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ORIGINAL RESEARCH PAPER

PRELIMINARY STUDIES CONCERNING THE INFLUENCE OF BUCKWHEAT FLOUR ON THE QUALITY OF WHITE WHEAT BREAD

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Abstract: Buckwheat flour is considered an important nutritious source of protein (high lysine content), polyphenols compounds with high antioxidant activity, dietary fibres, vitamins, minerals. Buckwheat flour in combination with other flours and used in bakery provide multiple health benefits (constipation, reducing cholesterol, obesity, reducing hypertension, cancer prevention, maintaining the optimal level of glycemic index). In the present paper, the effects of replacement of wheat white flour with whole buckwheat flour (0 to 12.5 %) on the sensory and physico-chemical properties of bread samples were investigated. The buckwheat flour had influenced positively the quality of white bread, the proportion of 10 % buckwheat flour showing better properties.

Keywords: *buckwheat flour, bread formulation, sensory analysis, physico-chemical analysis*

INTRODUCTION

The worldwide growing need for food, for gluten-allergic people, has led to research for obtaining gluten-free food products. Bakery products provide over 50 % of the food sources for humanity, and therefore, there has been a growing global interest in developing and diversifying gluten-free bakery products for the benefit of patients with celiac disease.
Gluten-free bakery products primarily rely on the use of pseudocereal flours such as: quinoa, amaranth, buckwheat, sorghum, barley, oats, chia and rice, which enhance the nutritional content [1 – 13].
Nowadays, buckwheat is not enough used as a food resource [14 – 17]. Buckwheat flour is one of the most suitable flours for making gluten-free bakery products because it is natural and hypoallergenic. Buckwheat (*Fagopyrum esculentum*) is a pseudocereal in the genus *Fagopyrum*, family *Polygonaceae* [2, 12, 18, 19]. It is an annual herbaceous plant, originally from Tibet, and later spread to Russia, Korea, Japan, Europe, and other regions [20 – 22].
Compared to other raw materials (wheat, rice, rye etc.) used in the bakery, pastry and confectionery industry, buckwheat is a valuable ingredient from a nutritional point of view, as it contains proteins (12 %), lipids (3 %), carbohydrates (70 %), fibers (10 %), minerals (2.5 %), vitamins and polyphenol compounds [18]. Proteins are mostly made up of albumin and globulin, poorer in prolamin, gluten. Among the essential amino acids, lysine, arginine, histidine, cysteine are present [18, 20, 21, 23 – 25]. Nonfibrous carbohydrates are mainly represented by starch, followed by sucrose and dextrin. Dietary fiber is mainly composed of cellulose and lignin. Buckwheat contains polyphenol compounds with high antioxidant activity, especially rutin and quercetin [11, 26].
Buckwheat flour is one of the ingredients enjoying increasing popularity because it provides multiple health benefits, such as relieving constipation, reducing cholesterol, combating obesity, lowering hypertension, preventing cancer, and maintaining optimal glycemic index levels [9, 27 – 39].
The aim of this paper was to study the influence of different amounts of buckwheat flour on sensory and physico-chemical properties of bread with low gluten content.

MATERIALS AND METHODS

Raw materials

Wheat flour 650 type (Pambac S.A., Bacau, Romania), buckwheat flour (BWF) (S.C. Solaris Plant SRL, Bucuresti, Romania), salt (Salrom S.A., Bucuresti, Romania), fresh yeast (Rompak SRL, Pașcani, Romania) and sun-flower oil (Bunge Romania SRL, Buzau, Romania) were purchased from local market.
Low-extraction flour for baking was chosen because it is the most used in the baking industry, it is lower in fiber and in addition, due to the content of gluten proteins of better quality compared to intermediate or whole flours, it behaves technologically better against high extraction flours.

In Table 1 are presented the average nutritional values of the white wheat flour type 650, buckwheat flour, according to the manufacturers' data.

