UDC 664.641.12:633.522:664.641.2

THE EFFECT TYPE OF RAW MATERIAL AND TECHNOLOGY OF PRODUCTION ON THE QUALITY OF WHEAT-HEMP BREAD

https://doi.org/ 10.15673/fst.v19i4.3300

S. Gunko[1], PhD, associate professor
O. Naumenko[2], Dr.Sc., head of the department
I. Hetman[2], PhD, senior research
A. Bober[1], PhD, associate professor
H. Podpriatov[1], PhD, prof., head of the department
V. Nasikovskyi[1], PhD, associate professor
V. Zavhorodnii[1], PhD, associate professor
V. Voitsekhivskyi[1], PhD, associate professor
[1]Department of Storage, Processing and Standardization of Plant Products after prof. B.V. Lesik
National University of Life and Environmental Sciences of Ukraine
Heroyiv Oborony str., 13, Kyiv, Ukraine, 03041
[2]Department of Bread Technologies and Biotransformation of Grain Products
Institute of Food Resources NAAS
E. Sverstyuka str., 4 a, Kyiv, Ukraine, 02002

Correspondence:
S. Gunko
E-mail: cgunko@gmail.com

Cite as Vancouver style citation

The effect type of raw material and technology of production on the quality of wheat-hemp bread / Gunko S. et al. Food science and technology. 2025;19(4):85-94
https://doi.org/ 10.15673/fst.v19i4.3300

Цитування згідно ДСТУ 8302:2015

The effect type of raw material and technology of production on the quality of wheat-hemp bread / Gunko S. et al.// Food science and technology. 2025. Vol. 19, Issue 4. P. 85-94.
https://doi.org/ 10.15673/fst.v19i4.3300

Copyright © 2025 by author and the journal "Food Science and Technology".
This work is licensed under the Creative Commons Attribution International License (CC BY). http://creativecommons.org/licenses/by/4.0

Abstract. The research belongs to the field of the technology bread production. Wheat bread is the most widespread food product that included in the rations of a large part of people. However, it has an unbalanced chemical composition in terms of dietary fiber, vitamins and minerals. To improve its nutritional and biological value, such bread is enriched by plant raw materials, in particular hemp seeds. The application of hemp in bread baking negatively affects on the rheological properties of the dough and the quality of the finished product. Therefore, it is important to explore ways to reduce the impact of this raw material on the final product in order to obtain good-quality wheat-hemp bread. The object of the study was wheat bread with the addition of products of hemp seed processing. The industrial hemp seeds of Hlesiia variety were processed into shelled hemp kernels, whole grain hemp flour and grade hemp flour. The quality assessment of the obtained flour indicate that it differs significantly from wheat one. In particular, the obtained samples were characterized by higher acidity, ash content, distribution of nonuniform particle size and larger particle size. The color of the experimental samples of hemp flour ranged from light yellow for the grade flour to light cream with light green spots of crushed shells for the whole grain flour. The smell was characteristic of hemp flour, with slight notes of walnut aroma. It has been determined that the rational dosage for producing quality wheat-hemp bread with the addition of whole grain flour is 10%, grade flour – 15% and 10% for shelled seeds. Wheat bread was produced using various types of hemp raw materials, applying both sponge and one-stage methods. The sponge method demonstrated the most favorable results. Bread weight increased by 8–22 g, a slight increase in acidity was observed but moisture content and porosity did not have a significant difference compared to the control. In contrast, loaf volume showed a significant improvement, ranging from 20 to 160 cm³, depending on the type of hemp product and the applied production technology.

Keywords: hemp seeds, flour, bread, sponge method, one-stage method, quality.

Introduction. Formulation of the problem

Bread made from cereal grains remains the main food product for humans [1]. Depending on the type of bread, this product provides requirements of our body about 35% of carbohydrate, 18–25% of protein and 3–4% of fat [2]. Wheat bread accounts for the main part of all bakery products, reaching 45–50% of total production. Despite its high organoleptic properties, this product has a significant number of disadvantages: it has relatively high in calories (approximately 240 kcal) and low levels of beneficial dietary fiber, vitamins and minerals. The basis of raw gluten in wheat flour is the protein glutenin, which has allergenic properties and can cause the development of an autoimmune disease – celiac and lead to the worsening of chronic diseases [3]. In view of this, the production of bread with partial replacement of wheat flour by plant raw materials has recently become widespread in order to increase its nutritional, biological and physiological value. For these purposes, grains and seeds of cereal and pseudo-cereal crops, waste from the processing of fruits and vegetables

and even such non-traditional raw materials as teff, spelt, amaranth, certain types of nuts and others are used [4, 5].

The application of industrial hemp seeds and products of their processing (flour, oil, crushed kernels, cake, etc.), which contain up to 35% oil, 25% protein, 30% carbohydrates and dietary fiber, vitamins and minerals, is quite promising for these purposes [6–8]. A unique feature of hemp oil is its high content of omega-6 and omega-3 unsaturated fatty acids in a ratio of 3:1, which is optimal for the human body [9]. The disadvantage of using hemp in bread making is its significant impact on the rheological properties of dough and the quality of bread [10]. In order to eliminate the negative effect of such raw materials on the product, various additives (lactic acid bacteria, sourdough, enzymes, thickeners, etc.) or special elements of the technology production are used [11, 12].

Current research on the use of hemp in bread-making technology shows significant differences in the types and recommended doses of this raw material, that range from 1 to 30%. Due to the significant impact of these additives on the quality of finished products, research in this area should be continue. An important part of such research is to determine the impact of wheat bread production technology with the addition of hemp raw materials on improving its quality.

Complex studies that combining the selection of rational dosages of different types of hemp raw materials in wheat bread recipes and research on the impact of production technology with the aim of improving the quality indicators of the finished product have not been conducted by scientists before, that confirms the actuality of this work.

