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Quality and Glycaemic Index of Wheat Bread with Different Share of Chickpea Flour †

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Abstract: The aim of the work was to evaluate the quality, i.e., to determine the volume, calculate the total baking loss and yield, and also organoleptic evaluation of wheat bread with chickpea flour. Moreover, the purpose of the work was also evaluation of the stalling change process of bread, determination of the content of chemical components, including protein and fat, ash and fiber, determination of the content of micro and macro elements and determination of the glycemic index in vitro. The research material was wheat bread and wheat bread supplemented with different proportions of chickpea flour (10%, 15% and 30%). On the basis of the conducted research, it was found that the addition of chickpea flour significantly influenced all quality characteristics, for example by reducing the volume of the loaves. In organoleptic evaluation the bread obtained quality class 1, with the exception of bread with 30% chickpea flour. Chickpea-wheat breads in a day of baking characterized by lower moisture than wheat bread, and this trend continued throughout the storage period storage. In case of nutrients and micro and macroelements the more share of chickpea flour, their content was bigger. Value of glycemic index was similar among breads supplemented with different proportions of chickpea flour and for wheat bread it was the biggest. Based on the survey it can be stated that bread with 10% and 15% share of chickpea flour had similar quality to wheat bread, that's why chickpea flour can be recommended as an addition in order to enrich wheat bread.

Keywords: quality; chickpea flour; glycaemic index

1. Introduction

The incorrect balanced diet is an etiological factor of metabolic disorders and largely contributes to the development of diseases called the common term of chronic non-communicable diseases, colloquially known in the past as "civilization diseases". Among them, there are: diabetes, atherosclerosis, obesity and cancer. In order to prevent these diseases, various types of pro-health products are promoted on the market. The grain and milling industry is also expanding the range of its preserves by introducing products enriched with the products of various non-bread crops, including legume seed products [2,3,11]. Chickpea seed flour is one of the possible raw materials used in supplementing wheat bread. It is characterized by a high content of: proteins, which in its composition contain almost all the necessary amino acids, macro- and microelements (phosphorus,

potassium, iron, magnesium) and fiber, as well as B vitamins. In addition, the seeds show healing properties. Hence, it seems justified to use this flour as a raw material in baking white bread in order to enrich it with nutrients [2,3,11,13].

2. Materials and Methods

The research material was wheat bread and wheat bread supplemented with different proportions of chickpea flour (10%, 15% and 30%).

The recipes for wheat bread and wheat bread supplemented with different proportions of chickpea flour (10%, 15% and 30%) are shown in Table 1.

Table 1. Recipes for wheat flour bread and wheat bread supplemented with different proportions of chickpea flour (10%, 15% and 30%).

Kind of Bread	Wheat Flour [g]	Chickpea Flour [g]	Salt [g]	Yeast [g]	Water [mL]
CHP *	1000	-	20	30	665
CHP10	900	100	20	30	665
CHP15	850	150	20	30	665
CHP30	700	300	20	30	665

* CHP—wheat bread, CHP10—wheat bread with 10% share of chickpea flour, CHP15—wheat bread with 15% share of chickpea flour, CHP30—wheat bread with 30% share of chickpea flour.

The dough was prepared using a straight method with a laboratory spiral mixer Diosna type SP 12 (Dierks & Söhne, Osnabrück, Germany). Baking was performed at 230 °C for 30 min, in an electric oven MIWE CO 2 P608. 6 loaves were baked for each batch. The loaves were cooled for 2 h, weighted and their volume was determined in a laser volume meter Volscan Profiler. Organoleptic assessment was performed according to PN-A74108:1996 [12]. Chemical composition of bread was determined according to the methods of AOAC (2006) including: dry mass (met. 925.10), total protein (met. 950.36), total dietary fibre (including soluble and insoluble fraction—met. 935.38), raw fat (met. 930.05), total ash (met. 930.05) as well as micor- and macro-elements (modified methods 985.01) [1].

The glycemic index in vitro of tested bread was determined according to Goni et al., [10] with the use of enzyme solutions: pancreatic α-amylase (P-7545, Sigma-Aldrich, St. Louis, MO, USA), amyloglucosidase (3300 U/mL, Megazyme International, Ireland Ltd., Bray, Ireland) and invertases (I 4504, 300 U/mg, Sigma-Aldrich, St. Louis, MO, USA). Glucose levels were determined by colorimetry using a reagent containing the enzymes: glucose oxidase and peroxidase (K-GLOX 09/12, Megazyme International, Ireland Ltd., Bray, Ireland).

Statistical Evaluation

All results were subjected to one-way analysis of variance (ANOVA) using the software STATISTICA 10. The significance of the differences was analysed by the Duncan test at $\alpha = 0.05$. Results are presented as mean and standard deviation (SD).

