

Effect of the Chickpea (*Cicer arietinum* L.) Flour Addition on Physicochemical Properties of Wheat Bread

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Bulletin UASVM Food Science and Technology 72(1) / 2015
ISSN-L 2344-2344; Print ISSN 2344-2344; Electronic ISSN 2344-5300
DOI: 10.15835/buasvmcn-fst:11023

ABSTRACT

Chickpea flour is a good source of proteins, fibers, minerals and other bioactive compounds and it could be an ideal ingredient for improving the nutritional value of bread and bakery products. The aim of this study was to supplement wheat flour (WF) with various levels of chickpea flour (CF) in order to obtain bread with good nutritional and quality characteristics.

Four experimental variants obtained by substituting wheat flour with different proportions (0%, 10%, 20%, and 30%) of chickpea flour were used. The results showed a valuable increment in bread protein and fiber content. The volume of the breads decreased as the level of chickpea flour (CF) increased due the dilution of gluten content in the blend and due to the interactions among fiber components, water and gluten. Nevertheless, substitution at 10%, 20% and 30%, gives parameter values at least as good as the control sample (WFB) and produces acceptable bread, in terms of weight, volume and sensorial properties.

Keywords: Chickpea, bread, fibre, manufacturing technology, protein.

INTRODUCTION

Bread has always been a staple diet in Europe, Middle East and North America. With the trends toward healthy eating and developments of functional food, the application of legumes in bread baking is a viable alternative (Ram *et al.*, 2010).

Production of wheat has not been sufficient to meet the increasing demand for bread to satisfy human needs. Recently, new efforts have been systematically undertaken to replace part of the wheat flour by other starch sources. Flours from corn, barley, cassava and chickpea are among the most predominant studied for the production of composite flour breads (Bushuk and Hulse, 1974; Almazan, 1990; Defloor *et al.*, 1993; Petrofsky and Hosney, 1995; Ali *et al.*, 2000; Noor *et al.*,

2012; Hefnawy *et al.*, 2012; Abdel *et al.*, 2013). Due to their good balance of amino acid, high protein bioavailability and relatively low levels of anti-nutritional factors, chickpea seed have been considered a suitable source of dietary proteins (Esmat *et al.*, 2010).

Chickpea (*Cicer arietinum* L.) is considered the 5th valuable legume in terms of worldwide economical standpoint and cheap source of legume protein which can be used as a substitute for animal protein (Pelletier, 1994; Ionescu *et al.*, 2009). It is another legume, grown in tropical and subtropical areas, that presents high potential as a functional ingredient for the food industry (Gamlath and Ravindran, 2009). The chickpeas contain moderately high protein (17–22%), low fat (6.48%), high available carbohydrate (50%)

and crude fiber contents of 3.82% on dry basis (Saleh and El-Adawy, 2006). The protein content of chickpea seed is highly variable and determined by both genetic and environmental factors (Chavan *et al.*, 1986; Ihsanullah *et al.*, 2008). They are rich sources of complex carbohydrates, vitamins and minerals (Wang *et al.*, 2010).

Chickpea (*Cicer arietinum* L.) is an annual grain legume (pulse crop) that is extensively cultivated for human consumption throughout the world, including the Mediterranean basin, the Near East, Central and South Asia, East Africa, South and North America, and Australia (Aharon *et al.*, 2012). It is the second-most important pulse crop in the world (after dry bean), covering 15% (10.2 million ha) of the area dedicated to pulse cultivation and accounting for 14% (7.9 million tons) of pulse production worldwide (FAOSTAT, <http://faostat.fao.org/default.aspx>, 2012).

Food crops have occupied an important place in human nutrition as they remain the major sources of calories and protein for a large proportion of the world's population, particularly in developing countries. For economic and social reasons, many millions of people in Asia and African countries depend on vegetable products of cereals and legumes sources. According to the FAO available data, about 80% of the protein consumed by the humans in developing countries is supplied by the plants. Pulses, including chickpea are one of the most important crops in the world because of its nutritional quality (Abdel *et al.*, 2013).

