Innovative Technology of the Scoured Core of the Sunflower Seeds After Oil Expression for the Bread Quality Increasing

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1 Introduction

At present, in the diets of the Ukrainian population, there is a deficit of macro- and microelements, protein, polyunsaturated fatty acids, vitamins, food fibers, and biologically active substances. There is an imbalance in their food consumption. This can be explained as available in the processing of inferior raw materials, the deterioration of the environmental situation, violations in the structure of nutrition, that is, the reasons that lead to an increase in the number of people suffering from various diseases, including malnutrition.

Improving the nutritional structure of Ukrainians and ensuring the quality and safety of food products have become the most important priority of our country's domestic policy. The current development of the production sphere of the healthy food products is oriented to the modern nutrition postulates. In particular, with the technology development which allows receiving on the basis of the rational use of natural raw materials, there are the food products that contribute to the nutrition improvement and prevent the diseases associated with the alimentary factor. One of the main tasks of Ukraine food industry is the sustainable production development

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of the domestic raw materials and the food in sufficient quantities to provide food products to the country's population using new advanced technologies for the deep and comprehensive processing of food raw materials [1–5].

At present, the secondary resources of oil and fat production are actively used in the food decision, ecological and energy problems being an additional source of substances of natural origin. A significant amount of secondary resources is formed during the sunflower seeds processing—the main oilseed crop in Ukraine—namely sunflower cake and sort. The most valuable properties of sunflower cake are high protein content, low cost, and the absence of toxic and antiviral substances in it. However, sunflower meal and cake are used mainly for the agricultural purposes, in particular as feed additives for poultry and livestock. Analyzing the chemical composition of the kernels of sunflower seeds containing 20% of protein, 50% of lipid, dietary fiber, minerals, and other substances, it can be concluded that they are a good source of nutrients and can be used in food technologies [4, 5].

The valuable nutrients promising source (essential fatty acids, essential amino acids, vitamins, etc.) as well as raw materials improves the functional and technological properties of the food products, and the quality of the finished product is the scoured core of the sunflowers seeds (SCSS). SCSS was made of using the complex innovation technologies as the low temperature of sunflower seeds extrusion. The most valuable properties of SCSS are: high protein content (more than 39% in terms of the dry substance), amino acids, essential polyunsaturated fatty acids, significant amount of antioxidants: vitamin E—15.4% and chlorogenic acid—0.3%; no toxic and anti-nutritional substances and low cost; water and fat-containing ability [6].

The studies' analyses results of the chemical composition showed that the sunflower seeds of modern selection (sorts of Source P-453 Master Buzuluk; hybrids Mercury, Melin, Altair) that is prevalent in the total gross harvest of the sunflower seeds in Ukraine is a prospective raw material for obtaining a range of high nutritional value of the food products, namely oil, lecithin, dietary protein, and natural complex of antioxidants, including chlorogenic acid.

In addition, the minimum content of phenolic compounds in SCSS provides the light color of the scoured core of the sunflower seeds which indicates the possibility of its inclusion in bakery products from the wheat flour without deterioration of crumb color as well as in other food production. All this makes SCSS one of the promising raw materials with a complex action that can be used in food industries [5, 6].

Therefore, it is relevant to use the scoured core of the sunflower seeds in food technology.

2 Literature Data Analysis and Problem Statement

Today, the problem of protein nutrients shortage in the diet of Ukraine population reached the maximum value. Economy changes led to the fact that for the last 3 years the purchasing power has decreased significantly. And the consumers economize first of all on food buying the cheap products of dubious quality and insufficient biological and nutritional value.

Indeed, the cost of quality raw materials has increased, and therefore, the use of the new sources of raw materials and enrichment is important today, first of all the mass consumption products—bread and bakery products.

Bread is the basic food consumed daily; therefore, its quality must be subject for all the medical–biological requirements. These figures depend on a number of factors; the main one is the quality of the main and additional raw materials used in the production of bread.

In industry, nearly 50% of the total flour is recycled with reduced properties and the big bakeries use the continuous technologies which have several disadvantages, including the impact on the bread quality.

Not enough is satisfied the need of the population in bakery products for medical–dietary, prophylactic, and functional purpose, especially in the war zones and the ecological trouble. There is also a problem in the production of bread and bakery products for a long storage.

