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Vol. 18 2024

Slovak Journal of Food Sciences

ISSN 1337-0960 (online)

Scientific peer-reviewed OPEN ACCESS journal focussed on food science

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Potravinarstvo Slovak Journal of Food Sciences
Vol. 18, 2024

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Slovak Journal of Food Sciences

• Journal title: ***Potravinarstvo Slovak Journal of Food Sciences*** • Volume: 18, Year 2024 • Evidence no. of the Ministry of Culture of Slovak Republic: 3771/09 • ISSN 1337-0960 (electronic version, online) • Publisher: HACCP Consulting, Slivková 12, 951 01 Nitrianske Hrnčiarovce, Slovakia, European Union • Publisher cooperates with SLP London, the Scientific Literature Publisher, 3rd Floor, 86-90 Paul Street, London EC2A 4NE, United Kingdom • The article XML conversion is provided by the contractual partner JatsTech, Rok Society Plot # R-278 near Jamali road Sch 33, Karachi, Pakistan • Editor-in-Chief: doc. Ing. Peter Zajác, PhD. • Periodicity: Articles are published continuously in the Volume during the year • Form of the publishing: electronic online • Journal language: English • Journal website: www.potravinarstvo.com • Address of Editor office: Potravinarstvo Slovak Journal of Food Sciences, Slivková 12, 951 01 Nitrianske Hrnčiarovce, Slovakia, European Union • E-mail: editor@potravinarstvo.com • Tel.: +421908164361, +421904138562 • Linguistic editing: Published articles undergone language editing by English proof-reader, authors are fully responsible for grammar in the articles • Graphic design: HACCP Consulting • Price: not for sale • Distributor: HACCP Consulting at www.potravinarstvo.com • Place of publication: Nitra, Slovakia, European Union • Legal information and authors rights: authors and advertisers are legally responsible for information published in articles or advertisement. Potravinarstvo Slovak Journal of Food Sciences, Editor and Editorial Board are not responsible for any third-party parties' damages or claims for compensation arising out of or in connection with published articles or advertisements in Potravinarstvo Slovak Journal of Food Sciences or journal website www.potravinarstvo.com • Journal is indexed in: SCOPUS, CrossRef, DOAJ Directory of Open Access Journals, EBSCO Host, CAB Abstracts and CABI Full text, FSTA – The Food Science Resource, UIUC OAI registry, AGRIS/FAO, DRJI Directory of Research Journals Indexing, Google Scholar, OCLC The OAIster database, INDEX Copernicus, UlrichsWeb Global Serials Directory, MENDELEY, EZB Electronic Journals • Name and abbreviation of the journal used for indexation in international databases: ***Potravinarstvo Slovak Journal of Food Sciences*** (***Potr. S. J. F. Sci.***). Former Slovak journal title: Potravinarstvo®.

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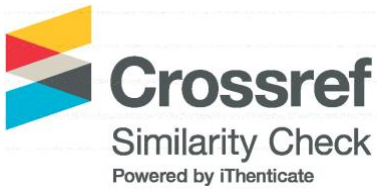

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SJR 2020: 0.259 SJR 2021: 0.228 SJR 2022: 0.278 SJR 2023: 0.232

CiteScore 2020: 1.6 CiteScore 2021: 1.9 CiteScore 2022: 2.5 CiteScore 2023: 2.5

potravinárstvo®
OPEN ACCESS
Received: 13.2.2024
Revised: 31.5.2024
Accepted: 18.6.2024
Published: 13.9.2024

Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 18, 2024, p. 792-806
https://doi.org/10.5219/1964
ISSN: 1337-0960 online
www.potravinarstvo.com

Innovative approach to the production of craft bread: A combination of tradition and innovation

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ABSTRACT

Today, the need to provide the population with high-quality food products, especially socially vulnerable citizens, requires significant efforts to find raw materials of high nutritional value available for mass consumption and their effective utilisation. This underscores the urgency of identifying reserves of available food nutrients to ensure balanced nutrition for the population of Ukraine, particularly as psycho-emotional stress increases in the conditions of martial law. These studies aim to scientifically justify and develop the latest technologies for bread incorporating sprouted wheat grain, hop sourdough, pumpkin puree, milk thistle, and fermented wort concentrate, which increase nutritional value. This article investigated the physicochemical and technological properties of dietary supplements and plant raw materials, scientifically substantiated the rational concentration and parameters of the technological process for the production of functional bakery products with their use, and studied the organoleptic, physicochemical properties, and nutritional value of the developed bakery products.

Keywords: rye-wheat bread, sprouted wheat grain, hop starter, pumpkin puree, milk thistle, dietary supplements

INTRODUCTION

An urgent contemporary issue is reducing environmental factors' negative impacts on health, particularly through improved nutrition. The unsatisfactory state of ecology and the deformed human diet lead to a decrease in the body's general resistance and the spread of several diseases, including those related to metabolism, such as diabetes, obesity, etc. **[1]**. Traditional nutrition does not provide a high preventive effect. According to the 'WHO Global Strategy in the Field of Nutrition, Physical Activity, and Health,' the gradual replacement of the traditional assortment of food products with functional ones, contributes to the maintenance of the normal functioning of all organs and systems of the human body, ensuring health and longevity, is the main direction of the civilised market **[2]**. Among the main principles is developing a strategy for creating new scientifically based technologies of ecologically clean food products, including functional purposes **[3]**.

In connection with the above, the formula for human nutrition at the beginning of the third millennium is the regular consumption of functional food products that, when consumed, specifically support and regulate specific physiological functions in the human body and reduce the occurrence of diseases **[4]**.

Due to their technological features, chemical composition, and biochemical characteristics of raw materials, bakery products have a high natural potential for correcting Ukrainians' nutritional status. Therefore, the efforts of domestic scientists and manufacturers are directed towards improving the assortment, developing, and implementing technologies of improved nutritional value with adjusted physiological properties **[5]**.