Analysis of recent research and publications

Industrial hemp (*Cannabis sativa subsp. sativa*) is a plant that has been cultivated for many years in many countries, as it is a valuable raw material for technical processing and has a unique combination of nutritional and medicinal properties [13]. All parts of the plant are suitable for processing, from the roots to the flowers and seeds. Hemp seeds are a powerful source of plant fats, high-value proteins, dietary fiber, vitamins and minerals. The leaves and flowers are used for medical purposes and the roots are an effective tool for the recultivation of contaminated lands [14–16].

One of the most valuable parts of industrial hemp for the food industry is its seeds, that besides containing a lot of hypoallergenic proteins, omega-3 and omega-6 unsaturated fatty acids and dietary fiber, but also have antioxidant, antihypertensive, antimicrobial, anticholesterol and antitumor effects [17, 18]. This makes it one of the most perspective additives for improving the nutritional, biological and physiological value of wheat bread.

The use of partially de-oiled hemp flour (HF) in the production of wheat bread worsened the consistency of the dough [10]. The elasticity, flexibility and cohesion of bread samples improved with the addition of up to 5% HF and then degraded. With an increase in the dose of HF, the color of the bread became darker, its firmness increased and its stickiness and chewability decreased. The authors stated that the addition of up to 10% HF had a positive effect on the following indicators: bread volume, porosity, cohesion, color, smell and taste. The investigations concerning the use of other hemp raw materials and the finding of ways to minimize its negative effect on the quality of bread were not carried out.

In [19], the authors investigated the effect of using hemp seeds, hemp flour from cake and hemp flour with a protein content of 46% and 54% for baking wheat bread. The authors stated that even adding 1% hemp raw materials causes significant changes in bread quality: its firmness increases, the elasticity of the crumb decreases and the color darkens. The research did not include the development of methods to improve the organoleptic properties of bread with the addition of hemp raw materials.

A positive effect on the quality of wheat bread when using HF in its recipe has been established and it has been determined that for industrial production, the percentage of such flour used should not exceed 30% [20]. Investigations into the use of other hemp raw materials in bread baking technology have not been conducted.

In [21], the authors stated that adding up to 20% cake of hemp seed instead of wheat flour to the recipe for biscuit semi-finished products not only preserves but also improves product quality and enriches it by valuable proteins, dietary fiber and other useful substances. The researchers did not investigated methods for improving the quality of such products.

HF made from hemp seeds of varieties Dacia Secuieni and Zenit were added to wheat bread in proportions of 5%, 10%, 15% and 20% to improve its nutritional properties [22]. It was found that the protein content in the new products increased from 8.76 to 11.48%, lipids from 0.59 to 5.41%, minerals from 1.33 to 1.62% and fiber from 1.17 to 5.84%. Elasticity and porosity decreased from 95.51 to 80% and from 78.65 to 72.24%, respectively. Analysis of the texture profile showed that the best results were obtained for samples with a 5% additive. Research on the use of other hemp seed products, determining their impact on the quality of finished bread and finding ways to improve the quality of such products has not been conducted.

Samples of wheat bread made using different types of hemp raw materials showed that the use of 15% HF, 4% dehulled hemp seeds and 8% hemp oil is the optimal dosage for use in bread baking technology [23]. The authors did not search for effective ways to improve the quality of bread with these additives.

In summary, there are a significant number of publications on the use of hemp in bread-making technology. However, recommendations on the optimal type and dosage of hemp raw materials differ

significantly. The impact of these additives on the quality of bread and the search for effective ways to reduce their negative effects remain a problem. Therefore, research on this topic is important and has scientific and practical value, as it allows not only to increase the range of bread for health and preventive purposes, but also to improve its organoleptic properties for widespread consumption.

The purpose of the research is to establish the rational dosage of hemp raw materials for the production of wheat bread and to determine the impact of the production technology on its quality. To achieve this purpose, the following **objectives** were formulated:

– to obtain products from the processing of hemp seeds and study their properties;

– to determine the effect of the use of different types of hemp raw materials and their dosage on the organoleptic properties of bread;

– to study the effect of different production technologies on the quality indicators of wheat-hemp bread.

Materials and methods.

The studies used hemp seeds of the Hlesiia variety breeding by the Institute of Bast Crops of the National Academy of Agrarian Sciences of Ukraine, grade wheat flour according to SSTU 46.004-99 Wheat flour. Technical Conditions (TM Zernari, Ukraine), pressed baker's yeast (TM Kryvorizki Yeast, Ukraine) in accordance with DSTU 4812:2007 «Pressed Baker's Yeast. Technical conditions»), table salt (DP Artemsil, Ukraine) according to DSTU 3583:2015 «Table salt. General technical requirements»), sugar (Sarkara-Group LLC, Ukraine), according to DSTU 4623:2023 «Sugar. Technical conditions» and drinking water according to DSTU 7525:2014 Drinking water. Requirements and methods of quality control.

The recipe for the control sample of wheat bread included: grade wheat flour, pressed baker's yeast, sugar, table salt and water [24]. In the experimental variants, part of the wheat flour was replaced by hemp raw materials: dehulled hemp kernels (HK), whole grain hemp flour (WGHF) and grade hemp flour (GHF).

Recipe per 100 g of flour for one-stage method with using WGHF: grade wheat flour – 90 g, WGHF – 10 g, pressed baker's yeast – 3 g, sugar – 2.5 g, table salt – 1.5 g, water – 60 ml.

Recipe per 100 g of flour for one-stage method with using HK: grade wheat flour – 90 g, HK – 10 g, pressed baker's yeast – 3 g, sugar – 2.5 g, table salt – 1.5 g, water – 55 ml.

Recipe per 100 g of flour for one-stage method with using GHF: grade wheat flour – 85 g, GHF – 15 g, pressed baker's yeast – 3 g, sugar – 2.5 g, table salt – 1.5 g, water – 55 ml.

