Utilisation of chickpea flour for crackers production

Zlatica Kohajdová, Jolana Karovičová, Michal Magala

Institute of Biotechnology and Food Science, Faculty of Chemical and Food Technology, Slovak University of Technology, Radlinského 9, 812 37 Bratislava, Slovak Republic

zlatica.kohajdova@stuba.sk

Abstract

In this study, nutritional quality of wheat crackers was improved by incorporation of chickpea flour. Chickpea flour was characterised with higher protein, fat and ash content in comparison to fine wheat flour. On the other hand, wheat flour contained higher starch level than that in chickpea flour. Chickpea flour was also characterised with good water holding and emulsifying capacities, but the lower water retention capacity and emulsifying stability. Furthermore, fine wheat flour was substituted with different levels of chickpea flour (0, 10, 20 and 30 % w/w) to produce crackers. The addition of chickpea flour at level more than 10 % showed adverse effect to physical properties of crackers embodied in reduced volume index, width and spread ratio. Sensory evaluation of crackers revealed that enhancing level of chickpea flour in crackers caused higher intensity of leguminous taste and odour and cracker had slightly bitter taste. Incorporation of chickpea flour also modified structure of crackers by increasing hardness and reduction porosity of final products.

Keywords: chickpea, functional properties, crackers, quality

Introduction

Legumes, such as beans and chickpea are one of the most important crops in the world because of their nutritional quality (Arab et al., 2010). Grain legumes are a valuable sources of protein (18-25 %, dry basis) and carbohydrates (50-60 %, dry basis), with starch (22-45 %, dry basis) and non-starch polysaccharides (dietary fibre) as predominant fractions and a small but significant amount of oligosaccharides (Hemeda and Mohamed, 2010) as well as vitamins and minerals (B-vitamins, folates, and iron), antioxidants and polyphenols (Han et al., 2010). The inclusion of legumes in the daily diet has many beneficial physiological effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart disease and colon cancer (Sid-diq et al., 2010). Legumes are used in a variety of food preparations either as such or in combination with cereals, because cereal proteins are generally deficient in some essential amino acids. The use of legumes are important as a cheap and concentrated source of proteins, due to the high cost of proteins of animal origin and their inaccessibility by the poorer part of the population (Tharanathan and Mahadevamma, 2003).

Chickpea (*Cicer arientum L.*) is considered the 5th valuable legume in terms of worldwide economical standpoint (Ionescu et al., 2009). Several studies are interested in the incorporation of chickpea flours to the basic recipe of various bakery products such as cakes (Gómez et al., 2008), cookies (Faheid and Hegazi, 1991) pasta (Goñi and Valentín-Gamazo, 2003; Wood 2009), bread (Abdel-Aal et al., 1987; Hatzikamari et al., 2007; Coda et al., 2010), extruded snack products (Shirani and Ganesharanee, 2009; Meng et al., 2010) and bakery fillings (Klamczynska et al., 2001).

The aim of this study was to determine the effect of the partial replacement (0, 10, 20 and 30 %, w/w) of fine wheat flour by chickpea flour on the quality of crackers. Proximate analysis and functional properties of flours used in this study were also analysed.

Materials

Commercial fine wheat flour (containing 32.8 % of wet gluten on dry basis) and instant chickpea flour were used in this study. All ingredients were commercially available in Slovak local market.

Preparation of flour blends

Fine wheat flour was substituted by instant chickpea flour at 0, 10, 20 and 30 % levels, w/w.

Cracker preparation

The soda crackers were prepared according to procedure of Han et al. (2010) that included: mixing of dry and liquid ingredients, 10 min resting of dough, sheeting and laminating of dough and cutting to circular shape. The crackers were baked in electric oven at 175 °C for 4 min and cooled to room temperature.

Proximate composition

Flour samples (fine wheat and instant chickpea flours) were analysed for their moisture, starch (Simsek et al. 2009), proteins (Kjeldahl method), fat (using a Soxhlet extraction) (Ibanoğlu et al. 1999) and ash content (Kaur et al., 2007). The pH of samples was determined with a pH-meter using a 10 % (w/v) (Ibanoğlu et al. 1999).

Determination of functional properties

Determination of functional properties, specifically, hydration properties: water holding capacity (WHC), water retention capacity (WRC) and swelling capacity (SW) (Raghavendra et al. 2004), emulsifying properties: emulsifying capacity (EC) and emulsifying stability (ES) and foaming capacity (FC) (Siddiq et al. 2010) were performed.