Bread is a product of mass regular consumption and occupies an average of 15% of the daily diet of Ukrainians. Increasing the nutritional value of bread and giving it functional properties is carried out by enriching it with natural products containing a significant amount of components, primarily biologically active substances **[29]**. It

contains carbohydrates, proteins, unsaturated fatty acids, and minerals **[6]**. However, despite having a fairly high caloric content, the chemical composition of bread needs to be more balanced in terms of vital components. Bread products have insufficient protein content. The ratio of proteins to carbohydrates is 1/6-1/7 compared to the optimal 1:4. Cereal proteins are inferior in amino acid composition. Bread proteins' main predominant amino acids are lysine, methionine, and tryptophan **[7]**.

Bread has high nutritional value. Unlike many other products, bread can give the human body significant energy and almost all vital substances: proteins, carbohydrates, vitamins, minerals, and fats. Thus, a bakery from high-grade wheat contains about 50% carbohydrates, 5-8% proteins, and 1% fats **[8]**. The energy value is 220 to 250 kcal per 100 g of the product. Additionally, wheat bakery products are important suppliers of some B vitamins (thiamine, riboflavin, niacin) and minerals (potassium, calcium, iron, magnesium, phosphorus) to the human body **[5]**.

Despite their rather high nutritional value according to modern requirements of nutritional science, bakery products need to improve their composition through enrichment with vegetable raw materials and dietary supplements **[6]**. In this regard, developing new functional bakery products using vegetable raw materials of increased biological value is relevant today **[25]**.

Due to their valuable chemical composition, pumpkin fruit processing products will allow for adjusting the bread recipe to obtain biologically valuable products with pronounced therapeutic and preventive properties **[9]**.

Milk thistle, which has been used in folk medicine for more than 2000 years as a remedy for various diseases, especially diseases of the liver, kidneys, and gall bladder, also has curative and preventive properties. Milk thistle is a rich source of amino acids (lysine, isoleucine, leucine, valine, and threonine), fatty acids, minerals, and phytochemicals, which, complementing the chemical composition and nutritional value of bread, will have a nutraceutical effect on human health (Table 1) **[10]**, **[11]**.

Table 1 Chemical composition of meals (per 100 g) **[30]**.

No	Indicator	Milk thistle meal
1	Protein, g	20
2	Fat, g	5.0
3	Carbohydrates, g	25.2
4	Fibre, g	35
5	Potassium, mg	920
6	Calcium, mg	1660
7	Magnesium, mg	420
8	Sodium, mg	4
9	Phosphorus, mg	960
10	Iron, mg	8
11	Iodine, mcg	9
12	Cobalt, mcg	10
13	Manganese, mcg	10
14	Copper, mcg	116
15	Vitamin A, mg	0.01
16	Vitamin C, mg	15
17	Vitamin B1, mg	0.3
18	Vitamin B2, mg	0.3
19	Vitamin B9, mcg	100
20	Vitamin E, mg	0.4
21	Vitamin PP, mg	2
22	Selenium, mcg	129

According to Table 2, milk thistle meal, in addition to high protein content, fat, and fibre, contains selenium, potassium, calcium, magnesium, iron, B vitamins, and vitamin E.

It has been established that such products can be used as food additives in products for medical and preventive purposes. Research data exists on the effect of plant additives on the properties of various types of dough and their components, as well as on the quality of finished products **[7]**.

Scientific Hypothesis

Dietary supplements can enhance the development of functional bread with increased nutritional value. After the addition of functional additives from sprouted wheat grain, pumpkin, fermented wort, and hops, we expect an increase in the amino acid composition and mineral substances in craft breads.

MATERIAL AND METHODOLOGY

Samples

The control sample of wheat yeast bread without additives was taken as a basis. The samples of semi-finished products made of dough for wheat bread with hops sourdough with sprouted wheat grain, wheat bread with hops sourdough with sprouted wheat grain with fermented wort concentrate, wheat bread with hops sourdough with sprouted wheat grain with pumpkin puree were tested.

Chemicals

All reagents (water, malt extract) were of USP purity and labelled LC/MS.

Animals, Plants and Biological Materials

This study used local raw materials from the Podillia region of Ukraine to produce craft bread.

Instruments

In the process of research, a MA 50.R weight moisture analyzer was used; laboratory scales TVE 3-0.05; hygrometer psychrometric VYT-2; 2-burner induction stove "ESPERANZA EKH008 St. Maria"; "Greentest" nitratometer; device for determining the humidity of food raw materials and products "Quartz" (Chyzhova's device); refractometer RPL-3; PH-262 pH meter; digital electronic thermometer with probe TP-101; laboratory tripod Bunsen SHL.

Laboratory Methods

Laboratory tests of raw materials were conducted at VITE's UTE laboratory of food technology, chemical, and microbiological research, which is certified by the quality management system (certificate No. UA.80050.063QMS-21). Indicators of raw materials and dough semi-finished products for craft bread were determined using physicochemical standard analysis methods following DSTU ISO 6820:2004 on Wheat and rye flour. General guidelines for the development of bread-making tests, corresponding to ISO 6820-1985 on Wheat flour and rye flour – General guidance on the development of bread-making tests, were followed as outlined in the relevant standards and instructions for technical and chemical control.

The preparation of the studied starter cultures was carried out following the recommendations **[12]**.

The rational amount of functional additives was determined experimentally. Organoleptic evaluation of the dough compositions was conducted on a 5-point scale.

The volume of starter cultures determined the physiological state of the microflora of liquid starter cultures. To one volume of spontaneously fermenting starter cultures, 3-5 volumes of water were added, shaken, and left for 1 minute. Afterward, the resulting suspension was used for the "crushed drop" preparation. In a stained preparation, a drop of Lugol's solution was added to the drop applied to the slide. The study was performed under a microscope at a magnification of *40 with a *10 or *15 eyepiece. The content of lactic acid bacteria and yeast was counted using standard methods with a Goryaev chamber **[3]**.

To determine the activity of lactic acid bacteria, 20 g of starter and 40 cm^3 of distilled water at 39 ±1 °C were stirred to a homogeneous consistency, and 10 cm^3 of the resulting suspension was taken into two test tubes. In one tube, 1 cm^3 of a 0.05% aqueous solution of methylene blue was added, and the other tube served as a control for color comparison. The tubes were closed with rubber stoppers, shaken, and placed in a thermostat at 40 °C. The time during which methylene blue discolored was recorded.

