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Physico-chemical properties of wheat flour varieties and sensory evaluation of the obtained bread

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Abstract

The research was conducted in order to evaluate the physico-chemical characteristics of wheat flours varieties and quality of the bread obtained from them. The following parameters were analised: moisture content, acidity, mineral content, water absorption capacity, wet gluten and gluten index, volume, and porosity of the bread. Organoleptic evaluation was performed and the bread volume and crumb porosity were measured at 240 minuntes after cooling. Between gluten content and the deformation index values, a strongly negative correlation was determined, R = -0.93. White flour had the highest content of wet gluten, there was determined an inverse correlation between the color of the flour and the gluten content. By microscope examination, the starch granules of whole wheat flour were more broken down, due to higher amylolytic activity, compared to white flour. The usage of whole wheat flour allowed to obtain good textural and sensory properties of the final bread sample. Consumption of whole grains as part of the diet is recommended for health reasons because they are good source of minerals, fibers, protein, and antioxidants.

Keywords: whole weat flour, bread, water absorption capacity, wet gluten, sensory analysis

1. Introduction

Bread is one of the basic foods, being indispensable in daily nutrition due to the nutritional properties, as well as the content in heat-producing substances. The activity related to the production of bakery products represents one of the oldest tasks in our country, and also one of the major components of food production. Due to the fact that man is evolving every day and his demands have changed, the assortments of bread for which they currently choose are different, depending on the state of health [1].

Applying new recipes and technologies, by using dietary or whole grain flours, a wide range of products can be obtained in order to meet the ever-increasing demands of the population. However, the purchasing power being low in the recent years, bakers tend to add improvers or preservatives in bread, to keep them longer on store shelves and to ensure that the products will be sold for profit [2, 3].

White flour is refined and processed,while whole wheat flour is made from cereals that have not undergone extensive processing. The production and demand of whole grain flour has increased in the last decade due to the beneficial effects associated with the introduction of whole grains in the diet. They can prevent cardiovascular disease as well as colon cancer, reduce the risk of diabetes and present prebiotic actions [4].

Whole wheat flour is highly susceptible to alteration due to the presence of lipolytic enzymes, especially lipases. This aspect influences the term of use and storage properties and generates losses of nutritional quality and sensory acceptability. Whole wheat flour is obtained by whole wheat grain grinding and contains a significant amount of vitamins, minerals, antioxidants and other nutrients that are concentrated in the peripheral parts of the wheat grain.

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In the case of white flour, these nutrients are introduced through the fortification process, and the mineral substances and fibers are found in small quantities. Whole wheat flour contains a greater amount of lipids and antioxidants than white flour and a more pronounced enzyme activity, which results in lower storage stability compared to white flour [5-10].

Hydrolytic rancidity is initiated by lipases that hydrolyze triglycerides with the release of fatty acids and glycerol. Hydrolytic reactions of whole wheat flour results in the decreased of sensory quality as well as functional properties, flour with a higher free fatty acid content has a bitter, rancid taste and odor [4]. Hydrolysis products influence the bakery properties of flour, in low concentrations unsaturated fatty acids having a favorable effect on bread volume by co-oxidation with sulfhydryl groups of gluten proteins during mixing. In large proportion, free unsaturated acids have an adverse effect on volume, by reducing the ability to bind lipids to gluten proteins. Free saturated fatty acids have no effect on the dough and baking properties. Also, free polyunsaturated acids are substrates for lipooxygenases, enzymes that generate oxidation products that reduce whole wheat flour quality and the degree of acceptance [7-10].

The oxidative rancidity of whole wheat flour can be enzymatic or autooxidation. Oxidation is catalyzed by lipooxygenases, which are mainly located in germs and hull. They attack the methylene groups of the double bonds in the constitution of unsaturated fatty acids. Autooxidation occurs by the non-enzymatic reaction of lipids with atmospheric oxygen, which are added to the double bonds of unsaturated fatty acids. In the first stage hydroperoxides are formed, which will be split into secondary oxidation compounds (aldehydes, ketones, lactones, furans) [11, 12].

Lipid oxidation settles slower than lipid hydrolysis, because lipooxygenases have very low activity at a moisture content of 14-15% and the whole wheat flour contains high amounts of protective antioxidants. Lipooxygenases become active when the flour is mixed with water and oxidizes unsaturated fatty acids reducing the nutritional qualities of bread [9, 10].

