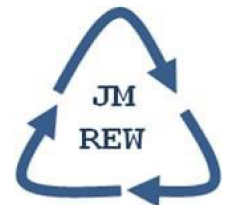




MINISTRY OF EDUCATION
AND SCIENCE OF UKRAINE
NATIONAL UNIVERSITY
OF FOOD TECHNOLOGIES
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EUROPEAN STUDIES PLATFORM



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EUROPEAN DIMENSIONS OF
SUSTAINABLE DEVELOPMENT



MAY 15-17, 2024, KYIV

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ENRICHMENT OF WHOLE GRAIN BREAD WITH HERBAL ADDITIVES

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A comparative assessment of the chemical composition of whole grain and hemp flour was carried out. We investigated the organoleptic parameters of sweet potato fruits and puree from it, as well as the chemical composition of the specified raw materials. We researched the influence of hemp flour and sweet potato puree on physico-chemical quality indicators of dough and whole grain bread. The dough was kneaded using a steamless method from wheat whole-grain flour with the addition of hemp flour in an amount of 4-10% and sweet potato puree – 2-8 %. Enrichment of whole wheat bread with hemp flour and sweet potato puree does not impair the porosity structure of products. If hemp flour is added in an amount of 4-8%, and sweet potato puree in an amount of 2-6%, the taste and aroma remain not only acceptable, but also acquire a pleasant light shade of enrichers. Whole grain bread enriched with hemp flour and sweet potato puree is a functional food product. It was found that the degree of provision of daily demand for macro- and micronutrients, adult population of the first group of intensity, due to the consumption of 100 g of whole grain bread enriched with hemp flour is: proteins – 15 %, fats – 3.1 %, carbohydrates – 15.6 %, dietary fiber – 11 %; vitamins: E – 18 %, β -carotene – 11.5 %, B₁ – 17 %, B₂ – 5.8 %.

Keywords: whole wheat flour, sweet potato puree, hemp flour, protein, nutritional value, vitamins

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Introduction

Today, in all progressive countries of the world, as well as in Ukraine, the current issue is the development of innovative types of food for health, functional and therapeutic and preventive purposes. The expansion of the raw material base and the use of non-traditional sources of biologically active compounds that contribute to the increase of the food and biological value of the finished products, in particular bread-bakery products, is an urgent task of food industry technologists.

Bread and bakery products are in high consumer demand in all social segments of the population and are prominent in the food diet. It is known that in the process of production, varietal types of flour lose a significant share of valuable micronutrients, which are contained in the peripheral parts of the grain and removed when grinding. Therefore, it is advisable to increase the use of whole grain flour in the technology of bread-bakery products, as well as the use of promising natural enrichers, in particular herbal raw materials, which are the source of the necessary nutrients.

Both domestic and foreign scientists are engaged in the enrichment of bread products with hemp processing products.

The influence of hemp flour on rheological properties of wheat dough and quality of finished products under condition of hemp/wheat flour ratio (0/100, 5/95, 10/90 and 20/80) is investigated. It was found that hemp flour influenced the absorption of water and the time of dough development, the specific volume of bread, the color and structural and textural properties of bread crumbs depending on the level of substitution. Bread supplemented with hemp flour had better nutrition, increased protein content and macro- and micronutrients, especially iron, compared to traditional bread (Pojić et al., 2015).

They note a significant improvement in the nutritional value of bread when adding hemp flour: products contain more proteins by 27.4%, fats – by 200.8%; dietary fiber by 497.2% compared to non-additive controls (Lukin et al., 2017).

It has been found that the addition of raw hemp flour to wheat flour in an amount of up to 20% and fried hemp flour up to 15% increases the content of minerals, protein, fat, phenolic compounds, as well as the value of antioxidant activity of confectionery products (Ertash et al., 2020).

Hemp seeds and flour is potential ingredient for protein enrichment of gluten-free raw materials in the production of bread-bakery products. Adding hemp seeds to sourdough increases the concentration of antimicrobial compounds, improves the nutritional value and organoleptic of the finished bread (Nissen et al., 2020).

Vegetable and fruit and berry raw materials, as well as its processing products, are used to enrich functional food products (Bashta et al., 2020). The addition of vegetable purees in an amount of 5 to 25% to the recipe composition of bread significantly improves the quality of raw gluten, increases the organoleptic and nutritional properties of the finished products, increases the content of phenolic compounds and folic acid in the finished products (Czarnowska-Kujawska, 2022; Bayramov et al., 2022). The use of vegetable purees, which contains dietary fibers that sorption heavy metals, in particular lead cations, cadmium, (Bazhay-Zhezherun et al., Guo et al., 2022) in the technology of mass consumption products and, in particular, bread, is an actual issue.