Humidity was determined by the drying method. The mass fraction of moisture was determined after baking by drying in an oven at 105 °C to a constant weight. The moisture content of semi-finished products (W), %, was calculated using the formula (1):

$$W = (m1-m2) \times 100 / m3; \quad (1)$$

Where:

m1, m2 – are the masses of the sample with the bag before and after drying, g; m3 – the weight of the semi-finished product, g.

The titratable acidity was determined using generally accepted methods (Figure 1).

Figure 1 Preparation of extract from the dough to determine acidity.

The lifting force of the dough was determined by the accelerated method by the floating of the dough ball, for which it was kneaded according to the recipes of the dough compositions. The dough food compositions were prepared by the dough batch method, and functional additives were introduced at the kneading stage.

Description of the Experiment

Number of samples analyzed: 5 samples.

Number of repeated analyses: All biochemical procedures were conducted in 15 repetitions.

Number of experiment replication: 2 times.

Design of the experiment: The experiment was carried out at the facilities of the craft bakery "Domashnya Vypichka Sonto France", Vinnytsia region, Ukraine.

The control sample of wheat yeast bread without additives was used as a basis. In the course of the experiment, semi-finished dough products were made for wheat bread on hop sourdough with germinated wheat grain "Semeyniy", wheat bread on hop sourdough from germinated wheat grain with fermented wort concentrate "Slovyanskiy", wheat bread on hop sourdough with germinated wheat grain with pumpkin puree "Selianskiy".

The specific measurement targets were the following indicators: active acidity for dough compositions, acidity of baked laboratory samples by the arbitration method, duration of fermentation of dough compositions, duration of proofing, spreading of the dough ball during fermentation and proofing, fermentation temperature, lifting power, mould stability, baking, specific volume of bread, porosity of crumb.

One method to enhance bakery products' microbiological purity is to utilize hop leavens in bread baking **[13]**. Hop-leavened bread has superior taste and aroma, undergoes less staling, and is less susceptible to foreign microflora **[14]**, **[15]**.

The studied starter cultures were prepared by fermenting 1st-grade wheat flour with a brew of hops (hops are poured with water and brewed for 15-20 minutes). After the hop brew has cooled, malt extract is added to it. The solution is poured into the fermentation vessel; additional flour is added and stirred. The starter is fermented at 30-32 °C to an acidity of 7-10 °T for 7-10 days until a specific "leaven" smell is obtained.

Arbitration method. Bread acidity was determined by the arbitration method. 25 g of crushed pulp was poured into a dry bottle with a capacity of 0.5 dm3, 250 cm^3 of room temperature water was added, and the pulp was thoroughly pounded with water with a wooden pestle. Shake vigorously for 2 minutes; stand for 10 min. Drained the extract through a sieve and pipetted 50 cm^3 into two conical flasks with a 100-150 cm^3 capacity and titrated. 0.1 mol/dm^3 sodium hydroxide solution. From 2-3 drops of phenolphthalein to a faint pink colour that does not disappear within 1 minute **[12]**.

To determine the rational amount of functional additives, experimental studies were conducted with the addition of germinated wheat grain in the amount of 10%, 20%, 30%, 40%, and 50% of the flour mass; pumpkin puree – 10%, 25%, 50%, 60%, 70% by mass of water; fermented wort concentrate – 0.1%, 0.5%, 1%, 2%, 4% by mass of sugar; milk thistle meal – 3%, 6%, 9%, 12%, 15% of the flour mass; hop starter – 100% of the mass of yeast. The influence of functional additives and plant raw materials on the structural and mechanical parameters of dough compositions is shown in Table 2.

The analysis of the research results showed that the addition of functional additives and vegetable raw materials in the production of dough food compositions helps to improve the elasticity of the dough for composition No. 1 – 4-10%, composition No. 2 – 9-12%, composition No. 3 – 12-18%; proofing of dough blanks - composition No. 1 – 4.9x103s., composition No. 2 – 4.6x103., composition No. 3 – 4.3x103s.; duration of fermentation on composition No. 1 – 7.5-8.6 x 103 s., composition No. 2 – 8.3-8.8 x 103 s., composition No. 3 – 6.6-7.8 x 103 s.; blurring of the dough ball during fermentation and proofing on THK No. 1 – 1-8%, THK No. 2 – 6-8%,

composition No. 3 – 8-17%; lifting force – composition No. 1 – 1.5 x 103 s, composition No. 2 – 1.4 x 103 s, composition No. 3 – 1.5 x 103 s. and dough properties improve during development.

Table 2 Structural and mechanical parameters of dough compositions.

Indexes	Control	Dough food composition No.1					Dough food composition No. 2					Dough food composition No. 3				
		Added SGW, % of the amount of flour					Added pumpkin puree, % of the amount of water					Added FWC, % of the amount of sugar, and RP, % of the amount of flour				
		D1	D2	D3	D4	D5	D1	D2	D3	D4	D5	D1	D2	D3	D4	D5
		10	20	30	40	50	10	20	50	60	70	3	6	9	12	15
Duration of fermentation, min.	150	144	140	135	130	125	148	145	144	140	139	130	125	120	115	110
Duration of resistance, min.	120	83	81	80	81	82	77	76	75	74	73	73	72	70	68	66
Blurring of the dough ball during fermentation and proofing, %	170	169	167	165	160	158	157	158	160	159	158	145	150	158	156	154
Fermentation temperature, °C	28	27	26	26	27	28	27	25	26	25	24	23	25	26	25	24
Acidity, degrees	12	10	10	11	10	10.2	11	11	11	10	10.4	10.7	10	10	10.4	10.1
Lifting force, min.	30	25	24	23	23	23	24	23	23	23	23	25	24	23	23	23

The preparation of dough food compositions is given in Table 3.

Table 3 Dough food compositions.