Lipooxygenases, also cause loss of carotenoids and vitamin E. It was found a 40% decrease in vitamin E content during storage of whole wheat flour at 20 ^{0}C over a 12-months period, which is associated with lipid oxidation. During storage, the oxidation of carotenoids was observed, as well as the reduction of thiamine content by 7-11% [13].

The aim of this work was to comparatively study some physico-chemical properties of wheat flours (white, black and whole wheat flours) as they affect composite breads. The following parameters were analised: moisture content, acidity, mineral content, water absorption capacity, wet gluten and gluten index, and also, volume, porosity and sensory analysis of the bread.

2. Materials and Methods

2.1 Samples

White, black and whole wheat flours were purchased from the local market. For bread baking in the laboratory, dough was prepared according to the following recipes: 500 g of white flour, 25 g of yeast, 10 g of salt, and a defined volume of water depending on the water absorption of flour (R1); 500 g of black flour, 25 g of yeast, 10 g of salt, and a defined volume of water depending on the water absorption of flour (R2); 500 g of whole wheat flour, 25 g of yeast, 10 g of salt, and a defined volume of water depending on the water absorption of flour (R3). Bread was baked at 220 ^{0}C for 40 min. Organoleptic evaluation was performed and the bread volume and crumb porosity were measured at 240 minuntes after cooling.

2.2 Physicochemical examination

The chemical composition of flours and bread products was determined according to the methods described by Pop et al. [14].

Acidity is based on the extraction of the acids and their titration with sodium hydroxide 0.1 N, using phenolphthaleine, as an indicator. The results were expressed as degree of acidity. The content of mineral substances is based on the calcination of a known mass of product up to constant weight.

Moisture content was determined by drying 5 g of samples in a oven set at 155 ^{0}C. The dried samples were weighed and the difference in weight before and after drying was assumed to be moisture loss. The ratio of moisture loss to weight of dried flour percentage was recorded as moisture content dry basis.

Wet gluten content and its gluten index were determined by standard methods. Gluten was washed in tap water at 18 ± 2 ^{0}C for 30 min. Then a gluten ball of mass 4 g was placed in water and characteristics of the ball were evaluated after 15 min. According to the scale, strong short-tearing gluten has an index of less than 35 units, while very weak gluten has an index of more than 105 units. Gluten of high quality has an index in the range 55-75 units.

The water absorption capacity was determined according to the method described by Oladunmoye et al. [15]. One gram sample was mixed with 10 mL distilled water and allowed to stand at ambient temperature (22^0C) for 30 min, and then centrifuged at 3.000 rpm for 30 min. Water absorption capacity was expressed as percent water bound per gram flour.

The percentage proportion of moisture, acidity, protein and carbohydrate of the accepted composite breads was carried out using recommended standard methods. The bread volume was determined by the volume of displaced small grains.

To determine the porosity, a 27 cm^3 piece of crumb was taken out and the volume occupied by the flour dry matter was measured in relation to the volume of the whole piece. The volume of the dry matter was calculated by dividing the total mass of the crumb piece by the dry substance density of dough flour. The difference between the piece volume and the volume of the dry matter divided by the total volume of the crumb piece, expressed as a percentage, represented the bread porosity.

Breads produced from the flours were subjected to sensory evaluation. Coded samples of the breads were served to 25 members/trained panelists positioned in partitioned booths.

The taste, smell, color, and texture of the breads were evaluated under amber light, while appearance was under bright illumination. These attributes were rated on a 5-point hedonic score scale as: 1-poor, 2-fair, 3-normal, 4-very good and 5-excellent.

All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean ± standard deviation (X ± SD). Significant differences between mean were determined by using “Student” (“t”) distribution.

3. Results and Discussion

Black and whole wheat flours showed higher acidity values compared to white flour, because they are large extraction flours that contain bran and germs, which come from the outer layers of the wheat grain, from the epicarp and the aleuronic layer.

White flour had the highest content of wet gluten, coming from the wheat grain endosperm. There was determined an inverse correlation between the color of the flour and the gluten content. The more flour is darker in color and the proportion of bran in its composition is higher, with that the gluten content is lower.

The values of the deformation index were in the range of 0-5 mm, what recommend that flours are good for baking. By deformation index value is higher, a flour is less satisfactory for baking, and if its value exceeds 25 mm the flour is unpalatable. Between gluten content and the deformation index values, a strongly negative correlation was determined, R = -0.93. The physico-chemical parameters of wheat flours are prezented in Table 1.

