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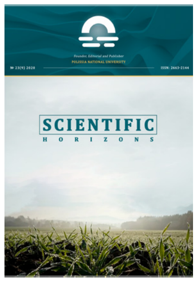

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Technological and Nutritional Benefits of Amaranth Groats in Breadmaking

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Abstract. To increase the nutritional value of wheat bread as a staple food using non-conventional wholesome floury ingredients should meet high expectations of consumers. The study was aimed to investigate the effect of amaranth groats application into breadmaking focused on the technological qualities and biological value of wheat bread enriched with onion powder and safflower oil. The influence of scalded amaranth groats on the bread quality was measured by technological, physical, chemical, instrumental, and computational methods analysing raw materials and developed products. The use of the amaranth grain-derived ingredient at 4-8% as a valuable plant source in the wheat bread formulations enhanced the product consumer characteristics. The proofing of dough of the developed formulations was intensified followed by 6-20% increase in the bread specific volume and better organoleptic properties of bread. Amaranth groats showed high amino acid score for lysine (156%), phenylalanine and tyrosine (125%), and scores for threonine, valine, and cysteine were 2-fold to wheat flour scarce in bioactive compounds. The developed wheat-amaranth bread had an improved amino acid composition due to an increase in the number of essential amino acids, a 2.6 times higher protein utility, contributing to its digestibility. The main factor in changing the fatty acid composition of the developed products was the introduction of safflower oil with a high content of linoleic acid into the product. Introduction of scalded amaranth groats into bread formulations with vegetable-based additives is promising way to attribute the product with therapeutic, and health-improving properties

Keywords: amaranth groats, scalding, safflower oil, onion powder, wheat bread, amino acid composition, fatty acid composition

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INTRODUCTION

Pseudo cereals, such as amaranth, have an exceptional nutritional as well as phytochemical profile with proteins of good balanced amino acid content. Due to the absence of gluten, these cereals can be included in the diet of people with gluten intolerance. Dietary fibre, vitamins, minerals, phenols, and other biologically active compounds found in pseudocereals have the potential to prevent chronic diseases such as cancer, diabetes, hypertension, and cardiovascular disease. Wheat bread is a staple food based on patent wheat flour, which is a reliable source of energy but not of high nutritional value. Thus, to explore the way of promoting health attributes of such staple food by using amaranth grain-derived products still underestimated in XXI century could be very beneficial for food value chain revaluation.

Baraniak & Kania-Dobrowolska (2022) highlight the presence of bioactive compounds in pseudocereals, and their great potential for diverse application in processed food, such as e.g. bakery products. Guardianelli *et al.* (2022) demonstrated that the nutritional properties of wheat flour can be improved through mixing with other functional ingredients, and amaranth grain-derived products added to wheat flour brings considerable health benefits to the nutritional value due to high protein content, rich in lysine, precious dietary fibre, and lipids composition.

Shevkani *et al.* (2022) state that amaranth flour adds a light-yellow grain-like colour to the composite flour, which is described as nutty, earthy, and grassy. Amaranth flour protein receives high quality marks due to its rich content of lysine and methionine. It is also recognized as one of the best proteins of plant origin which is close to the ideal protein. Studies conducted by Castro-Martínez *et al.* (2012) testify that amaranth is one of the leaders among plants in terms of the content of lysine, threonine, arginine, phenylalanine. In a two-year study, Hlinková *et al.* (2013) pointed out found that amaranth seeds were also rich in 77% polyunsaturated fatty acids content, considerably presented by linoleic acid as a source of arachidonic acid, which is used to the basis for the synthesis of prostaglandins in the body.

Amaranth proteins digestibility is close to the digestibility of proteins of animal origin. Amaranth exceeds conventional crops by content lysine and methionine. Alicia Martinez-Lopez *et al.* (2020) consider this plant is a source of fibre, polyunsaturated acids, phytosterols, phospholipids, squalene, vitamins C, E, PP, B2, B1, A, folate, macro- and microelements (sodium, magnesium, potassium, phosphorus, calcium, iron, copper), which are crucial for the optimal functioning of the digestive, immune, and endocrine systems, etc. The authors indicate that 700-80% of amaranth grain tocopherols are represented by β- and γ-tocopherols, 20.0-25.0% by δ-tocopherols, and 5.0-10.0% by α-tocopherols.

Nauman Khalid *et al.* (2017) investigated safflower oil as a source of magnesium, vitamins (B1, B2, PP, E, β-tocopherol), which contains carotenoids. The oil extracted from the kernels of safflower seeds has a bitter taste and a floral smell. In terms of the balanced composition of unsaturated fats, this oil is superior to sunflower oil and, moreover, suitable to be hydrogenated to margarine of the best quality (Xin *et al.*, 2022).