Table 1. *Average nutritional values g / 100 g*

Composition	White wheat flour type 650	Buckwheat flour
Energy, [kcal·kJ^{-1}]	347	335
Fats, [g/100 g]	0.9	3.1
Proteins, [g/100 g]	11.5	12.6
Carbohydrates, [g/100 g]	73	70.6
Fibers, [g/100 g]	0.6	10
Sugars, [g/100 g]	1	2.6
Salt, [g/100 g]	0	0

Bread - making process

White wheat flour was replaced with whole buckwheat flour (BWF) in different proportions (0 to 12.5 %) in order to obtain different blends of flour (Table 2).

Table 2. *Proportion of whole buckwheat flour*

Samples	Sample 1 (*B-BWF0*)	Sample 2 (*B-BWF2.5*)	Sample 3 (*B-BWF5*)	Sample 4 (*B-BWF7.5*)	Sample 5 (*B-BWF10*)	Sample 6 (*B-BWF12.5*)
Buckwheat flour proportion, [%]	0.0 (control)	2.5	5.0	7.5	10.0	12.5

The control bread (without *BWF*) and bread with different proportions of *BWF* were obtained according to the production recipe presented in Table 3, by direct method using a bread machine (Moulinex B11-A, China), program 8.

Table 3. *Bread with BWF formulation*

Raw materials	Quantity
Wheat flour 650 type [g]	640
Buckwheat flour [%]	0 – 12.5
Water [mL]	400
Salt [g]	10
Fresh yeast [g]	25
Sun-flower oil [mL]	20
Technological regime	
Kneading time	18 min
Fermentation and baking time	75 min

Bread analysis

After baking, the bread samples were left for 3 h at room temperature for cooling, and then the sensory and physico-chemical properties were analyzed.

Bread sensory analysis

The sensory analysis of the bread samples was carried out by assessing the quality of the bread based on scoring. In the present study, a Romanian scoring scheme was used to assess the quality of bread of 20 points, according to SR 91:2007 [34].

The sensory evaluation was carried out by a team of 21 trained tasters. The external appearance of the bread, the color and structure of the crust, the elasticity and porosity of the crumb, taste, smell and aroma were assessed.

Bread physico-chemical analysis

Moisture (%), acidity (degrees of acidity), porosity (%), crumb elasticity (%), ash content (%), crumb Redox-*r*H (mV) and electrical conductivity of crumb ($mS \cdot cm^{-1}$) were also determined according to Table 4.

Table 4. *Physico-chemical analysis of bread*

Physico-chemical analysis	Materials	Methods
Porosity, [%]	- cylindrical metal with the height of 6 cm and diameter of 3 cm - SHIMADZU Digital Balance for weighing the crumb cylinder	STAS 91/1983
Elasticity, [%]	- cylindrical perforator with diameter of 3 cm - device for determining the elasticity of the bread crumb	STAS 91/1983
Acidity, *degrees of acidity*	- Schilling automatic burette 10 mL ISOLAB with division by 0.05 mL	STAS 91/1983 [34]
Moisture, [%]	- oven 631 Nahita	SR 91:90
Ash content, [%]	- oven L1003 CALORIS	SR 91:90
Oxidation-reduction potential of crumb, [mV]	- Multi-parameter HI5521, Hanna Instruments	[34, 36]
Electrical conductivity of crumb, [$mS \cdot cm^{-1}$]		

RESULTS AND DISCUSSION

In the present paper the sensorial and physico-chemical properties were investigated. From the sectional images of the breads enriched with BWF presented in Figure 1 it can be observed the change in the surface characteristics of bread with different proportions of buckwheat flour. The color intensity of bread samples increased with the substitution level of wheat white flour with buckwheat flour and the internal structure of crumb presented irregular pores.

The height of the bread samples with buckwheat flour is lower than the control sample, as a result of the decrease in gluten content, which would have favored their increase in volume. The results of the sensorial and physico-chemical properties for bread samples are graphically illustrated using histograms. The sensorial properties of breads were affected by wheat flour substitution and reflect the effects of buckwheat flour on bread characteristics (Figure 2).