Experiments		Experiment No. 1	Experiment No. 2	Experiment No. 3	Experiment No. 4	Experiment No. 5
Dough food composition No. 1, %	Wheat flour	90	80	70	60	40
	Sprouted grain of wheat	10	20	30	40	50
	Hop starter	100	100	100	100	100
Dough food composition No. 2, %	Wheat flour	90	80	70	60	40
	Sprouted grain of wheat	100	100	100	100	100
	Hop starter	100	100	100	100	100
	Water	90	80	50	40	30
	Pumpkin puree	10	20	50	60	70
Dough food composition No. 3, %	Wheat flour	90	80	70	60	40
	Sprouted grain of wheat	10	20	30	40	50
	Hop starter	100	100	100	100	100
	Wheat flour	97	94	91	88	85
	Spotted milk thistle	3	6	9	12	15
	Sugar	99.7	99.5	99	98	96
	Concentrate fermented wort	0.1	0.5	1	2	4

The dough was prepared using the steam method; functional additives and vegetable raw materials were introduced at the stage of kneading (Figure 2).

A . B. C.

Figure 2 The preparation of the dough. Note: A) displacement of dry ingredients with liquid; B) addition of hop starter; C) general view of the ooze.

When choosing the dosage of pumpkin puree when preparing dough composition No. 2, several factors were taken into account: the need for maximum enrichment of semi-finished products with vitamins and other biologically active substances; achieving optimal concentration in terms of their impact on the human body; obtaining baked semi-finished products with high organoleptic properties (color, taste, smell); economic feasibility. The concentration of pumpkin puree in the amount of 50% of the mass of water corresponds to these factors and is appropriate. Introducing pumpkin puree into the recipe allows you to increase the content of vitamins (A, B1, B2, and B6), and minerals (calcium, phosphorus, magnesium, potassium, and sodium) and reduce the energy value of baked semi-finished products. As a result of experimental studies, adding pumpkin puree to doughy food compositions improves the color, porosity, and elasticity of the pulp, and the shape of baked semi-finished products (Figure 3).

Figure 3 Determination of active acidity dough food composition No. 2 (pumpkin puree), dough food composition No. 3 (spotted milk thistle).

Statistical Analysis

Calculations were used on a computer. Experimental data was primarily processed using application programs for statistical analysis using criteria. The research was carried out in five repetitions. An application program for experiment planning and optimization was used to optimize the package of technological process parameters. The data were analyzed statistically using Microsoft Excel and Statistica 15. All experiments were performed in duplicate, and the results are presented as the results of these repeated determinations with standard deviations. The Students' t-test was used to analyze the results statistically. Data are presented as mean ± standard error of the mean (SEM). The minimum permissible difference for probes from the same sample was 5%. Test compositions with a larger difference were not considered.

RESULTS AND DISCUSSION

In the process of research, we used the following ingredients: wheat flour (DSTU 46.004-99 Wheat flour, Agrofirma Birkoff LLC, Ukraine), sprouted wheat grain (TM Dobra Ezhya Eco Choice, Ukraine), hop starter (SugrA-roma Durum Intense, Dr. Suwelack, Germany), pumpkin puree (local raw materials from Podillia region, Ukraine) **[24]**, milk thistle meal (Pharmacom Ltd., Ukraine), kvass wort concentrate (Kaniv Malt Extracts Plant Ltd., Ukraine), vegetable oil "Shchedryi Dar" DSTU 4292:2005 produced by Vinnytsia Oil and Fat Plant, Vinnytsia **[22]**.

Hop starters contain significantly more yeast cells than liquid rye starters, which affects their leavening power. Hop leavens rise in 18 minutes, compared to 25 minutes for rye leavens. The acidity of hop starters is typically 9.0 ±1.0 degrees **[13]** (Table 4).

Table 4 Comparative characteristics of sourdough acid accumulation **[13]**.

Time, min	Titrated sourdough acidity, degrees		
	hops	rye	grain
60	6.5	6.3	6.6
120	6.9	6.7	7.0
180	7.3	7.5	7.3
240	7.8	8.0	7.9
300	8.3	8.8	8.4
360	8.9	9.4	9.1
420	9.2	10.2	9.9
480	9.7	11.0	10.7
540	10.3	11.6	11.2
600	10.8	12.1	11.9
660	11.2	12.5	12.4
720	11.4	13.0	12.9

The data in Table 1 show that with an increase in fermentation time, the indicators of the hop leaven have the most optimal values, which will affect the acidity of the dough using this leaven and the quality of the finished products. Many scientists recommend including sprouted grain products in the diet, which cleanse the body, help remove toxins, and increase the immune system's resistance. The technology of making bread from sprouted wheat allows you to preserve a large amount of B vitamins and fiber in the final product, which are necessary for maintaining normal bodily functions **[23]**, **[26]**. This is achieved because grains are not ground into flour, and yeast is not added to the dough, allowing the healing properties of grain germs to be preserved **[14]**.

The use of fermented wort concentrate in the preparation of yeast-free bakery products allows not only to exclude sugar from the recipe while preserving the sweet taste of the product but also to enrich it with biologically active substances. Fermented wort concentrate is a brown, viscous liquid with a sweet-sour taste, maintained by kneading rye and barley malt with water, followed by clarification. It is well preserved due to its thick consistency (80%) **[16]**.

During the laboratory experiment, the tasting committee determined and analyzed the organoleptic indicators of all dough compositions **[30]**. The organoleptic evaluation on a 5-point scale is presented in Table 5.

After researching the rational amount of additives, the influence of sprouted wheat grain, hop sourdough, pumpkin puree, milk thistle, and fermented wort concentrate on the structural-mechanical, functional-technological, and physical properties of dough food compositions were determined **[28]**.

In the research process, laboratory baking of the developed dough compositions was conducted **[21]**. To fully characterize the nutritional value of baked samples, the chemical composition of bakery products with the addition of wheat sprouts and hop starter was investigated. Quantitative analysis showed that incorporating hop sourdough significantly improved dough quality, increasing volume by 5.7% and achieving more uniform porosity **[27]**.

The results of the experimental studies are presented in Table 6.

Comparing the chemical composition of the control and researched bakery products, it can be concluded that the nutritional value of the products increased according to the following indicators: proteins by 22.5% and 25.25% (Figure 4); potassium – by 32.6% and 32.65%; magnesium – by 186.2% and 188.18%, thiamine – by 285% and 585%, pyridoxine – by 180% and 344%; dietary fibers satisfy the daily requirement by 27% in experiments No. 1 and No. 2, respectively.

The organoleptic evaluation of dough composition No. 1 for “Family” bread is shown in Figure 4.