One of the promising types of vegetables is batat, or sweet potato (*Ipomoea batatas L.* - Lam.) is a perennial herbaceous plant. Comes from South America. One of the most common food and feed crops in the world. More than 7,000 varieties of sweet potato are currently known worldwide (Escobar-Puentes et al., 2022).

The sweet potato is grown en masse in the hot heat belt, southern and eastern Asia. Production leaders: China, Latin America. In our country, sweet potato began to be cultivated from the 30s of the last century, in the southern regions. Now in Ukraine, sweet potato is grown on homesteads and small farms.

Sweet potato tubers are consumed raw, baked, fried, boiled and canned, processed into starch, molasses.

Sweet potato is characterized by a high content of ascorbic acid, beta-carotene, pyridoxine. Scientists have studied that due to the rich polyphenol composition, when consuming sweet potato, oxidative stress and inflammation of an acute and chronic nature in the human body are mitigated. Sweet potato contains a significant amount of antioxidants, has a high therapeutic potential and can be recommended as an anti-inflammatory and anti-arthritis agent (Cartabiano Leite et al., 2020).

In the literature there is data on the use of vegetable puree (E. Bayramov et al., 2022; Ebrahimi Met al., 2022), for enriching bread with bioavailable phenols and natural sorbents. The influence of the addition of sweet potato puree and orange pulp on the physico-chemical and microbiological parameters of wheat bread is investigated.

However, there are no studies on the possibility of complex use of natural enrichers: sweet potato purees and hemp flour for the production of wheat bread for health purposes.

The purpose of the work is to substantiate the feasibility of inclusion in the recipe of whole wheat bread of high-protein raw materials – hemp flour and sweet potato puree, as a source of antioxidant compounds and natural sorbents to increase the nutritional value of the finished product.

Materials and Methods

During the experimental researches, root crops of the Vinnytsia pink sweet potato variety, zoned in the Kyiv region, were used; whole wheat and hemp flour, made samples of bread.

The moisture of the test samples was determined by drying to a constant mass at a temperature of 105°C. Protein content was determined by Bradford (Carlsson et al., 2011). The amount of starch was determined by the polarimetric method (International Standard ISO 10520:1997). Fat was determined by exhaustive extraction with chemically pure hexane (Erickson, 2005).

Vitamin E was determined by a method based on the formation of quinones during the oxidation of tocopherol molecules extracted from the test product by chloric iron. Chlorine iron is reduced to chloride, the amount of which is determined by the intensity of color during the addition of orthophenanthroline (Gamna, 2021).

Vitamin C content of vitamin C was determined by titrometric method, which is based on extraction of vitamin C from the test sample with a solution of acid (hydrochloric, metaphosphoric or a mixture of acetic and metaphosphoric) followed by titration visually or potentiometrically with a solution of 2,6-dichlorophenoline sodium phenolate (Majidi et al.) Vitamin P (rutin) was determined by spectrophotometric method (Dong et al., 2020); β -carotene were determined by spectrophotometric methods (Biehler et al., 2009); the content of phenolic compounds were determined by spectrophotometric method (Waterhouse, 2002). The vitamin content was B₁, B₂ determined fluorometrically (Zajicek J.L. et al., 2005).

To determine the content of pectin, a weight calcium-pectate method was used, which includes hydrolysis of pectin substances to pectin acids, their precipitation in the form of calcium salts, drying and weighing (Chandel et al., 2022).

The determination of the mass fraction of fiber was based on the decomposition of all other organic substances with concentrated nitric acid in mixture with acetic and trichloroacetic acids (Möller et al., 2008).

The preparation of sweet potato puree included washing of raw materials, cleaning, cutting into pieces, blanching, wiping, homogenization, pasteurization, packing with subsequent storage at a temperature of 2-4°C for 2-3 days, or at a temperature from -18 to -22°C for 5-6 months (Tokar et al., 2020).

The dough was kneaded using a steamless method from wheat whole-grain flour with the addition of hemp flour in an amount of 4-10% and sweet potato puree – 2-8%. Yeast and salt were added in an amount of – 1-1.5% on the mass of flour.

Titrated acidity in semi-finished products (dough) and finished products was determined by titration (Lebedenko, 2014).

The porosity of the bread was determined using the Zhuravlev's device. The specific volume was determined using the standard method (Drobot, 2019).

Determination of all experimental values was performed in triplicate.

Results and Discussion

Whole wheat flour, which includes the shell parts of grain, aleiron layer and germ, contains powerful antioxidants – vitamin E, C, carotenoids, choline, a number of B vitamins, phenolic compounds; cofactors of antioxidant enzymes – microelements Se, Cu, Mg, food sorbents – fiber, lignin, lignans. However, the content of protein substances in the grain raw material is relatively not high, and the protein is also not balanced in amino acid composition. Therefore, the addition of wheat flour with high protein raw materials will increase the nutritional value of bakery products.

