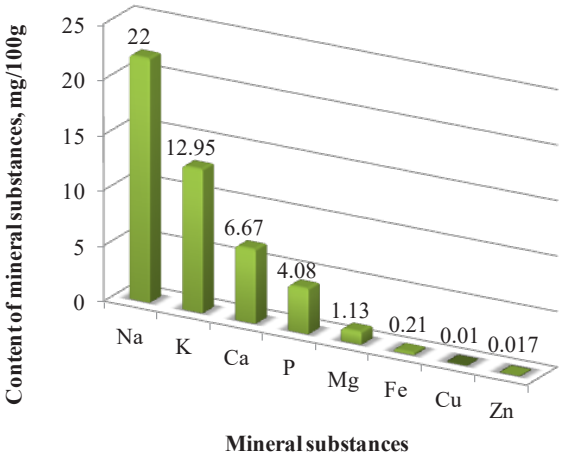

Fig. 2. Difference in the content of mineral substances in bread with pumpkin puree and control sample

5. 3. Analysis of the vitamin substances of raw materials and bread with additives

As seen in Table 5, the high grade wheat flour and the control bread made of it lack beta-carotene, but 1.45 mg/100 g and 1.31 mg/100 g of beta-carotene were detected in pumpkin and pumpkin puree, respectively. Increasing beta-carotene amounts in bread by adding pumpkin puree is considered to be advisable. The presence of beta-carotene in the composition of bread is very important because beta-carotene is converted into vitamin A by the effect of the carotinase enzyme in the human body. Vitamin A deficiency causes vision deterioration and a number of diseases resulting in blindness. The beta-carotene concentration was found to be 0.118 mg/100 g in the bread made by mixing the high grade wheat flour with pumpkin puree (10 % of the total content).

The high grade wheat flour and the control bread made of this flour contain relatively larger amounts of vitamin B1. Thus, in the high grade wheat flour, control bread, pumpkin and pumpkin puree 0.17 mg/100 g, 0.11 mg/100 g, 0.06 mg/100 g and 0.042 mg/100 g of vitamin B1 were detected, respectively. The lack of vitamin B1 causes the violation in the nervous system, heart and muscle functions, digestion (especially digestion of carbohydrates), as well as mental and physical fatigue. The amount of vitamin B1 decreased to 0.113 mg/100 g in the bread made by adding pumpkin puree to the high grade wheat flour (10 % of the total content) during the technological process. Nevertheless, the amount of vitamin B1 was 0.003 mg/100 g higher in the bread containing pumpkin puree than in the control bread.

The vitamin B2 amount is relatively high in pumpkin and pumpkin puree. In the high grade wheat flour and the control bread, its amount was in the range of 0.03–0.04 mg/100 g, whereas in pumpkin and pumpkin puree, the vitamin B2 amount was between 0.06 mg/100 g and 0.07 mg/100 g. This indicates that the amount of vitamin B2 was 0.02–0.04 mg/100 g higher in pumpkin and pumpkin puree. As seen in Table 5, in the bread made by adding pumpkin puree to the high grade wheat flour (10 % of the total content), the amount of vitamin B2 was equal to 0.035 mg/100 g, which is 0.005 mg/100 g higher compared to that in the control bread. The lack of vitamin B2 leads to appetite deterioration, weakness, decreased body weight and impaired vision. Vitamin B2 protects hair, nails and skin, participates in the metabolism of proteins, fats and carbohydrates, is used in the treatment of ulcers in tongue, mouth and lips. Therefore, bread can be enriched with natural vitamin B2 by adding pumpkin puree.

The high grade wheat flour and the control bread are rich in vitamin PP. Pumpkin and its puree contain 0.53 mg/100 g and 0.4 mg/100 g vitamin PP, respectively. Whereas, the amount of the vitamin in the high grade wheat flour and the control bread was 1.18 mg/100 g and 0.89 mg/100 g, respectively. In the bread made by adding pumpkin puree to the high grade wheat flour (10 % of the total content), the niacin concentration was found to be 0.915 mg/100 g, which exceeds the vitamin amount in the control bread by 0.025 mg/100 g. Vitamin PP deficiency causes pellagra.

