Impact of adding chickpea (*Cicer arietinum* L.) flour to wheat flour on the rheological properties of toast bread

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Abstract: Legume flours, due to their amino acid composition and fibre content, are ideal ingredients for improving the nutritional value of bread and bakery products. In this study, the influence of the total or partial replacement of wheat flour by chickpea flour on the quality characteristics of toast bread was analyzed. Chickpea flour was added to medium strength wheat flour to replace 15 and 30% w/w of wheat flour. The effects of chickpea flour supplementation on dough physical properties, such as water absorption capacity, dough development time, dough stability, crumb, porosity and toast bread structure as well as quality characteristics were studied. Chickpea flour at 15 and 30% substitution levels increased the stability and the tolerance index of the dough. The volumes of the breads decreased as the level of chickpea flour increased due to the dilution of the gluten structure by added protein. Nevertheless, substitution at 15 and 30%, gives parameter values at least as good as the control sample and produces an acceptable toast bread, in terms of weight, volume, texture and crumb structure.

Keywords: Chickpea, wheat flour, rheological properties, toast bread, protein

Introduction

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 Hoseney, 1995; Ali *et al*., 2000).

Legumes including beans and chickpea are important crops because of their nutritional quality. They are rich sources of complex carbohydrates, vitamins and minerals (Wang *et al*., 2010). Legumes have been considered a rich source of protein throughout the world and contain approximately three times more proteins than cereals. Chickpea (*Cicer arietinum* L.) is one of the top five important legumes on the basis of whole grain production. Chickpea is a valuable, ancient leguminous plant which grows well in different soils and climates. 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. Whole chickpea contains 17.1% protein, 5.3% fat and 3.0% minerals wherein the food energy being 1507 kJ. The corresponding values for dehusked split chickpea are 20.8%, 5.6% and 2.7% and 1557 kg, respectively (Gopalan and Balasubramanian, 1993). Different traditional oriental foods are prepared using chickpea flour both at household and industrial levels. Dried legume seeds generally promote slow and moderate postprandial blood glucose increase. 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).

During fermentation and baking process, amino acids react with sugars as well as their metabolites which increase the production of carbonyl compounds responsible for bread flavor. Each amino acid gives rise to a different flavor compound. The amount of any compound, found in the crust of bend, depends on the level of its amino precursor available to react with reducing sugars (Ravi and Suvendu, 2004). The unique bread-making properties of wheat flour can be attributed mainly to the ability of its gluten proteins to form a viscoelastic network when mixed with water. The reduction of viscoelastic properties of wheat flour dough, after substitution by chickpea flour, reduces bread-making potential. The weakening effect of foreign proteins on wheat flour dough was the result of a dilution of the gluten structure by the added protein. This results in lower loaf volume and subsequently has a negative affect on other quality attributes, such as crumb grain and tenderness. Chickpea flours can be an excellent choice for improving the nutritional value of bread. The high lysine, low methionine content complements that of wheat flour proteins, which are poor in lysine and relatively higher in the

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sulphur-containing amino acids. In chickpea, the main limiting amino acids are methionine and cystine, followed by valine and then tryptophan (Knorr and Betschart, 1978; Bloksma and Bushuk, 1988). Chickpea protein isolates, prepared on a bench scale, have been shown to have good nutritional properties when supplemented with methionine or mixed with cereals. Studies have shown that chickpea flour can be successfully incorporated into products at up to 20% inclusion, to produce products that rate higher in terms of color, texture, taste and overall acceptability. A number of pasta products containing chickpea flour are currently available on the domestic market. Also, chickpea can be incorporated at up to the 50% level in biscuits (Navickis, 1987; Doxastakis *et al*., 2002). This work was designed to study the impact of the partial replacement of wheat flour by chickpea flour on the functional properties of toast bread dough and final bread quality.

Materials and Methods

Materials

One batch of local chickpea seeds (*Cicer arietinum* L.) were purchased from the local market at Zagazig (Egypt). The seeds were hand-sorted to remove wrinkled, moldy seeds and foreign materials. Also, commercial blends of wheat flour (11.48%) were obtained from local market.

