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STUDY OF THE INFLUENCE OF NATIVE AND GERMINATED PUMPKIN AND WATERMELON SEEDS ON THE QUALITY OF DOUGH AND BREAD

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Correspondence:

Zh. Zamaï

E-mail: zamaizhanna@gmail.com

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O. Gumeniuk, PhD in Chemical Sciences, Associate Professor

Zh. Zamaï, PhD in Technical Sciences, Associate Professor

S. Tsybulia, Doctor of Technical Sciences, Professor

O. Khrebtan, PhD in Technical Sciences, Associate Professor

R. Volkova, lecturer of the of CPNU

Department of Food Technology

Chernihiv Polytechnic National University

95, Shevchenko street, Chernihiv, Ukraine 14035

Abstract. The paper examines the effect of native and germinated pumpkin and watermelon seeds on the quality of semi-finished and finished bread products. Native and germinated seeds, pre-dried and ground into flour, were used as an additive to bread in the amount 5%, 10%, 15% by weight of the flour. Pumpkin and watermelon seeds were added in order to enrich the bread with micronutrients. The influence of these additives on the quantity and quality of gluten has been analysed. It has been found that the addition of pumpkin seed flour in quantities of 5%, 10% and 15% by weight of wheat flour leads to a decrease in the gluten content and an increase in its elasticity. The study has shown that adding native pumpkin seeds does not have a significant effect on the moisture and acidity of semi-finished and finished products, and adding germinated seeds leads to a slight increase in these parameters. Thus, the moisture content of the crumb with native pumpkin and watermelon seeds added increased by 0.2–1.3%, as compared with the reference sample, and with germinated seed flour added, it increased by 0.5–2.2%. The acidity of the crumb changes slightly, within experimental error. According to the physicochemical quality parameters, the most practical amount of the additives is 5% by weight of wheat flour. A comparative analysis has been carried out to establish how addition of 5% of native and germinated pumpkin and watermelon seeds changes the organoleptic properties of bread. The analysis has shown that ready-made bread products containing native pumpkin seeds taste better and have better olfactory properties than products with germinated seeds. The nutritional and calorific values of the reference sample and of bread with 5% of pumpkin and watermelon seed flour have been compared and characterised. It has been found that the addition of native pumpkin seeds will increase the content of minerals: of iron by 230%, of magnesium by 116%, and of potassium by 118%. The addition of native watermelon seeds will increase the phosphorus content by 13%. As a result of this research, the prospects of using flour of native pumpkin and watermelon seeds to fortify wheat bread have been shown.

Keywords: wheat bread, fortification, native pumpkin and watermelon seeds, germinated pumpkin and watermelon seeds.

Introduction. Formulation of the problem

One of the urgent tasks facing the food industry today is establishing the manufacture of fortified food products, which will enrich people's daily diet with products of high biological value [1]. Fortification is the practice of intentionally increasing the content of essential micronutrients (i.e. vitamins and minerals) in food, in order to improve their biological value and ensure the health benefits with minimal health risk for people [2]. Obviously, it is required from food fortification that fortified food should be consumed in appropriate quantities by a large proportion of the

population [2]. And, as world practice shows, it is the fortification of flour and manufacture of bakery products from it that allows strengthening health without too much extra expense [1,2]. Wheat is an important cereal crop and along with maize and rice accounts for a significant share of total grain consumption worldwide [3]. Therefore, the enrichment of industrially processed wheat flour, when properly implemented, is an effective, simple, and inexpensive strategy to supply the general public with vitamins and minerals in their diet [2]. The need to develop and implement innovative products, in particular, bakery products, is also due to the fact that products with high

sensory characteristics are made from high-grade flour that does not contain hulls, germs, or the aleurone layer of wheat grain. Preparation of bakery products and flour confectionery from high-quality flour leads to additional loss of important bioactive substances. For example, the content of B vitamins (thiamine, niacin, vitamin B-6, folic acid), iron, and calcium in the course of bread preparation, starting from grinding the grain and ending with baking, is reduced by 2–6 times [4-6].

The recent decades are characterised by significant fluctuations in the properties of raw materials and trends towards the spread of resource-saving accelerated technologies. All this complicates the work of bakeries, reduces the quality of bakery products, leads to the use of improvers and preservatives, often of synthetic origin, which worries consumers [7]. Thus, improving the quality of traditional bakery products by using natural raw materials high in bioactive substances is a task of current importance.

Analysis of recent research and publications

The most popular and widespread bakery product in Ukraine is wheat bread. Food enrichment should be carried out for the most widely used products, so improving the recipe of wheat bread is one of the priority areas of research. In particular, cereals, legumes, medicinal plants, seeds, products of processing oilseeds, fruit, and vegetables, etc. are often used as non-traditional raw materials [4-8].

Enrichment of food products with vitamins and minerals should not impair the consumer properties of these products: reduce the content and digestibility of other substances, significantly change the taste, aroma, freshness of products, and shorten their shelf life. The effectiveness of fortified foods must be convincingly confirmed by testing, which demonstrates not only their absolute safety and appropriate taste qualities, but also good digestibility. These foods should significantly improve the body's supply of vitamins and minerals included in their composition and the health indicators dependent on these substances. From

functional ingredients, it is specially required not to reduce the nutritional value of the product and be safe in terms of a balanced diet, etc. [4,6-9]

Thus, the authors [4,6] studied the possibility of enriching bread with hemp seed flour, which contains proteins with a balanced amino acid composition, polyunsaturated fatty acids, dietary fibre, vitamins and minerals. It was also found that the introduction of 10–20% of hemp flour helps to intensify the process of dough maturation and reduces the duration of the technological process by 8–20 minutes [6].