The highest score was obtained in the case of bread with 10 % buckwheat flour (*B-BWF10*), respectively 15.9 points. The fact that the control bread received the lowest score shows that the buckwheat flour bread was accepted and appreciated by the tasters. The intensity of color in the case of bread samples with buckwheat flour did not bother consumers, as they are used to the commercial availability of whole meal bread.

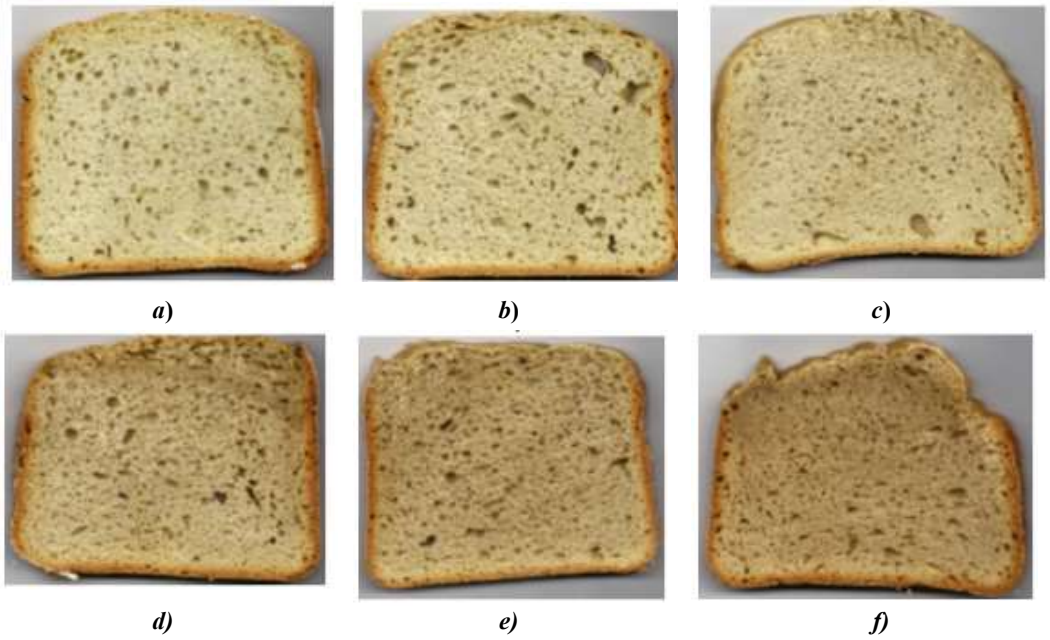

Figure 1. *Section images of bread with various BWF substitution levels a) Bread control (B-BWF0); b) Bread with 2.5 % BWF (B-BWF2.5); c) Bread with 5 % BWF (B-BWF5); d) Bread with 7.5 % BWF (B-BF7.5); e) Bread with 10 % BWF (B-BWF10); f) Bread with 12.5 % BWF (B-BWF12.5)*