Chemical determinations

Nitrogen content was determined using Kjeldahl method and was multiplied by a factor of 5.7 to (Hudson et al., 1976). Moisture content was determined by drying the samples at 105°C to constant weight. All the determinations, such as fat, moisture, falling number and ash, were determined and expressed on a dry weight basis due to the recommended methods as well as nitrogen were determined according to the official methods (AOAC, 1975). Starch was determined enzymatically according to (Kerr *et al*., 1951).

Amino acid analysis

Protein hydrolyzate was prepared by treating 300 mg from each treatment with 6N HC1 in an evacuated test tube for 24 h at 105°C. After evaporation, the dried residue was dissolved in citrate buffer (pH 2.2). Aliquots were analyzed in an LKB Biochrome automatic amino acid analyzer (model 4151) using a buffer system as described by Zarkdas *et al.* (1993). Methionine and cystine + cysteine were analyzed separately after performic acid oxidation and subsequent hydrolysis with HCl (Khalil and Durani, 1990). Tryptophan was determined after alkali (NaOH) hydrolysis by a calorimetric method (Freidman and Finely, 1971).

Farinograph procedure

The dough mixing properties of different wheat-chickpea flour blends were examined with the Brabender farinograph (Brabender, Duisburg, Germany) according to the constant flour weight procedure (AACC, 1983; ICC, 1992). Dough development time was determined as the time to the point of the curve immediately before the first sign of decrease in consistency. The maximum consistency was defined as the consistency in B.U., measured at the development time and in the middle of the curve bend, while the dough stability was defined as the drop of the curve (B.U.) during the first 2 min after dough development time.

Extensograph procedure

Doughs from the farinograph measurements were cut into two parts (150 g each) and passed through the balling and molder unit of a Brabender extensograph (Brabender, Duisburg, Germany). After 45 min resting in the fermentation cabinet, the dough was stretched. After this first test, the balling and mounding operations were repeated and the dough's were tested again after a further 45 min resting time. The same procedure was repeated for a third time, following the official procedure (AACC, 1983; ICC, 1992). The results were expressed as the resistance to constant deformation after 50 mm stretching (R50); the extensibility (Ex) was described as the distance traveled by the recorder paper from the moment that the hook touches the test piece until rupture of the test piece and the ratio between the two of them (R50/Ex).

Baking test

Experimental bread-making was done according to the method described by Boudonas *et al*. (1976). The baking formula, based on 300 g (14%) of flour weight was; flour (295.2 g), salt (6 g) and fresh compressed yeast (5 g). The wheat flour was substituted by chickpea flour at levels of 5, 15 and 25%. Flours (or flour blends) were stirred for 1 min in the farinograph bowl. After this period, the other ingredients (salt and yeast), previously dissolved separately in water were added. The amount of water to be used was determined by the farinograph absorption value. The dough was then mixed for 5 min and placed in baking pans and fermented at 30°C and 80–90% relative humidity. Then the dough was re-mixed and was replaced for re-fermentation.

The above two fermentation periods were 45 min in both cases. Baking for each 400 g dough piece was at 220ºC for 45 min. During baking, some water was vaporized in the oven to avoid any extreme dryness of the bread crust. Specific loaf volume was measured by rapeseed displacement after cooling.

Organoleptic evaluation

Panelists from the staff of the Egyptian Baking Technology Center (Giza, Egypt) were asked for sensory evaluation of toast bread appearance, crumb, odor, crust, color and taste according to the method of (Kramer and Twigg, 1974).

Loaf measurements

Loaves were weighed as they came out of the oven. Volume (Cm^3) was determined by rapeseed displacement; specific volume (Cm^3/g) was calculated by dividing volume by weight and oven spring (Cm) was calculated by differences between loaf height before and after baking.