The authors [5,8,10,11] studied the effect of different types of grain additives on the physicochemical and organoleptic characteristics of wheat bread. Based on the results obtained, a new method of preparation of wheat bread with grain additives was suggested, namely, fermentation based on sourdough, the use of which has a positive effect on the sensory properties of bread, improves its texture, and slows down its firming.

A promising direction in the fortification of bakery products from high-grade flour is the use of pumpkin seeds, which are a source of valuable nutrients [12-14]: minerals, vitamins, essential amino acids, polyunsaturated fatty acids [15] (Table 1).

Pumpkin and watermelon seeds are richer in macro- and micronutrients, vitamins, polyunsaturated fatty acids, and essential amino acids than premium wheat flour is. Thus, the content of calcium, iron, potassium, and zinc in native pumpkin seeds exceeds their content in wheat flour by several times [16-19]. Analysis of the amino acid composition of pumpkin seeds shows that their protein fractions contain a complete set of amino acids, including essential, which suggests their high biological value. The content of some essential amino acids (leucine, lysine) is at the level of the FAO/WHO standards, and that of phenylalanine and threonine significantly exceeds it. However, valine, isoleucine, the sum of methionine and cystine, as well as tryptophan are limiting [14].

Table 1 – Comparison of the content of some nutrients in 100 g of native seeds of pumpkin, watermelon, and wheat flour* [16-18]

Name	Amount			Name	Amount		
	the kernel of dried seeds		Flour*		the kernel of dried seeds		Flour**
	pumpkin	watermelon			pumpkin	watermelon	
Calcium, Ca, mg	46.0	54.0	15	Vitamin B ₆ , mg	0.14	0.09	0.044
Iron, Fe, mg	8.82	7.28	1.17	Folate, B ₉ , mcg	58.0	58.0	26
Magnesium, Mg, mg	592.0	515.0	22	Choline, B ₄ , mg	63.0	–	10,4
Phosphorus, P, mg	1230.0	755.0	108	Vitamin A, mcg	1.0	–	–
Potassium, K, mg	809.0	648.0	107	Vitamin E, mg	2.18	–	0.06
Sodium, Na, mg	7.0	99.0	2	Vitamin K, mcg	7.3	–	0.3
Zinc, Zn, mg	7.8	10.2	0.7	PSFA**, g	21	28.1	0.413
Copper, Cu, mg	1.34	0.69	0.144	Tryptophan, g	0.58	0.39	0.127
Manganese, Mn, mg	4.54	1.61	0.682	Threonine, g	0.99	1.11	0.281
Selenium, Se, mg	9.4	–	33.9	Isoleucine, g	1.28	1.34	0.357
Vitamin C, mg	1.9	–	0	Leucine, g	2.42	2.15	0.71
Thiamine, B ₁ , mg	0.27	0.19	0.12	Lysine, g	1.24	0.89	0.228
Riboflavin, B ₂ , mg	0.15	0.15	0.04	Methionine, g	0.60	0.83	0.183
Niacin, B ₃ , mg	4.99	3.55	1.25	Phenylalanine, g	1.73	2.03	0.52
Pantothenic acid, B ₅ , mg	0.75	0.35	0.438	Valin, g	1.58	1.56	0.415

Notes. * Wheat flour of the highest grade.

**PSFA – polyunsaturated fatty acids.

The authors [19] state that since no substances harmful for human health are found in pumpkin seeds, their deep processing is impractical. The best option from the physiological, technological, and economic point of view will be processing of pumpkin seeds into flour.

Ordinary pumpkin seeds have already been studied as additives to baking flour [19-24], but germinated ones have not. Germinated seeds contain up to 28% of vegetable proteins, up to 46% of fats. These seeds are recommended in case of deficiency of phosphorus, magnesium, manganese, iron, zinc, selenium. It also has a higher content of vitamins B₁, B₂, C, E [25,26], as compared with native seeds.

The main benefit of germinated seeds is that during germination, bioactive substances are activated. Seedlings are an affordable and cheap natural source of vitamins, minerals, enzymes, and amino acids. In the seeds, they are in the most concentrated form [25-26]. Besides, in contrast to native seeds, all these substances in seedlings are in the form most available for the body. Analysis of literature sources has shown that the possibility of using germinated pumpkin and watermelon seeds in the baking technology has not been studied before.

The authors [27] studied how a method of processing pumpkin seeds affected their nutritional and calorific value, amino acid and fatty acid composition. Pumpkin seeds were processed, boiled, fermented, germinated, fried, and then dried at 50°C, crushed, and sifted. The method of processing was found to affect the level of nutrients in pumpkin seed flour. Germination and fermentation had a positive effect on the quality of seed flour protein, reduced harmful elements, and improved the bioavailability.

Native watermelon seed flour, too, is already used in the technology of flour products. The authors [28] studied the production and evaluation of biscuits from wheat flour and toasted watermelon seed meal as a fat substitute. The results of studying the functional properties of flour mixtures showed that composite flour mixtures could be suitable for the production of biscuits and other food recipes. Biscuits made from this compound flour can help fight protein-energy malnutrition. They can be viewed as a functional product, especially for coeliac patients, diabetics, obese people, and cardiac patients, due to the high content of protein, dietary fibre, minerals, and low fat and carbohydrates, compared with biscuits made from 100% wheat flour [28].