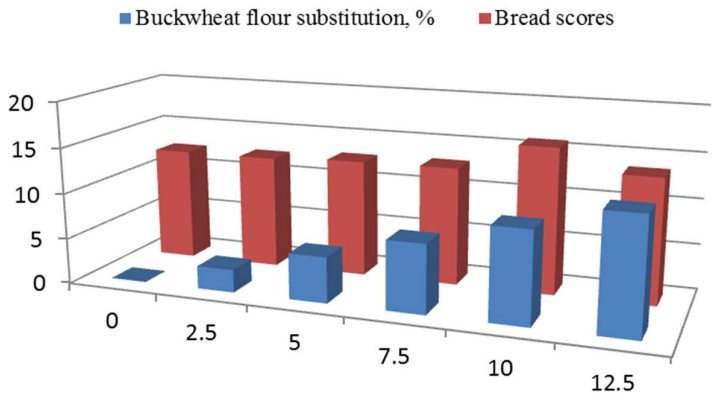

Figure 2. *Bread scores for sensorial analysis*

The influences of the *BWF* substitution on the physico-chemical properties of bread samples are presented in Figures 3 - 8. The acidity of the bread obtained only from white wheat flour (control) is the lowest (2 degrees of acidity); the bread obtained from flour with the substitution level of wheat white flour presents higher acidity values. Acidity values increase with increasing of buckwheat flour content, but with insignificant differences ($p > 0.05$). In the case of *B-BWF12.5* sample, the acidity reached 2.30 degrees of acidity.

The moisture content of bread samples with buckwheat flour increased compared to the control sample, being between 42.00 % (*B-BWF0*) and 45.60 (*B-BWF12.5*). The increase in bread moisture is due to the increase in the hydration capacity of the white wheat flour-buckwheat flour mixtures due to the fiber input from the added buckwheat flour.

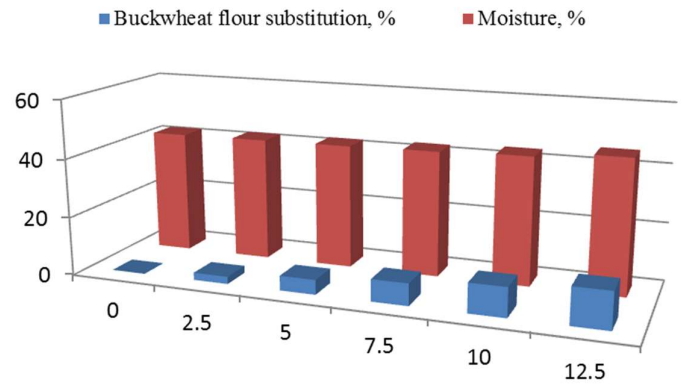

Figure 3. *Moisture of bread crumb at different level of wheat flour substitution*

White wheat flour has a low mineral content, so with the substitution with buckwheat flour, the ash content has increased from 1.76 % (control sample) to 2.46 % (bread with 12.5 % buckwheat flour).

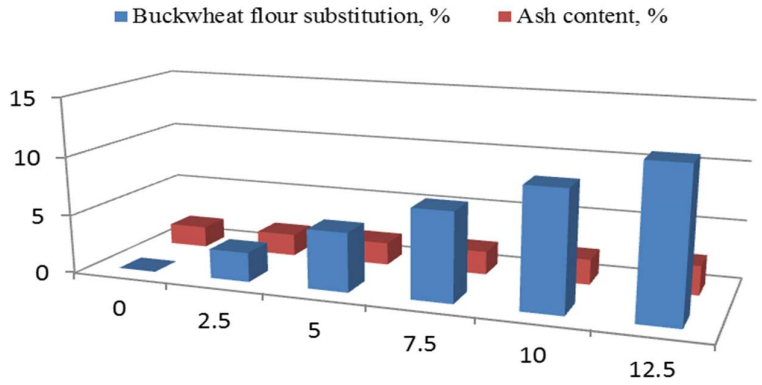

Figure 4. *Ash content of bread crumb at different level of wheat flour substitution*

The elasticity of the bread crumb is its property of returning to its original shape after the cessation of the pressing force. It depends on the quality and quantity of gluten and the freshness of the product. The experimental data obtained are presented in Figure 5. The values obtained for the crumb elasticity are between 98.8 % for the control sample and 93.4 % for the *B-BWF12.5* sample, i.e., they decrease with increasing buckwheat flour content. Differences are significant ($p < 0.05$).
The elasticity and porosity of bread crumb had decreased with substitution level of wheat white flour with buckwheat flour.