Results and Discussion

Chemical constituents of flour

The chemical constituents of wheat flour, chickpea flour and different flour mixtures (B1 and B2) are shown in Table 1. The obtained results indicate that adding chickpea flour (mixture B2) increased total protein from 8.3 to 17.2%. Also total ash and total lipids were increased from 0.85 to 2.5% and from 1.94 to 3.1%, respectively. Meantime other constituents showed remarkable reduction in their values, i.e. total carbohydrates contents 72.2 to 71.2%. Table 1 shows the effect of chickpea flour on falling numbers (viscosity) of wheat flour and flour mixtures. The results illustrate that addition of chickpea flour was accompanied with raise in the values of falling number. This may be attributed to the high levels of total protein and ash percentage in mixtures (Pomeronz, 1971). Protein values found in the chickpea were in agreement with date presented by other authors (Iqbal *et al*., 2006; Giovana *et al*., 2006).

Amine acid composition of protein hydrolyzates from wheat flour and flour mixtures (B1 and B2) indicated the presence of eighteen amino acids (Table 2). The obtained results indicate that chickpea flour addition to wheat flour resulted in increasing the levels of aspartic acid, lysine and arginine acids (from 4.7 to 8.79%, from 2.42 to 5.24% and from 4.6 to 6.47 %, respectively). Conversely, some amino acids were found in lower levels (glutamic and serine content from 36.7 to 25.8% and from 5.68 to 4.32%, respectively). The amount of other amino acids (threonine, valine and glycine) was not changed in wheat flour and mixtures containing chickpea flour (B1 and B2). The results are in fair agreement with those reported by Bhatty *et al*. (2000) and Hussain and Basahy (1998).

Table 1. Composition of wheat flour 72%, chickpea flour and wheat-chickpea flour blends

Parameter	Wheat flour	Chickpea flour	Wheat-chickpea flour blends	
			B1	B2
Moisture	10.5	9.5	9.1	9.5
Ash	0.85	3.4	1.9	2.5
Total lipids	1.94	4.7	2.6	3.1
Crude protein	8.3	19.3	15.6	17.2
Available carbohydrate	72.2	69.3	70.6	71.2
Falling number	330	271	325	310

B 1 = 85% wheat flour + 15% chickpea flour; B 2 = 70% wheat flour + 30% chickpea flour

Table 2. Individual amino acid content of wheat flour 72%, chickpea flour and wheat-chickpea flour blends

Amino acids	Wheat flour 72%	Chickpea flour	Wheat-chickpea flour blends	
			B 1	B 2
Arginine	4.60	8.3	5.70	6.47
Histidine	2.33	3.0	2.46	2.73
Isoleucine	3.90	4.8	4.20	4.51
Leucine	7.48	8.7	7.51	7.94
Lysine	2.42	7.2	3.12	5.24
Methionine	1.78	1.1	1.32	1.53
Phenylalanine	4.95	5.5	5.1	5.23
Threonine	3.36	3.1	3.30	3.26
Tryptophan	1.14	0.9	1.00	1.10
Valine	4.78	4.6	4.69	4.66
Alanine	3.38	4.8	3.62	4.14
Aspartic acid	4.70	11.0	5.62	8.79
Cystine	1.11	0.6	0.76	0.88
Glutamic acid	36.27	17.3	31.4	25.8
Glycine	3.79	3.7	3.68	3.65
Proline	12.63	3.8	10.24	8.33
Serine	5.68	3.7	5.23	4.32
Tyrosine	2.33	3.0	2.46	2.73

B 1 = 85% wheat flour + 15% chickpea flour; B 2 = 70% wheat flour + 30% chickpea flour
*Expressed as g / 16 g N

Rheological properties

Farinograph test

The results presented in Table 3 shows that water absorption was increased with increasing the levels of chickpea flour ratio in the dough (values were 54.0, 57.3 and 61.7 for control, B1 and B2, respectively). Dough development and stability were decreased by increasing chickpea ratio. On the other hand, dough weaking had positive proportional relation with the added chickpea flour. For example, stability values were 1.3, 1.4 and 1.6 min for control, B1 and B2, respectively. However, weaking of the dough was a result of the break down of gluten network after elapsing on appropriate time (10 and 20 min). Protein in first bread flour-chickpea mixture was of low quality because of its deficiency in gluten and therefore the weaking values were increased. The obtained results indicate that first bread flour chickpea mixture had less desirable rheological properties.