The authors [15] studied the nutritional qualities and functional properties of paprika seed flour and flour from pumpkin and watermelon seed kernels, as well as the characteristics and structure of their oils. Paprika seeds and pumpkin and watermelon seeds were found to be rich in oil and protein. All the flour samples contained significant amounts of P, K, Mg, Mn, and Ca. Compounds such as stachyose, raffinose,

verbascose, trypsin inhibitor, phytic acid, and tannins were found in all flour types studied. The pumpkin seed flour had higher values of chemical evaluation, index of essential amino acids, and protein digestibility in vitro than other flour types did. The first limiting amino acid was lysine for flour from watermelon seeds and pumpkin seeds. Both watermelon seed and pumpkin seed flours had good protein solubility indices, water absorption, fat absorption, and emulsifying properties. As a result of the research, the authors [15] concluded that pumpkin and watermelon seed flour could be added to bakery products not only as a nutritional additive, but also as a functional agent in their composition.

The research [29] suggests using pumpkin seeds in the production of cupcakes. Wheat flour was partially replaced with pumpkin seed flour, and three compositions of flour mixtures with different ratios of pumpkin seed flour and wheat flour were studied. Partial wheat flour replacement was evaluated by its effects on texture, height, diameter, specific volume, colour, and approximate composition. The samples considered in this work were the reference (made from wheat flour) and three samples with 25%, 50% and 75% of wheat flour partially replaced with pumpkin seed flour. The inclusion of pumpkin seed flour significantly affected the products and resulted in a better texture, consistency, pH and other characteristics. According to the results, the best ratio was that in the sample with 50% of pumpkin seed flour: it was similar to the composition of 100% wheat flour sample, except for a large amount of protein. Thus, it was found that making cakes from a mixture of 50% of wheat flour and 50% of pumpkin seed flour was a real alternative, as it helped to increase the protein and did not make significant changes to the original characteristics of the finished product.

The authors [13] studied the consumer properties of bakery products enriched with pumpkin seed flour. By the example of three recipes of buns, the authors studied the basic patterns of change in the consumer properties of products baked from wheat flour partially replaced with pumpkin seed flour. It was found that with increasing the dosage of pumpkin flour, the water absorption capacity of the flour mixture decreased, but the plasticity of the dough and the shape of the dough pieces were preserved through maturation and baking. The baked products were also characterised by good organoleptic properties, with a slight natural increase in the acidity of the crumb, reduced porosity, and shape stability of the buns. The introduction of pumpkin seed flour helps to increase the nutritional value of buns by increasing the proportion of protein, polyunsaturated fats, dietary fibre, and minerals. The ratio of wheat flour and pumpkin flour recommended by the authors for making bakery products is 85–90% to 15–10%.

The work [12] considered how pumpkin seed flour affected the baking properties of wheat flour. Based on

the research conducted and the findings analysed, the authors concluded that pumpkin flour, when combined with wheat flour, reduced the ability of the latter to form a strong three-dimensional gluten structure and weakens the elasticity of gluten. That is why the researchers [12] recommended using a small amount of pumpkin flour in products made from long-fermentation yeast dough and puff pastry. If "strong" wheat flour is used, additives should be introduced into the dough to increase the elasticity of gluten.

The authors [21] conducted research on the nutritional, calorific, and biological value of cakes made by replacing wheat flour with pumpkin fruit (10%) and its seeds (40%). It was also evaluated how these additives affected the biochemical analysis of the serum and the histological examination of the pancreas of diabetic male rats. The authors noted that the fortified cakes were higher in protein, fibre, minerals, phenols, and flavonoids compared with the reference sample and lower (21.0%) in the calorific value. A lower blood glucose level was also recorded after eating pumpkin seed cakes, as compared with the reference sample.

The authors [22] evaluated the glycaemic response and antioxidant activity of pumpkin seed powder in biscuits, in which refined wheat flour was replaced with pumpkin seed powder by 5, 7.5, and 10%. According to their findings, the antioxidant activity of the biscuits with 5% of pumpkin seed powder was 27.60 mg of ascorbic acid equivalent per 100 g, and the glycaemic index was 74.61, as compared with the value 100 of white bread.

The authors [23] investigated whether pumpkin seed powder could be used as a functional additive to replace part of wheat flour when making biscuits. The researchers found that pumpkin seed powder had good emulsifying properties and improved the properties of biscuits if the flour mixture contained 15% of it.

The paper [24] considered replacing wheat flour with 5, 10, 15, and 20% of pumpkin seed powder. Chemical analysis of biscuits containing 20% of pumpkin seed showed the highest content of protein (12.30%), fat (28.29%), ash (4.13%), iron (2.28%), and zinc (3.11%) in comparison with other test samples and the reference. The results of sensory analysis conducted by the authors [24] showed the acceptability of all four compositions, but the biscuits with 15% of pumpkin seed powder were rated the highest.

According to the authors [30], pumpkin seeds, rich in protein, can be used to fortify wholemeal bread. On analysing the physical and sensory properties, it was found that the use of 5%, 10%, and 15% of pumpkin seed flour in a mixture with wholemeal flour improved the properties of bread, increased its volume yield, specific volume, and resulted in smaller losses during baking.

The analysis of the literature data has shown that using pumpkin seed flour to enrich bread products made from yeast dough has not been studied so far.

Thus, determining how native flour and germinated pumpkin and watermelon seeds affect the quality of semi-finished and finished products of fortified wheat bread is a task of current importance.

The purpose of this work is establishing the possibility of using pumpkin seed additives to enrich yeast bakery products. For this purpose, the following **objectives** were achieved:

- investigating the effect of pumpkin seed flour additives on the properties of the gluten of high-grade wheat flour: on its quality and quantity, on the properties of semi-finished and finished products (their acidity, moisture content, sensory properties);
- analysing the change in the nutritional composition of wheat bread with the addition of pumpkin seeds;
- determining the effect of pumpkin seed additives on the calorific value of finished products.