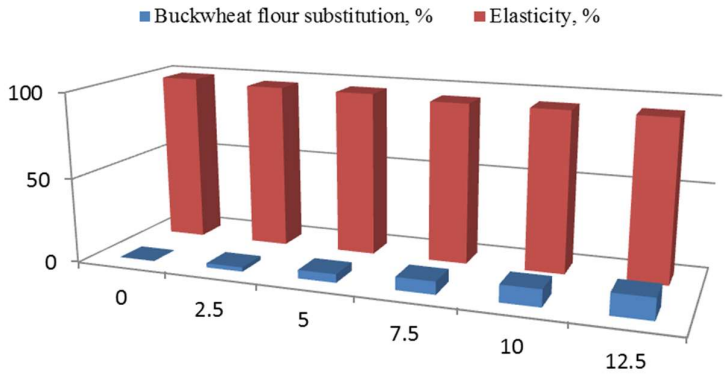

Figure 5. *Elasticity of bread crumb at different level of wheat flour substitution*

The breads obtained are characterized by medium values in the case of porosity (Figure 6). Thus, the control bread had a porosity of 68.40 %, and lower values were obtained for the breads with buckwheat flour. In the case of sample *B-BWF12.5*, the porosity was 57.40 %. Correlating the data obtained for porosity with the images shown in Figure 1 for the bread samples in section, it can be seen that the pores are generally small and their distribution is uniform, with a few exceptions of larger pores located near the bread crust.

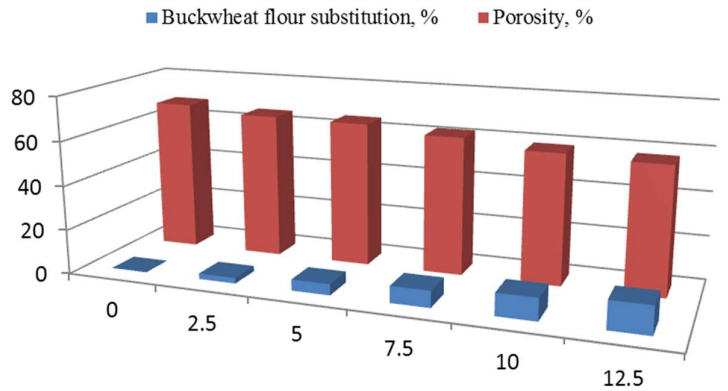

Figure 6. *Porosity of bread crumb at different level of wheat flour substitution*

The value of the redox potential allows the assessment of the orientation of the reactions, either towards oxidation or towards reduction [37 – 38]. Figure 7 shows the measured values of Redox-*r*H of the bread samples with BWF. The increasing of white flour substitution leads to decreasing of redox-*r*H, due to increasing of polyphenols compounds content with high antioxidant activity from 144 mV (control sample) to 111 mV (bread with 12.5 % buckwheat flour).

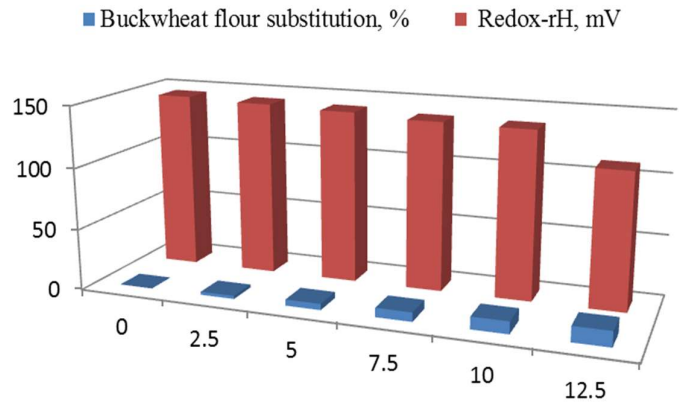

Figure 7. *Redox-rH of bread crumb at different level of wheat flour substitution*

In Figure 8 are presented the measured values of electrical conductivity.