Hemp flour has high nutritional and biological value. This raw material is a source of protein, polyunsaturated fatty acids, dietary fibers, vitamins E, β -carotene, C, D and K, vitamins of group B, vitamin-like substance inositol, mineral compounds.

To compare the nutritional value, we investigated samples of whole grain and hemp flour. The results are shown in Table 1.

Table 1. Generalized characteristics of flour

Indicator	Flour sample	
	Hemp	Whole grain wheat
Moisture, %	9.54±0.2	11.5±0.2
Acidity, deg	3.4±0.01	2.5±0.01
Amount of raw gluten, %	–	20.0±0.3
Proteins, %	39.67 ±0.12	12.6 ±0.18
Fats, %	10.76±0.14	1.5±0.05
Starch, %	5.25±0.06	68.04±0.08
Fiber, %	13.81±0.05	2.42±0.02
Total ash content, %	8.42±0.03	2.5±0.01
Vitamins, mg/100 g		
E	44.8±0.08	0.5±0.03
β -carotene	6.24±0.02	0.15±0.01
C	5.84±0.01	2.6±0.01
B ₁	1.23±0.01	0.18±0.01
B ₂	0.11±0.01	0.15±0.02
PP	4.4±0.02	3.5±0.01

It is noted that hemp flour contains more than three times protein, in seven times more fats and five times more fiber, compared to wheat whole grain flour; the amount of vitamins, in particular tocopherols, carotenoids, B₁, is also significantly higher in hemp flour.

We investigated the organoleptic parameters of sweet potato fruits and puree made from it. Root crops have pink skin, white flesh. The taste is pleasant sweet, the aroma is fresh vegetable. In appearance, sweet potato puree is a homogeneous puree-like uniformly wiped mass that does not spread on a horizontal surface; light cream color; the smell is inherent in vegetable puree without extraneous shades; the taste is sweet.

The chemical composition of sweet potato fruits and its puree (Table 2) are also investigated.

Table 2. Comparative characteristics of the chemical composition of fruits and sweet potato puree

Indicators	Sweet potato	Sweet potato puree
Dry substances, %	24.7±0.08	20.53±0.04
Proteins, %	1.50±0.05	1.20±0.03
Starch, %	13.52±0.04	11.22±0.02
Sugars, %	4.2±0.10	3.49±0.05
Pectin substances, %	1.90±0.02	1.58±0.01
Fiber, %	2.60±0.05	2.22±0.02
Ascorbic acid, mg/100g	23.0±0.12	19.12±0.25
β -carotene, mg/100g	8.25±0.02	6.13±0.01
P, mg/100g	64.21±0.05	59.84±0.08
Phenolic compounds, mg/100g	228.12±0.05	194.27±0.02

The preparation of sweet potato puree included washing of raw materials, cleaning, cutting into pieces, blanching, wiping, homogenization, pasteurization, packing with subsequent storage at a temperature of 2-4°C for 2-3 days, or at a temperature from -18 to -22°C for 5-6 months.

In the process of technological processing in the finished product, the content of vitamins is slightly reduced, compared to the starting material, but the total number of these important micronutrients remains high. The data shown in the table 2 show that the use of sweet potato puree will increase the biological value of whole grain bread due to the presence in raw material of dietary fibers, natural antioxidants: rutin, carotinoids and phenolic compounds.

The presence of hemp flour in this type of bread has important effects, since this raw material contains valuable biologically active compounds, in particular essential amino acids, vitamins, phenols, dietary fibers, which reduce the cholesterol content.

The dough was kneaded using a steamless method from wheat whole-grain flour with the addition of hemp flour in an amount of 4-10% and sweet potato puree – 2-8%.

Yeast and salt were added in an amount of – 1-1.5% on the mass of flour. The developed recipes are given in Table 3.

Table 3. Recipes of bread

№	Recipe components, %				
	Wheat whole grain flour	Hemp flour	Sweet potato puree	Yeast	Salt
1 (control)	97	-	-	1.5	1.5
2	92	4.0	2.0	1.0	1.0
3	88	6.0	4.0	1.0	1.0
4	83	8.0	6.0	1.5	1.5
5	79	10.0	8.0	1.5	1.5

Physico-chemical indicators of the quality of dough and whole wheat bread (control), as well as bread enriched with hemp flour and sweet potato puree are shown in Table 4.