Prokopov *et al.* (2018) claim that onion powders in confectionery, dairy, bakery, and pasta formulations can enrich their techno-functional properties. Bae *et al.* (2003) presented data on the quality characteristics of wheat bread with the addition of 2-8% onion powder. The colour index of bread with onion powder had lower lightness and higher redness and yellowness than that of the control bread. The specific volume of the onion powder-added bread increased, and the texture measurement showed that hardness, springiness, stickiness, and chewiness decreased as the amount of onion powder added was enlarged. Masood *et al.* (2020) was aimed to improve the nutritional quality of bread by adding onion peel extract (OPE) and onion powder (OP) at 1-7% replacement of wheat flour. The obtained properties illustrate that onion powder can serve as a good flavour ingredient for baking wheat bread.

The purpose of this study is to evaluate the effect of scalded amaranth grains on techno-functionality and biological value of wheat bread enriched with onion powder and safflower oil. The purpose was fulfilled by solving the following tasks: to investigate the chemical composition, technological properties of amaranth groats; to assess the effect of scalded amaranth groats on the breadmaking; to evaluate organoleptic, physicochemical indicators of the quality of bread enriched with amaranth groats, onion powder and safflower oil; to estimate the biological value of the developed bread with scalded amaranth groats.

MATERIALS AND METHODS

The following types of raw materials were used for the study: wheat flour; amaranth flour; amaranth groats; onion powder; pressed bakery yeast and salt (Table 1). Water was added to the formulations to dough moisture content of 43.5%. The moisture content of raw materials was determined by the thermogravimetric method according to DSTU ISO 712:2015 (2015) using a SESH-3M drying oven, Ukraine. Whiteness was determined as the light reflation of flour with the use of RZ-BPL-CM, Ukraine, according to DSTU 26361:2019 (2019). The flour water absorption capacity was determined for 100 g of flour during dough kneading by ISO 17718:2013 method (2013). Falling number was analysed according to Perten method of ISO 3093:2009 (2009) with the use of PChP-99-2, Ukraine. Autolytic activity was determined as the ability of flour to form sugars during heating according to the DSTU 3016-95 (1995) method.

Table 1. *Bread with scalded amaranth groats and vegetable additives*

Sample	Quantity of raw materials in the recipe, g							
	Wheat flour	Scalded amaranth groats	Safflower oil	Onion powder	Sugar	Yeast	Salt	Water
1	600	0	18	24	24	18	9.6	365
2	600	72	18	24	24	18	9.6	312
3	600	144	18	24	24	18	9.6	259
4	600	216	18	24	24	18	9.6	206
5	600	288	18	24	24	18	9.6	153
6	600	360	18	24	24	18	9.6	100

Source: *compiled by the authors*

Baking loss of the bread was determined as the ratio of the weight of the bread removed from the oven, to the weight of the bread after 4 hours of storage at room temperature, expressed in %. Drying loss was measured as the ratio of the weight of the bread after 4 hours of storage at room temperature, to the weight of the bread after 24 hours of storage at room temperature, expressed in %. Bread shape stability was determined as the ratio of height to width of the central part of the loaf. Bread specific volume was analysed by millet seed replacement method according to AACC 10-05.01 (2000). Bread crumb porosity was determined using Zhuravlov's device (Hlinková *et al*., 2013). Staleness of the bread was assessed during three days of storage of the loaves at room temperature. Moisture content of the crumb was analysed by the thermogravimetric method as the weight loss of 5 g of crushed bread crumb from the central part of the loaf according to AACC 44-15.02 (1999). Water absorption capacity of the crumb was determined as the amount of water absorbed by the crushed crumb, g per g of the dry crumb. Organoleptic properties of bread samples were analysed by a panel of experts by the following indicators: crust colour and smoothness; crumb colour, porosity structure, and rheological properties; aroma, taste, and chewiness of crumb, expressed in a five-point scale. The acidity of the bread crumb was determined by the titrimetric method (DSTU 7045:2009, 2009).

Crude protein content was analysed by the Kjeldahl method (DSTU 7169:2010, 2011). Crude fat content was determined by the Soxhlet method (ISO 6492:1999, 1999). Crude fibre content was analysed by sequential solvent extraction (ISO 6865:2000, 2000). Crude ash content was determined by burning the sample in a muffle furnace according to ISO 5984:2002 (2002). Carbohydrate content was calculated according to FAO recommendations. The amino acid composition was determined by ion-exchange liquid column chromatography on amino acid analyser T 339 (Mikrotechna, Czech Republic). Total protein utility, amino acid composition difference coefficient (AACDC) and protein utility (PU) were calculated by the method presented by Martinez-Lopez *et al*., 2020.

The fatty acid composition of flour and bread samples was determined by gas chromatography on Agilent 6890B (Agilent Technologies, USA), equipped with the flame ionization detector (FID) and HP-Innowax capillary column. Experiments were performed in 3-5-fold repetition.