Different traditional oriental foods are prepared using chickpea flour both at household and industrial levels. They are also a source of high-quality protein and have been known as "a poor man's meat" (Isabel and Garmen, 2003; Rincon *et al.*, 1998; Hefnawy *et al.*, 2012). Even though chickpea is a member of the "founder crop package" (Zohary and Hopf, 2000) with potential nutritional/medicinal qualities, it has not received due attention for research like other founder crops (e.g. wheat or barley). Chickpea has been and is being consumed by humans since ancient times owing to its good nutritional properties. Furthermore, chickpea is of interest as a functional food with potential beneficial effects on human health. Although other publications have described the physicochemical and nutritional characteristics of chickpea, there is limited information relating its nutritional components to

health benefits (Jukanti, 2012). Globally, chickpea is mostly consumed as a seed food in several different forms and preparations are determined by ethnic and regional factors (Muehlbauer and Tullu, 1997, Ibrikci, 2003). In the Indian subcontinent, chickpea is split (cotyledons) as dhal and ground to make flour (besan) that is used to prepare different snacks (Hulse, 1991, Jukanti, 2012). In other parts of the world, especially in Asia and Africa chickpea is used in stews, soups/salads and consumed in roasted, boiled, salted and fermented forms (Gecit, 1991, Jukanti, 2012). These different forms of consumption provide consumers with valuable nutrition and potential health benefits.

Chickpea proteins are considered suitable source of dietary protein due to excellent balance of essential amino acid composition (Zhang *et al.*, 2007). It is used as food by people surrounding the Mediterranean Sea. It has been used for the preparation of various traditional foods (Ravi and Suvendu, 2004), such as an ingredient in bakery products, imitation milk, infant food formulations and meat products. Isolation of protein from chickpea flour leads to a reduction in carbohydrate content from 57.88% to 10.33%, which may help in deciding on the beneficial use of the isolated protein as an additive in bread (Ionescu *et al.*, 2009). This is due to the fact, that the lower availability and amount of carbohydrates present in the raw materials for confectionery may lead to a lessening of the Maillard reaction, and thus prevent the intermediate reactions leading to the formation of acrylamide (Rachwa-Rosiak *et al.*, 2015). Whole chickpea contains 17.1% protein, 5.3% fat and 3.0% minerals wherein the food energy being 1507 kJ (Hefnawy *et al.*, 2012). The corresponding values for dehusked split chickpea are 20.8%, 5.6% and 2.7% and 1557 kJ, respectively (Hefnawy *et al.*, 2012). Also, chickpea is a good source of polyunsaturated fatty acids, ca. 66% of the crude lipids are PUFA, mainly linoleic acid (51.2%); folic acid, tocopherols, sterols, carotenoids (especially β -carotene), isoflavones are other bioactive compounds found in balanced amounts in chickpea (Jukanti *et al.*, 2012) and they are conferring important health benefits for consumer. According the scientific literature the chickpea consumption is helpful in lowering the risk of coronary heart disease and control the cholesterol accumulation, in improving the glucose

tolerance and insulin sensitivity; also if chickpea seeds are incorporated as a part of regular diet that may help to reduce blood pressure, to prevent different forms of cancer, to control the body weight increment etc.

The objectives of this study were to supplement wheat flour with various levels of chickpea flour for baking purpose in order to obtain a chickpea supplemented bread with good nutritional and quality characteristics.

MATERIALS AND METHODS

Procurement of raw materials

Chickpea flour was purchased from the local market at Cluj-Napoca (Romania). A commercial wheat flour type 650 (according to ash content 0.65% by the Romanian classification), with 12.9 % moisture and 31.3 % gluten content was used. All the raw materials (as seen in Table 1) were purchased from the local market. The chickpea flour was mixed with wheat flour in different portions (10%, 20% and 30%) for producing chickpea bread.

Chemical determinations of the flours and flour blends

The moisture, crude lipid and ash were determined **according to the Romanian official methods** (STAS 90-2007). The total fibers were determined by the gravimetric method according to the AACC 32-07.01 (1999) standard. Nitrogen (N) content was determined by Kjeldhal apparatus and crude protein was calculated utilizing 5.7 as N conversion factor for wheat flour protein (SR ISO 1871/2002).

Experimental plan

The experimental plan used for the present research is given in Tab. 1, while the Tab. 2 shows the different combination of chickpea flour (CF) and wheat flour (WF) to obtain 4 types of breads (B).

Baking test

Experimental breads were obtained from wheat flour blends containing 0% (100% wheat flour) and 10%, 20% and 30% of CF (as wheat flour replacement). The bread prepared from wheat flour without CF substitution served as control. The bread dough was obtained in a laboratory mixer by kneading 500 g flour, 9 g iodized salt and 25 g fresh yeast (Pakmaya Yeast Rompak, Romania) with water 290 ml for control bread (WFB) and 305 ml, 315 ml, 330 ml respectively for bread supplemented with chickpea flour (WCFB₁, WCFB₂, WCFB₃).