Table 4. Quality indicators of dough and bread with herbal enrichers

Indicator	Recipe number				
	1 (control)	2	3	4	5
Dough					
Mass fraction of moisture, %	44.5±0.4	43.8±0.1	43.5±0.2	42.9±0.1	42.5±0.3
Titrated acidity, deg.					
initial	2.4±0.1	2.7±0.1	3.0±0.2	3.1±0.1	3.3±0.1
final	2.9±0.1	3.0±0.1	3.2±0.2	3.4±0.1	3.6±0.1
Bread					
Mass fraction of moisture, %	43.5±0.4	43.2±0.1	42.9±0.3	42.5±0.1	42.1±0.1
Acidity, degrees	2.7±0.2	3.0±0.2	3.1±0.1	3.3±0.1	3.5±0.3
Specific volume, cm ³ /g	2.86±0.02	2.82±0.02	2.80±0.01	2.78±0.05	2.69±0.01
Porosity, %	70±0.02	68±0.01	67±0.01	65±0.02	63±0.04

It was noted that the acidity of the dough and, accordingly, finished products with herbal additives changed slightly – within 0.1-0.6 deg. It has been found that when hemp flour and sweet potato puree are added to the whole wheat bread recipe, the specific volume of products is slightly reduced by 2.5-5.7%, depending on the introduction of enrichment agents; the porosity of the bread also decreased, most significantly in the sample with the maximum number of enrichment agents. Results of organoleptic analysis of quality parameters of finished products are given in Table 5.

The research results showed that the enrichment of whole wheat bread with hemp flour and sweet potato puree does not impair the porosity structure of products. If hemp flour is added in an amount of 4-8%, and sweet potato puree in an amount of 2-6%, the taste and aroma remain not only acceptable, but also acquire a pleasant light shade of enrichers. With an increase in the amount of hemp flour and sweet potato puree, respectively, to 10 and 8%, the state of the surface of the finished products slightly deteriorates, the taste acquires a sufficiently tangible taste of enrichers, which is not advisable.

Analyzing the calculated nutritional and biological value of bread enriched with hemp flour and sweet potato puree, the total increase in the content of important macronutrients was noted: the amount of protein substances increased by 26.18-44.36%, fiber by 2-2.5 times; lipids, which are a source of polyunsaturated fatty acids by three times compared the amount in whole grain bread. The amount of vitamins in enriched bread has significantly increased: tocopherols from 0.5 mg% to 2.5-4.9 mg%, β -carotene from 0.1 mg% to 0.58-0.82 mg%; thiamine from 0.18 mg% to 0.27-0.36 mg%, depending on the content of herbal additives in the formulation. The content of mineral compounds, in particular Ca, Mg, P, Fe, has increased.

Whole grain bread enriched with hemp flour and sweet potato puree is a functional food product. It was found that the degree of provision of daily demand for macro- and micronutrients, adult population of the first group of intensity, due to the consumption of 100 g of whole grain bread

enriched with hemp flour is: proteins – 15%, fats - 3.1%, carbohydrates – 15.6%, dietary fiber – 11%; vitamins: E – 18%, β -carotene – 11.5%, B₁ – 17%, B₂ – 5.8%.

Table 5. Organoleptic indicators of bread enriched with hemp processing products

Indicators	Recipe number				
	1 (control)	2	3	4	5
Crust color	Grayish brown	Light brown	Brown	Brown saturated	
Surface condition	Smooth, flat flour	Smooth, flat flour		Flat with minor cracks	Flat with noticeable cracks
Condition of crumb: - porosity structure - baked	Elastic, uniform, developed, without voids and seals	Elastic, medium, uniform, thin-walled	Elastic, medium, uniform, thin-walled	Medium, uniform, thin-walled	Small, uneven, thin-walled
	Baked, without traces of not mixed, not moist to the touch				
Color of crumb	Light gray	Gray with a slight brown tint	Gray with a light brown tint	Gray with a brown tint, noticeable	Gray-brown visible impregnations of enriching particles
The smell of bread	Peculiar to wheat bread	Peculiar to wheat bread	Peculiar to bread, with a barely tangible pleasant nut aroma	Peculiar to bread with a tangible pleasant aroma of enrichers	Peculiar to bread with a rather tangible aroma of enricherst
Taste	Peculiar to wheat bread	Peculiar to wheat bread	Peculiar to bread, with barely tangible nut taste	Peculiar to bread, with tangible pleasant nut taste	Peculiar to bread, with nut-soldier taste

Conclusions

Therefore, the actual task of the bakery industry is the production of products from whole grain flour, as well as the use of high-protein raw materials, in particular hemp flour for the enrichment of bread. The use of vegetable puree, in particular sweet potato, in baking helps to increase the content of dietary fiber in products: fiber and pectin substances, which are natural sorbents, as well as vitamins and phenolic compounds, etc. Application of hemp flour in the amount of 4-8% and sweet potato puree in the amount of 2-6% to the recipe, provides good organoleptic indicators of bread and helps to increase the content of protein substances, dietary fibers and vitamin complex.

Conflict of interest

The authors state no conflict of interest.

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