RESULTS AND DISCUSSION

Table 2 demonstrates that the amaranth flour presented the lowest moisture content of 10%, while the onion powder had the lowest whiteness. The highest falling number was represented by wheat flour (610 s), which needed to be increased for optimising the dough rheological characteristics, through mixing with such ingredients as the amaranth grain-derived products. Water absorption capacity of the studied samples was related to the particle size distribution and chemical composition, varying between 144% (amaranth flour) to 500% (onion powder).

Table 2. *Technological properties of composite flour ingredients*

Ingredient	Moisture content, %	Whiteness, c.u.	Water absorption capacity, %	Falling number, s	Autolytic activity, %
Wheat flour	14.5 ± 0.2	61.6 ± 0.1	184.0 ± 11.3	610.1 ± 9.9	31.6 ± 0.2
Amaranth flour	10 ± 0.1	19.3 ± 0.1	224.1 ± 12.1	70.5 ± 2.1	30.6 ± 0.2
Amaranth groats	11.8 ± 0.3	22.9 ± 0.1	144.0 ± 9.1	61.1 ± 0.9	17.1 ± 0.2
Onion powder	12.5 ± 0.2	11.8 ± 0.1	500.2 ± 15.3	426.5 ± 10.6	34.3 ± 0.2

Source: *compiled by the authors*

Figure 1 presents the developed samples of wheat bread with scalded amaranth groats enriched with onion powder and safflower oil, when the technological characteristics of the samples are demonstrated by Figure 2.

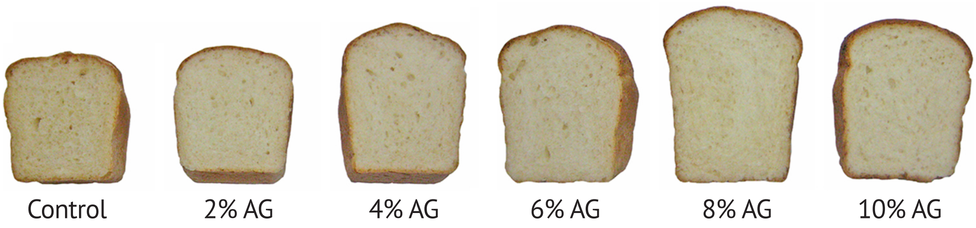

***Figure 1**. Wheat bread with scalded amaranth groats (%), enriched with onion powder and safflower oil*
***Source:** photographed by the authors*