Research materials and methods

Raw materials for wheat bread are: top-grade wheat flour (DSTU 46.004-99 "Wheat flour. Specifications"); pressed yeast (DSTU 4812:2007 "Pressed baker's yeast. Specifications"); table salt (DSTU 3583:2015 "Table salt. General specifications"); sunflower oil (DSTU 4492:2017 "Sunflower oil. Specifications"); drinking water (DSTU 7525:2014 "Drinking water. Requirements and methods of quality control," DSanPiN (State Sanitary Rules and Regulations) 2.2.4-171-10 "Hygienic requirements for drinking water").

Flour from native and germinated pumpkin and watermelon seeds was used as the source of micronutrients. We used pumpkin seeds of the Danaë variety and watermelon seeds of the Crimson Sweet variety, which complies with DSTU 5046:2008. "Watermelon, melon, and pumpkin seeds. Technology of growing. General requirements."

To prepare the flour from native pumpkin watermelon seeds, the seeds were washed with water and dried on racks (at the temperature of the drying agent $T=22\pm5^{\circ}\text{C}$, $W=60\%$, $\tau=72$ hours), then dried in an oven SNOL-67/350 ($T=70\pm5^{\circ}\text{C}$, $\tau=5$ hours) to the humidity 7% (this was measured with a moisture meter VSP-100), and ground on a laboratory mill LZMK-1. Flour from germinated pumpkin and watermelon seeds was prepared as follows: the seeds were cleaned, sorted, washed, disinfected, and soaked by the air-water method for 28 hours. Initially, the seeds, put into bags, were steeped in water at $18-20^{\circ}\text{C}$ for 8 hours until complete swelling. The swollen seeds were spread in a 6–8 cm layer, covered with wet gunnysack cloth and kept at $25-30^{\circ}\text{C}$. The grain was germinated to the size of a seedling root (60–70% of the grain length). The germination time was 4–5 days for pumpkin seeds and 7 days for watermelon seeds. After drying naturally on the racks ($T=22\pm5^{\circ}\text{C}$, $W=60\%$, $\tau=48$ hours), the germinated seeds were dried in an oven SNOL-67/350 (at the temperature of the drying

agent $T=70\pm5^{\circ}\text{C}$, $\tau=5$ hours) to the humidity 7%, and then ground in a laboratory mill LZMK-1.

The particle size of the flour types obtained was determined by sieving on a laboratory sifter RL-1. It was found that the residue on the sieve No. 067 was 1.9%, which corresponds to the norm for wholemeal wheat flour, according to DSTU 46.004-99 "Wheat flour. Technical specifications."

The moisture content of the flour types obtained was 11.8% for flour from native pumpkin seeds, 11.9% for flour from germinated pumpkin seeds, 9.33% for flour from native watermelon seeds, and 9.58% for germinated watermelon seeds.

The reference sample was bread loaf *Urozhayny* from top-grade wheat flour (DSTU 15.8-00389676.009–2000).

The quality of bread was evaluated by test baking in the laboratory. The samples were made from premium wheat flour (100 kg), pressed baker's yeast (2 kg), salt (1.5 kg), oil (1 kg), with the addition of flour from native pumpkin and watermelon seeds and flour from germinated pumpkin and watermelon seeds. The amount of the additives was 5% (5 kg) 10% (10 kg) and 15% (15 kg) by weight of flour. The dough was prepared by the straight-dough procedure. The dough was kneaded in a double-speed kneading machine. The products were formed by hand, maturation was carried out in a maturation cabinet for 40 minutes at $30\pm2^{\circ}\text{C}$ and the relative humidity $78\pm2\%$. Bread was baked in a steam convection oven UNOX XFT133 Arianna at $210\text{--}230^{\circ}\text{C}$.

The moisture content of native and germinated pumpkin and watermelon seeds was determined by the accelerated method using moisture scales AXIS ADGS50. Humidity of finished products was determined in accordance with DSTU 7045:2009 "Bakery products. Methods of determining the physicochemical parameters." The quantity and quality of gluten were determined according to DSTU ISO 21415-1:2009 "Wheat and wheat flour. Gluten content. Part 1. Determination of raw gluten by hand," the moisture content of the dough was measured by the rapid method using the Chizhova moisture meter: a dough sample weighing 5 g was dried at 160°C for 5 minutes. The percentage of moisture was calculated from the difference in the weight of the sample before and after drying.

The total amount of titrated acids in the dough was determined by the method for determination of acidity by whisked flour and water mixture (State Standard 27493–87). The acidity of the crumb was determined by the titrimetric method (DSTU 7045:2009). In both cases, to measure the total titratable acidity, a dough or crumb sample was comminuted, mixed with water ($T=40^{\circ}\text{C}$), and filtered. The filtrate was titrated using 0.1 M NaOH, with phenolphthalein as an indicator, and expressed in ml NaOH.

The porosity of the crumb was determined by analysing three bread cuts of a certain volume

($V=27\text{ cm}^3$) separated from the loaf with the help of the Zhuravliova's probe. Based on the results of weighing the samples, the porosity of the bread was calculated by the formula:

$$V = \frac{V_{total} - \frac{m}{\rho}}{V_{total}} \times 100\% \quad (1)$$

where V_{total} – total volume of the cuts, cm^3 ;

m – mass of the cuts, g;

ρ – density of the non-porous mass of wheat flour crumb (1.31 g/cm^3).

The sensory evaluation of the finished products was carried out in accordance with DSTU 7517:2014 "Wheat flour bread. General specifications." The comprehensive assessment of the quality of the products was performed by the taste characteristics and appearance using a universal system with the five-point scale and the significance factor (FS) for each of the six parameters: shape (FS=4), condition of the crust (FS=3.3), condition of the crumb (FS=3.3), taste (FS=4), aroma (FS=3.3), and freshness of the product (FS=2.1). The whole evaluation system has 100 points. Depending on the total amount of points, the quality of bread can be: excellent (100–90 points), very good (89–80 points), good (79–70 points), average (69–55 points), satisfactory (54–40), and unsatisfactory (less than 40 points).