Recipe for 100 g of flour for sponge technology (traditional sponge with 45% moisture content was prepared) using WGHF: grade wheat flour – 90 g (50% of the total amount of flour in the sponge), WGHF – 10 g, pressed baker's yeast – 1.5 g, sugar – 2.0 g, table salt – 1.5 g, water – 60 ml.

Recipe for 100 g of flour for sponge technology (traditional sponge with 45% moisture content was prepared) using HK: grade wheat flour – 90 g (50% of the total amount of flour in the sponge), HK – 10 g, pressed baker's yeast – 1.5 g, sugar – 2.0 g, table salt – 1.5 g, water – 55 ml.

Recipe for 100 g of flour for sponge technology using GHF: grade wheat flour – 85 g (50% of the total amount of flour in the sponge), GHF – 15 g, pressed baker's yeast – 2.0 g, sugar – 2.5 g, table salt – 1.5 g, water – 55 ml.

To determine the rational dosage of different types of hemp raw materials, the dough was prepared using the one-stage method. To determine the effect of the production technology on the quality of wheat-hemp bread, experimental variants were produced using the sponge and one-stage methods. In all studies, wheat bread produced using the one-stage method was used as a control.

The technology for making bread using the sponge method and one-stage method was carried out in accordance with the methodology [24].

One-stage method. The fermentation time for dough with using one-stage method of wheat bread production was 90–100 minutes until the required acidity was reached. When using HK, a mixture of wheat flour and hemp seeds was prepared before kneading. Kneading was carried out on a KVL4100S dough mixer (China) for 15±1 min. The dough pieces were formed manually. The proofing time was 35–45 min at a temperature of (35±2) ºC in an XLT 133-UNOX (Italy) cabinet. The weight of the dough pieces was 220 ± 10 g. The readiness of the dough pieces during proofing was determined by their volume and shape. The dough pieces were then p to the oven, where they were baked at a temperature of 180–200 °C in an Unox XFT133 oven (Italy) for 30–35 minutes.

Sponge method. When using the sponge method, the first step was to prepare the sponge. About half of the total amount of flour, up to 2/3 of the water and all of the yeast were used. When using HK, it was added at the first stage, mixing it beforehand with half of the flour. After kneading the sponge, it was kept at a temperature of 28–32 °C for 180–190 minutes. After that, all other ingredients were added according to the recipe and the dough was kneaded. Kneading was carried out on a KVL4100S dough mixer (China) for 15±1 min. The fermentation time of the dough was 40–50 min. The dough pieces were formed manually. The dough was proofed for 30–40 minutes at a temperature of 35 ± 2 °C in an XLT 133-UNOX (Italy) cabinet. The weight of the dough pieces was 220 ± 10 g. The readiness of the dough pieces during proofing was determined by their volume and shape. The dough pieces were then placed in an oven, where they were baked at a temperature of 180–200 °C in an Unox XFT133 oven (Italy) for 30–35 minutes.

The organoleptic quality indicators of flour were determined according to the methodology [24]. The acidity of flour was determined using the "flour–water slurry" method in the presence of phenolphthalein indicator [25]. The granulometric composition was determined by sieving through sieves with hole sizes of 160 μm and 250 μm. Ash content was determined by the ashing (burning) method in a SNOL 8.2/1100 muffle oven (Lithuania) using magnesium acetate as an accelerator [26]. The organoleptic and physicochemical quality indicators of the finished bread (moisture content, acidity, volume, weight, specific volume) were determined according to [26] 4 hours after baking. The moisture content of bread was determined by the standard method of drying the sample in a SESH-3M drying oven (UkrAnalytika LLC, Ukraine) at a temperature of 130 °C [26]. Porosity was studied using the Zhuravleva device (NVF Standard-M LLC, Ukraine) [24].

Statistical data processing. All results obtained were processed using Excel from the Microsoft Office 2007 software package. The experiment was conducted in three repetitions. The data are presented as mean values ± standard deviation.

Results of the research and their discussion

Obtaining products of hemp seed processing and studying their properties. Hemp seeds should be well-prepared before using them in baking. In our research, hemp seeds of Hlesiia variety (Fig. 1) were cleaned of admixtures and processed into products: dehulled HK, WGHF and GHF.

Dehulled hemp kernels were obtained by passing the cleaned seeds through a GDF-1M laboratory hulling machine.

Whole grain hemp flour was obtained by grinding whole cleaned seeds by a water-cooled laboratory mill SM-3C (China) and subsequent sieving through sieves with a hole diameter of 160 and 250 μm.

Grade hemp flour was obtained by grinding dehulled hemp kernels on a water-cooled laboratory mill SM-3C (China) and subsequent sieving on sieves with a holes of 160 and 250 μm.

Fig. 1. Hemp seeds of Hlesiia variety

The results of the study of the quality of flour obtained from hemp seeds are presented in Table 1.

The results in Table 1 indicate that flour obtained from hemp seeds has significantly lower moisture content (9.5±0.1% and 8.3±0.1%) compared to wheat flour (14.8±0.1%), that should be taken into account when calculating the amount of water needed for kneading dough. The acidity of hemp seed flour samples exceeded the control by 1.1–1.8 degrees. This is a positive factor, as it will increase the resistance of bread with its addition to the action of biological agents, as noted by some authors in their studies [22]. However, an increase in total acidity due to this additive will have a negative effect on the taste of the finished product, that is also necessary to take into account when developing a bread recipe. In terms of ash content, the highest content was obtained in sample WGHF (4.7±0.1%). This is explained by the technology of its production, that included grinding the whole hemp seeds into flour and the inclusion of a large amount of peripheral layers rich in ash elements in its composition. The presence of a large amount of crushed shells in the composition of this flour is also confirmed by the results of sieve analysis.