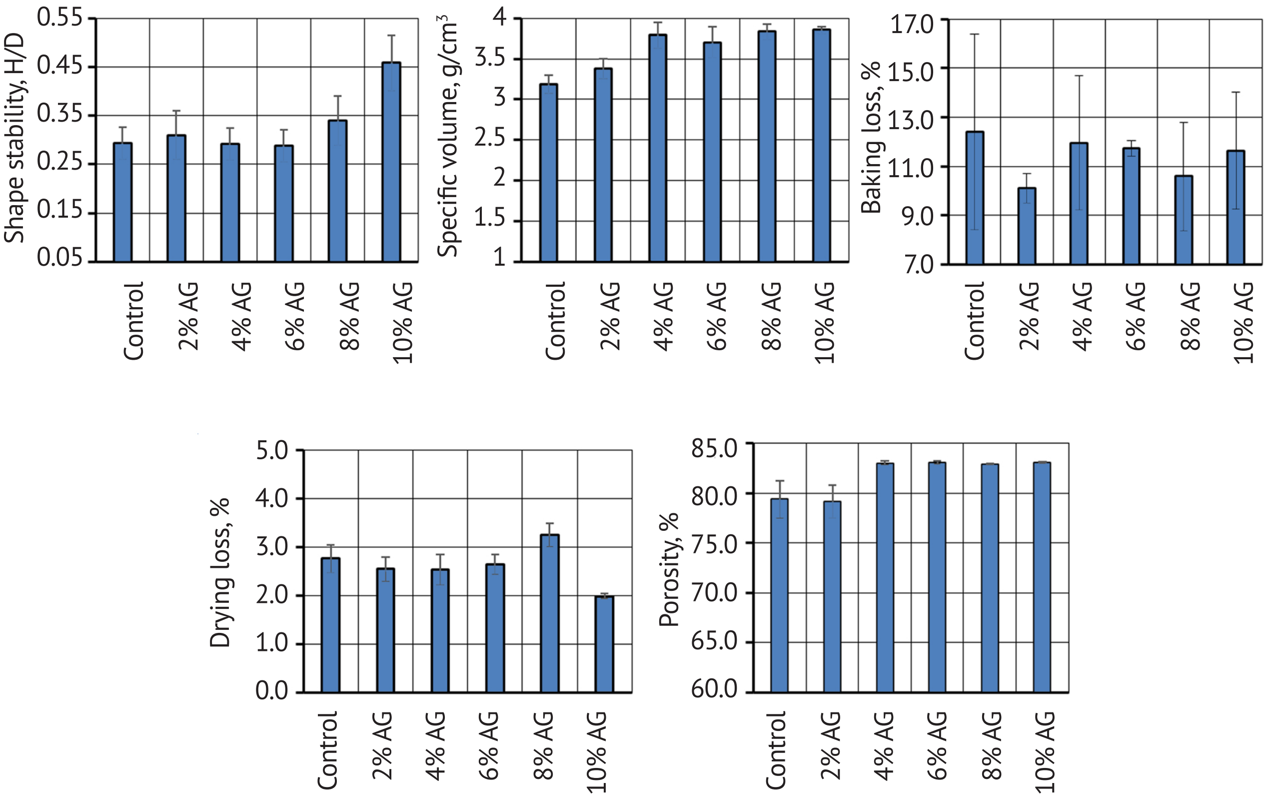

***Figure 2**. Technological characteristics of wheat bread with scalded amaranth groats (%)*
***Source:** compiled by the authors*

Application of scalded amaranth groats into the wheat bread formulations led to a specific volume increase of 1.06-1.2 times with improved crumb colour, taste and aroma of bread. Also, the use of scalded amaranth groats as an ingredient in the bread formulations promoted 5% higher porosity of the products. Taking into account the change in the dough rheological characteristics, shape stability of the loaves increased drastically when 10% of scalded amaranth groats were introduced to the product. Crumb acidity of the samples with 8-10% of the amaranth grain-derived ingredient was slightly lowered in comparison to the control sample due to speedy proofing of the dough. Thus, scalded amaranth groats application intensified the wheat dough fermentation which is in agreement with higher falling number of amaranth groats (Table 2). Considering the obtained effects, scalded amaranth groats could be a promising ingredient of the wheat bread at 4-8% amaranth groats content to the wheat flour in the formulation.

Moisture content and water absorption capacity of the bread crumb tend to decrease with the loosing of bread freshness indicating its staling. The scalded amaranth groats application contributed to retaining more water by the bread crumb (Fig. 3) with an effect predominately on water absorption capacity of the crumb at 2-6% scalded amaranth groats after 3 days of storage.

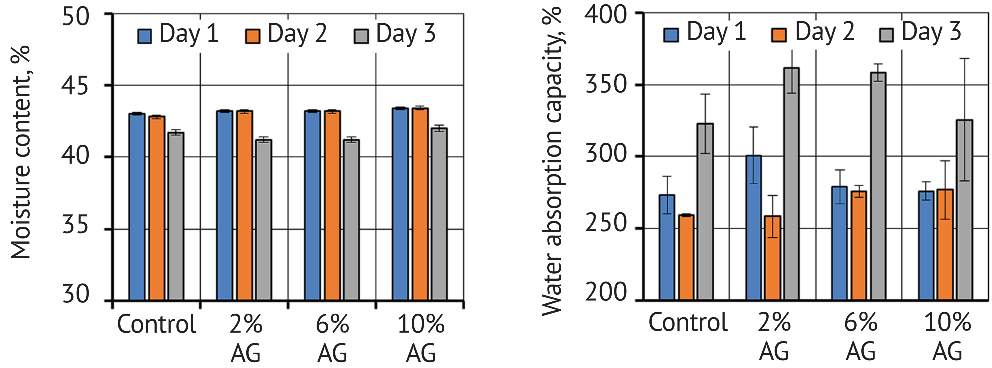

Figure 3. *Effect of scalded amaranth groats (%) of freshness of wheat bread*
Source: *compiled by the authors*

Table 3 shows the chemical composition of wheat patent flour, amaranth groats, and the bread made with their use following the developed formulations including onion powder and safflower oil (Table 1). Such a combination of the ingredients has the potential to enrich the product with biologically active compounds providing the quality of the product, which could meet the high expectations of consumers. The last, but not least benefit of using amaranth grain-derived products is related to its sustainability as a drought and pest-resistant crop capable to withstand climate change and global warming issues.

Table 3*. Nutritional profile of amaranth groats and wheat bread enriched with scalded amaranth groats, onion powder and safflower oil*

Indicator	Wheat flour	Amaranth groats	Wheat bread with onion powder and safflower oil	Wheat bread with scalded amaranth groats, onion powder and safflower oil
Crude protein, %	12.01 ± 0.22	3.68 ± 0.22	12.01 ± 0.16	11.46 ± 0.12
Crude fat, %	1.82 ± 0.07	0.94 ± 0.06	1.55 ± 0.20	1.22 ± 0.17
Crude fibre, %	0.18 ± 0.02	0.06 ± 0.02	0.24 ± 0.01	0.23 ± 0.01
Crude ash, %	0.64 ± 0.02	0.89 ± 0.18	2.37 ± 0.13	2.15 ± 0.08
Carbohydrate content, %	85.35 ± 0.43	94.42 ± 0.40	83.83 ± 0.58	84.94 ± 0.04