The chemical composition and energy value (EV) of the products obtained were calculated in accordance with the recipe of bread and the chemical composition of the raw material components. For each sample, we first calculated the weight of each recipe component in 100 g of product, then the weights of protein, lipids, carbohydrates, minerals (Na, K, Ca, Mg, P, Fe), the mass of vitamins (B_1 , B_2 , PP), then the calorific value of the bread by the formula:

$$EV_{bread} = \sum m_i \times DC_i \times EV_i \quad (2)$$

where DC_i – digestibility coefficient (0.71 for proteins, 0.96 for lipids, 1.0 for carbohydrates);

EV_i – calorific values, kJ/g (proteins – 23.64, lipids – 39.12, carbohydrates – 15.69);

m_i – weight of protein, lipids, and carbohydrates in 100 g of the product.

Results of the research and their discussion

On determining the amount of gluten in the samples studied, it has been found (Fig. 1) that the addition of 5%, 10%, 15% of pumpkin seed flour to wheat flour leads to a decrease in the gluten content, as compared with the reference sample. The decrease in the amount of crude gluten may be due to the presence of dietary fibres in the flour of pumpkin seeds. These fibres impair the swelling of gluten proteins due to their high hydration capacity. For germinated pumpkin seeds, the difference in the amount of crude gluten in comparison with the reference sample was lower by 5.7–8.4% (Fig. 1), which is probably due to enzymatic processes that occurred in the germinated grain and led

to partial hydrolysis of carbohydrates and proteins and to changes in the conformation of protein molecules. These findings correlate with the similar results of studying the effect of native pumpkin flour, which were described by the authors [12,13,31].

The results of studying how pumpkin seed flour affects the quality of gluten (Fig. 2) show that with an increase in the amount of additives, the elasticity of gluten increases, compared with the reference sample. This is indicated by the 3–23% decrease in the gluten deformation index (determined with VDK). This may be because the powder of pumpkin seeds contains fatty acids, products of their oxidation, and bioactive substances, which oxidise SH-bonds and thus help the formation of disulphide bonds. As a result, protein molecules are compacted, and this leads to the decreased extensibility of gluten. As noted by the authors [31], increasing the dosage of pumpkin flour increases the elasticity of gluten and reduces its extensibility. This strengthening of gluten is to some extent due to the action of the enzyme lipoxygenase. The enzyme lipoxygenase plays a significant role in oxidative processes. It promotes oxidation of

unsaturated fatty acids of flour lipids by oxygen from the air, with the formation of hydroperoxide compounds, and their oxidising effect on the components of the protein-proteinase complex of wheat flour improves its baking properties.

With an increase in the amount of pumpkin seed flour added, the moisture content of the dough increases but slightly (Fig. 3), compared with the reference sample. The nature of the additive does not affect the moisture content of the dough either. With the addition of 15% of germinated pumpkin seed flour, the moisture content of the dough increases the most (2.2%), compared with the reference sample, which may be due to the better moisture holding capacity of germinated pumpkin and watermelon seeds. According to the authors [13], additional amounts of protein introduced with pumpkin flour promote better moisture retention of the crumb.

The acidity of the dough of the samples tested (Fig. 4) either remains the same, or increases insignificantly, within the measurement accuracy, which will not affect the taste of the finished products.

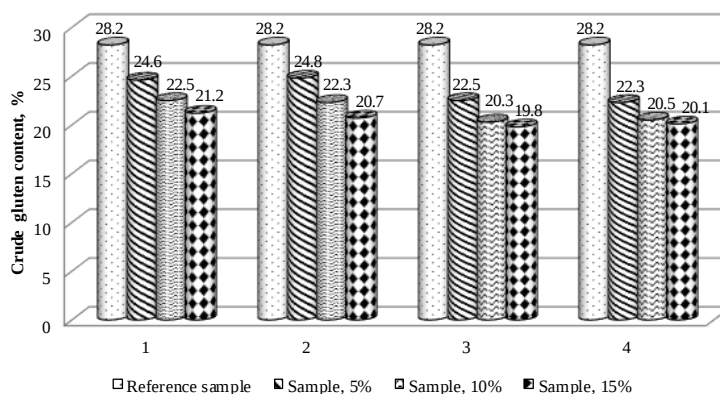


Fig. 1. The dependence of the amount of gluten on the pumpkin seed flour content ($n=3$, $p \leq 0.95$):
1 – native pumpkin seeds; 2 – native watermelon seeds; 3 – germinated pumpkin seeds;
4 – germinated watermelon seeds

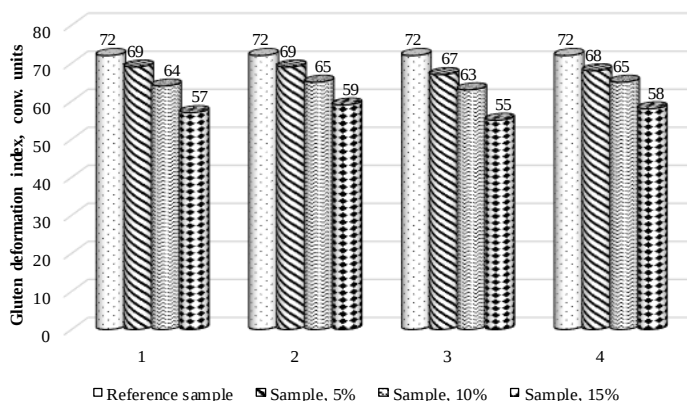


Fig. 2. Dependence of the gluten quality on the pumpkin seed flour content ($n=3$, $p \leq 0.95$):
1 – native pumpkin seeds; 2 – native watermelon seeds; 3 – germinated pumpkin seeds;
4 – germinated watermelon seeds