Vitamin C is practically absent in the high grade wheat flour and the control bread. Whereas, in pumpkin and pumpkin puree, its amount was found to be 7.8 mg/100 g, and 3.9 mg/100 g, respectively. As seen in Table 5, due to losses in technological processes, the vitamin C amount decreased and was 0.195 mg/100 g in the bread made by mixing pumpkin puree with the high grade wheat flour (10 % of the total content). The deficiency of vitamin C, which is also called ascorbic acid, causes weakening immunity of the organism.

The amount of niacin equivalent was 2.87 mg/100 g in the high grade wheat flour and 2.19 mg/100 g in the control bread, while in pumpkin and pumpkin puree it was equal to 0.7 mg/100 g. Niacin equivalent characterizes the total amount of niacin (PP vitamin) in the product and niacin formed from tryphighhan in the organism, i.e. 60 mg tryphighhan – 1 mg niacin. When adding pumpkin puree to the dough, it is possible to increase the niacin equivalent by 0.048 mg/100 g in bread. As seen in Table 5, in the bread made by mixing pumpkin puree with the high grade wheat flour (10 % of the total content), the niacin equivalent was 2.238 mg/100 g.

Table 5

Vitamin substances of raw materials and bread with additives, mg/100 g

Indices	Pumpkin	Pumpkin puree	High grade wheat flour	Changes in indices during the technological process, %	Bread made from the high grade wheat flour	
					Control bread	Bread containing 10 % pumpkin puree
Beta-carotene	1.45	1.310	0.00	–10.0	0.00	0.118
Thiamine	0.06	0.042	0.17	–35.3	0.11	0.113
Riboflavin	0.07	0.060	0.04	–25.0	0.03	0.035
Niacin	0.53	0.400	1.18	–25.0	0.89	0.915
Ascorbic acid	7.80	3.900	0.00	–50.0	0.00	0.195
Niacin equivalent	0.70	0.700	2.88	–24.14	2.19	2.238
Retinol equivalent	0.242	0.153	0.00	–36.8	0.00	0.010
Tocopherol equivalent	0.40	0.900	1.48	–26.7	1.08	1.151

Retinol equivalent is practically absent in the high grade wheat flour and the control bread. Whereas, in pumpkin and pumpkin puree, its amount was found to be 0.242 mg/100 g, and 0.153 mg/100 g, respectively. Retinol equivalent characterizes the total amount of retinol in the product and retinol formed from beta-carotene in the organism. 1 mg of retinol is equivalent to 6 mg of beta-carotene and 12 mg of other carotenoids, i.e. 1 mg retinol – 3.33 IU. As seen in Table 5, in the bread made by mixing pumpkin puree with the high grade wheat flour (10 % of the total content), the retinol equivalent was equal to 0.01 mg/100 g.

Tocopherol equivalent was equal to 1.48 mg/100 g in the high grade wheat flour and 1.08 mg/100 g in the control bread made of this flour. It is possible to increase the tocopherol equivalent by 0.071 mg/100 g with the addition of pumpkin puree. All groups of tocopherol compounds (4 tocopherols, 4 tocotrienols) are characterized by tocopherol equivalent. As seen in Table 5, in the bread made by mixing pumpkin puree with the high grade wheat flour (10 % of the total content), the tocopherol equivalent increased to 1.51 mg/100 g.

Changes in vitamin substances in the technological process and the difference in their content in bread (control and with additive) samples are presented in Table 6.

The content of vitamin substances in raw materials and the character of their changes in the technological process of making bread with the addition of pumpkin puree to wheat flour are clearly shown in Fig. 3.