It is therefore necessary to pay close attention to the selection of assortment and creation of new formulations that provide specified consumer properties of finished products.

In Ukraine, the large acreage is sunflower. However, known as oil-bearing crop, it consists of 20% of protein and other valuable substances, and that is why, it can be served as a basis for its use as a polyfunctional component.

The feasibility of secondary products using of oil-bearing seeds processing particularly in SCSS in the bread production is associated with increasing the biological value and improving technological and taste qualities of the products [7, 8].

By now, there are famous works about the improvement in biological value of bakery products by enriching them with the processing products of sunflower protein isolate [8–10]. Its disadvantage is the narrow focus of the action.

The recent work [11–14] has shown that the bread production is enriched with the nutrients of the sunflower seeds and their processing products had certain difficulties.

The introduction of 5% or more of the seed flour or protein isolate from the sunflower seeds or meal using the traditional technology of making bread has led to the deterioration of its quality—eclipse crumb, poorly developed porosity, which significantly reduced the consumer appeal of the finished products [12, 14].

The disadvantages of the other technologies of the sunflower seeds processing and getting the oil are the high-temperature regimes leading to a deep denaturation of seed proteins excludes obtaining possibility from them and the food protein products without additional processing [6, 15].

A complex processing technology of the scoured core of the sunflower seeds (SCSS) is perspective that provides for receiving product—SCSS enriched the physiologically valuable oil and is also very popular in the food technology ingredients like vegetable protein and lecithin.

SCSS also has moisture and the fat-containing ability; the ability to form persistent emulsions has an antimicrobial effect.

Therefore, the scientific rationale for using SCSS for bakery products of high quality and nutritional value has the great practical prospects in the food industry.

3 The Purpose and Objectives of the Research

The work purpose is the processing technology development of SCSS for improving the quality of wheat bread and bakery products.

To achieve the goal next tasks were set:

- to investigate the chemical composition and functional–technological properties of the scoured core of the sunflower seeds after the oil expression (SCSS);
- to investigate the SCSS influence on the organoleptical characteristics of the wheat bread prototypes;
- to investigate the SCSS influence on physicochemical characteristics of the experimental samples of the wheat bread;
- to investigate the SCSS influence on the structural and mechanical properties of the experimental samples of the wheat bread;
- to investigate the SCSS influence on the microbiological properties of the experimental samples of the wheat bread.

4 Materials, Equipment, and Research Methods of the Scoured Core of the Sunflower Seeds After the Oil Expression

In this work, we investigated the influence on the scoured core of the sunflower seeds (SCSS) after the oil expression on the organoleptical, physicochemical, structural–mechanical, and microbiological characteristics of the wheat grain with the aim of improving its quality, nutritional, and biological value.

The research object is the bread technology from the wheat flour. The research subjects are:

- the scoured core of the sunflower seeds after the oil expression (SCSS) obtained by using the innovative integrated technology for the sunflower seeds processing [the producer of LLC “NAUTECH PLUS,” Ukraine];
- pattern 1 the control—wheat bread SSU 7517:2014 quality indicators: humidity crumb—not more than 43.0%; acidity not more than—3.5°; porosity—not less than 57.0%;
- pattern 2—the wheat bread with SCSS in the amount of 2, 5% by weight of flour in powder form;
- pattern 3—wheat bread with SCSS in the amount of 5, 0% by weight of flour in powder form.

To implement the set tasks were used the conventional and standard methods of testing according to SSU-P 4583:2006 and SSU 7517:2014, the modern instrumental methods of biochemical, physicochemical, and microbiological analysis. The contents of crude fat and moisture were determined by using IMR-relaxometry minispec mq-20 (Bruker, Germany) according to AUSS (All Union State Standard) 8.597. Mass fraction of protein was determined by using the system of quantitative identification of N2/DKL 8 protein (VELP Scientifica, Italy) according to AUSS 13496.4. The biological value of the protein complex was studied by experimental determination of amino acid composition with using the system of capillary electrophoresis “KRAPEL-105M,” manufacturer Lyumeks (Russia).

Relative biological value (RBV) of protein products was determined by the rapid method by using infusorium Tetrahymena pyriformis in accordance with the recommendation of Ignatiev A. D. et al. Mass fraction of dietary fiber was determined in the apparatus for analysis of fiber Fibretherm FT12 (Gerhardt, Germany) in accordance with AUSS 31675.