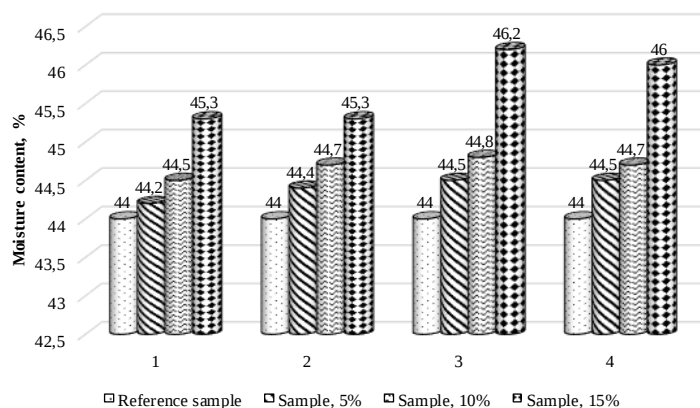


Fig. 3. Effect of adding pumpkin seed flour on the moisture content of the dough ($n=3$, $p \leq 0.95$):
 1 – native pumpkin seeds; 2 – native watermelon seeds; 3 – germinated pumpkin seeds;
 4 – germinated watermelon seeds

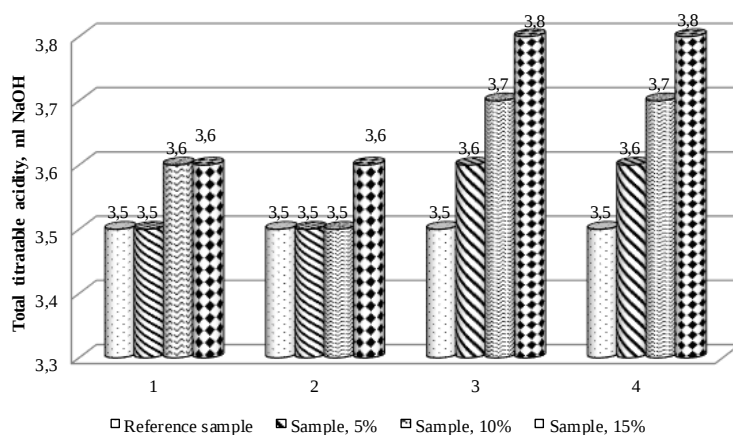


Fig. 4. Effect of adding pumpkin seed flour on the acidity of the dough ($n=3$, $p \leq 0.95$):
 1 – native pumpkin seeds; 2 – native watermelon seeds; 3 – germinated pumpkin seeds;
 4 – germinated watermelon seeds

Due to addition of 5 and 10% of flour from native and germinated pumpkin and watermelon seeds, the moisture content of the crumb changes by 0.1–0.4%, compared with the reference sample, and addition of 15% changes it by 0.8–2.1% (Table 2). The acidity of the crumb of the samples with additives differs from that of the reference sample within the error (0.1–0.4), which does not affect the taste of the finished products. The difference between the porosity of the crumb of the products with additives and of the reference sample is 1.7–4.5%. This difference is the biggest for the samples with 5% of germinated pumpkin seeds added (Table 2).

Thus, the results of determining the moisture level, acidity, and porosity of the crumb allow concluding that the addition of flour from native and germinated pumpkin seeds does not impair the properties of bread. The effect of the additive on the physicochemical quality characteristics has not been observed to depend on the plant species. Instead, there is a small correlation of changes in these properties from the dosage of the additives. There is also a relationship with the method of pre-treatment of seeds: the samples with germinated pumpkin and watermelon seeds have higher values of moisture and porosity of the crumb than the samples with native seeds do (Table 2).

The sensory evaluation of finished bread samples with the addition of 5%, 10%, and 15% of pumpkin seed flour, (Table 3) has shown that, by the total number of points, the best of the fortified samples of finished products were those with the addition of pumpkin seed flour in the amount of 5%. The samples of finished products with pumpkin seed flour added in the amount of 10% were rated 54.8 to 68.5, and the samples with 15% of the additive were rated 51.5 to 58.1, which corresponds to the average and satisfactory quality. At the same time, the organoleptic evaluation of the finished products with the addition of germinated pumpkin and watermelon seeds revealed that their taste and smell were below the consumer qualities of bread (Table 3).

According to the results of analysing the physicochemical and organoleptic quality indicators of finished fortified bread with pumpkin seeds added, the best samples corresponding to the consumer qualities of white bread are the samples containing 5% of flour from native pumpkin and watermelon seeds (Table 4). The values of the moisture content, acidity, and porosity of the crumb of the finished products do not differ significantly from those of the reference sample. This shows a minimum effect of adding 5% of

pumpkin seed flour on the mechanostuctural and chemical properties of the finished products. Therefore, this amount of additives can be considered the most practical.

Further studies consisted in calculating the effect of additives of native pumpkin and watermelon seed powder on the nutritional and calorific value of fortified bread (Table 5). Calculations were performed according to the recipe of bread and the chemical

composition of raw material components [16-18,32,33]. The chemical compositions of the main raw material in 100 g of bread *Urozhayny* [34] and fortified bread with pumpkin seed flour added are given in Table 5.

The results of calculations of the chemical composition and calorific value of bread are given in Tables 6, 7.