Table 6

Changes in vitamin substances in the technological process and the difference in their content in bread samples

Indices	Designation	Reduction in the content of vitamins in the technological process, %	Increase in the content of vitamins in bread with the additive, mg/100 g
Beta-carotene	A	–10.0	0.118
Thiamine	B_1	–35.3	0.003
Riboflavin	B_2	–25.0	0.005
Niacin	PP	–25.0	0.025
Ascorbic acid	C	–50.0	0.195
Niacin equivalent	NE	–24.14	0.048
Retinol equivalent	RAE	–36.8	0.01
Tocopherol equivalent	E	–26.7	0.071

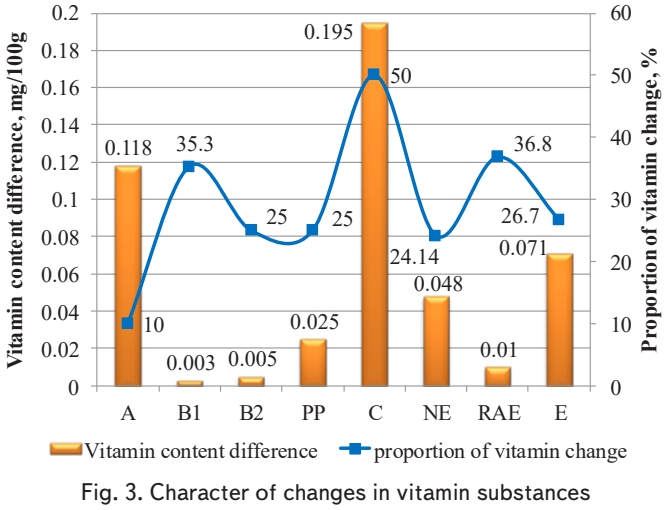

Fig. 3. Character of changes in vitamin substances in the technological process of making bread with pumpkin puree

5. 4. Analysis of the effect of pumpkin puree on gluten compression deformation

Total protein decreased in the bread due to the dissolution of albumin and globulin fractions in water and salt solution. The quality of bread depends on the gliadin and glutenin fractions forming gluten.

The wet gluten quantity in the «Mehriban» flour was not affected by pumpkin puree. Thus, in dough samples prepared before (control) and after adding pumpkin puree, the gluten quantity remained unchanged and was 30.1 %, according to the GOST 27839-2013 standard. But it should be noted that pumpkin puree had an effect on GDI. It was found that the GDI of wet gluten taken as a control was 60 units, whereas in the flour containing pumpkin puree (10 % of the total content) GDI was equal to 77.5 units. This kind of gluten is included in the I quality group. This means that using pumpkin puree allows increasing the deformation of gluten having low squeezing ability and regulating rheological properties.

Table 7 shows changes in the compression strain index of gluten depending on the amount of pumpkin puree added to wheat flour.

Table 7

Changes in the compression strain index of gluten depending on the amount of pumpkin puree added to wheat flour, units instrument

Pumpkin puree, %, x_i	0	5	10	15	20	25
GDI, units instrument	60	68.5	77.5	84.4	89.6	94.7

The analysis of the obtained results showed that the use of pumpkin puree at a dosage of up to 25 % in the bread production technology leads to an increase in the gluten deformation index. A further increase in the dosage of puree leads to a thinning of the dough and gluten. The increase in the gluten deformation index is explained by the fact that pumpkin puree relaxes the gluten.

For clarity, Fig. 4 shows a diagram of changes in the gluten deformation index depending on the dosage of pumpkin puree in wheat flour.

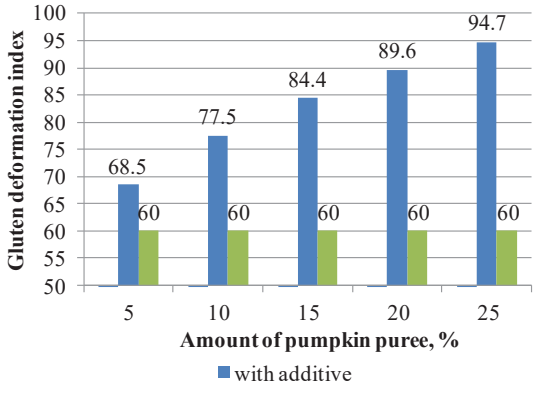

Fig. 4. Changes in the gluten deformation index depending on the dosage of pumpkin puree in wheat flour

It was also found that when pumpkin puree is added, as a result of gluten relaxation, the adhesion of dough increases. This is clearly seen when the pumpkin puree dosage is increased by more than 10 %. With an increase in dough adhesion, the conditions and modes of mechanical processing are violated, which leads to a deterioration

in organoleptic quality indicators. Therefore, it is also promising to study the adhesive properties of dough, depending on the dosage of pumpkin puree.