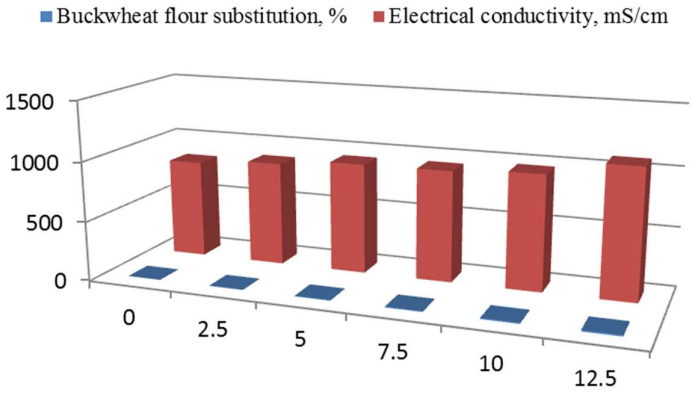

Figure 8. *Electrical conductivity of bread crumb at different level of wheat flour substitution*

There is a dependence between humidity and electrical conductivity, so an increase in the humidity value will show that the electrical conductivity value will also increase. As the substitution of white flour increases, the electrical conductivity of the breadcrumbs increases from 826 $mS \cdot cm^{-1}$ (control sample) to 1089 $mS \cdot cm^{-1}$ (bread with 12.5 % buckwheat flour).

CONCLUSIONS

Bread moisture increased compared to the control sample for all bread samples with buckwheat flour, the differences being significant ($p < 0.05$). Acidity increased with increasing in buckwheat flour content with non-significant differences ($p > 0.05$). The breads obtained had medium porosity, with significant differences ($p < 0.05$) depending on the *BWF* content. Crumb elasticity decreased with significant values ($p < 0.05$) compared to the control sample, with increasing of *BWF* content. Breads with *BWF* scored higher than the control sample, which means they were accepted by the tasters.
The buckwheat flour content had influenced positively the quality of white bread. The bread sample with 10 % of *BWF* showed better sensory properties. The crumb and crust color became darker with the level of wheat flour substitution. The internal structure of crumb became coarser, with irregular pores. Bread with buckwheat flour will contribute to the health of the population through the benefits of fibers, high quality proteins and antioxidant activity.

REFERENCES

1. Coronel, E.B., Guiotto, E.N., Aspiroz, M.C., Tom, M.C., Nolasco, S.M., Capitani, M.I.: Development of gluten-free premixes with buckwheat and chia flours: Application in a bread product, LWT, *Food Science and Technology*, **2021**, **141**, 110916;
2. Costantini, L., Lukšic, L., Molinari, R., Kreft, I., Bonafaccia, G., Manzi, L., Merendino, N.: Development of gluten-free bread using tartary buckwheat and chia flour rich in flavonoids and *omega*-3 fatty acids as ingredients, *Food Chemistry*, **2014**, **165**, 232-240;
3. Kaur, M., Sandhu, K.S., Arora, A., Sharma, A.: Gluten free biscuits prepared from buckwheat flour by incorporation of various gums: Physicochemical and sensory properties, LWT, *Food Science and Technology*, **2015**, **62**, 628-632;
4. Sakač, M., Torbica, A., Sedej, I., Hadnađev, M.: Influence of breadmaking on antioxidant capacity of gluten free breads based on rice and buckwheat flours, *Food Research International*, **2011**, **44**, 2806-2813;
5. Farzana, T., Hossain, F.B., Abedin, M.J., Afrin, S., Rahman, S.S.: Nutritional and sensory attributes of biscuits enriched with buckwheat, *Journal of Agriculture and Food Research*, **2022, 10**, 100394;
6. Wronkowska, M., Jarmułowicz, A., Lamparski, G., Jeliński, T., Haros, C.M.: Oat-buckwheat breads-technological quality, staling and sensory properties, *Irish Journal of Agricultural and Food Research***,** Original Study, **2020, 59** (1), 33-41;
7. Lin, L-Y., Liu, H-M., Yu, Y-W., Lin, S-D., Mau, J-L.: Quality and antioxidant property of buckwheat enhanced wheat bread, *Food Chemistry*, **2009**, **112,** 987-991;
8. Sedej, I., Saka, M., Mandi, A., Misan, A., Pestori, M., Simurina, O., Brunet, J.C.: Quality assessment of gluten-free crackers based on buckwheat flour, LWT, *Food Science and Technology*, **2011**, **44**, 694-699;
9. Stoki, E., Mandi, A., Saka, M., Misan, A., Pestori, M., Simurina, O., Jambrec, D., Jovanov, P., Nedeljkovi, N., Milovanovi I., Sedej I.: Quality of buckwheat-enriched wheat bread and its antihyperlipidemic effect in statin treated patients, LWT, *Food Science and Technology*, **2015**, **63**, 556-561;
10. Torbica, A., Hadnadev, M., Dapcevic, T.: Rheological, textural and sensory properties of gluten-free bread formulations based on rice and buckwheat flour, *Food Hydrocolloids*, **2010**, **24**, 626-632;