Table 2 – Summary indicators of the quality of the finished products (n=3, p≤0.95)

Parameter	Reference	Native pumpkin seeds			Native watermelon seeds			Germinated pumpkin seeds			Germinated watermelon seeds		
		5%	10%	15%	5%	10%	15%	5%	10%	15%	5%	10%	15%
Crumb moisture, %	43.2	43.4	43.4	44.4	43.1	43.3	44.0	43.6	43.7	45.3	43.3	43.5	44.8
Crumb acidity, ml	3.0	3.0	3.0	3.1	2.9	3.0	3.1	3.1	3.3	3.4	3.1	3.2	3.3
Crumb porosity, %	69.7	71.3	71.3	70.6	72.5	72.0	71.6	74.2	73.9	72.7	73.5	72.8	72.1

Table 3 – Results of sensory evaluation of the quality of finished products, point (n=5, p≤0.97)

Parameter	Reference	Native pumpkin seeds			Native watermelon seeds			Germinated pumpkin seeds			Germinated watermelon seeds		
		5%	10%	15%	5%	10%	15%	5%	10%	15%	5%	10%	15%
The shape of bread	20.0	16.0	16.0	16.0	20.0	16.0	16.0	20.0	16.0	16.0	20.0	16.0	16.0
The condition of the crust	16.5	16.5	9.9	9.9	16.5	16.5	13.2	16.5	16.5	13.2	16.5	16.5	13.2
The state of the crumb	16.5	16.5	9.9	6.6	16.5	13.2	13.2	16.5	13.2	13.2	16.5	13.2	13.2
Taste	20	8.0	4.0	4.0	16.5	9.9	6.6	10.0	6.0	4.0	8.0	4.0	4.0
Aroma	13.2	9.9	6.6	6.6	6.6	6.6	3.3	8.3	3.3	1.7	6.6	3.3	3.3
Freshness	10.5	8.4	8.4	8.4	8.4	6.3	6.3	8.4	8.4	7.4	8.4	8.4	8.4
Total score	96.7	75.3	54.8	51.5	84.5	68.5	58.6	79.7	63.4	55.5	76.0	61.4	58.1

Table 4 – Summary indicators of the quality of finished products (n=3, p≤0.95)

Quality parameter	Reference sample	With 5% of pumpkin seed flour added	With 5% of watermelon seed flour added
Crumb moisture, %	43.2	44.3	43.0
Crumb acidity, ml	3.1	3.2	3.1
Crumb porosity, %	69.7	71.3	72.5
Surface colour and condition	Smooth, even, light brown		
Colour and condition of the crumb	Light yellow, without traces of impurity, porosity is uniform		Light grey, without traces of impurity, porosity is uniform
Taste	Typical of this type of product	Typical of this type of product, with a bitterish aftertaste	Typical of this type of product
Smell	Typical of this type of product, without foreign odour		

Table 5 – Chemical composition of the main raw materials (100 g)

Raw material	Proteins, g	Lipids, g	Carbohydrates, g	Minerals, mg						Vitamins, mg		
				Na	K	Ca	Mg	P	Fe	B ₁	B ₂	PP
Top-grade wheat flour	10.3	0.9	74.2	10	122	18	16	86	1.2	0.17	0.08	1.2
Pressed yeast	12.5	0.4	8.3	19	560	27	64	385	3.1	0.60	0.68	11.4
Table salt	–	–	–	3741	15	485	97	–	10.0	–	–	–
Sunflower oil	–	99.8	–	–	–	–	–	–	–	–	–	–
Pumpkin seed flour	35.0	55.0	5.0	7	809	46	595	1	8.8	0.27	0.15	–
Watermelon seed flour	28.4	47.5	15.3	100	650	55	514	750	7.3	0.19	0.15	–

Table 6 – Calculated chemical composition of the samples*

Sample	Proteins, g	Lipids, g	Carbohydrates, g	Minerals, mg						Vitamins, mg		
				Na	K	Ca	Mg	P	Fe	B-1	B-2	PP
Reference sample	6.63	1.84	46.77	359.67	83.91	16.22	11.75	58.94	0.89	0.11	0.00	0.90
With 5% of pumpkin seed flour	7.15	3.06	44.60	386.87	99.14	16.56	25.46	56.39	2.94	0.11	0.06	0.86
With 5% of watermelon seed flour	6.82	2.38	45.83	352.22	89.92	16.49	17.83	66.73	0.94	0.12	0.08	0.90

Note. *Calculations of the chemical composition are made at natural humidity.

According to the results of calculations (Table 6), the addition of watermelon seed flour will potentially increase the amount of protein by 3%, and pumpkin seed flour will increase it by 7.8%. Fats increase, respectively, by 29% and 66%, and the carbohydrate content varies but slightly, by 0.2 and 0.5% respectively. The amount of almost all minerals increases, but the largest is the increase in iron in the sample with pumpkin seeds (230%), followed by magnesium (116%) and potassium (188%). As a result of adding watermelon seed flour, the mineral content increases, too, but not as significantly as with pumpkin seed flour added. Only the phosphorus content in this sample increased by 13%, compared with the sample with pumpkin seeds, where the increase in the phosphorus content was only 4.3%. The increase in the content of vitamins is not as significant as in the content of microelements.

Thus, in comparison with the reference sample made of top-grade wheat flour, the nutritional value of products made with the use of pumpkin and watermelon seed flour increases.

Comparison of the energy value of the reference sample and the samples with 5% of pumpkin seed flour added has shown that the highest calorific value, according to the calculations, is that of the sample with pumpkin seeds, where this parameter is by 80.4 kJ/100g higher than it is in the reference sample (Table 7).