After kneading ca. 8 min, the dough was fermented at 30°C for 60 min, then divided into 400 g portions and placed into non-stick baking trays.

The dough was then proofed for 40 min at 35°C and 85% relative humidity in a proofer (Zanolli Teorema Polis 3 PW, Italy), and baked immediately in a preheated oven (Zanolli Teorema Polis 3 PW, Italy), with top and bottom heat, at 220°C, for 45 min. The oven was pre-steamed before and again after putting the bread in.

Physical-chemical properties

Bread samples were subjected to physico-chemical examination, aiming: weight, volume and specific volume of bread, height/diameter ratio, protein content and acidity (according to STAS 91 -2007 „Pâine și produse proaspete de patiserie. Metode de analiză”).

The weight of the bread was taken using a digital balance. The bread volume was determined by the seeds displacement method. The loaf was placed in a container of known volume into which small seeds (millet seeds) were run until the container was full. The volume of seeds displaced by the loaf was considered as the loaf bread volume. The specific volume of loaf was calculated by dividing volume by weight. The crude protein was determined using Kjeldahl method and was multiplied by a factor of 5.7 (SR ISO1871/2002).

Tab. 1. Experimental Plan

S. No.	Parameter	Level	Description
1.	Materials	5	Wheat flour, chickpea flour, salt, yeast and water
2.	Samples	4	WFB, WCFB1, WCFB2 and WCFB3
3.	Analysis	3	Physico- chemical analysis of the flours and flour blends (5), sensory analysis (5), Physico- chemical analysis of the bread samples (6)

Tab. 2. Treatments descriptions. Different blends of wheat flour and chickpea flour for bread manufacturing

Treatment	Wheat flour (WF), %	Chickpea flour (CF), %
WFB	100	0
WCFB ₁	90	10
WCFB ₂	80	20
WCFB ₃	70	30

Sensory evaluation

Hedonic test of the bread samples was conducted within 24 h after the bread was prepared, in the sensory evaluation laboratory of the Faculty of Food Science and Technology, Cluj-Napoca. The sensory attributes (colour, aroma, taste, texture and overall acceptability) was carried out by ten semi trained panellists. In every session, bread made only with wheat flour was included as reference and samples were coded with random three-digit numbers and presented in a randomized order under white light. Fresh water was used to cleanse the palate between samples. The samples were presented so that each sample had an equal chance to be tested first, second or last. The panellists evaluated all four bread formulations using a 9-point hedonic scale with 1 being “dislike extremely” and 9 being “like extremely”.

Statistical analysis

The results of three independent (n=3) assays performed with replicates each were expressed as mean. Data were compared by one-way analysis of variance (ANOVA). Linear regression analysis were carried out using Microsoft Excel 2010.

RESULTS AND DISCUSSION

Chemical composition of flour blends

Some chemical parameters for wheat flour, chickpea flour and flour blends (WCF₁, WCF₂, WCF₃) are shown in Tab. 3.

High nutrient potential of chickpea flour is due in large part to the high content of protein and fiber. According to the results shown in Tab. 3, the average of the protein content for the tested chickpea flour is 21.9% and 9.9 % for the fiber content; these results show, that comparatively with the wheat flour, the protein content of the chickpea flour is 2.5 times higher, while the fibre content is 16.6 times higher than the wheat flour (type 650).

According to the scientific literature, the total fiber content of chickpea flour is approximately 10-18% in most part insoluble fiber (Rincón et al.,1998; Dalgetty and Baik, 2003) and the total protein content is about 17-22% (Jukanti et al., 2012). Our results are consistent with those from the literature.