11. Selimović, A., Miličević, D., Jašić, M., Selimović, A., Ačka, Đ., Pešić, T.: The effect of baking temperature and buckwheat flour addition on the selected properties of wheat bread, *Croatian Journal of Food Science and Technology*, **2014**, **6** (1), 43-50;
12. Goldan, E., Nedeff, V., Barsan, N., Culea, M., Panainte-Lehadus, M., Mosnegutu, E., Tomozei, C., Chitimus, D., Irimia, O.: Assessment of manure compost used as soil amendment-A Review, *Processes*, **2023**, **11** (4), 1167;
13. Panainte-Lehăduș, M., Moșneguțu, E., Bârsan, N., Andrioai, G., Tomozei, C., Irimia, O. Mathematical perspectives in the variable texture products cutting process, *Processes*, **2022**, **10** (8), 1603;
14. Ouyang, B., Duan, M., Zhu, S., Zhou, X., Zhou, Y.: Effect of tartary buckwheat sourdough fermented by different exogenous lactic acid bacteria on antifreeze property of frozen dough, *Food Chemistry Advances*, **2023**, **2**, 100182;
15. Belinska, K: Ways to increase the nutritional value of culinary dishes, *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2022**, **23** (1), 031-039;
16. Ciocan, M.E., Salamon, R.V., Ambrus, A., Codina, G.G., Chetrariu, A., Dabja, A.: Brewing with buckwheat and sorghum: impact on beer quality, *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2023**, **24** (3), 219-232;
17. Nakov, G., Temkov, M., Stamatovska, V., Lukinac, J.: Insights on the protease activity and on total and soluble proteins during germination of wheat and barley, *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2023**, **24** (3), 261-269;
18. Zhu F.: Buckwheat proteins and peptides: Biological functions and food applications, *Trends in Food Science & Technology*, **2021**, **110**, 155-167;
19. Gernet, M.V., Zakharov, M.A., Gribkova, I. N.: The antioxidant compounds determination of various brewer's spent grain extracts, *Scientific Study & Research, Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2020**, **21** (2), 263-270;
20. Cotovanu, I., Mironeasa, S.: Influence of buckwheat seed fractions on dough and baking performance of wheat bread**,** *Agronomy*, **2022**, **12**, 137;
21. Cotovanu, I., Mironeasa, C., Mironeasa, S.: Insights into the potential of buckwheat flour fractions in wheat bread dough, *Applied Sciences*, **2022**, **12**, 2302;
22. Ognean, M., Ognean, C.F. Damian, D.: Buckwheat, sustainable ingredient for bread baking:rheological and technological investigation, *Management of Sustainable Development* Sibiu, Romania, **2017**, **9** (2), 15-18;
23. Platon, N., Georgescu, A.M., Arus, V.A., Sion, I., Silion, M., Ursu A-V., Nistor, I.D.: Valorization of eggshells waste for bread production, *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2022**, **23** (1), 049-061;
24. Platon, N., Arus, V.A., Georgescu, A.M., Nistor, I.D., Barsan, N.: White bread fortified with calcium from eggshell powder, *Revista de Chimie*, **2020**, **71** (7), 299-306;
25. Besliu, A., Chiselita, N., Chiselita, O., Efremova, N., Tofan, E., Darie, G., Sprincean, A., Rotari, D.: New processes for obtaining mannoproteins from beer yeast sediments and their biochemical properties, *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2022**, **23** (1), 041-048;
26. Ion, V.A., Pârvulescu, O.C., Velcea, D., Popa, O., AhmadI, M.: Physico-chemical parameters and antioxidant activity of Romanian sea buckthorn berries, *Revista de Chimie*, **2019**, **70** (12), 4187-4192;
27. Wronkowska, M., Haros, M., Smietana, M.S.: Effect of Starch Substitution by Buckwheat Flour on Gluten-Free Bread Quality, *Food Bioprocess Technology*, **2013**, **6**, 1820-1827;
28. Verardo, V., Glicerina, V., Cocci, E., Frenich, A.G., Romani, S., Caboni, M.F.: Determination of free and bound phenolic compounds and their antioxidant activity in buckwheat bread loaf, crust and crumb, LWT, *Food Science and Technology*, **2018**, **87**, 217-224;
29. Pircu Vartolomei, N., Arus, V-A., Moroi, A-M., Zaharia, D., Turtoi, M.: Influence of rosehip powder addition on quality indicators of mixtures obtained with different types of wheat flour, *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2020**, **21** (3), 379-393;