The mass fraction of fat in the protein complex was determined on the automatic setup for solid–liquid extraction SOX414a SOXTHERM (Gerhardt, Germany) according to the instructions and AUSS 10857. Fatty acid composition of lipids was determined by the gas chromatograph with a flame ionization detector and integrator “Crystal 5000.”

Calcium and magnesium were determined by complexometrically method. The statistical processing of the experiment results was carried out according to the method of student. The organoleptical and physicochemical properties of the wheat bread were determined according to standard methods [16, 17].

The structural and mechanical properties of the crumb of the loaf (elasticity, %; a modulus of elasticity E, Pa; shrinkage, %,) were determined by measuring ai elastic properties enabling the penetrameters AP-4/2. With the help of this device was determined the overall deformation of the bread crumb (ΔH_{com}) that describes its compressibility; plastic deformation ($\Delta H_{plastic}$) or elasticity; and elastic deformation ($\Delta H_{elasticity}$) or shrinkage methods [16, 17].

For characteristics of the bread, staling process was used, the determining method of the elasticity modulus E which characterizes the depth of immersion of the indenter cone penetrometer under a load in the bread crumb [16, 17]. Friable was determined in % of the resulting crumbs to take of crumb mass [16, 17]. Dimensional stability of the wheat bread was determined by the formula: $F = H/P$ (H—height, cm; P—perimeter, cm); specific volume (V_{pit}., cm^3/g), which was determined by dividing the bread amount on its mass, expressed to the nearest 0.01 cm^3/g, and the bread volume was measured in cm^3 using the device RZ-BIO, which works on the principle of the volume measuring of loose filler material displaced by the bread (the bread volume was measured three times) [16, 17].

The microbiological parameters list which carried out quality control of the finished bakery products was established on the base of the requirements of SSP 4.4.5.078 and MBR No. 5061-89: the number of mesophilical aerobic and facultative anaerobic microorganisms (NMAFAM, CPU/g); the presence of the bacteria of the intestinal sticks group (BGIS (coliforms) in 0.001 g); the detection of staphylococcus aureus; proteus; and other pathogens (pathogenic microorganisms, including the bacteria of Salmonella, in 25 g) [18–20].

5 The Research Results of the Influence of the Unlimited Nucleus of Sunflower Seeds. After Oil Expression on the Quality Indicators of the Wheat Bread Prototypes

The chemical composition of the scoured core of the sunflower seeds (SCSS) was investigated and due to the fact that SCSS used to enhance the nutritional value of the bread and conducted a comparative analysis of the relative chemical composition of the primary raw materials—the wheat flour and the second grade (Table 1).

SCSS studied for GMO content. It was found that SCSS is not genetically modified by DNA has a target sequence of the 35S promoter and NOS-terminator.

Table 2 shows the physicochemical quality indicators of the scoured core of the sunflower seeds (SCSS) after oil expression.

The analysis of the physicochemical quality indicators is presented in Table 2 and shows that SCSS scoured core of the sunflower seeds is characterized by fairly high protein content (42.7%) and fat (25.67%).

Table 3 shows the results of amino acids determination in SCSS and wheat flour.

The analysis showed (Table 3) that the total number of essential amino acids in the SCSS is 2.1–3.1 times higher than in the wheat flour. The first limiting amino acid is lysine.

Due to the fact that in addition to proteins and minerals to physiologically functional ingredients are unsaturated fatty acids and in the work it was done the comparative analysis of fatty acid profile of SCSS and the wheat flour (Table 4).

As shown in Table 4, sample SCSS obtained by innovative resource-saving technologies of complex processing of sunflower seeds (manufacturer LLC "NEWTECH PLUS," Ukraine) meets the requirements of AUSS 30623-98 in terms of quality—fatty acid composition.

Table 1 Comparative chemical composition of SCSS and the wheat flour of the high grade and the second grade

Product	Protein (g)	Fat (g)	Sugar (g)	Starch (g)	Fiber (g)	Ash (g)	Ca (mg)	Mg (mg)
SCSS	42.7	25.7	3.7	12.5	11.9	2.9	367	317
Wheat flour: High grade	12.0	1.3	1.9	79.7	0.12	0.58	21	19
Second grade	13.6	2.1	1.0	72.8	0.7	1.3	37	84

From the data in Table 4, it follows that in SCSS a significant content of linoleum acid refers to the essential fatty acids.