6. Discussion of the experimental results of the study of the possibility of using pumpkin puree to improve the food value of bread

The results obtained are explained by the enrichment of bread products with biologically active additives, in particular, carotene-containing raw materials – of pumpkin puree. They increase the adaptive capacity of the body, compensate for the deficiency of nutrients and vitamins in the diet without increasing its calorie content. In addition, biologically active additives in bread with the addition of pumpkin puree differ from pharmaceutical dietary supplements in that they are natural. Some commercial firms produce dietary supplements in an artisanal way. Therefore, the term «dietary supplement» has become ambiguous among both consumers and medical personnel, which often leads to serious misconceptions, even wrong actions. Thus, providing the population with bakery products with the addition of pumpkin puree can today be a priority for all states.

Comparative analysis of quality parameters of the highest grade wheat flour and control bread showed that the content of water, fat, mono- and disaccharides, saturated fatty acids and ash was higher, while the content of proteins, starch, dietary fiber and organic substances was lower (Table 1). The food value of bread prepared from the highest grade wheat flour with the addition of pumpkin puree in an amount of 10 % to the mass of flour was higher compared to the control sample.

Synergistic improvement of the textural and organoleptic properties of the product requires the reasonable use of pumpkin puree and sourdough [4]. This is possible only if the nature and proportion of changes in the chemical composition of the raw materials used for the production of bread with increased biological value are known.

From the results of the studies presented in Table 2, it can be seen that the content of nutrients in bread from wheat flour with pumpkin puree is higher than in the control sample of bread. It has been found that in the technological process there is a decrease in the content of nutrients. However, adding pumpkin puree to wheat flour can increase their content in bread. The study of the nature of changes in nutrients in the technological process allows you to determine the proportion of reduction in their content (in %). Based on this, it is possible to adjust the content of nutrients before and after the technological process of processing raw materials and making bread with additives.

The nature of changes in nutrients in the technological process of bread production can be represented as follows (Table 2 and Fig. 1): with a decrease in protein by 26.2 %, its increase in bread with pumpkin puree is 0.13 g/100 g; with a decrease in fat by 30 %, its increase in bread with pumpkin puree is 0.397 g/100 g; with a decrease in carbohydrates by 30.3 %, its increase in bread with pumpkin puree is 0.45 g/100 g; with a decrease in dietary fiber by 25.7 %, its increase in bread with pumpkin puree is 0.09 g/100 g. It has been found that saturated fatty acids and pectin do not change during the technological process and the increase in their content in bread with pumpkin puree is 0.34 and 0.03 g/100 g, respectively. The results of the effect of pumpkin puree on the nutritional value of bread allow us to determine a relationship between the proportions of changes in nutrients and the increase in their content in bread.

In [8], the importance of purposeful enrichment of therapeutic and prophylactic bakery products is interpreted. To solve this problem, it is necessary to know the nature and proportion of changes in nutrients, mineral and vitamin composition of raw materials. This is supported by the results of our research.

In a comparative analysis of minerals, the amounts of sodium, potassium, calcium, iron and copper in the pumpkin puree were greater than the higher grade wheat flour, while the amounts of phosphorus, magnesium and zinc were less. Compared to the control bread sample, except for sodium, the amount of potassium, calcium, iron, and copper was greater in the pumpkin puree and the amount of phosphorus, magnesium, and zinc was also less. However, in the bread prepared from the highest grade wheat flour with the addition of pumpkin puree in an amount of 10 % to the mass of flour, the amount of minerals was higher compared to the control sample of bread (Table 3).

From the results of the studies presented in Table 4, it can be seen that the content of mineral substances in bread from wheat flour with pumpkin puree is higher than in the control sample of bread. It has been found that in the technological process there is a change in the content of mineral substances. But, adding pumpkin puree to wheat flour allows you to increase the mineral content in bread. The study of the nature of changes in mineral substances in the technological process allows us to determine the proportion of changes in their content (in %). Based on this, it is possible to adjust the content of mineral substances before and after the technological process of processing raw materials and making bread with additives.