Table 5 Organoleptic evaluation of dough food compositions, points.

Experiment	Appearance	Color	Scent	Consistency	Taste	Porosity	Overall assessment
Dough food composition No. 1							
Control	4.79 ±0.10	4.82 ±0.10	4.74 ±0.10	4.65 ±0.10	4.46 ±0.10	4.45 ±0.10	4.65 ±0.10
Experiment No. 1	4.80 ±0.10	4.83 ±0.10	4.74 ±0.10	4.66 ±0.10	4.46 ±0.10	4.46 ±0.10	4.66 ±0.10
Experiment No. 2	4.81 ±0.10	4.82 ±0.10	4.75 ±0.10	4.65 ±0.10	4.45 ±0.10	4.46 ±0.10	4.66 ±0.10
Experiment No. 3	4.86 ±0.10	4.94 ±0.10	4.89 ±0.10	4.75 ±0.10	4.63 ±0.10	4.73 ±0.10	4.80 ±0.10
Experiment No. 4	4.76 ±0.10	4.80 ±0.10	4.72 ±0.10	4.60 ±0.10	4.44 ±0.10	4.43 ±0.10	4.62 ±0.10
Experiment No. 5	4.75 ±0.10	4.76 ±0.10	4.70 ±0.10	4.58 ±0.10	4.40 ±0.10	4.41 ±0.10	4.60 ±0.10
Dough food composition No. 2							
Control	4.79 ±0.10	4.82 ±0.10	4.74 ±0.10	4.65 ±0.10	4.46 ±0.10	4.45 ±0.10	4.65 ±0.10
Experiment No. 1	4.81 ±0.10	4.84 ±0.10	4.76 ±0.10	4.68 ±0.10	4.47 ±0.10	4.48 ±0.10	4.67 ±0.10
Experiment No. 2	4.83 ±0.10	4.85 ±0.10	4.77 ±0.10	4.67 ±0.10	4.48 ±0.10	4.49 ±0.10	4.68 ±0.10
Experiment No. 3	4.87 ±0.10	4.92 ±0.10	4.90 ±0.10	4.77 ±0.10	4.68 ±0.10	4.75 ±0.10	4.82 ±0.10
Experiment No. 4	4.77 ±0.10	4.82 ±0.10	4.74 ±0.10	4.62 ±0.10	4.47 ±0.10	4.47 ±0.10	4.69 ±0.10
Experiment No. 5	4.78 ±0.10	4.78 ±0.10	4.72 ±0.10	4.60 ±0.10	4.48 ±0.10	4.45 ±0.10	4.70 ±0.10
Dough food composition No. 3							
Control	4.79 ±0.10	4.82 ±0.10	4.74 ±0.10	4.65 ±0.10	4.46 ±0.10	4.45 ±0.10	4.65 ±0.10
Experiment No. 1	4.82 ±0.10	4.85 ±0.10	4.76 ±0.10	4.68 ±0.10	4.48 ±0.10	4.47 ±0.10	4.67 ±0.10
Experiment No. 2	4.84 ±0.10	4.84 ±0.10	4.77 ±0.10	4.67 ±0.10	4.47 ±0.10	4.48 ±0.10	4.68 ±0.10
Experiment No. 3	4.88 ±0.10	4.99 ±0.10	4.90 ±0.10	4.79 ±0.10	4.69 ±0.10	4.75 ±0.10	4.82 ±0.10
Experiment No. 4	4.78 ±0.10	4.82 ±0.10	4.73 ±0.10	4.62 ±0.10	4.45 ±0.10	4.45 ±0.10	4.64 ±0.10
Experiment No. 5	4.77 ±0.10	4.75 ±0.10	4.74 ±0.10	4.60 ±0.10	4.44 ±0.10	4.44 ±0.10	4.63 ±0.10

Table 6 Chemical composition of bakery products with the addition of sprouted wheat and hop leaven.

Nutrients	Control	Experiment No. 1	Experiment No. 2	Difference (experiment No. 1)	Difference (experiment No. 2)	Relative deviation, % (experiment No. 1)	Relative deviation, % (experiment No. 2)
Belky, g	16.0	19.16	20.04	3.16	4.04	22.50	25.25
Carbohydrates,g	70.0	76.24	76.7	6.24	6.70	8.90	9.57
Dietary fibers, g	0.3	7.94	7.96	7.64	7.66	2646	2653
K, mg	300	397.87	397.95	97.87	97.95	32.60	32.65
Ca, mg	250	261.55	261.87	11.55	11.87	4.62	4.75
P, mg	250	431.2	431.88	181.2	181.88	72.48	72.75
Fe, mg	2.0	4.45	11.8	2.45	9.8	2.22	5.90
Mg, mg	50	143.1	144.09	93.1	94.09	186.20	188.18
B_1, mg	0.2	0.77	1.37	0.57	1.17	285.0	585.0
B_3, mg	1.0	1.35	3.08	0.35	2.08	35.0	308.0
B_6, mg	0.5	0.9	1.72	0.40	1.22	180.0	344.0
PP, mg	5.0	5.35	5.39	0.35	0.37	7.0	7.8
E, mg	6.0	6.3	7.04	0.30	1.04	5.0	17.3
Folic acid, mg	-	0.11	0.18	0.11	0.18	-	-
Energetic value, kcal	335.5	395.1	445.91	59.60	110.41	17.8	32.9

Note: all values are expressed as the mean ±SD (standard deviation). The difference with the control is statistically significant, $p < 0.05$.