In this work, the optimal weight ratio of SCSS was determined experimentally. The weight ratio was established by taking into account the consumer properties of the bread and based on the calculation of the finished products' cost.

Thus, judging by the presented characteristics, SCSS is a very valuable raw material for the bakery industry and the decisive task of which is to create bakery products that have an increased nutritional value.

The indicators of oxidative damage to the scoured core of the sunflower seeds after oil extraction calculated taking into account the oil content are within the normal range; extraneous, metal magnetic impurities and pest infestation are absent. In general, the results of a study of the safety and nutritional values of SCSS allow us to classify the sample of the scoured core of the sunflower seeds after oil expression as a standard food raw material.

Table 5 presents the organoleptic quality control of the experimental samples of the wheat bread with SCSS additive on a 5-point scale. The following indicators were evaluated as appearance: *appearance*: shape, surface condition, color; *the state of the crumb*: got scorched, stirring, porosity; taste; smell.

Table 6 shows the results of the organoleptic analysis of the wheat bread with SCSS additive in the optimum amount of 2.5% to the weight of flour as compared to the control sample.

As follows from the data (Table 6), the prototypes were estimated at 90.2–97.6 points depending on the grade of the wheat flour and the quantity of SCSS. The determining factors for increasing the total score in relation to the control sample were the aroma and taste of bread.

Table 2 Physicochemical quality parameters of SCSS

Component name, SCSS	Component quantity (%)
Mass fraction of moisture and volatile substances	8.2
Mass fraction of crude protein in recalculation on s. r.	42.7
Mass fraction of crude fat in recalculation on s. r.	25.67
Mass fraction of crude fiber	11.87
Mass fraction of starch	12.53
Mass fraction of chlorogenic acid	0.3
Mass fraction of vitamin E, mg%	15.4
Allergens: Mass fraction of gluten, mg/kg less than 5 (gluten-free, if the mass fraction of gluten, less than 20 mg/kg	4 mg/kg

Table 3 Content of essential amino acids in SCSS and the wheat flour

Amino acids	Mass fraction, mg per 100 g of product		
	SCSS	Wheat flour	
		High grade	Second grade
Amino acids amount	7416	3471	4105
Including: valin	1070	471	525
Isoleucine	710	430	560
Leucine	1343	806	840
Lysine	693	250	330
Methionine + cystine	785	353	430
Threonine	886	311	365
Tryptophan	337	100	130
Phenylalanine + tyrosine	1592	750	925

Table 4 Content of fatty acids in SCSS and the wheat flour (%)

Fatty acid	SCSS	Wheat flour	
		High grade	Second grade
Palmitinum (C 16: 0)	3.2	0.13	0.26
Stearic acid (C 18: 0)	2.1	0.01	0.02
Oleinov (C 18: 1)	12.5	0.10	0.21
Linolev (C 18: 2)	31.8	0.48	0.77
Linolenov (C 18: 3)	–	0.03	0.04

Table 5 Organoleptic characteristics assessment of the experimental samples of the wheat bread is enriched with SCSS in comparison with the control sample

Wheat bread samples	Organoleptic parameters of wheat bread				
	Taste	Color	Porosity	Appearance and surface of bread	Flavor
Sample 1—control	5	4	4	5	4
Sample 2	5	5	5	5	5
Sample 3	5	5	4	5	5

Table 6 Results of the organoleptic analysis of the wheat bread with SCSS additive in the optimum amount of 2.5% to the weight of flour as compared to the control sample

Indicator	Experimental samples of the bread from the wheat flour of the highest grade	
	Sample 1—control	Sample 2
Shape, surface condition of the plug, $C_w = 2$	9.0	9.6
Color cork, $C_w = 2$	9.4	9.6
Color of crumb, $C_w = 2$	14.4	14.4
Character of porosity $C_w = 2$	13.8	14.4
Elasticity of crumb $C_w = 23$	12.0	13.8
Aroma (flavor) $C_w = 23$	13.8	15.0
Taste $C_w = 23$	13.8	15.0
Compressibility $C_w = 21$	4.0	4.8
Total quality index $\Sigma X_i \times C_w$*	90.2	97.6