3. Result and Discussions

Chickpea seed flour seems to be a suitable raw material for baking bread due to its nutritional value, i.e., high protein content, with almost all the necessary amino acids, as well as a high content of macro- and microelements, fiber and vitamins, likewise good emulsifying properties. Therefore, it seems justified to use this flour as a raw material in baking white bread in order to enrich it with nutrients. Hence, the aim of the study was to assess the quality of bread and chemical composition, as well as the in vitro glycemic index with 10, 15 and 30% flour from chickpeas. The results in Table 2 show the quality of wheat bread and wheat-chickpea bread.

Table 2. Evaluation of quality of baked breads on baking.

Type of Bread	Weight of Cold Bread [g]	Volume [cm³]	Bread Yield [%]	Total Baking Loss [%]	Crumb Moisture [%]	Points Assessment	
						Score	Quality Class
CHP *	220.44 a ** ± 2.67	796.25 c ± 1.12	145.93 a ± 0.43	11.82 c ± 0.67	45.10 a ± 0.50	39 a ± 0.00	I
CHPC10	224.42 b ± 1.58	691.82 b ± 1.14	147.51 b ± 0.26	10.06 b ± 0.57	45.82 a ± 0.45	39 a ± 0.41	I
CHPC15	227.35 b ± 5.05	600.54 a ± 1.71	148.55 b ± 0.12	10.03 b ± 0.15	45.80 a ± 0.72	39 a ± 0.87	I
CHPC30	227.35 b ± 5.05	550.54 a ± 11.71	150.55 c ± 0.12	9.03 a ± 0.15	45.80 a ± 0.72	36 a ± 0.12	II

* CHP—wheat bread, CHP10—wheat bread with 10% share of chickpea flour, CHP15—wheat bread with 15% share of chickpea flour, CHP30—wheat bread with 30% share of chickpea flour; ** mean values in columns denoted by different letters differ statistically significantly at $p \leq 0.05$.

Increased water absorption of flour is a very important and desirable feature in the production of bread [5,9]. It has a large impact on the greater efficiency of bread, and as a result, a lower baking loss [9]. The yield of breads with chickpea flour was higher than this parameter which characterized wheat bread, and thus the baking loss of these breads was significantly lower compared to the standard—Table 2. The obtained results confirm the good quality of wheat-chickpea bread.

The effect of the addition of chickpea flour can also be seen when comparing the volume and weight of the loaves. It was found that the greater the proportion of chickpea flour, the smaller the volume and weight of the loaves. With regard to wheat bread, one can also notice large differences between the volumes of the bread. For bread with 30% chickpea flour (CHPC30), this value is 30% lower compared to wheat bread (CHP). Moreover, there is an inverse relationship between the volume of the loaves and the amount of chickpea flour added. The volume of wheat bread is higher, which is related to the fact that wheat flour contains gluten proteins, which are not found in chickpea flour. These proteins are responsible for the structure and porosity of the loaf.

The differences between the tested breads can be noticed not only in terms of their structural properties, such as weight or volume, but also in the color of the crust or the crumb, Figure 1. The color of the crust and the flesh of the bread depends to a large extent on the content of pigments present in the flour. For this reason, breads with chickpea flour characterized a darker color than wheat bread, and individual wheat-chickpea breads showed differences in color, the greater the addition of chickpea flour, the darker the color. The darker color of these breads depends on the pigments contained in the chickpea flour, such as riboflavin, which is responsible for the cream color of the chickpea grain, and thus also the flour [2]. The skin color is also influenced by the products of many reactions known as non-enzymatic browning. These include: the Maillard reaction, during which brown melanoids are produced, caramelization of saccharides, reactions of quinones with amines, reactions with metal ions and oxidized lipids with proteins. The speed of the non-enzymatic browning reaction increases in direct proportion to the temperature, it depends on the amount of water in the product and on the pH of the environment [14].

Replacing wheat flour with chickpea flour in the amount of 10, 15 and 30% increased the weight of wheat-chickpea bread, compared to wheat bread—Table 8. It is probably caused by greater water retention in the bread crumb, which is confirmed by the greater efficiency of this bread, and thus lower baking loss—Table 2.

On the baking day, an organoleptic evaluation was also performed. The evaluation was carried out by a fifteen-person evaluation panel with proven sensory sensitivity. Only bread with a 30% share of chickpea seed flour was rated worse and qualified for the 2nd quality class—Table 2. Breads with chickpea flour were rated worse in terms of taste and aroma.

Figure 1. The external appearance of the bread: CHP, CHP10, CHP15, CHP 30.

Numerous studies have shown that enriching wheat bread with plant additives has a positive effect on its nutritional value [6], hence the content of selected chemical components in both wheat flour and chickpea flour as well as the bread obtained from them was determined. The results are presented in Table 3.

Table 3. Chemical composition of testes bread.