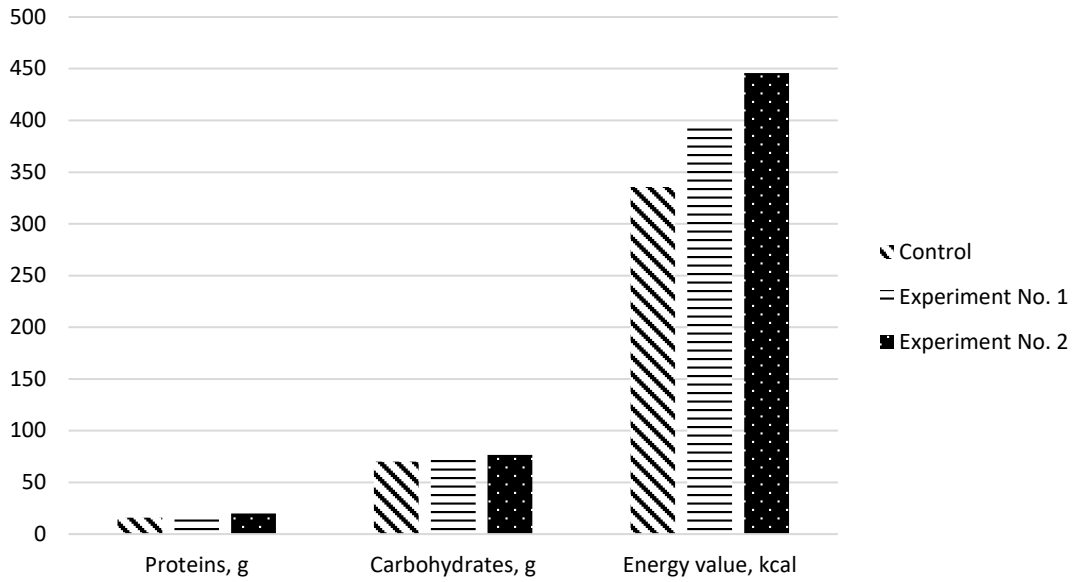


Figure 4 Composition and energy value of bakery products with the addition of sprouted wheat and hop starter.

The quality of baked laboratory samples according to organoleptic indicators corresponds to the regulatory and technological documentation – ISO 6820-1985.

Organoleptic and physicochemical indicators of the quality of experimental samples are given in Table 7.

Table 7 Organoleptic indicators of the quality of wheat bread with sprouted wheat grain.

Name indicator	Bread wheat (Control)	Wheat bread 'Family' (experiment)	Wheat bread 'Peasant' (experiment)	'Slavyansky' wheat bread (experiment)
Organoleptic indicators				
Surface	Smooth without pollution. large cracks and undermining	Coarse, without pollution, without large cracks and undermining, the grinding of soft wheat grains is visible		
Condition of the pulp	Baked, elastic, with developed porosity, without traces of unbaked and compacted pulp	Baked, compacted, soft without traces of unthreshing, on the cut you can see crushed soft grains of wheat		
The color of the crust	Light yellow	Yellow. without burning and pollution		
Taste and smell	Characteristic of this name of bread. without extraneous taste and smell	Pleasant without extraneous aftertaste and smell. characteristic of this type of bread and the raw materials and additives used		
Physico-chemical parameters				
Acidity, degrees	7.0	3.0	3.0	3.0
Humidity, %	45.0	44.0	42.0	43.0
Porosity, %	50.0	72.0	70.0	71.0

During experimental studies, it was established that a further increase in the concentration of functional additives leads to a decrease in quality, namely, a decrease in the volume of wheat bread, deterioration of the crumb structure, and loss of its elasticity, characteristics of products with such additives. The taste and smell of products with the recommended amount of additives acquire pleasant shades. Still, a further increase in the dosage of dietary supplements gives the products an excessively pronounced taste and smell **[3]**.

The introduction of germinated wheat grain practically does not affect the ough's initial titrated acidity. However, as the additive's dosage increases, the process of acid accumulation in dough samples with the additive is more intense than in the control one. The use of wheat germ processing products intensifies the process of acid accumulation in the dough, confirming the possibility of reducing the duration of its ripening **[17]**, **[12]**.

According to scientists' research, pumpkin fruit processing products (due to their valuable chemical composition) will allow for adjusting the bread recipe to obtain biologically valuable products with pronounced therapeutic and preventive properties **[9]**.

It was established that the addition of 70% pumpkin puree to the mass of water in the recipe of bread made from high-grade flour reliably reduces the baking of bread, its volume, specific volume, the ratio of the volume of bread to the volume of the dough, and convexity **[18]**.

Fermented wort concentrate is a brown, viscous liquid with a sweet-sour taste, maintained by kneading rye and barley malt with water, followed by clarification. It keeps well due to its thick consistency (80%). The use of fermented wort concentrate in the preparation of yeast-free bakery products makes it possible not only to exclude sugar from the recipe while preserving the sweet taste of the product but also to enrich it with biologically active substances **[16]**.

Milk thistle (Silybum marianum) contains fat-soluble vitamins such as vitamins A, D, E, and K, especially vitamin E, the main antioxidant among vitamins. This vitamin plays a significant role in the human body, protecting it from the effects of chemical and physical factors that contribute to the development of tumors **[11]**, **[19]**.

The plant contains the antioxidant silymarin, proteins (17%), which contain all essential amino acids, and water-soluble vitamins **[10]**, **[2]**. Based on the obtained data, it can be concluded that the baked semi-finished product, made with the addition of milk thistle in the amount of 9% of the flour mass and fermented wort concentrate in the amount of 1 % of the sugar mass, has the highest organoleptic indicators (Table 2, Figures 4-6).

The organoleptic evaluation of dough composition No. 1 for “Family” bread is presented in Figure 5.