Table 1 - Quality indicators of flour from hemp seeds (*n=3, p≤0.05*)

No.	Name of indicators	High-grade wheat flour (control)	Whole grain hemp flour	Grade hemp flour
1	Mass fraction of moisture, %, not more than	14.8±0.1	9.5±0.1	8.3±0.1
2	Acidity, degrees	3.0±0.2	4.8±0.2	4.1±0.2
3	Mass fraction of metal admixtures, mg per 1 kg of flour, not more than	1.0±0.1	1.0±0.1	1.0±0.1
4	Ash content in calculation to dry matter, %, not more than	0.7±0.1	4.7±0.1	2.3±0.1
5	Mass fraction of product passing through a 160 μm sieve, not less than, %	82.0±0.1	64.0±0.1	75.0±0.1
6	Mass fraction of the product retained on a 250 μm sieve, not more than, %	1.5±0.1	4.6±0.1	2.8±0.1
7	Infestation of grain by pests	Not detected		

In the WGHF sample, the smallest passage through the 160 μm sieve (64.0±0.1%) and the largest remaining residue on the 250 μm sieve (4.6±0.1%) were obtained. Due to the separated shells, GHF provided a passage through a 160 μm sieve at a level of 75.0±0.1% and a residue on a 250 μm sieve of 2.8±0.1. The lower passage and higher residue in GHF compared to the control variant is explained by the high oil content, which promotes the sticking of crushed particles and worsens these indicators. According to other indicators, all three flour samples corresponded to the established standards for bread baking.

According to the organoleptic assessment (appearance and color), the experimental hemp flour samples ranged from light yellow in GHF to light cream with light green spots of crushed shells in WGHF. The smell of both test samples was characteristic of hemp flour, with light notes of walnut aroma, not musty or moldy.

The effect of using different types of hemp raw materials and their dosage on the organoleptic properties of wheat bread. To obtain wheat-hemp bread, it was made with partial replacement of wheat flour by products of processing Hlesiia hemp seeds: WGHF (variant 1), GHF (variant 2) and HK (variant 3). For each variant, composites were developed – hemp product : wheat flour, %. The dosage of hemp products was chosen based on the results of a literature review [10, 20, 23]. Variants with WGHF: 5:95; 10:90; 20:80; 30:70. Variants with GHF: 5:95; 10:90; 15:85. Variants with HK: 5:95; 10:90; 15:85. The control for all three variants was wheat bread without the addition of hemp, made using a one-stage method.

Organoleptic assessment of bread quality (variant 1) indicated that the application of WGHF in the recipe changed the color of the finished product (Fig. 2) from light yellow (control) to dark brown (characteristic of rye) with green spots, at maximum concentrations of the additive (20–30%). The porosity of the bread worsened with an increase in the amount of WGHF and changed from fine in the control sample to coarse and non-uniform at high levels of application.

The smell also changed. Thus, when using 5% WGHF, a slight herbal smell was noticeable, at 10% it became more intense, with slight tones of walnut in the aroma. The addition of 20–30% WGHF gave the bread a very intense herbal smell.

A dosage of 5–10% WGHF did not significantly change the taste of bread. A concentration of 20–30% made the taste overpowering, the crumb of the bread became hard and coarse, its elasticity worsened and as a result chewing, a slight crunch of hemp shells was felt. That is, the results of the organoleptic evaluation indicate that the rational dosage of WGHF in the wheat bread recipe is 5–10%.

In variant 2, the difference in color between the control and experimental bread samples was insignificant and the GHF dosage did not have the same significance as in variant 1. Fig. 3 demonstrates that the color of the sliced bread has slight greenish tints, the intensity of which grows with increasing GHF concentration (Fig. 3).

The porosity of the crumb in all experimental samples was uniform and did not depend on the GHF dose. In terms of this indicator, the experimental variants exceeded the control, that can be explained by the high content of oil, that acted as an emulsifier and thus improved the quality of the bread.

The aroma of the experimental bread samples with GHF intensified with increasing concentration, and even the maximum doses had no negative effect on this indicator. The aroma of the experimental bread samples was pleasant, with pronounced notes of walnut, the intensity of aroma intensified with increasing GHF concentration.

The addition of GHF had a positive effect on the taste. It was pleasant, characteristic of wheat bread and improved with increasing concentration, becoming more saturated and fully. Increasing the GHF dosage also improved the elasticity of the crumb, that is also explained by the positive effect of the high oil content in this flour. Thus, when using GHF for baking bread, its rational dosage is within the range of 10–15%. In variant 3, when dehulled hemp kernels were added, the color of the sliced bread in the experimental bread samples had a slightly noticeable greenish tint (Fig. 4).

Fig. 2. Samples of wheat bread with the addition of whole grain hemp flour: from left to right – control, 5%, 10%, 20% and 30% flour

Fig. 3. Samples of wheat bread with the addition of grade hemp flour: from left to right: control, 5%, 10% and 15% flour

Fig. 4. Samples of wheat bread with addition of dehulled HK: from left to right – control, 5%, 10%, and 15% seeds

The taste of bread was practically the same as the control sample at 5% and improved when the concentration was increased to 10–15%. The same was observed for the aroma. It should be noted that the use of HK did not have the same effect on the appearance of walnut notes in the aroma of bread as the addition of WGHF and GHF. It was pleasant, characteristic of wheat bread. The HK concentration of 15% contributed to a decrease in bread volume. The reason for this is a general decrease in the amount of raw gluten due to the partial replacement of wheat flour by hemp raw materials. Wheat gluten plays a main role in the formation of the bread structure and therefore a decrease in its amount causes a degradation of the rheological properties of the dough, in particular its elasticity and significantly reduces the volume, as indicated by other researchers [10, 27]. That is, in variant 3, the rational dosage of HK was a concentration of 10%.