Source: *compiled by the authors*

Compared to wheat patent flour which is scarce in bioactive compounds, amaranth groats as an ingredient for breadmaking showed 4-fold less crude protein content, 2-3-fold less crude fat and fibre, but higher by 10-50% total carbohydrates and ash content. This is related to the distribution of nutrients in the amaranth grain and thus, amaranth groats with removed fatty and proteinous otter part of the seed during processing demonstrated mostly starchy perisperm with well-distributed essential mineral elements. To be emphasized, amaranth groats introduction to the wheat bread formulations could bring benefits to the consumer characteristics of the wheat bread, and make the application of other non-traditional ingredients, which are prone to deteriorate the quality of the product, an appropriate option. Therefore, to determine the nutritional profile of the bread, the developed formulations with onion powder and safflower oil were used combined with 8% of scalded amaranth groats.

Only the difference in the chemical composition of the experimental and control sample of bread is statistically significant for the content of crude protein, which decreases by 5% for the experimental sample, and available carbohydrates, which increases by 1%. As Figure 4 shows, wheat flour has an inferior amino acid composition, while the limiting essential amino acids are isoleucine and valine.

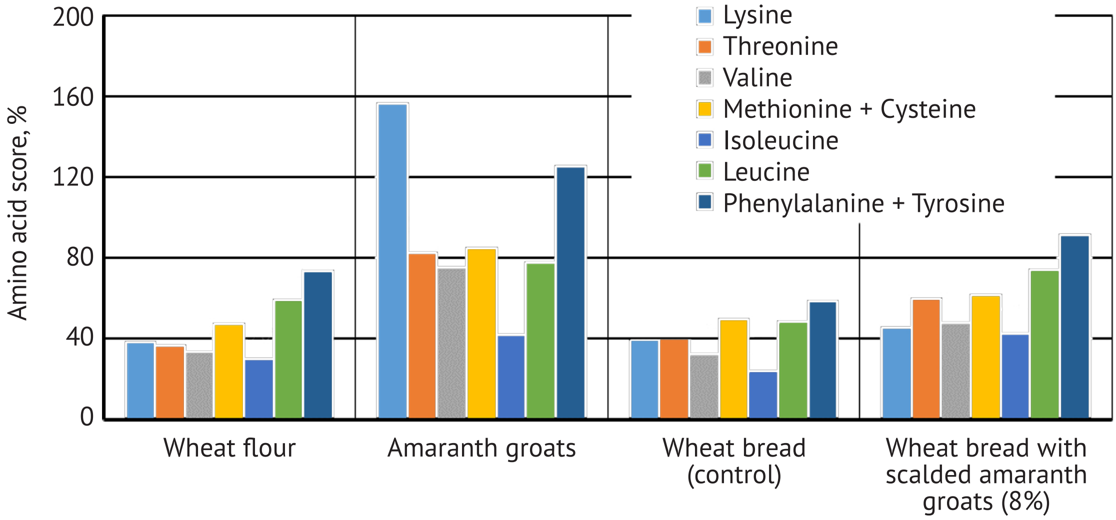

Figure 4*. Amino acid composition of the used raw materials and developed wheat bread with different dosages of amaranth groats and onion powder (control and experiment)*
Source: *compiled by the authors*

The amino acid composition of raw materials and bread made according to the developed recipe and technology was studied (Fig. 5). Amaranth groats differ substantially in their very high content of lysine (156%), phenylalanine and tyrosine (125%) relative to ideal protein and to wheat flour. Therewith, the contents of threonine, valine, methionine, and cysteine in amaranth groats are twice as high as for wheat flour, and are 75-85%. Limiting are isoleucine and valine, as for wheat flour, but their crusts are much higher. Even though the rates of all essential amino acids are higher for amaranth groats in raw form, the difference coefficient of the amino acid rate is higher, the biological value is lower, as well as the utility of the protein, so the use of the groats requires its hydrothermal treatment to balance the amino acid score (Fig. 5, Table 4).