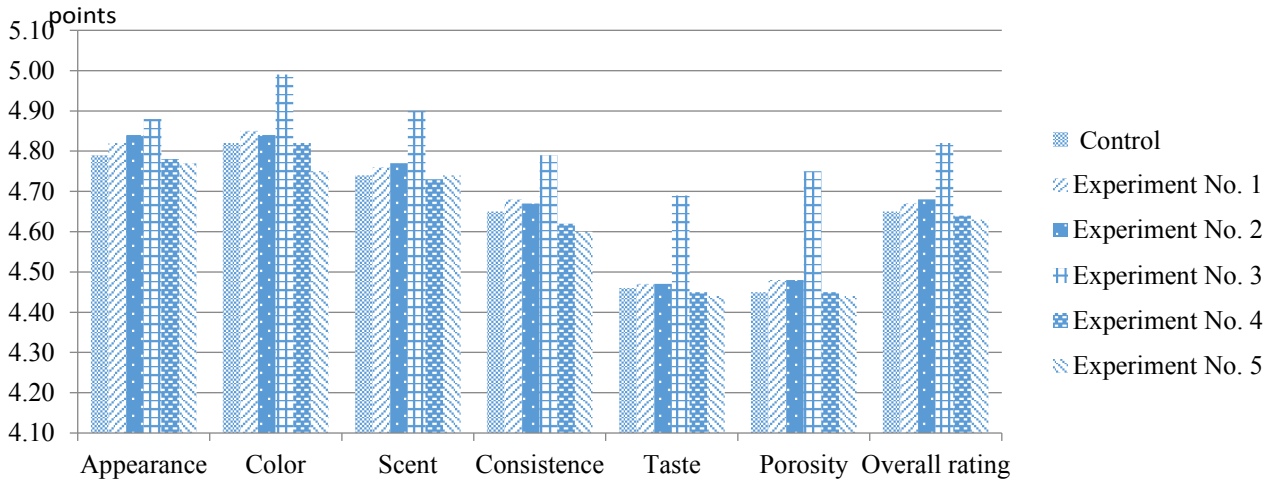


Figure 5 Organoleptic evaluation of dough food composition No. 1.

The organoleptic evaluation of dough composition No. 2 for “Selyansky” bread is presented in Figure 6.

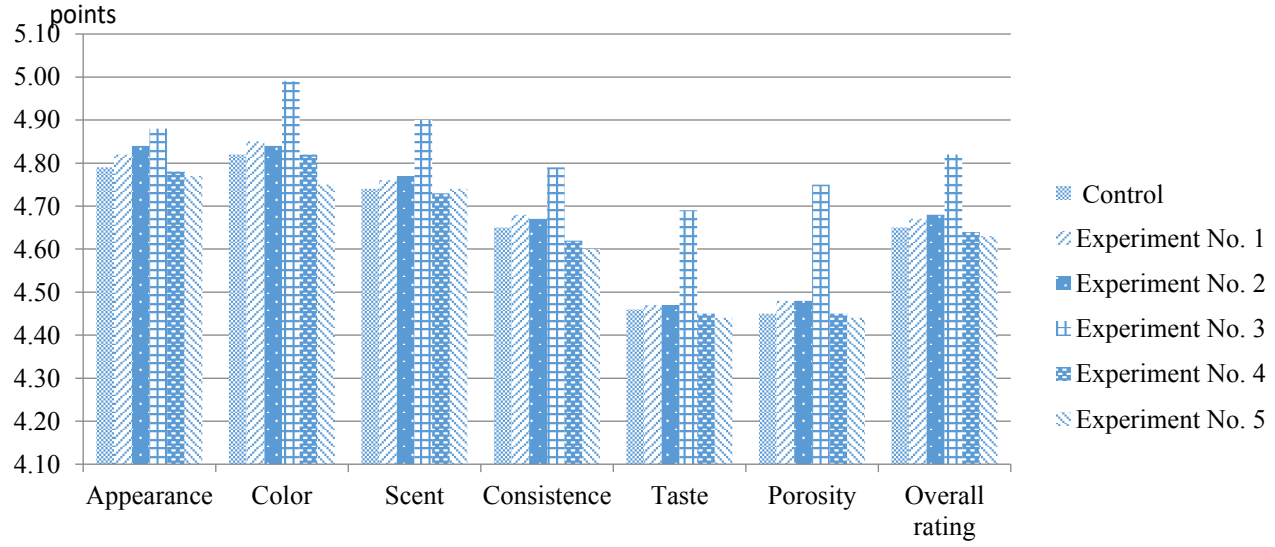


Figure 6 Organoleptic evaluation of dough food composition No. 2.

The organoleptic evaluation of dough composition No. 3 for "Slovyansky" bread is presented in Figure 7.

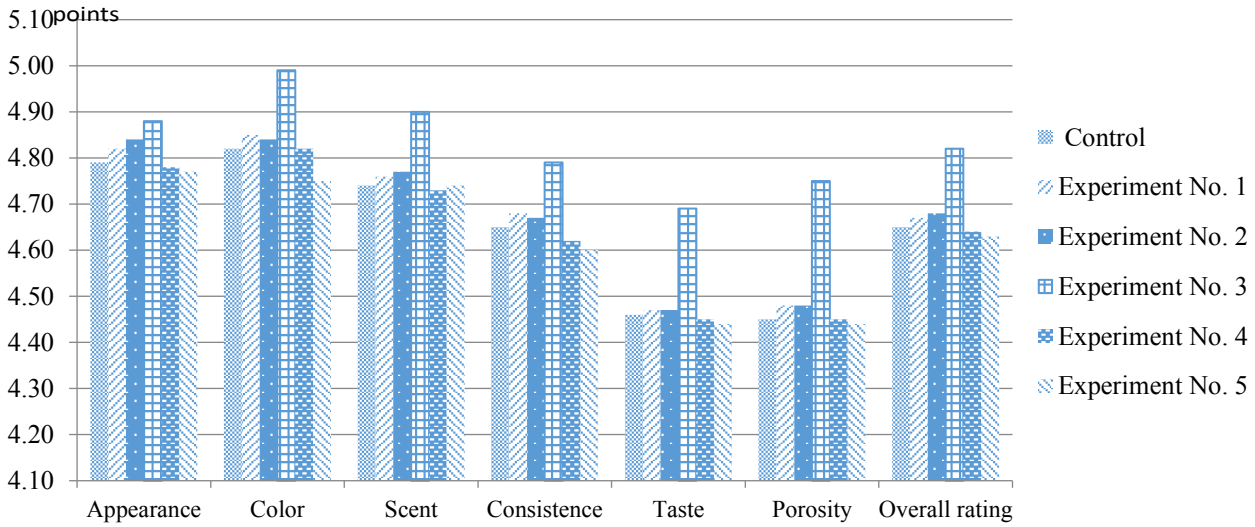
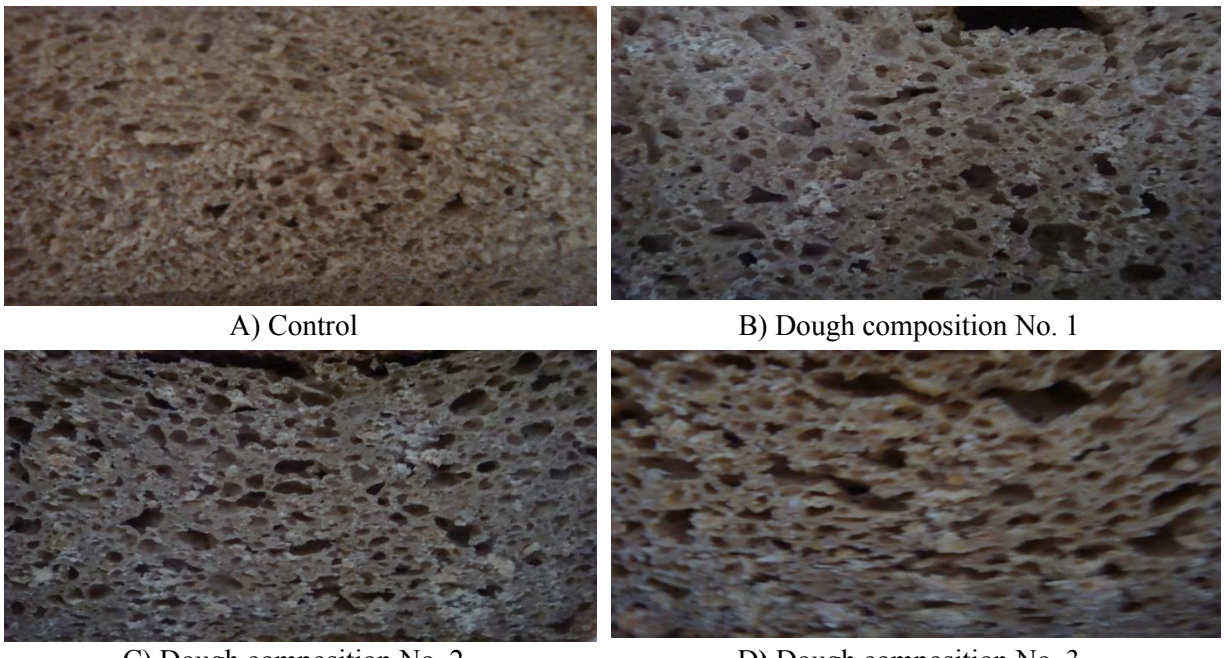