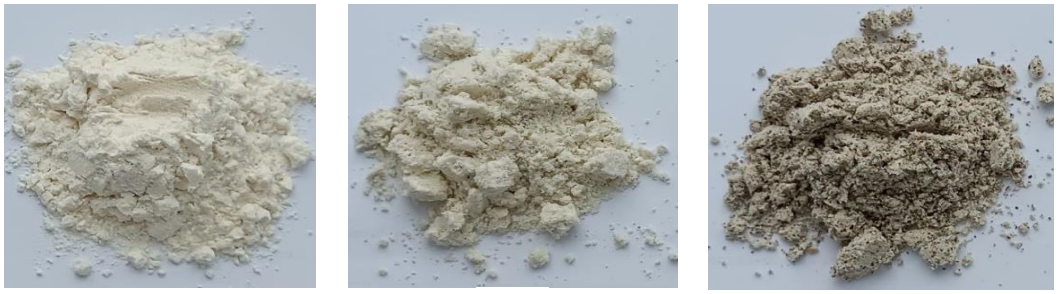
Investigation of the influence of production technology on the quality of wheat-hemp bread. Hemp raw material, that is characterized by a balanced chemical composition, is one of the most perspective for enrichment of wheat bread by valuable nutrients [11, 17, 18]. However, its use in baking technology can negatively affect the rheological properties of dough and the quality of bread [10]. There are series of publications in which authors propose in order to improve the quality of bread of lactic acid bacteria, enzymes, sourdough, the sponge method and etc. [28, 29].

We studied the effect of the sponge and one-stage methods production on the quality of wheat bread with the addition of hemp raw materials. In the experimental variants, hemp raw materials were used in their rational concentrations (WGHF – 10%, GHF – 15%, HK – 10%). The control was wheat bread without the addition of hemp raw materials made by one-stage method.

The general appearance of wheat flour composites with hemp raw materials is presented on Fig. 5.

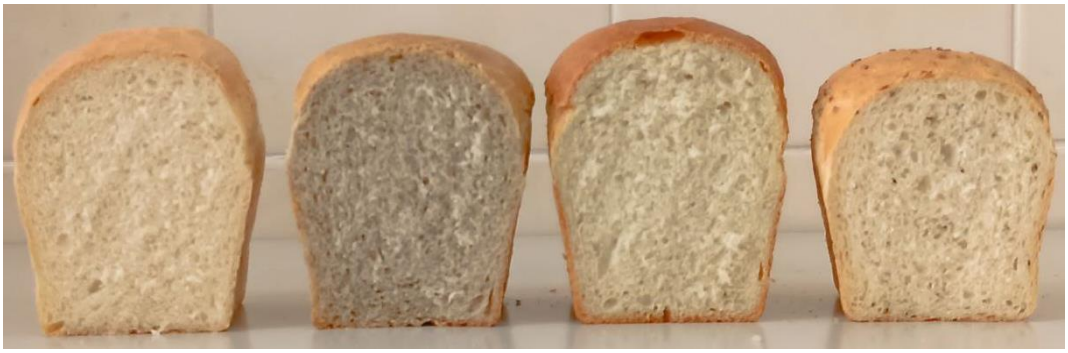
The results of baking wheat bread with the addition of hemp raw materials and made using by sponge and one-stage methods are presented on Fig. 6

The results of the organoleptic evaluation of bread indicate that the type of hemp raw material and technology of its production have an impact on the quality. In particular, the sponge method provided an increase in the volume of baked bread, especially in the variant with WGHF. This is explained by several factors: the increased content of dietary fiber in the raw material [18] and the activation of endogenous enzymes (amylase, protease, xylanase, etc.) in the dough when using the sponge method [30]. As a result, partial hydrolysis of biopolymers (starch, proteins, and polysaccharides) promotes their better integration into the structure of the finished product [31]. These factors also have a slight effect on the color of the crumb and the porosity of the bread. The results of the quality assessment of wheat bread enriched by hemp raw materials and produced by different technologies are presented in Table 2.

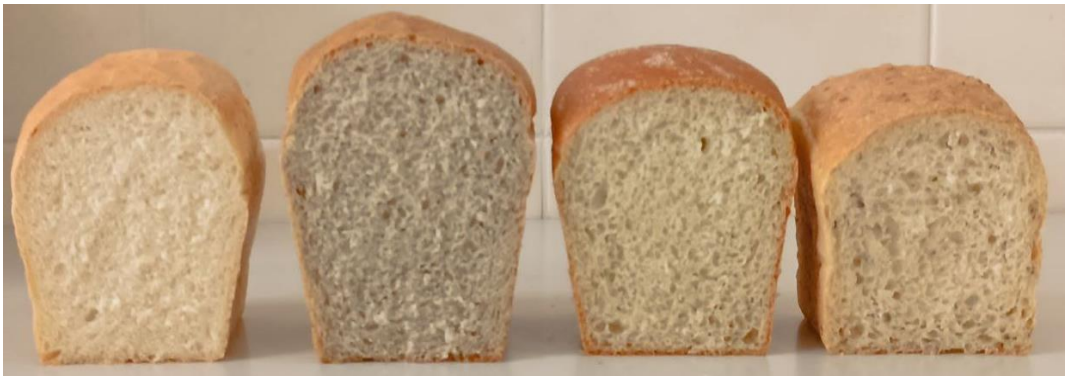


a *b* *c*

Fig. 5. Flour samples: a – high-grade wheat flour (control); b – wheat flour composite with 15% GHF; c – wheat flour composite with 10% WGHF



one-stage method production



sponge method production

Fig. 6. Samples of baked wheat bread with added hemp raw materials. From left to right: control, with 10% WGHF added, with 15% GHF added, with 10% HK added

Table 2 – Physicochemical quality indicators of wheat-hemp bread produced by different method (n = 3, p ≤ 0.05)