*C_w—Weight coefficient, X_i—i-th quality indicator

Table 7 Assessment of the influence of the food additive of SCSS on the physicochemical parameters of the experimental samples of the wheat bread

Experimental bread samples	Physicochemical parameters			
	Moisture of the crumb, %, not more	Acidity of crumb, degree, not more	Porosity, %, not less	Specific volume (cm^3/g)
Sample 1	42.0	3.5	57.0	4.09
Sample 2	42.5	3.0	65.0	5.21
Sample 3	43.0	2.8	64.0	5.19

To assess the influence of SCSS on the finished products' quality, the physicochemical parameters of the experimental samples of the wheat bread were determined: the mass fraction of crumb moisture, the specific volume, acidity, and porosity of the crumb. Table 7 shows the physicochemical parameters of the experimental samples of the wheat bread, enriched with SCSS as compared to the control sample.

Mass fraction of moisture in the crumb—with this indicator the quality and stability of bread is closely linked during storage as the excess moisture contributes to the flow of the enzymic and chemical reactions for activating the microorganisms' activity including those that lead to the damage of bread, in particular its mold.

The important indicators of the bread quality and bakery products are porosity and acidity. The porosity of bakery products shows the ratio of pore volume to the total volume of the crumb of bakery products and is expressed as a percentage. The dependence of the porosity of the experimental samples of the wheat bread on the amount of SCSS additive is presented in Table 7.

Acidity characterizes the freshness and flavor of bread. Bread and bakery products with the low acidity last longer. It should be noted that the level of acidity of the

Table 8 Evaluation of the influence of SCSS additive on the crumbling, form stability, and spores contamination of zygomycetes of experimental samples of the wheat bread

Amount of additive HC, mass %	Quality indices				
	Slightness of crumb (in 12 days), %	Form stability (in 3 days)	The appearance of mold (at 7° C) through		
			5 days	10 days	13 days
Sample 1	2.5 (6.5)	0.46 (0.42)	+	+	+
Sample 2	2.0 (3.5)	0.60 (0.58)	–	–	+
Sample 3	1.8 (3.2)	0.58 (0.56)	–	+	+

wheat bread and bakery products with the addition of SCSS is lower in comparison with the control (Table 7).

From the data in Table 7, it follows that using SCSS for the wheat bread in an amount of 2.5–5.0% to the flour weight improves the physicochemical characteristics.

The experimental samples of the wheat bread which are enriched with the additive SCSS had the good elasticity and developed the same porosity; the same size pores with thin walls; the crumb did not crumble and did not jam.

Table 8 shows the research data of the influence of the SCSS additive on the crumbling, form stability, and spores contamination of filamentous fungi (Penicillium, Aspergillus, Mucor, etc.) which cause molds of bread and bakery products.

The increase in the specific volume (Table 7) and the form stability (Table 8) of the bread, which enriched with SCSS, is associated with the components' ability of the sunflower seeds (in particular, lipids, glucolipid, and lipoproteins) to complex formation and clustering.

Table 9 shows the microbiological characteristics of the experimental samples of the wheat bread immediately after baking and after storage for 72 h and 10 days (when determining the spores of bacteria, Vas. Subtilis).

The data in Table 9 confirm the antimicrobial action of SCSS and the microbiological safety of developmental prototypes of the wheat bread enriched with SCSS and compliance with the standards established for this type of product [18–20].

Table 10 shows the results of determining the crumb deformation of the samples bread (ΔH_{com}, mm) during storage for 12 days.

The data analysis in Table 10 shows that the bread staling with SCSS additive passes slower than in the control.

The conducted researches made it possible to develop recipes for new bakery products using SCSS and to determine the preferred way for each of them for dough-making.

Thus, protein sunflower products, in particular SCSS, improve many quality indicators of the wheat bread, significantly increasing its nutritional value.