Table 1. Proximate analysis of wheat flours

Parameters	White flour	Black flour	Whole wheat flour
Moisture (%)	$10.95^a \pm 0.02$	$13.38^b \pm 0.06$	$12.69^{ab} \pm 0.04$
Ash (%)	$0.65^a \pm 0.05$	$1.05^{ab} \pm 0.01$	$1.44^b \pm 0.07$
Acidity (mL NaOH 0.1N/100g)	$3.52^a \pm 0.04$	$4.93^b \pm 0.02$	$4.21^b \pm 0.05$
Gluten content (%)	$29.63^b \pm 0.02$	$24.18^a \pm 0.01$	$26.73^{ab} \pm 0.01$
Gluten index (%)	$39.23^c \pm 0.04$	$32.15^a \pm 0.02$	$35.32^b \pm 0.06$
Water absorption capacity (%)	$28.32^c \pm 0.01$	$21.54^a \pm 0.05$	$23.64^b \pm 0.03$

Values are means of triplicates ± standard deviation. Values with the same superscript in a column are not significantly different (P > 0.05).

Moisture content of 12-15.5% has been specified for cereal flour storage. Failure to store flour under this conditions leads to moisture absorption from the atmosphere, which eventually leads to caking [15].

Wang et al. reported inverse relationship between flour-water requirement for bread dough and water absorption capacity of varieties of wheat flour [16]. The baking quality of flours is a function of water absorption capacity [17].

Oladunmoye et al., studied the physical and chemical characteristics of wheat, cassava, maize and cowpea flours and evaluated the particle size, moisture content, bulk density, color, water absorption capacity, pasting viscosity, fat and protein contents. The researchers cocluded that most of the studied properties of the flours differ signifificantly at $P < 0.05$. Each of the flours has advantages that are beneficial in composite bread making: wheat flour possesses high quality protein; the water absorption capacity of cassava is high; maize flour has high fat content; and cowpea contains high quantity of protein. They showed that the protein content of wheat-cassava and wheat-maize composite flours can be increased by the inclusion of cowpea flour [15].

Kaprelyants et al., determined the enzyme activity in peripheral parts of grain that may be related to changes in properties of protein and starch in dough bran and the optimal enzyme activity of bran and shorts in order to minimize negative effects on bread quality and increase the nutritional value of bioactive components. The researchers showed that the maximum quantity of bran or shorts in flour blends must not exceed 11%, because the baking properties of flour deteriorate at higher bran content, the peripheral parts of grain have high activity of proteolytic enzymes. The authors argued that the introduction of peripheral parts into flour leads to an increase in hydrolytic enzyme activity and a significant increase in antioxidant activity, which minimizes the negative effect of hydrolytic enzymes on the technological properties of flour, and all streams of wheat milled fractions including peripheral parts of grain improve the content of bioactive substances and dietary fibre in blends with wheat graded flour [18].

Between water absorption capacity and the moisture content, was determined an inverse correlation, R = -0.99, this results were in agreement with the findings of Wilkes et al. and Vardakou et al. [19, 20]. By microscope examination, the starch granules of whole wheat flour were more broken down, due to higher amylolytic activity, compared to white flour (Fig. 1-3).