Indicators	Control	One-stage method			Sponge method		
		WGHF	GHF	HK	WGHF	GHF	HK
Bread weight, g	180.0±1.0	181.0±1.0	179.0±1.0	181.0±1.0	202.0±1.0	188.0±1.0	193.0 ±1.0
Moisture, %	42.4±0.1	41.7±0.1	39.1±0.1	42.6±0.1	41.2± 0.1	41.4±0.1	44.4±0.1
Acidity, degrees	1.8±0.1	2.2±0.1	2.0±0.1	1.8±0.1	2.4±0.1	2.6±0.1	2.4±0.1
Porosity, %	76.0±1.0	71.0±1.0	77.0±1.0	71.0±1.0	73.0±1.0	70.0±1.0	69.0±1.0
Bread volume, cm^3	520.0±1.0	560.0±1.0	540.0±1.0	415.0±1.0	680.0±1.0	595.0±1.0	500.0±1.0
Specific volume of bread, cm^3/g	2.9±0.2	3.1±0.2	3.0±0.2	2.3±0.2	3.4±0.2	3.2±0.2	2.6±0.2

Analyzing Table 2, we can summarize that the use of the one-stage method of bread production did not affect the weight of bread with the addition of hemp raw materials. The difference between the control and experimental variants was only 1 g, which is within the experimental error. The use of the sponge method contributed to an increase in this indicator from 8 g for bread samples with the addition of GHF to 22 g in the variant with WGHF. This is explained by an increase in the water-holding capacity of the dough as a result of prolonged fermentation and partial biodegradation of raw materials using the sponge method [31]. The higher values of this indicator in the WGHF variant are explained by the increased content of dietary fiber in this raw material, which is characterized by a high ability to bind and retain water [32].

The moisture content in the experimental variants (Table 2) did not differ significantly from the control. It was slightly higher when using HK, which can be explained by the strong bond of water inside the hemp kernel. The influence of the raw materials used and the

production technology on this indicator was not established.

The acidity of the baked bread depended on both the type of hemp raw material and the technology used in its production. Table 2 demonstrates that the highest acidity values were obtained when using WGHF and GHF in the bread recipe, especially in the sponge method. The increase compared to the control was 0.6–0.8%, depending on the type of raw material. With the one-stage method in the HK variant, the acidity was at the level of the control sample, which is explained by the low availability of acids in whole hemp seeds and the impossibility of their transfer into solution during the short period of dough fermentation.

The porosity of baked bread with the addition of hemp raw materials and produced using different technologies (Table 2) shows that the type of additive and bread production technology did not have a significant effect on this indicator, that remains within the optimal range of 70–76%.

A significant positive effect on the volume of bread made with the addition of hemp raw materials was established, especially using the sponge method (Table 2). The application of GHF and WGHF, even using the one-stage method, contributed to an increase in volume by 20 cm^3 and 40 cm^3, respectively, compared to the control. The sponge method provided an even greater increase in this indicator: by 75 cm^3 in the GHF variant, by 85 cm^3 in the HK variant and by 160 cm^3 in the WGHF variant, compared to the control. As a result, the specific volume of bread using the one-stage method increased in samples with WGHF and GHF by 3.4–7% and in the sample with HK it decreased by 20.7%. In contrast, using the sponge method, the specific volume increased by 10.3–17.2% in samples with WGHF and GHF and decreased by only 10.3% in the sample with HK. This indicates the positive effect of long-term fermentation on improving the quality indicators of bread made with hemp raw materials.

Conclusion

The seeds of the Hlesiia industrial hemp variety were processed to obtain dehulled hemp kernels, whole grain hemp flour and grade hemp flour.

Studies of the quality of the obtained hemp raw materials indicate that they have 1.1–1.8% higher acidity, 1.6–4.0% higher ash content, non-uniformity granulometric composition of the flour and larger particle size, compared to wheat one. That will be negatively affect on the quality of bread made with it. Organoleptic evaluation of the flour samples obtained indicates that the experimental samples had a light yellow color in GHF and a light cream color with light green spots of crushed shells in WGHF. The smell of both samples was characteristic of hemp flour, with slight notes of walnut aroma.

The rational dosage of hemp raw materials was determined: whole grain flour (variant 1), grade flour (variant 2) and dehulled kernels (variant 3). It was established that the optimal dosage for obtaining quality wheat-hemp bread is 10% for the first variant, 15% for the second and 10% for the third.

Trial laboratory baking of wheat bread with the addition of various types of hemp raw materials in their rational concentrations was carried out using the sponge and one-stage methods of production. It was found that the use of hemp raw materials increases the weight of bread by 8–22 g, increases its acidity (by a maximum of 0.8 degree), has practically no effect on moisture content and porosity, compared to the control and increases the volume of bread. Its growth, depending on the type of additive and the applied of production technology, ranges from 20 to 160 cm^3. Summarizing the obtained results, it can be concluded that when production wheat bread with the addition of hemp raw materials, the sponge method of production provides better results in terms of the quality of the finished product.