Table 9 Influence of SCSS additive on the microbiological parameters of the experimental samples of the wheat bread, which enriched the products of the sunflower seeds processing in comparison with the control during storage

Indicators name	Standard	Experimental samples of wheat bakery products		
		Control	Sample 2	Sample 3
NMAFAnM, CFU/g, immediately/72 h later.	1.0×10^3	$1.0 \times 10^3/1.2 \times 10^3$	$0.25 \times 10^3/0.30 \times 10^3$	$0.22 \times 10^3/0.26 \times 10^3$
S. aureus immediately/72 h later	Not allow at 1.0 g	Absent in 1.0 g	Absent in 1.0 g	Absent in 1.0 g
BGIS, immediately/72 h later	Not allow 0.001 g	Absent in 0.001 g	Absent in 0.001 g	Absent in 0.001 g
Proteus, immediately/72 h later	Not allow at 0.1 g	Absent in 0.1 g	Absent in 0.1 g	Absent in 0.1 g
Salmonella, L. monocytogenes, immediately/72 h later	Not allow at 25.0 g	Absent in 25.0 g	Absent in 25.0 g	Absent in 25.0 g
Number of bacteria spores Bac. Subtilis, CPU/immediately/72 h later	0.4×10^3	$0.20 \times 10^3/0.26 \times 10^3$	$0.15 \times 10^3/0.16 \times 10^3$	$0.13 \times 10^3/0.15 \times 10^3$
Number of bacteria spores Bac. Subtilis, CPU/immediately/after 10 days	0.4×10^3	$0.20 \times 10^3/0.40 \times 10^3$	$0.15 \times 10^3/0.20 \times 10^3$	$0.13 \times 10^3/0.17 \times 10^3$

Table 10 Influence of the SCSS additive of the crumb deformation of the experimental bread samples when stored in comparison with the control sample

Developmental prototype of the bread	The crumb deformation, mm, during storage for			
	0 h	6 h	72 h	12 days
Sample 1	8.0	7.0	4.5	1.5
Sample 2	11.5	10.8	9.7	6.5
Sample 3	11.5	10.8	9.7	6.5

6 Discussion of the Investigation Results of the Influence of SCSS on the Wheat Bread Quality

In evaluating of the introducing possibility of the scoured core of the sunflower seeds (SCSS) into the bakery products in order to increase its nutritional and biological value and studied the quality indicators of SCSS, namely: organoleptic indicators, chemical composition and safety indicators. The sample of SCSS has no deviations in taste and smell; it is characterized by the unexpressed with a slight herbaceous tinge flavor, inherent in the sunflower seed without a specific oily taste.

As it can be seen from the data given (Table 1), in SCSS in comparison with the wheat flour a much higher content of fat, mineral substances including calcium and magnesium are observed.

From Table 2, it can be seen that the sunflowers' scoured core contains a significant amount of antioxidants: vitamin E—15.4 mg% and chlorogenic acid—0.3% which effects on the oxalic acid exchange in the human body and prevents gout.

Especially, it would be desirable to pay attention to such property of SCSS as the content of gluten (the mass fraction of gluten, mg/kg less than 5) which allows attributing it to gluten-free products.

When studying the composition of protein of SCSS obtained by the innovative resource-saving integrated technology of the processing sunflower seeds, it was revealed that the developed technology does not lead to a significant change in the native composition of amino acids in the protein part of the sunflower core. The content of essential amino acids in the protein complex of the scoured core of the sunflower seeds after oil expression is more than 36%. In SCSS, the suppressing amino acid is lysine; in addition, a higher content of amino acids leucine and threonine deficient for all varieties of the wheat flour is noted (Table 3).

When evaluating the indices that determine the physiological value of the oil (Table 4) contained in the scoured core of the sunflower seeds, it is established that the lipid part has fat-soluble physiologically valuable nutrients in native form, as well as interchangeable and irreplaceable fatty acids.

It was revealed that, in comparison with the sunflower meal obtained by the pressing method, the efficiency of the technological functional properties of the unlimited nucleus of the sunflower seeds is increased by 15–20%.

The organoleptic analysis of the experimental samples of the wheat bread with the addition of SCSS (Tables 5 and 6) showed that the bread quality from the wheat flour with the additive of the sunflower seeds in the above-mentioned doses differed from the control sample by more pleasant taste, expressed by aroma, well-developed porosity, and large volume. In the experiment process, rational mass fraction of SCSS was determined: for bread from wheat flour of the highest grade—2.5%.