30. Dima, A.D., Pârvulescu, O.C., Mateescu, C., Dobre, T.: Optimization of substrate composition in anaerobic co-digestion of agricultural waste using central composite design, *Biomass and Bioenergy*, **2020**, **138**, 105602;
31. Leonte, M.: *Tehnologii, utilaje, rețete și controlul calității în industria de panificație, patiserie, cofetărie, biscuiți și paste făinoase, Materii prime si auxiliare*, Editura Ecozone, Iași, **2003**, 185-195;
32. Mencinicopschi, G.: *Și noi ce mai mâncăm?* Coreus Publishing, **2010**, 73-85;
33. Leonte, M.: *Tehnologii, utilaje, rețete și controlul calității în industria de panificație, patiserie, cofetărie, biscuiți și paste făinoase, Depozitarea, defectele pâinii și măsuri de prevenire. Valoarea alimentară a pâinii*, Editura Ecozone, Iași, **2007**, 315-326;
34. Bordei, D.: *Controlul calităţii în industria panificaţiei. Metode de analiză*, Editura Academica, Galati, **2007**, 524;
35. Brites, L.T.G.F., Rebellato, A.P., Meinhart, A.D., Godoy, H.T., Pallone, J.A.L., Steel, C.J.: Technological, sensory, nutritional and bioactive potential of pan breads produced with refined and whole grain buckwheat flours, *Food Chemistry*, **2022**, **X** (13), 100243;
36. Zlatev, Z., Kolev, T., Taneva, I., Baycheva, S.: Influence of amaranth (amaranthus spp.) flour on the main characteristics of butter biscuits, *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2022**, **23** (4), 273-293;
37. Mencinicopschi Ghe.: *Crezi că ştii ce bei?* Coreus Publishing, **2014**, 50;
38. Bales, J.R., Gibbons, B.T., Short, R.P., Shivkumar S.S.*: Creating and analyzing an 'ideal' white bread based on consumer preferences,* An Interactive Qualifying Project Report submitted to the Faculty of the Worcester Polytechnic Institute, E-project-030411-163031, **2011**, March 4;
39. Plescan, O.M., Nedeff, F.M., Partal, E., Mosnegutu, E., Panainte-Lehadus, M., Irimia, O., Tomozei, C.: Influence of soil fertilization systems on soil characteristics for a monoculture of sunflower, *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2019**, **20** (4), 585-595.