The nature of changes in the content of mineral substances in the technological process of bread production can be represented as follows (Table 4): with a decrease in potassium by 23.8 %, its increase in bread with pumpkin puree is 12.95 mg/100 g; with a decrease in phosphorus by 24.42 %, its increase in bread with pumpkin puree is 4.08 mg/100 g; with a decrease in magnesium by 12.5 %, its increase in bread with pumpkin puree is 1.13 mg/100 g; with a decrease in iron by 8.33 %, its increase in bread with pumpkin puree is 0.21 mg/100 g; with a decrease in copper by 20 %, its increase in bread with pumpkin puree is 0.01 mg/100 g; with a decrease in zinc by 24.86 %, its increase in bread with pumpkin puree is 0.017 mg/100 g. It was found that sodium and calcium increase without loss in bread with pumpkin puree by 22 and 6.67 mg/100 g, respectively.

For a visual representation of the nature of changes in the mineral composition, a series was built as their content decreases in bread with pumpkin puree (Fig. 2). The results of the influence of pumpkin puree on the mineral composition of bread allow us to determine a relationship between the proportions of changes in mineral substances and the increase in their content in bread.

In a comparative analysis of vitamins, it was found that there were no vitamins C and A and beta-carotene in the wheat flour of the highest grade and the control sample of bread. However, the bread prepared from the highest grade wheat flour with the addition of pumpkin puree in an amount of 10 % to the mass of flour contained beta-carotene, vitamins C and A, and the amount of other vitamins was slightly higher compared to the control sample of bread (Table 5).

From the results of the studies presented in Table 6, it can be seen that the content of vitamins in bread from wheat

flour with pumpkin puree is higher than in the control sample of bread. It has been found that in the technological process there is a decrease in the content of vitamins. However, adding pumpkin puree to wheat flour can increase their content in bread. The study of the nature of changes in vitamins in the technological process allows you to determine the proportion of reduction in their content (in %). Based on this, it is possible to adjust the content of vitamins before and after the technological process of processing raw materials and making bread with additives.

The nature of changes in the content of vitamin substances in the technological process of bread production can be represented as follows (Table 6): with a decrease in beta-carotene by 10 %, its increase in bread with pumpkin puree is 0.118 mg/100 g; with a decrease in vitamin B1 by 35.3 %, its increase in bread with pumpkin puree is 0.003 mg/100 g; with a decrease in vitamin B2 by 25 %, its increase in bread with pumpkin puree is 0.005 mg/100g; with a decrease in vitamin PP by 25 %, its increase in bread with pumpkin puree is 0.025 mg/100 g; with a decrease in vitamin C by 50 %, its increase in bread with pumpkin puree is 0.195 mg/100 g; with a decrease in NE by 24.14 %, its increase in bread with pumpkin puree is 0.048 mg/100 g; with a 36.8 % decrease in RAE, its increase in bread with pumpkin puree is 0.01 mg/100 g; with a decrease in vitamin E by 26.7 %, its increase in bread with pumpkin puree is 0.071 mg/100 g.

The results of studying the effect of pumpkin puree on the vitamin substances of bread allow us to determine a relationship between the proportions of changes in vitamin substances and the increase in their content in bread (Fig. 3).

It has also been found that the addition of 10 % pumpkin puree to premium wheat flour does not change the gluten content. The gluten strain index of the control sample was 60 units of the instrument. Based on the data obtained, it can be concluded that the introduction of pumpkin puree has practically no effect on the amount of washed gluten. However, at a dosage of pumpkin puree from 5 to 25 %, the compression strain of raw gluten increases from 68.5 to 94.7 units of the instrument (Table 7). This makes it possible to regulate the desired final properties of bread and the deformation of gluten in the dough.

The change in the gluten deformation index is approximated by the linear equation $y=6.45x_i+63.59$, where x_i – pumpkin puree dosage, %.

It is mentioned in [6] that an increase in the dosage of pumpkin puree leads to a thinning of the dough and a decrease in the limiting shear stress at the beginning and at the end of fermentation. It should be noted that the increase in dough adhesion negatively affects the course of the technological process of bread production. The results of our studies allow us to determine a relationship between the ultimate shear stress and the gluten strain index. Knowing the nature of changes in the gluten deformation index in further studies, this relationship can be determined.