Table 7 – Calculated calorific value of the samples of finished products (100 g)

Sample	Calorific value, kJ
Reference sample	1065.2
With 5% of pumpkin seed flour	1145.6
With 5% of watermelon seed flour	1102.5

Approbation of results. The results of the research have been implemented in the technology of the small enterprises JSC *Basis*, pizzeria No. 2, and the PE *Pit Stop* (T. Potapenko, Chernihiv). Expanding the range of bakery products of these enterprises by including foods enriched with micronutrients is of practical importance, since it increases consumer demand for healthy food products.

Conclusion

1. It has been established that the addition of flour from native and germinated pumpkin and watermelon

seeds in the quantities 5%, 10%, and 15% by weight of wheat flour leads to a decrease in the gluten content, as compared with the reference sample, while the elasticity of gluten increases by 3–23% respectively. This makes it reasonable to recommend pumpkin seed flour to improve low-gluten flour. The effect of adding flour from native and germinated pumpkin and watermelon seeds on the acidity of the crumb is insignificant and remains within the error. According to the sensory studies of the shape of the finished products, the condition of their crust, and the porosity of the crumb, the highest-rated samples are those with the addition of flour from all types of seeds in the amount of 5%. However, sensory evaluation of the finished products with germinated pumpkin and watermelon seeds added has revealed that their taste and smell are below the consumer qualities of bread. According to the results of physicochemical and sensory studies, the most practical amount has been established for the addition of flour from native pumpkin and watermelon seeds, which is 5% by weight of wheat flour.

2. The calculation of the chemical composition of the finished products enriched with the recommended doses of the additives under study (5%) has shown that as a result of adding watermelon seed flour, the amount of protein will increase by 3.0%, and that of pumpkin seed flour by 7.8%. The fat content in the samples with the addition of watermelon seeds will increase by 29%, and with the addition of pumpkin seeds by 66%. The content of most minerals will also increase, the highest will be the increase in the iron content of the sample with pumpkin seed flour (230%), followed by an increase in magnesium (116%) and potassium (188%). As a result of adding watermelon seed flour, the mineral content will not increase significantly, compared with the addition of pumpkin seed flour (the exception is the phosphorus content, which will increase by 13%).

3. Calculations of the calorific value of the reference sample and the samples with 5% of pumpkin and watermelon seed flour have shown that the highest calorific value is that of the sample enriched with native pumpkin seeds. Its calorific value is higher than the same parameter in the reference sample by 80.4 kJ/100g.

4. To manufacture bread products from yeast dough, the addition of flour from native pumpkin seeds can be recommended, as it can enrich finished products with the necessary micronutrients and increase their calorific value.

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ДОСЛІДЖЕННЯ ВПЛИВУ НАТИВНОГО ТА ПРОРОСЛОГО НАСІННЯ ГАРБУЗА І КАВУНА НА ЯКІСТЬ ТІСТА І ХЛІБА

О.Л. Гуменюк, кандидат хімічних наук, доцент, *E-mail: gum_ok@ukr.net*

Ж.В. Замай, кандидат технічних наук, доцент, *E-mail: zamaizhanna@gmail.com*

С.Д. Цибуля, доктор технічних наук, професор, *E-mail: stcibula@gmail.com*

О.Б. Хребтань, кандидат технічних наук, доцент, *E-mail: olenaborisovnahrebtan@gmail.com*

Р.М. Волкова, викладач, *E-mail: volkova6402@ukr.net*

кафедра харчових технологій

Національний університет «Чернігівська політехніка», вул. Шевченка, 95, м. Чернігів, Україна 14035

Анотація. У статті досліджено вплив нативного та пророслого насіння гарбуза і кавуна на якість напівфабрикатів та готових хлібних виробів. Нативне та проросле насіння, попередньо висушене та перемелене в борошно, використовували як добавку до хліба білого в кількості 5%, 10%, 15% до маси борошна. Добавки насіння гарбуза та кавуна вводили з метою збагачення хліба мікронутрієнтами. Встановлено, що додавання борошна з насіння гарбузових у кількостях 5%, 10% та 15% до маси пшеничного борошна приводить до зниження вмісту клейковини та збільшення її пружності. Досліджено, що добавка нативного насіння гарбузових не чинить суттєвого впливу на вологість, кислотність напівфабрикатів та готових виробів, а добавка з пророслого насіння – приводить до незначного зростання цих показників. Так, вологість м'якушки з додаванням нативного насіння гарбуза і кавуна зросла на 0,2–1,3% в порівнянні з контрольним зразком, а з добавкою борошна пророслого насіння – на 0,5–2,2%, кислотність м'якушки змінюється незначно – в межах похибки експерименту. За фізико-хімічними показниками якості напівфабрикатів та готових хлібних виробів раціональною кількістю добавок є 5% до маси пшеничного борошна. У результаті порівняльного аналізу впливу 5% добавки борошна нативного і пророслого насіння гарбуза та кавуна на органолептичні властивості хліба з'ясовано, що готові хлібні вироби з добавкою нативного насіння гарбузових відрізняються кращими смаковими і ольфактичними властивостями, ніж вироби з добавкою борошна пророслого насіння. Здійснено порівняльну характеристику харчової та енергетичної цінності контрольного зразка і хліба з добавкою 5% борошна насіння гарбуза та кавуна. З'ясовано, що добавка нативного насіння гарбуза призведе до збільшення вмісту таких мінеральних речовин як залізо – на 230%, магній – на 116%, калій – на 118%, а добавка нативного насіння кавуна – до зростання вмісту фосфору – на 13%. У результаті проведених досліджень показана перспективність використання борошна нативного насіння гарбуза і кавуна для фортифікації дріжджового хліба з борошна пшеничного вищого сорту.

Ключові слова: пшеничний хліб, фортифікація, нативне насіння гарбуза і кавуна, проросле насіння гарбуза і кавуна.

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