Type of Bread	Dry Mater [%]	Protein [% d.m.] * 6.25	Fat [% d.m.]	Total Ash [% d.m.]	Dietary Fiber [% d.m.]		
					Insoluble Fraction	Soluble Fraction	Total
CHP	90.56 c * ± 0.05	16.50 a ± 0.04	1.57 a ± 0.08	2.75 a ± 0.09	2.49 a ± 0.09	1.30 a ± 0.01	3.79 a ± 0.16
CHPC10	90.54 c ± 0,02	18.06 b ± 0.02	2.19 b ± 0.02	3.28 c ± 0.08	4.00 b ± 0.03	1.87 b ± 0.09	5.87 b ± 0.01
CHPC15	89.03 b ± 0.06	18.32 b ± 0.04	2.46 c ± 0.04	2.93 b ± 0.07	4.58 c ± 0.02	1.82 b ± 0.03	6.40 c ± 0.04
CHPC30	89.57 a ± 0.03	19.64 c ± 0.01	2.58 d ± 0.08	3.65 d ± 0.04	6.03 d ± 0.02	2.33 c ± 0.06	8.35 d ± 0.08

* Mean values in columns denoted by different letters differ statistically significantly at $p \leq 0.05$.

All breads with chickpea flour showed a higher nutritional value than wheat bread—Table 3. Already 10% share of this flour significantly influenced the content of protein (1.5% more), fat and ash (almost 1% more), as well as total fiber (2% more), compared to wheat bread—Table 3. The highest content of all tested ingredients was found in bread with a 30% share of chickpea flour, however, it was rated the worst in terms of quality.

In the tested breads with chickpea flour, a significantly higher ash content was found, which mainly consists of minerals. Hence, the content of selected micro- and macronutrients was also determined. The results are shown in Tables 4

Table 4. Content of selected macro- and micro nutrients.

Type of Bread	Content of Selected Macro- and Micro Nutrients [mg/kg d.m.]								
	Ca	K	Mg	P	Na	Fe	Zn	Cu	Mn
CHP	265.19 a * ±4.12	2397.00 a ±72.75	7.,65 a ±0.66	1617.27 a ±163.8	8417.93 a ±190.95	16.83 a ±0.46	14.17 a ± 1.75	1.71 a ±0.07	7.65 a ±0.36
CHPC10	427.84 b ±3.23	3515.31 b ±43.11	459.68 b ±12.32	2096.28 b ±32.87	8246.98 b ±0.15	28.68 b ± 0.17	15.76 b ± 0.26	1.96 b ± 0.03	12.05 b ± 0.03
CHPC15	488.11 c ±5.78	3647.80 c ±21.65	506.44 c ±12.41	2101.11 c ±15.76	7515.72 c ±0.00	31.35 c ± 0.26	16.11 c ± 1.05	2.19 c ± 0.03	13.26 c ± 0.03
CHPC30	516.30 d ± 10.41	5149.88 d ±14.32	629.32 d ±15.32	2379.82 d ±5.43	8228.93 d ±0.09	72.11 d ± 0.07	19.77 d ± 0.14	3.24 d ± 0.00	15.47 d ± 0.01

* Mean values in columns denoted by different letters differ statistically significantly at $p \leq 0.05$.

In all breads with chickpea flour, a significantly higher content of all determined macro- and micronutrients was found—Table 4. Particularly noteworthy is the increase in the content of iron ions (approx. 12% in bread with a 10% share) and the increase in the content of manganese (approx. 5%) compared to wheat bread—Table 4. The increase in the content of Mg, Ca and P in the tested wheat-

chickpea bread is equally valuable. Already 10% of chickpea flour increased the content of Ca by a half, Mg 65 times, and P 1.5 times, in relation to wheat bread—Table 4.

The glycemic index was also determined in the tested bread with the in vitro method. The results are presented in Table 5. All breads with chickpea flour showed a significantly lower in vitro glycemic index, compared to wheat bread. A inversely proportional relationship was found: the higher the proportion of chickpea flour, the lower the IG—Table 5.

Table 5. Glycemic index of tested bread.

Type of Bread	IG [%]
CHP	94.6 d *
CHPC10	86.9 c
CHPC15	80.3 b
CHPC30	74.9 a

* Mean values in columns denoted by different letters differ statistically significantly at $p \leq 0.05$.

The favorable reduction in the glycemic index of wheat-chickpea breads in relation to wheat bread was the result of a difference in their chemical composition (Table 5). The higher content of fat and dietary fiber had a significant impact. As shown in the studies of other authors, fatty compounds, in addition to protein and organic acids, create a physical barrier surrounding carbohydrates, thus reducing the rate of their decomposition and digestion, which reduces the glycemic index of the product [7].

Significantly higher protein content noted in wheat-chickpea breads probably decreased the glycemic index, because the protein reduces the glycemic index by stimulating insulin secretion [7,15], as well as limiting the availability of starch to α-amylase by "encapsulating" it in its structures [8].

It should be emphasized that eating more dense bread results in a lower glycemic response in the body. This bread stays longer in the digestive tract during the digestion process, and its particles are larger, so the surface area of alpha-amylase action on starch is reduced. As a result, starch hydrolysis is slower and the glycemic index is lowered [8], which was confirmed by the research of this work.

4. Conclusions

Supplementation of wheat bread with chickpea flour showed a comparable quality of these breads to wheat bread, and at the same time they had a much better chemical composition. In addition, significantly lower values of the glycemic index of these breads were found in relation to wheat bread, therefore chickpea flour should be considered a wholesome raw material in production

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