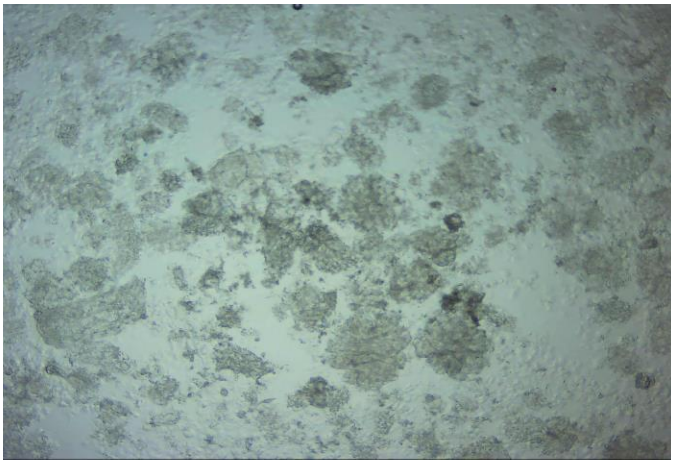

Figure 1. Microscope view of white flour starch

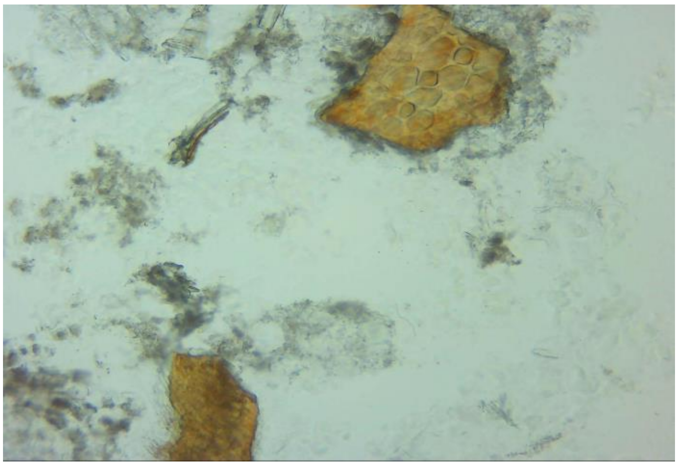

Figure 2. Microscope view of whole wheat flour starch

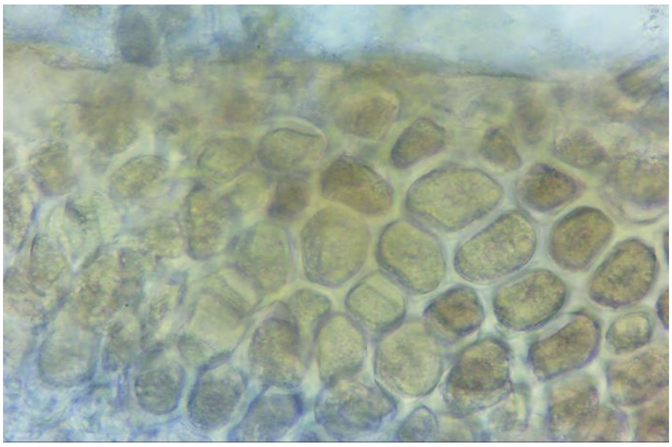

Figure 3. Cellular structure of the bran particle

To assess the state of freshness we used the descriptive sensory analysis, which is an ideal technique to identify flavors in a product and to distinguish the products between them, using tasters familiar with methods of scoring and sensory language.

Sensory analysis was performed on a sample of 25 people, aged between 20 and 55 years, according to Pop et al. [21]. Selected attributes were: smell, taste, color, appearance and texture. For sensory analysis the descriptive scale was: 1-poor, 2-fair, 3-normal, 4-very good and 5-excellent (Fig. 4).

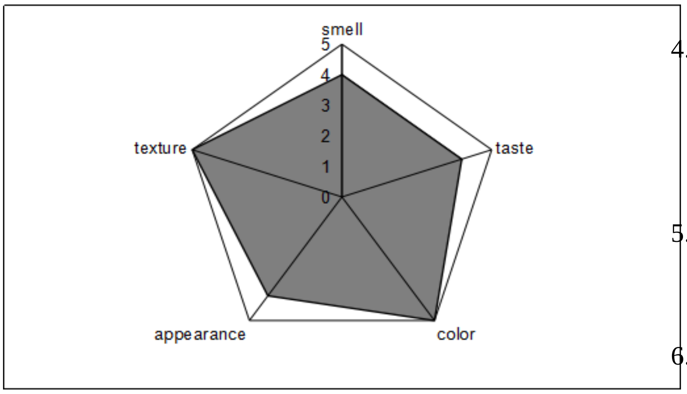

Figure 4. Sensory analysis of bread obtained from whole wheat flour

4. Conclusions

The physical and chemical properties of different varieties of wheat flours determine the performances in bread making. Black and whole wheat flours showed higher acidity values compared to white flour, because they are large extraction flours that contain bran and germs. White flour has the highest content of wet gluten, between the flour color and the gluten content, there was determined an inverse correlation. A strong positive correlation was found between the bread volume and the wet gluten content of the flour.

The usage of whole wheat flour allowed to obtain good textural and sensory properties of the final bread sample. In addition, wholemeal bread samples showed a high ash and total soluble fibre content, and provided a good balance between nutritional and sensorial quality.