Physicochemical parameters are better for samples with SCSS food additive (Table 7): The humidity of the crumb is increased by 0.5–1.0%; the acidity of the crumb is reduced by 0.5–0.7°; porosity is increased by 2.0–3.0%; the specific volume increases by 1.12–1.17 cm^3/h. This is due to the surface-active properties; moisture and fat-sensitive lipids; and lipo-glycoprotein of SCSS. Adding SCSS in an amount of 2.5–5.0% to the weight of the flour helps to reduce the crumbling of the wheat bread by 1.0–1.3% (Table 8) and increase the form stability by 1.0–1.5% (Table 8).

Bread with the addition of SCSS is moldy for 5–8 days later compared to the control (Table 8). This is due to the bactericidal effect of the terpenoid sunflower seeds (in particular, thymol, borneol, camphor), which inhibit growth and destroy pathogenic microbes, fungi, micelles.

Experimental data (Tables 8 and 9) confirm the antimicrobial action of SCSS and the microbiological safety of prototypes of wheat bread enriched with sunflower seeds processing products (SCSS).

When storing the experimental bread samples for 12 days (Table 10), the crumb compressibility is reduced for control—by 5.3 times, for sample 2 and sample 3—by 1.8 times. That is, staling bread with the addition of SCSS is slower.

7 Conclusions

1. The chemical composition and functional–technological properties of the scoured core of the sunflower seeds after oil expression were studied. SCSS compared to the wheat flour has a significantly higher content of protein, fat, minerals, including calcium and magnesium.
   Also, SCSS contains a significant amount of antioxidants: vitamin E—15.4 mg% and chlorogenic acid—0.3%, which affects the exchange of oxalic acid in the human body.
   Especially, it would be desirable to pay attention to such property of SCSS as the content of gluten (the mass fraction of gluten, mg/kg less than 5) which allows attributing it to gluten-free products.
   The content of essential amino acids in the protein complex of SCSS is more than 36%. In SCSS, the suppressing amino acid is lysine; in addition, a higher content of amino acids leucine and threonine deficient for all varieties of the wheat flour was noted.
   The technology of obtaining SCSS provides a gentle effect on the lipid part of the scoured core of the sunflower seeds and allows maximally to preserve in the product fat-soluble physiologically valuable nutrients in the native form, as well as interchangeable and irreplaceable fatty acids. It was revealed that, in comparison with the sunflower meal obtained by the pressing method, the efficiency of the technologically functional properties is increased by 15–20%.
2. The data of organoleptic analysis confirm the improvement of the wheat bread quality with SCSS additive by an average of 5.0–7.0% in comparison with the control. SCSS rational dosage for the bread from the wheat flour of superior quality of 2.5% was established.
3. The effect of SCSS additive on the physicochemical parameters of the experimental samples of the wheat bread has been studied.
   SCSS additive contributes to: increase the moisture content of the crumb by 0.5–1.0%; decrease the acidity of the crumb by 0.5–0.7°; increase the porosity

by 2.0–3.0%; increase the specific volume by 1.12–1.17 cm^3/g; increase the form stability by 1.0–1.5%; reduce the crumbling by 1.0–1.3%.

4. The influence of SCSS additive on the structural and mechanical characteristics of the experimental samples of the wheat bread in their storage process is studied. When the experimental bread samples are stored for 12 days, the compressibility of the crumb is reduced by 5.3 times for the control, for sample 2 and sample 3—by 1.8 times. That is, staling bread with SCSS additive is slower.
5. The influence of SCSS additive on the microbiological parameters of the experimental samples of the wheat bread during storage has been studied.

The total microbial contamination level of both freshly baked wheat bread and the bread stored for 72 h (and 10 days) at a temperature of 20 °C did not exceed the permissible levels and amounted to: after baking and cooling, the number of microorganisms (NMAFAnM) in 1 g of samples for 2 3 in comparison with the control decreases in 4.0–4.2 times both immediately and through 72 h; the number of bacterial spores Bac. Subtilis after 10 days increases: in control in 2 times, and in samples 2, 3—in 1.3 times. All the prototypes stored for 72 h (and 10 days) at a temperature of 20 °C met the requirements of microbiological standards established for this type of product in Ukraine [18–20].

That is, SCSS has an antimicrobial effect and helps to improve the quality and the shelf life of the wheat bread.

Thus, the results of the conducted studies make it possible to justify the expediency of using the scoured core of the sunflower seeds after oil expression of SCSS by the wheat bread technology.

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