As we expected, the results (Tab. 3) indicate that the addition of the chickpea flour increased total protein content of blends, from 14.9 in the case of WCF₁, to 16.9% for the sample with the highest chickpea flour content (WCF₃), while the wheat flour content in crude protein is 8.9%. By increasing the addition of chickpea flour from 10% to 30%, also the crude fibre content increased from 3.1 to 6.3%, the ash content and total lipids content were increased from 1.80 to 2.70% and from 2.3 to 3.4%, respectively. Also, we noticed that an addition of CF up to 30% increases the amount of total lipids by almost 2 times compared to the wheat flour; similarly, an addition of CF up to 30% increases the amount of ash (minerals) by almost 4 times compared to the wheat flour. Both

Tab. 3. Chemical parameters for wheat flour, chickpea flour and wheat-chickpea flour blends

Parameter	Wheat flour (WF)	Chickpea Flour (CF)	Wheat-chickpea flour blends		
			10%WCF ₁ *	20%WCF ₂ *	30%WCF ₃ *
Moisture, g%	12.7	8.9	11.6	11.4	11.0
Ash, g%	0.67	3.24	1.80	2.11	2.70
Crude protein, g%	8.9	21.9	14.9	15.3	16.9
Total lipids, g%	1.8	6.3	2.3	2.9	3.4
Crude fibre g%	0.6	9.9	3.1	4.7	6.3

*10%WCF 1 = 90% wheat flour + 10% chickpea flour; 20%WCF 1 = 80% wheat flour + 20% chickpea flour; 30%WCF 1 = 70% wheat flour + 30% chickpea flour; **Data represents means of three determinations.

increments, in the ash and the lipids contents, are beneficial for health since chickpea can provide important amounts of iron, zinc, magnesium and calcium as well as polyunsaturated fatty acids. These results were in agreement with Hefnawy *et al.* (2012), who reported that the crude protein content ranged between 8.3 to 17.2%, the ash content ranged between 0.85 to 2.5% and total lipids ranged between 1.94 to 3.1 in blends of chickpea flour and wheat flour.

Physico-chemical properties of loaf bread

The appearance of bread is, for most consumers, the main criterion for assessing the quality and also, the key purchasing decision.

Influence of chickpea flour addition on bread quality parameters (weight, volume, specific volume, H/D ratio, protein content, acidity) is graphically represented in the Fig.1-6. Pearson correlation coefficients were calculated in order

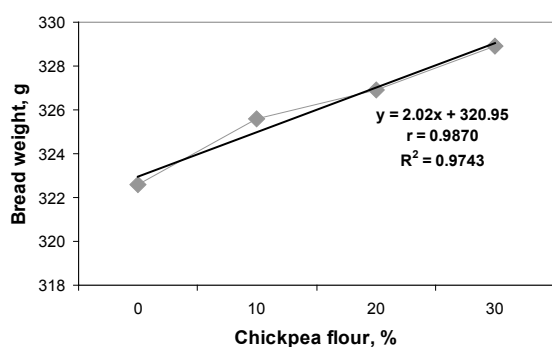


Fig. 1. The influence of the chickpea flour addition on loaf bread weight.

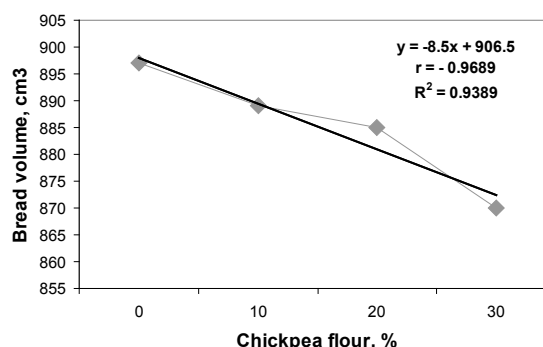


Fig. 2. The influence of the chickpea flour on addition bread volume.

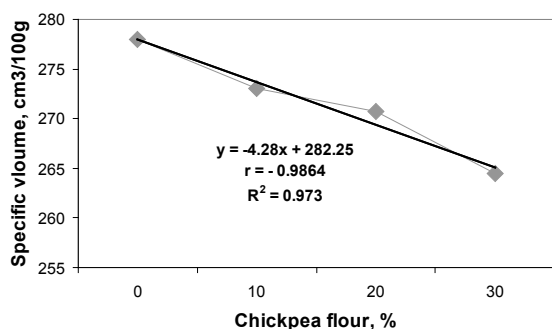


Fig. 3. The influence of the chickpea flour addition on specific volume for the bread.

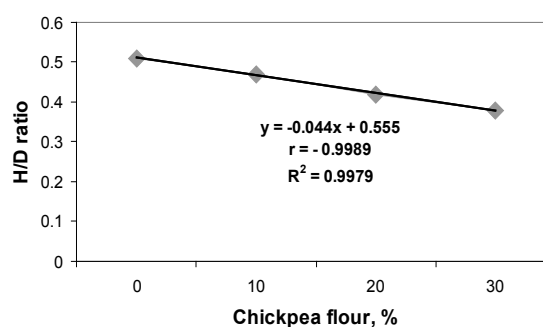


Fig. 4. The influence of the chickpea flour addition on H/D ratio.