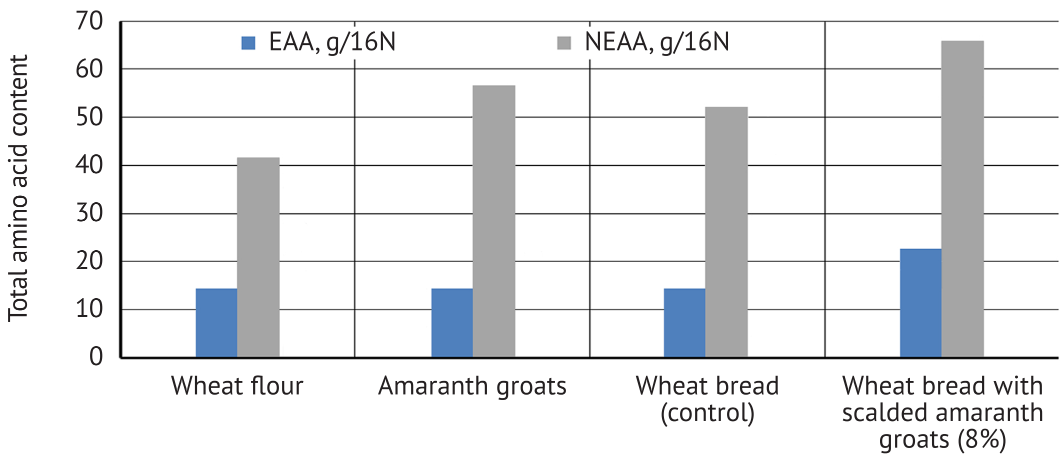

Figure 5*. Amino acid composition of raw materials and bread made according to the developed recipe and technology*
Source: *compiled by the authors*

Table 4*. Amino acid composition of raw materials and developed functional bread*

Amino acid	Control (wheat flour)		Amaranth groats		Wheat bread (control)		Wheat bread with scalded amaranthgroats (8%)	
	AG g/100 g protein	Score, %	AG g/100 g protein	Score, %	AG g/100 g protein	Score, %	AG g/100 g protein	Score, %
Lysine	2.12	39	8.59	156	2.17	39	2.51	46
Histidine	1.07	–	2.49	–	1.16	–	1.46	–

Table 4, Continued

Amino acid	Control (wheat flour)		Amaranth groats		Wheat bread (control)		Wheat bread with scalded amaranthgroats (8%)	
	AG g/100 g protein	Score, %	AG g/100 g protein	Score, %	AG g/100 g protein	Score, %	AG g/100 g protein	Score, %
Arginine	2.54	–	14.46	–	1.66	–	2.78	–
Aspartic acid	2.25	–	8.97	–	2.79	–	3.26	–
Threonine	1.47	37	3.30	82	1.60	40	2.40	60
Serine	3.02	–	4.36	–	3.25	–	4.17	–
Glutamic acid	23.05	–	10.24	–	24.29	–	30.35	–
Proline	7.64	–	6.82	–	8.71	–	9.93	–
Glycine	2.54	–	5.96	–	2.53	–	3.31	–
Alanine	2.11	–	5.87	–	1.80	–	2.75	–
Valine	1.68	34	3.76	75	1.64	33	2.41	48
Meteonin + + cystine	1.66	47	2.98	85	1.73	50	2.15	62
Isoleucine	1.20	30	1.67	42	0.96	24	1.71	43
Leucine	4.14	59	5.44	78	3.41	49	5.21	74
Phenylalanine + + Tyrosine	4.42	74	7.52	125	3.53	59	5.50	92
Total EAA	16.69		33.27		15.03		21.89	
Biological value of protein								
Total protein utility	0.63		0.44		0.56		0.68	
AACDC, %	15.47		50.14		17.90		17.77	
BV, %	84.53		49.86		82.10		82.23	

Source: *compiled by the authors*

As Figure 5 shows, according to all indicators, the control and experimental samples of the developed wheat bread with different dosages of amaranth groats and onion powder differ in the biological value of protein in favour of the latter. The values of essential amino acids increase by 1.1-1.45 times compared to the control without amaranth cereals and the protein utility in the product increases by 2.6 times, which indicates an increase in its digestibility by the human body when using developed bread.

Lipids as fatty acids and their derivatives, as well as substances biosynthetically or functionally related to these compounds in the raw material and developed wheat bread with different dosages of amaranth groats and onion powder are presented in Table 5.

Table 5*. Fatty acid composition of flour raw materials and bread*

Fatty acid Wheat flour		Sample			
		Wheat flour	Amaranth groats	Onion bread with safflower oil	Onion bread with safflower oil and amaranth groats
C8:0	Caprylic	0.01	0.02	0.01	traces
C9:0	Pelargonic	–	0.01	traces	–
C10:0	Capric	–	0.03	0.01	traces
C11:0	Undecylic	–	0.03	0.01	0.01
C12:0	Isolauric	–	0.01	traces	–
C12:0	Lauric	0.03	0.37	0.04	0.02
C12:1	Lauroleic	–	0.05	0.01	–
C13:0	Tridecylic	–	0.13	0.01	–
C14:0	Myristic	0.13	0.88	0.29	0.21