Extensograph test

The results in Table 4 indicate that dough resistance

Table 3. Farinograph parameters of wheat flour 72% and wheat flour-chickpea flour blends

Parameters	Wheat flour 72 %	Wheat-chickpea flour blends	
		B 1	B 2
Water absorption (%)	54.0	57.3	61.7
Arrival time min(min)	0.70	0.9	1.1
Dough development:			
Time (min)	0.85	1	1.2
Stability (min)	1.3	1.4	1.7
Degree after (10 min)	95	100	105
Weakening after (20 min)	115	120	128

B 1= 85% wheat flour + 15% chickpea flour; B 2 = 70% wheat flour + 30% chickpea flour

to extension proportional number and energy of mixture B1 were higher than those of mixture B2 which could be attributed to its higher percentage of the added chickpea. Addition of chickpea which is used extensively as gelling, stabilizer and thickener in food industry improved dough extensibility and reduced the other parameter values.

Table 4. Extensograph parameters of wheat flour 72% and wheat flour-chickpea flour blends

Parameters	Wheat flour 72%	Wheat-chickpea flour blends	
		B 1	B 2
Extensibility (min)	153	142	135
Resistance to:			
Extensibility (B.U.)	370	375	300
Proportional number	3.3	3.0	2.7
Higher peak (B.U.)	390	400	360
Energy (cm3)	48	38	36

Organoleptic qualities

Table 5 shows the characteristics including loaf height, loaf volume and oven spring of bread made from wheat flour, B1 and B2. Obtained results were found to be similar to control bread prepared from wheat flour and lower than of B1 and B2. On the other hand, the same characteristics obtained from control flour, B1 and B2 levels were lower than those control loaf weights. This might be due to the lower water absorption of composite flours compared to controls. Specific volume, the most important characteristic of bread quality of bread loaves obtained from B1 and B2 were similar to control. Also, results in Table 6 reflected the effect of chickpea added to wheat flour, on the extensibility elasticity and energy as measured by the extensograph. It can be noticed that the addition of chickpea at low levels slightly increased the extensibility but, on contrary, decreased it at high levels. Low or high chickpea addition had different effect on the elasticity and energy of dough. Data of sensory evaluation (Table 6) indicated that all breads obtained from control composite flours and mixed flours (B1 and B2) had acceptable sensory qualities similar to those obtained from control. In addition, breads from B2 had similar appearance and crumb texture to those obtained from control. Breads obtained from composite flour (B1 and B2) were lower than those obtained from control in all sensory traits except taste. On the other hand, breads prepared from control had the least preferable sensory qualities. The sensory results indicated that control breads had the highest overall acceptability scores followed by bread from mixture B1. Addition of 30% chickpea flour to the wheat composite flours improved rheological properties. This improvement was translated into good bread making potential. The resulted in good quality bread similar to that obtained from wheat flour 72% (control).

Table 5. Loaf characteristics of wheat flour 72% and wheat-chickpea flour blends

Treatments	Loaf height (Cm)	Oven spring (Cm)	Loaf weight (g)	Loaf volume (Cm^3)	Specific volume (Cm^3/g)
Wheat flour 72%	6.4	1.00	169.5	465	2.74
B 1	6.00	0.70	127	432	3.40
B 2	5.80	0.64	113	375	3.30

B 1 = 85 % wheat flour + 15 % chickpea flour; B 2 = 7% wheat flour + 3% chickpea flour

Table 6. Sensory traits of control bread wheat flour 72% and bread from wheat-chickpea flour blends

Treatments	Appearance	Crumb texture	Crumb grain	Crust color	Taste	Odor	Overall acceptability
Wheat flour 72 %	7.0	8.0	7.4	7.8	7.0	7.0	8.2
B 1	7.3	8.1	7.6	8	7.1	7.2	7.6
B 2	7.5	8.2	8.1	8.3	7.6	7.5	7.1

B 1 = 85% wheat flour + 15% chickpea flour; B 2 = 70% wheat flour + 30% chickpea flour

Conclusions

It has been observed that it is possible to use chickpea flour to partially substitute wheat flour in the elaboration of bread. The substitution percentage and the kind of chickpea flour used should be experimentally determined in each case depending on the kind of bread, and the pursued objectives (nutritional improvement, free-gluten products, special organoleptic characteristics)

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