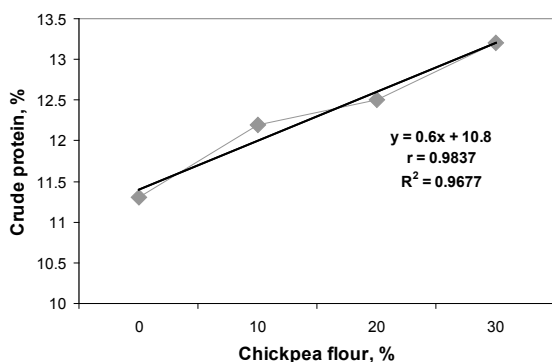


Fig. 5. The influence of the chickpea flour addition crude protein.

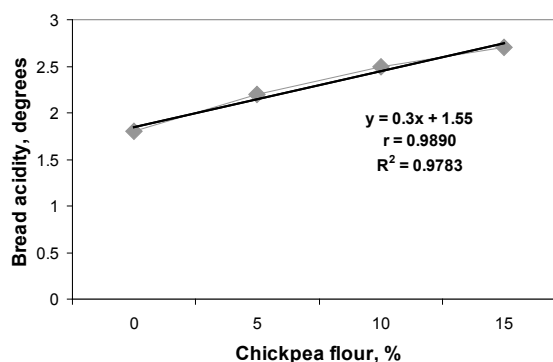


Fig. 6. The influence of the chickpea flour addition bread acidity.

to assess the strength and direction of a linear relationship among the discussed parameters.

Regarding the weight of bread with added CF (Fig. 1), a directly proportional increment between the bread weight and the % CF incorporated was found; the bread weight ranged from 322.6 g in the control wheat bread to 325.0, 326.9 and 328.4 g in supplemented bread samples (WCF_{1,2,3}). The bread weight increment was found significant ($p < 0.05$). The high fiber and protein content of the chickpea flour, comparatively to the wheat flour contribute to a higher water absorption in the finished product and consequently increases the product weight. The water absorption of the flour blends increased from 61% to 66% with increasing amount of CF from 10% to 30%; the wheat flour (WF) water absorption was 58%. The higher water absorption capacity of the chickpea flour could be attributed to the presence of greater amounts of hydrophilic constituents such as polysaccharides and proteins. This is confirmed by the positive regression coefficient obtained ($r = 0.9870$), which describes a very strong positive relationship between these two parameters. The physical properties of fiber including water holding, oil holding, and swelling capacity, viscosity or gel formation significantly affect product processing and quality (Collar *et al.* 2007). The incorporation of apple fiber into bread might increase product density as a result of the water-binding capacity of fiber (Sudha *et al.* 2007).

The main effect of the addition of fibers to bakery products refers on the decrease of their volume. According to the results shown in Fig. 2 and 3, we can notice that the relationship between the change in the percentage of added CF and the volume of the bread with 100g, as well as the specific volume is described by a straight line regression with a slope downward. The coefficients of correlation of $r = -0.9689$ that $r = -0.9864$ indicating a perfect negative linear relationship between these two parameters. In both cases, the variation was found significant ($p < 0.05$).

The decrease of the bread volume from 278.0 cm³/100g in the case of the control sample to 264.5 cm³/100 g for the bread with 30% added CF, is due to a reduced gluten content in the dough and consequently, a reduce capacity of the dough to retain the fermentation gases. Hung *et al.* (2007) argued that the existence of dietary fibre diluted the protein and interfered with the optimal gluten

matrix formation during dough mixing. According to literature, the addition of different materials rich in fiber, up to 7%, produced a volume drop which is proportional to the reduction of gluten content in the blend. Laurikainen *et al.*, 1998 reported that above this value, bread volume decreases at a rate higher than the theoretical one, due to lower gluten protein content. Nevertheless, Izzo and Franck (1998) assert that the addition up to 20% of fibers, the volume downward trend is not significant, while at 40-50% the obtained bread is inadequate.

Wang *et al.* (2002) reported that the fiber's impact on dough stability and on bread volume is due to the hydroxyl groups of fiber that interact with water through hydrogen bonding. Brennan and Cleary (2007) consider that appreciable amounts of water could have strongly bound to the added fibers during breadmaking, so less water was available for the development of the starch-gluten network, causing an underdeveloped gluten network and reduced loaf volume. The dilution of gluten, and the interactions among fiber components, water and gluten are the two mechanisms considered as causing reduced bread volume (Anil, 2007; Collar *et al.*, 2007).