References

1. Švec I, Hrušková M. Evaluation of wheat bread features. Journal of Food Engineering. 2010; 99(4): 505–510. https://doi.org/10.1016/j.jfoodeng.2009.09.022
2. Dewettinck K, Van Bockstaele F, Kühne B, Van de Walle D, Courtens TM, Gellynck X. Nutritional value of bread: Influence of processing, food interaction and consumer perception. Journal of Cereal Science. 2008; 48(2): 243–257. https://doi.org/10.1016/j.jcs.2008.01.003
3. Brouns F, van Rooy G, Shewry P, Rustgi S, Jonkers D. Adverse reactions to wheat or wheat components. Comprehensive Reviews in Food Science and Food Safety. 2019; 18(5): 1437–1452. https://doi.org/10.1111/1541-4337.12475
4. Wirkijowska A, Zarzycki P, Teterycz D, Nawrocka A, Blicharz-Kania A, & Łysakowska P. The Influence of Tomato and Pepper Processing Waste on Bread Quality. Applied Sciences. 2023; 13(16): 9312. https://doi.org/10.3390/app13169312;
5. Naumenko O, Hetman I, Chyzh V, Gunko S, Bal-Prylypko L, Bilko M, Tsentylo L, Lialyk A, Ivanytska A, Liashenko S. Improving the quality of wheat bread by enriching teff flour. Eastern-European Journal of Enterprise Technologies. 2023; 3(11 (123): 33–41. https://doi.org/10.15587/1729-4061.2023.279286
6. Pasichnyi V, Shubina Y, Svyatnenko R, & Moroz O. The effect of freezing on the characteristics of semifinished products in a dough covering using non-conventional protein-containing raw materials. Animal Science and Food Technology. 2022; 13(1): 47–56. https://doi.org/10.31548/animal.13(1).2022.47-56
7. Mikulec A, Kowalski S, Sabat R, Skoczylas L, Tabaszewska M, Wywrocka-Gurgul A. Hemp flour as a valuable component for enriching physicochemical and antioxidant properties of wheat bread. LWT-Food Sci Techn. 2019; 102: 164–172. https://doi.org/10.1016/j.lwt.2018.12.028.
8. Ferrante C, Recinella L, Ronci M, Menghini L, Brunetti L, Chiavaroli A, Leone S, Iorio LD, Carradori S, Tirillini B, Angelini P, Covino S, Venanzoni R, Orlando G. Multiple pharmacognostic characterization on hemp commercial cultivars: Focus on inflorescence water extract activity. Food Chem Toxicol. 2019; 125: 452–461. https://doi.org/10.1016/j.fct.2019.01.035
9. Siudem P, Wawer I, Paradowska K. Rapid evaluation of edible hemp oil quality using NMR and FT-IR spectroscopy. J Mole Struct. 2019; 1177: 204–208. https://doi.org/10.1016/j.molstruc.2018.09.057

10. Istrate AM, Dabija A, Codină GG, Rusu L. Influence of hemp flour on dough rheology and bread quality. Scientific Study & Research. Chemistry & Chemical Engineering, Biotechnology, Food Industry. 2021; 22(4): 521–531. ISSN 1582-540X
11. Tebben L, Shen Y, & Li Y. Improvers and functional ingredients in whole wheat bread: A review of their effects on dough properties and bread quality. Trends in Food Science & Technology. 2018; 81: 10–24. https://doi.org/10.1016/j.tifs.2018.08.015
12. Korzhenivska A, Danylenko S, Gunko S, Kozlovska G, Lukianets A. Application of bacterial sourdough and enzymes in the production of bread from a mixture of rye and wheat flour. Food Science and Technology. 2023: 17(4). https://doi.org/10.15673/fst.v17i4.2761
13. Promhuad K, Srisa A, San H, Laorenza Y, Wongphan P, Sodsai J, ... & Harnkarnsujarit N. Applications of Hemp Polymers and Extracts in Food, Textile and Packaging: A Review. Polymers. 2022; 14(20): 4274. https://doi.org/10.3390/polym14204274.
14. Rehman M, Fahad S, Du G, Cheng X, Yang Y, Tang K, ... & Deng G. Evaluation of hemp (*Cannabis sativa L.)* as an industrial crop: A review. Environmental Science and Pollution Research. 2021; 28(38): 52832-52843. https://doi.org/10.1007/s11356-021-16264-5
15. Jin D, Dai KP, Xie Z, Chen J. Secondary metabolites profled in Cannabis inforescences, leaves, stembarks, and roots for medicinal purposes. Sci Rep. 2020; 10(1): 3309. https://doi.org/10.1038/s41598-020-60172-6
16. Kornpointner C, Martinez A, Marinovic S, Haselmair-Gosch C, Jamnik P, Schröder K, Löfke C, Halbwirth H. Chemical composition and antioxidant potential of *Cannabis sativa L.* roots. Ind Crop Prod. 2021; 165: 113422. https://doi.org/10.1016/j.indcrop.2021.113422
17. Leonard W, Zhang PZ, Ying DY, Fang ZX. Hempseed in food industry: nutritional value, health benefts, and industrial applications. Compr Rev Food Sci Food Saf. 2020; 19: 282–308. https://doi.org/10.1111/1541-4337.12517
18. Gunko SM, Naumenko OV, Getman IA, Korolyuk KE, Lukyanchuk IV, Kuznetsova IV. Use of hemp seed processing products for bread production. Food Resources. 2024; 12(22): 50–60. https://doi.org/10.31073/foodresources2024-22-06
19. Wiedemair V, Gruber K, Knöpfle N, & Bach KE. Technological changes in wheat-based breads enriched with hemp seed press cakes and hemp seed grit. Molecules. 2022; 27(6): 1840. https://doi.org/10.3390/molecules27061840
20. Crini G, Lichtfouse E, Chanet G, & Morin-Crini N. Applications of hemp in textiles, paper industry, insulation and building materials, horticulture, animal nutrition, food and beverages, nutraceuticals, cosmetics and hygiene, medicine, agrochemistry, energy production and environment: A review. Environmental Chemistry Letters. 2020; 18(5): 1451–1476. https://doi.org/10.1007/s10311-020-01029-2
21. Rodionova T., Zaporenkova G., Gontar T., Oliinyk N., and Lipovyi D. Study of the effect of hemp seed cake on the quality indicators of biscuit semi-finished products. Bulletin of the National Technical University "KhPI". Series: New solutions in modern technologies. 2025; (2(24): 91–96. https://doi.org/10.20998/2413-4295.2025.02.13
22. Rusu IE, Marc RA, Mureşan CC, Mureşan AE, Mureşan V, Pop CR, ... & Muste S. Hemp (*Cannabis sativa L.)* flour-based wheat bread as fortified bakery product. Plants. 2021; 10(8): 1558. https://doi.org/10.3390/plants10081558
23. Liliana BC, Livia A, & Laura M. Effects of hemp flour, seeds and oil additions on bread quality. J. Eng. Res. Appl. 2018; 8: 73–78. https://doi.org/10.9790/9622-0805037378
24. Drobot VI. Handbook on bakery production technology: a study guide. Kyiv: ProfKniga; 2019.
25. Lebedenko TE, Pshenishnyuk GF, Sokolova NY. Bakery production technology. Practical Guide. Odessa: Education of Ukraine; 2014.
26. Drobot VI. Technochemical Control of Raw Materials and Bakery and Pasta Products. Kyiv: Kondor Publishing House; 2015.
27. Korus J, Witczak M, Ziobro R, Juszczak L. Hemp (*Cannabis sativa subsp. sativa*) flour and protein preparation as natural nutrients and structure forming agents in starch based gluten-free bread. LWT. 2017; 84: 143–150. https://doi.org/10.1016/j.lwt.2017.05.046
28. Amr A, & Ajo R. Production of two types of pocket-forming flat bread by the sponge and dough method. Cereal Chemistry. 2005; 82(5): 499–503. https://doi.org/10.1094/CC-82-0499
29. Gunko SM. Use of improvers for wheat flour in bread making. Bulletin of the National University of Food Technologies. 2010; (24): 151–160.
30. Zeng F, Yang Y, Liu Q, Yang J, Jin Z, Jiao A. Effect of fermentation methods on properties of dough and whole wheat bread. Journal of the Science of Food and Agriculture. 2023; 103(10): 4876–4886. https://doi.org/10.1002/jsfa.12565
31. Isla MA, Islam S. Sourdough bread quality: Facts and Factors. Foods. 2024; 13(13): 2132. https://doi.org/10.3390/foods13132132
32. Bonnand-Ducasse M, Della Valle G, Lefebvre J & Saulnier L. Effect of wheat dietary fibres on bread dough development and rheological properties. Journal of Cereal Science. 2010; 52(2): 200–206. https://doi.org/10.1016/j.jcs.2010.05.006