Thus, the use of pumpkin puree in the production of bakery products from wheat flour will improve the rheological properties of dough, increase the biological value of bread, expand the range, raw material base and use of non-traditional raw materials.

In the study, limitations were identified related to the amount of pumpkin puree added to wheat flour. With an increase in the dosage of pumpkin puree, more than 10 % leads to an increase in the adhesive properties of dough. This is especially observed at a dosage of pumpkin puree from 20 to 30 % by weight of flour. During the fermentation process, the dough liquefies, as a result, the adhesion of the dough increases, and thus the modes and conditions of mechanical processing are violated (for example, when kneading the dough, when dividing the fermented dough into pieces, when laying dough pieces on the bottom of a proofer, baking oven, etc.). Therefore, in further studies it is necessary to find out the relationship between the gluten deformation index and the adhesive properties of dough, as well as to identify the pattern of their changes depending on the dosage of pumpkin puree. This will make it possible to develop and introduce new anti-adhesive materials and thereby determine the optimal modes of the technological process of bread production.

It should be noted that the technological process of baking bread has a greater effect on the chemical composition, which results in a decrease in nutritional value. Successful practical application of pumpkin puree is to further improve relevant technological parameters of bread production to achieve greater preservation of useful substances with lower energy consumption.

The best indicator is a great product. Process parameters should be improved taking into account the use of different raw materials for limiting biologically active components. This diversity will further expand the range of bakery products. The development of new technological methods for the use of fortified products will make it possible to modernize the existing technologies for providing the population with rational nutrition.

7. Conclusions

1. It was determined that pectin was not found in the control sample of bread without the addition of pumpkin puree. But in bread with the addition of pumpkin puree, the pectin content was 0.03 mg/100 g. The quality indicators of bread with the addition of pumpkin puree were higher than those of the control sample (mg/100 g): proteins by 0.13, fats by 0.397, saturated fatty acids by 0.34, carbohydrates – 0.45, pectin – 0.03, organic acids – 0.034. The study of the nature of changes in nutrients in the technological process allows you to determine the proportion of reduction in their content (in %). Based on this, it is possible to adjust the content of nutrients before and after the technological process of processing raw materials and making bread with additives.

2. It has been found that the content of minerals in bread increases when pumpkin puree is added (mg/100 g): sodium by 22, potassium – 12.95, calcium – 6.67, magnesium – 1.13, phosphorus – 4.08, iron – 0.21, copper – 0.01, zinc – 0.017. The study of the nature of changes in mineral substances in the technological process allows us to determine the proportion of changes in their content (in %). Based on this, it is possible to adjust the content of mineral substances before and after the technological process of processing raw materials and making bread with additives.

3. It has been found that bread vitamins increase when pumpkin puree is added. However, beta-carotene, ascorbic acid, and retinol were not found in the control sample of bread. But in bread with the addition of pumpkin puree, their content was 0.118, 0.195, and 0.01 mg/100 g, respectively. The content of the determined vitamins in bread with the addition of pumpkin puree was higher than in the control sample (mg/100 g): thiamine B1 by 0.003, riboflavin B2 – 0.005, niacin PP – 0.025, niacin equivalent – 0.048, tocopherol

equivalent – 0.071. The study of the nature of changes in vitamins in the technological process allows us to determine the proportion of their content reduction (in %). Based on this, it is possible to adjust the content of vitamins before and after the technological process of processing raw materials and making bread with additives.

4. It has been found that the introduction of pumpkin puree has practically no effect on the amount of washed gluten. However, at a dosage of pumpkin puree from 5 to 25 %, the compression strain of raw gluten increases from 68.5 to 94.7 units instrument. This makes it possible to regulate the desired final properties of bread and the deformation of gluten in the dough. This is very important in the development of new technological methods for the use of enrichment products to provide the population with rational nutrition.

Acknowledgments

We would like to thank the Department of Food Engineering and Expertise of the Azerbaijan University of Technology.

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