Figure 7 Organoleptic evaluation of dough food composition No. 3.

The results of the organoleptic evaluation of dough food compositions No. 3 established that the addition of milk thistle in the amount of 3-6% of the mass of flour and fermented wort concentrate in the amount of 0.1-0.5% of the mass of sugar does not significantly affect the organoleptic indicators of baked semi-finished products **[20]**.

Using hop leaven in dough food compositions improves the quality of baked semi-finished products: the pulp is more elastic, the porosity is more developed and uniform, and the baked semi-finished product acquires a specific pronounced taste and aroma. The time for preparing the dough and semi-finished product is reduced by 30 minutes **[15]**. The organoleptic evaluation of dough food compositions established that adding 10-20% sprouted wheat grain from the flour mass does not affect the organoleptic indicators of baked semi-finished products (Table 4). In 40-60%, sprouted wheat grain gives semi-finished products an excessively pronounced taste and smell and a too-dense consistency, reducing the organoleptic evaluation **[8]**. So, based on the obtained data, it can be concluded that the baked semi-finished product made with the addition of sprouted wheat grain in the amount of 30% of the flour mass has the highest organoleptic indicators.

After laboratory baking, photographic images were received of the structure of baked dough compositions using sprouted wheat grains, hop sourdough, pumpkin puree, sourdough wort concentrate, and milk (Figure 8).



A) Control B) Dough composition No. 1

C) Dough composition No. 2 D**)** Dough composition No. 3

Figure 8 Samples of laboratory baking of developed dough compositions.

As can be seen from Figure 8, the addition of dietary supplements and vegetable raw materials improves the structure of the porosity of the dough blanks compared to the control. In the first baking period, a crust's formation occurs due to thermal and moisture conductivity, and the amount of baking in this regard is insignificant. In contrast, the rate of moisture release gradually increases. In the second baking period, the rate of moisture release remains constant and equal to the maximum rate reached at the end of the first baking period. Therefore, the main baking loss occurs during the second baking period. The surface layer of the dough blanks is subjected to dehydration to a greater extent, while part of the moisture (approximately 80-85%) that evaporates passes into the gaseous environment of the baking chamber, and part – 20-15% moves due to thermal moisture conductivity into the soft dough blanks. As a result, to reduce baking losses, it is advisable to complete the baking of dough blanks at a reduced temperature of the baking chamber – 200 °C.

CONCLUSION

Our findings support the strategic inclusion of functional additives such as sprouted wheat grain, pumpkin puree, and milk thistle meal in craft bread dough formulations, marking a significant advance in nutrition and healthy eating. The rational amount of functional additives in dough food compositions was determined: sprouted wheat grain – 30%, milk thistle meal – 9%, pumpkin puree – 50% by weight of water, fermented wort concentrate – 1% by weight of sugar, hop sourdough starter – 100% by weight of yeast. It was found that a further increase in the concentration of functional additives leads to a decrease in bread quality, namely, a decrease in the volume of wheat bread, deterioration of the crumb structure, and loss of elasticity. As a result of the studies of the dough samples, it can be concluded that the nutritional value of the products increased by the following indicators: proteins by 22.5% and 25.25%; potassium by 32.6% and 32.65%; magnesium by 186.2% and 188.18%, thiamine by 285% and 585%, pyridoxine by 180% and 344%; dietary fibre satisfied the daily requirement by 27% in experiments No. 1 and No. 2, respectively. Developing dough compositions for producing Semeyniy, Slavyansky, and Selyansky bread will enable the production of products of high biological value for functional purposes that meet modern requirements for healthy eating. Our further scientific research aims to substantiate the technological modes of molding and baking the above types of bread.

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Funds:

This research received no external funding.

Acknowledgments:

We would like to express our gratitude to the Slobodianiuk family's craft bakery "Home Baking "Sonto Frans", Vinnytsia region, Ukraine, which was used for the research.

Conflict of Interest:

The authors declare no conflict of interest.

Ethical Statement:

This article does not contain any studies that would require an ethical statement.

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