ВПЛИВ ВИДУ СИРОВИНИ ТА ТЕХНОЛОГІЇ ВИГОТОВЛЕННЯ НА ЯКІСТЬ ПШЕНИЧНО-КОНОПЛЯНОГО ХЛІБА

С. Гунько[1], к.т.н., доцент кафедри, *E-mail*: cgunko@gmail.com
О. Науменко[2], д.т.н., зав. відділом, *E-mail*: ovnaumenko1@gmail.com,
І. Гетьман[2], к.т.н., с.н.с., *E-mail*: getmaninna7@gmail.com
А. Бобер[1], к.с.-г.н., доцент кафедри, *E-mail*: bober_1980@i.ua
Г. Подпрятов[1], к.с.-г.н., професор, завідувач кафедри, *E-mail*: podpratovg@gmail.com,
В. Насіковський[1], к.с.-г.н., доцент кафедри, *E-mail*: vanasikovskiy@gmail.com
В. Завгородній[1], к.с.-г.н., доцент кафедри, *E-mail*: Zavgorvlad@gmail.com
В. Войцехівський[1], к.с.-г.н., доцент кафедри, *E-mail*: vinodel@i.ua
[1]Кафедра технології зберігання, переробки та стандартизації продукції рослинництва ім. проф. Б.В. Лесика
Національний університету біоресурсів і природокористування України
вул. Героїв Оборони, 13, м. Київ, Україна, 03041
[2]Відділ технологій хліба та біотрансформації зернових продуктів
Інститут продовольчих ресурсів НААН України
вул. Є. Сверстюка, 4 А, м. Київ, Україна, 02002

Анотація. Дослідження відносяться до технології виробництва хліба. Пшеничний хліб є найбільш розповсюдженим харчовим продуктом, що входить до раціону великої кількості людей. Однак, він має незбалансований хімічний склад за вмістом харчових волокон, вітамінів та мінеральних речовин. Для покращення харчової та біологічної

цінності, такий хліб збагачують рослинною сировиною, зокрема насінням конопель. Використання конопель у хлібопеченні негативно впливає на реологічні властивості тіста та якість готового продукту. Тому, актуальним є пошук шляхів усунення дії цієї сировини на продукцію для отримання якісного пшенично-конопляного хліба. Об'єктом дослідження був пшеничний хліб із додаванням продуктів переробки насіння конопель. Насіння технічних конопель сорту Глесія переробляли на обрушене ядро конопель, борошно конопляне цільнозернове та борошно конопляне сортове. Оцінка якості отриманого борошна свідчить про його значні відмінності від пшеничного. Зокрема, отримані зразки характеризувалися вищою кислотністю, зольністю, нерівномірним гранулометричним складом та більшим розміром часточок. Колір дослідних зразків конопляного борошна змінювався від світло-жовтого у сортового до світло-кремового із світло-зеленими вкрапленнями подрібнених оболонок – для цільнозернового. Запах був властивий конопляному борошну, із легкими нотками аромату горіха волоського. Визначено, що оптимальним дозуванням, яке забезпечує отримання якісного пшенично-конопляного хліба із додаванням цільнозернового борошна є 10%, борошна сортового – 15% та 10% – для обрушеного насіння. Пшеничний хліб виготовляли з використанням різних видів конопляної сировини, застосовуючи як опарну, так і безопарну технологію виготовлення. Найкращі результати отримали за опарної технології. Маса хліба збільшилася на 8–22 г, а упікання зменшилося. Спостерігалося незначне збільшення кислотності, а вміст вологи та пористість залишилися майже незмінними. Натомість об'єм буханця значно покращився, змінюючись від 20 до 160 см³, залежно від виду конопляної сировини та застосованої технології виробництва.

Ключові слова: насіння конопель, борошно, хліб, опарна технологія, безопарна технологія, якість.