Table 5, Continued

Fatty acid Wheat flour		Sample			
		Wheat flour	Amaranth groats	Onion bread with safflower oil	Onion bread with safflower oil and amaranth groats
C14:1	Myristoleic	0.02	0.38	0.02	0.04
C14:2	Tetradecadienoic	–	0.05	–	–
C15:0	Pentadecylic	0.07	0.19	0.11	–
C16:0	Isopalmitic	–	0.15	0.06	–
C16:0	Palmitic	23.82	22.48	18.84	16.61
C16:1	Palmitoleic	0.29	0.89	0.64	0.45
C17:0	Margaric	0.13	0.70	0.27	0.08
C17:1	Heptadecenic	0.05	0.21	0.09	0.03
C18:0	Isostearic	–	0.40	–	–
C18:0	Stearic	1.87	3.88	5.99	4.59
C18:1	Oleic	18.15	31.35	25.58	24.63
C18:2	Linoleic	49.85	30.87	41.61	49.30
C18:3	Linolenic	2.58	0.44	1.58	0.96
C20:0	Arachidic	0.30	0.50	0.93	0.62
C20:1	Gondoic	0.61	0.52	0.72	0.45
C21:0	Heneicosylic	0.08	0.12	0.46	0.05
C20:2	Eicosadienoic	0.79	–	0.48	0.55
C20:4	Arachidonic	0.64	2.01	1.14	0.67
C22:0	Docosanoic	0.14	1.05	0.28	0.23
C22:3	Docosatrienic	0.06	0.30	0.04	0.02
C22:5	Docosapentaenoic	0.36	–	0.40	0.25
C22:6	Docosahexaenoic	0.03	–	0.38	0.19
C22:6	Docosahexaenoic	–	1.40	–	–

Source: *compiled by the authors*

Free fatty acids (Table 6), and especially linoleic and linolenic acids, take part in the absorption of oxygen. It is assumed that the mechanism of these processes is the oxidation of free linoleic and linolenic acids of flour with the combined oxidation of sulfhydryl groups of gluten. Aerobic mixing of flour and water results in the loss of free fatty acids within 10 min, but not the loss of other nonphosphorus lipids. Losses of free fatty acids can occur through lipoxidase oxidation of essential fatty acids and concomitant enzymatic oxidation of free fatty acids (Mercier & Gélinas, 2001).

Table 6*. Features of the fatty acid composition of raw materials and bread with amaranth groats (8%) and vegetable additives*

Fatty acid spectrum indicator	Wheat flour	Amaranth groats	Bread enriched with onion powder and safflower oil	Bread enriched with amaranth groats, onion powder and safflower oil	Safflower oil
Saturated	26.57	30.95	27.32	22.44	8.10
Monounsaturated	19.11	33.40	27.06	25.58	11.20
Polyunsaturated	54.32	35.27	45.62	51.95	80.70
Unsaturated: saturated	2.76	2.22	2.66	3.45	11.35
Essential	1.15		0.88	0.80	–
Omega-3	4.40	3.85	3.97	2.63	0.30
Omega-6	49.91	31.42	41.65	49.32	80.40
Omega 6:3	11.33	8.17	10.49	18.77	268.00
Omega-9	19.11	33.40	27.06	25.61	11.20

Source: *compiled by the authors*

The obtained results from Table 6 are consistent with the data presented by Aliieva *et al.* (2022) and Ruyvaran *et al.* (2022), where the authors indicate that the use of amaranth grain processing products, namely amaranth groats, can have technological advantages along with increasing the biological value of bread with their use.

Thakur *et al.* (2022) conducted a study of grinding gluten-free amaranth grain into flour for nutrient composition, antinutrients, total and bioavailable minerals, fatty acids and amino acids, acid profile and functional properties of the flour. It was found that the fine fraction, which is 44% of the total amount of amaranth flour, contains more protein (19.7%), fat (8.54%), minerals (3.46%) and dietary fibre content (20.09%), as well as a higher total amino acid content with lysine as the main essential amino acid. The content of linoleic acid in fine flour was (44.8%). Coarsely ground flour was dominated by linoleic acid (37.2-44.8%), which is a polyunsaturated fatty acid, oleic acid (27.9-29.4%), and palmitic acid by (26.5-29.6%). Differentially sifted flour of amaranth grain fractions showed a wide distribution of nutrients and of the finely dispersed fraction. In this way, to compensate for the loss of free fatty acids in wheat flour during the production of bread, Guardianelli *et al.* (2022) suggested the use of amaranth flour with the indicated content of nutrients, including free fatty acids.

Ballester-Sánchez *et al.* (2019) proved that wheat flour has a very low falling number, indicating low alpha-amylase activity. In turn, Saubhik (2016) claimed that amaranth flour and amaranth groats have highly active alpha-amylase, which together with wheat flour will activate the dough ripening processes due to the breakdown of starch and the initiation of the release of sufficient maltose to feed the yeast. The lowest autolytic activity is inherent in amaranth groats.

Wolosik & Markowska (2019) analysed onion powder and proved that it has anti-inflammatory and decontaminating properties; even after baking, onion powder has a considerable part of useful substances. The paper (Castro-Martínez, 2012) examines the nature and biological activity of onion thiosulphinates, as well as their potential value as food preservatives for preserving food and extending its shelf life, and their effectiveness as food preservatives and chemical substitutes.