Consumption of whole grains as part of the diet is recommended for health reasons because they are good source of minerals, fibers, protein, and antioxidants.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

References

1. Gebruers, K.; Delcour, J.A., Wheat flour constituents: how they impact bread quality, and how to impact their functionality, *Trends in Food Science and Technology*, **2005**, *16*, 12-30.
2. Sloan, A.E., Consumer Trends: Consumers go with the grain, *Food Technology*, **2011**, *65*, 35-42.
3. Sosland, L.J., Whole wheat flour production tops 20 million cwts; growth rate slows, *Milling & Baking News*, **2011**, *90*, 30-32.
4. McKeown, N.M.; Meigs, J.B.; Liu, S.; Wilson, P.W.F.; Jacques, P.F., Whole-grain intake is favorably associated with metabolic risk factors for type 2 diabetes and cardiovascular disease in the Framingham Offspring Study, *The American Journal of Clinical Nutrition*, **2002**, *76*, 390-8.
5. Rose, D.J.; Ogden, L.V.; Dunn, M.L.; Pike, O.A., Enhanced lipid stability in whole wheat flour by lipase inactivation and antioxidant retention, *Cereal Chemistry*, **2008**, *2*, 218-223.
6. Carr, N.O.; Daniels, N.W.; Frazier, P.J., Lipid interactions in breadmaking. *Critical Reviews in Food Science and Nutrition*, **1992**, *31*, 237-258.
7. Marathe, S.A.; Machaiah, J.; Rao, B.Y.; Pednekar, M.D.; Sudha Rao, V., Extension of shelf-life of whole-wheat flour by gamma radiation, *International Journal of Food Science and Technology*, **2002**, *37*, 163-168.
8. Every, D.; Simmons, L.D.; Ross, M.P., Distribution of redox enzymes in millstreams and relationships to chemical and baking properties of flour, *Cereal Chemistry*, **2006**, *83*, 62-68.
9. Leenhardt, F.; Lyan, B.; Rock, E.; Boussard, A.; Potus, J.; Chanliaud, E.; Remesy, C., Wheat lipoxygenase activity induces greater loss of carotenoids than vitamin E during breadmaking, *Journal of Agricultural and Food Chemistry*, **2006**, *54*, 1710-1715.
10. Loiseau, J.; Vu, B.L.; Macherel, M.H.; Le Deunff, Y., Seed lipoxygenases: ocurrence and functions, *Seed Science Research*, **2001**, *11*, 199-211.
11. Noort, M.W.J.; Van Haaster, D.; Hemery, Y.; Schols, H.A.; Hamer, R.J., The effect of particle size of wheat bran fractions on bread quality-Evidence for fibre-protein interactions, *Journal of Cereal Science*, **2010**, *52*, 59-64.
12. Doblado-Maldonado, A.F., *New Technologies for Whole Wheat Processing: Addressing Milling and Storage Issues*, Dissertations & Theses in Food Science and Technolog, **2012**, University of Nebraska - Lincoln.

13. Nielsen, M.M.; Hansen, A., Stability of vitamin E in wheat flour and whole wheat flour during storage, *Cereal Chemistry*, **2008**, *85*, 716-720.
14. Pop, F.; Voşgan, Z.; Mihalescu, L., Supplementation of wheat flour with soy flour, sensory and physicochemical evaluation of fortified biscuits, *Food and Environment Safety*, **2017**, *16(4)*, 250-255.
15. Oladunmoye, O.O.; Akinoso, R.; Olapade, A.A., Evaluation of some physical-chemical properties of wheat, cassava, maize and cowpea flours for bread making, *Journal of Food Quality*, **2010**, *33*, 693-708.
16. Wang, M.W.; Van Vliet, T.; Hamer, R.J., How gluten properties are affected by pentosans, *Journal of Cereal Science*, **2004**, *39*, 395-402.
17. Zhang, D.; Moore, W.R., Wheat bran particle size effects on bread baking performance and quality, *J. of the Sci. of Food and Agric*, **2000**, *79*, 805-809.
18. Kaprelyants, L;, Fedosov, S.; Zhygunov, D., Baking properties and biochemical composition of wheat flour with bran and shorts, *Journal of the Science of Food and Agriculture*, **2013**, *93*, 3611-3616.
19. Wilkes, M.; Copeland, L., Storage of wheat grains at elevated temperatures increases solubilization of glutenin subunits, *Cereal Chemistry*, **2008**, *85*, 335-338.
20. Vardakou, M.; Palop, C.; Christakopoulos, P.; Faulds, C.; Gasson, M.; Narbad, A., Evaluation of the prebiotic properties of wheat arabinoxylan fractions and induction of hydrolase activity in gut microflora, *International Journal of Food Microbiology*, **2008**, *123*, 166-170.
21. Pop, F., Improvement of the nutritional value of pasta by the addition of wheat bran, *Journal of Agroalimentary Processes and Technologies*, **2017**, *23(4)*, 245-249.