The correlation between the ratio H/D and the percentage of CF incorporated, graphically represented in Fig. 4, is described by a straight line regression with a slope downward. The coefficient of determination ($R^2 = 0.9979$) shows that the variation ratio H/D of bread is due 99% of the variation amount of added chickpea flour.

Regarding the bread protein content and the bread acidity, in relation with the CF addition there is a direct proportional increase between these parameters and the percentage of CF incorporated, as confirmed by the positive regression coefficient obtained $r = 0.9837$ (fig.5) and $r = 0.9890$ (fig.6). Since legume proteins are rich in lysine and deficient in sulphur containing amino acids, whereas cereal proteins are deficient in lysine, but have adequate amounts of sulphur amino acids, the combination of grain and legume proteins could provide better overall essential amino acid balance (Livingstone *et al.*, 1993). The enhancement of the dough and bread acidity in wheat -chickpea blends contribute to a good development of the gluten colloidal properties and improve the bread taste and flavor.

Sensory Analysis

Hedonic test is often used to determine consumer's attitude towards the food by measuring the degree of acceptance of a new product or improving the existing food product (Meilgard *et al.*, 1991). It is very important that the organoleptic properties of bread enhanced with chickpea flour remained acceptable to consumers and the quality level similar to the current commercially available products (Fărcaș *et al.*, 2014).

The results of sensorial evaluation of bread samples containing different level of CF (WCFB₁; WCFB₂; WCFB₃) substitution compared to the control sample (WFB) are shown in the Table 4.

The sample with 10% CF addition had the highest acceptability score (7.97) as well as for the other organoleptic characteristics. Also, it can be observed that the bread sample with 10% added CF obtained scores very close to the control sample (100% wheat flour). A decrease in acceptability was observed when the levels of CF were higher than 10%, but with slight differences.

The colour of the bread slices became visually darker as the level of CF increased. Also, a darker colour of the crumbs was reported by Hu *et al.* (2007) and Fărcaș *et al.* (2014) and directly linked to increased fibre content and to the high content in carotenoids. The effect of chickpea flour addition on crumb color was not significant ($p > 0.05$). For all the bread samples the scores for aroma, taste and texture have decreased with increase in CF substitution.

The scores of general acceptability are found to be 8.1, 7.91, 7.62 and 7.1 in control bread and bread supplemented with 10, 20 and 30% chickpea flour (WCFB₁; WCFB₂; WCFB₃), while in the case of 10% CF addition similar scores with control bread (WFB) were obtained.

A study performed by Abdel *et al.* (2013) demonstrated that bread with 5% chickpea flour

was found to be more acceptable in sensory evaluation compared with flour wheat bread. Instead, Hefnawy *et al.* (2012) found that at a level of addition of 30% CF, the sensory qualities are similar to those obtained from control bread. These results demonstrate a relatively high gradient of acceptability among panellists but also a greater willingness of consumers to new tastes.

CONCLUSION

The experiment demonstrated that it is possible to use chickpea flour to partially substitute wheat flour in the elaboration of bread. From present results, it could be noticed that, the addition of chickpea flour to wheat flour improved the protein, fibres and mineral content of the bread. The overall acceptability of the CF enriched breads was performed by sensorial analysis, revealing good organoleptic attributes for the samples up to 10% CF. Supplementation with 10% chickpea flour could be adopted in wheat bread manufacturing without affecting quality adversely. Further studies will be conducted in order to find appropriate emulsifier in order to significantly improve the bread volume and crumb properties.

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Tab. 4. Sensory evaluation of different bread samples*

Treatments	Colour	Aroma	Taste	Texture	Overall acceptability
WFB	8.3	7.7	7.72	8.2	8.1
WCFB ₁	8.27	7.67	7.7	8.0	7.97
WCFB ₂	8.0	7.5	7.3	7.69	7.67
WCFB ₃	7.91	7	6.9	7.1	7.37

*WFB = 100% wheat flour + 0% chickpea flour; WCFB₁ = 90% wheat flour + 10% chickpea flour; 20%WCFB₂ = 80% wheat flour + 20% chickpea flour; WCFB₃ = 70% wheat flour + 30% chickpea flour; **Data represents means of three determinations.

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