Comparing the research presented in this paper with the results known from individual literature sources, one can draw several important conclusions that reflect the further research prospects started by the authors to create fundamentally new varieties of wheat bread enriched with useful components of amaranth groats and plant additives. Firstly, the favourable increase in the total number of drops of the composition of wheat and amaranth flour leads to the achievement of the creation of high-quality consumer bread with high physical and chemical component indicators, which ultimately cannot but attract a wide range of Ukrainian consumers of the product with preventive and curative properties. Secondly, the saturation of developed varieties of wheat bread, enriched by adding amaranth groats and plant additives with a sufficient amount of useful minerals, vitamins, flavour enhancers due to high-quality lipid components can create the conditions for placing such bread products in the range of the greatest consumer demand, provided effective management and quality control production. Thirdly, an attractive, readily available raw material environment will have a favourable effect on the improved production technology of a qualitatively new mass consumption product without any conversion of technological lines to produce new types of bread.

CONCLUSIONS

It was established that the use of amaranth groats as a component of wheat bread, provided that it is hydrothermally processed and introduced into the dough recipe in the form of porridge, leads to the improvement of the technological properties of semifinished products during the ripening of the products and gives the products improved technological qualities. The use of amaranth groats as an ingredient in the recipe of bread enriched with onion powder and safflower oil substantially affects the growth of the dimensional stability of bread from 0.25 to 0.45, the increase in the specific volume of products by 6-20% and its porosity by 5%, subject to improvement the colour of the pulp, a more pronounced taste and aroma of bread with a slight decrease in the acidity of the pulp. The optimal introduction of amaranth groats in the form of porridge to the recipe of bread with onion powder and safflower oil is 4-8% by weight of wheat flour.

Amaranth groats differ substantially in their high content of lysine (156%), phenylalanine, and tyrosine (125%) relative to the amino acid scores of wheat flour. Therewith, the contents of threonine, valine, metheonine, and cysteine in amaranth groats are twice as high as for wheat flour, and amount to 75-85%. Bread made according to the developed recipes with amaranth groats has a rate of essential amino acids 1.1-1.45 times higher than for the developed bread without amaranth groats, and 2.6 times higher protein utility in the product, which indicates an increase in its digestibility by the human body when using the developed bread.

Considering the fatty acid composition of the product, the proven improvement of the amino acid composition of the products as a result of enrichment with all essential amino acids and the growth of protein utility, the developed recipe and technologies are promising for introduction at enterprises of various power levels, which allows them to produce more competitive health products.

To increase the functional status of the developed bread with amaranth groats and plant additives in towards their enrichment with organic acids and increase the assimilation of essential metals that are part of amaranth grain processing products, further research aimed at the development of bread based on sour-milk sourdough of spontaneous fermentation is relevant.

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Технологічні та харчові переваги крупи амаранту в хлібопеченні

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Анотація. Підвищення біологічної цінності пшеничного хліба за рахунок використання нетрадиційної борошняної сировини, багатої на біологічно цінні компоненти, як продукту масового споживання має відповідати вимогам високої якості його споживчих властивостей. Мета роботи – дослідження впливу амарантової крупи на технологічні якості і біологічну цінність пшеничного хліба, збагаченого такими рослинними добавками, як цибулевий порошок і сафлорова олія. Вплив амарантової крупи на формування якості хліба визначали шляхом використання технологічних, фізичних, хімічних, інструментальних і розрахункових методів аналізу сировини і розроблених виробів. Застосування продуктів переробки зерна амаранту і сафлору як цінної продовольчої рослинної сировини у рецептурі пшеничного хліба призводило до поліпшення споживчих якостей хліба за умови 4–8 % введення амарантової крупи. Забезпечення інтенсифікації дозрівання тістових напівфабрикатів супроводжувалося поліпшенням органолептичних властивостей виробів, 6–20 % зростанням питомого об'єму. Встановлено, що амарантова крупа мала високий амінокислотний скор за лізином (156 %), феніналаніном і тирозином (125 %), а скори за треоніном, валіном і цистеїном були удвічі вищими порівняно з пшеничним борошном, збідненим на біологічно цінні речовини. Розроблений пшенично-амарантовий хліб мав поліпшений амінокислотний склад за рахунок зростання скорів незамінних амінокислот, у 2,6 разів вищої утилітарності білку, що може сприяти його засвоюваності. Основним чинником зміни жирнокислотного складу виробів виступало введення до складу продукту сафлорової олії з високим вмістом лінолевої кислоти. Практична цінність роботи визначається тим, що такий хліб має всі ознаки профілактично-лікувального і оздоровчого продукту

Ключові слова: амарантова крупа, заварювання, сафлорова олія, цибулевий порошок, пшеничний хліб, амінокислотний склад, жирнокислотний склад