The minimal gelation concentration (LGC) of instant chickpea flour and fine wheat flour were determined by method of Kaur and Singh (2005). LGC represents the concentration above which the sample did not fall drop or slip when the test tube was inverted.

Determination physical properties of final products (crackers)

Spread ratio was determined by the formula W/T, where W is the average diameter (width in mm) and T is the average thickness (in mm) of crackers (Bose and Shams-Ud-Din, 2010).

Sensory evaluation

Sensory evaluation was conducted using 11 untrained panellists who were asked to score odour, taste and texture on 5-point hedonic scales (1 = dislike extremely, 5 = like extremely). Overall acceptability of cookies was assessed was carried out using a 100 mm graphical non-structured abscissas with the description of extreme points (minimal or maximal intensity, from 0 to 100%).

Statistical analysis

Three measurements were taken on each analysis, and the results were expressed as the mean of those values ± standard deviation. The analysis of variance was performed using the statistical software Statgraphic Plus for Windows, Version 3.1 (Statsoft-Inc., USA). Fisher's least significant differences (LSD) test was used to describe means with 95 % confidence.

Results and discussion

Proximate analysis

The proximate composition of used flours is presented in the Table 1. Chickpea flour was characterised 2 times higher amount of proteins as fine wheat flour. Similar results were described by Boye et al. (2010a) in desi chickpea flour (20.52 %), higher values were found by Sanjeewa et al. (2010) and Arab et al. (2010) for chickpea flours (21.80-24.90 %) and different processed chickpea flours (22.87-24.63 %). Chickpea flour contained 2.88 % of ash. Similar results were determined by Kaur and Singh (2005) (2.72-2.88 %) and Boye et al. (2010a) (2.76-3.04 %) in the chickpea flour from different cultivars and in the whole flour from various legume seeds. Instant chickpea flour included about 3.86 times more fats in comparison to fine wheat flour. Lower amount of fat was recorded by Siddiq et al. (2010) in different bean varieties (3.14-3.62 %). On the other hand, Sanjeewa et al. (2010) found higher fat concentration (6.70-7.60 %) in various types of chickpea flours.

Table 1. Proximate composition of used flours.

Sample	Moisture (%)	Fat (%)	Protein (%)	Starch (%)	pH	Ash (%)
fine wheat flour	13.60 ± 0.02	1.54 ± 0.03	10.70 ± 0.08	75.00 ± 0.66	5.41 ± 0.07	0.51 ± 0.04
instant chickpea flour	11.16 ± 0.11	5.95 ± 0.10	20.64 ± 0.39	47.83 ± 0.71	6.23 ± 0.01	2.88 ± 0.11

Functional properties

Functional properties of studied flours are showed in the Table 2. Chickpea flour was characterised by higher WHC than that found in fine wheat flour (5.00 g H_2O/g flour). Similar values were determined by Wang and Toews (2011) in different fibre fraction of chickpea (4.50-4.9 $g.g^{-1}$). Lower WHC was recorded by Boye at al. (2010a) and Sanjeewa et al. (2010) for legume protein concentrates (0.60-2.70 $g.g^{-1}$) and for chickpea flours (0.71-0.84 $g.g^{-1}$). It was reported that flours with high WHC could be good ingredients in bakery applications (e.g., bread formulation), since a higher WHC enables bakers to add more water to the dough, thus improving the handling characteristics and maintaining freshness in bread (Ma et al., 2011).

Table 2. Functional properties of used flours.

Functional parameters	Fine wheat flour	Instant chickpea flour
Water holding capacity [$g.g^{-1}$]	3.20 ± 0.04	5.00 ± 0.12
Water retention capacity [$g.g^{-1}$]	0.76 ± 0.02	2.37 ± 0.09
Swelling capacity [$cm^3.g^{-1}$]	2.05 ± 0.05	3.30 ± 0.23
Emulsifying capacity [$cm^3.100\ cm^{-3}$]	*	45.00 ± 0.26
Emulsion stability [$cm^3.\ 100\ cm^{-3}$]	*	12.08 ± 0.09
Foaming capacity [$cm^3.\ 100\ cm^{-3}$]	1.50 ± 0.02	40.00 ± 0.10

* did not form emulsion

Chickpea flour showed relatively low WRC (2.37 $g.g^{-1}$). Higher WRC was observed by Wang and Toews (2011) for chickpea fibre fraction (7.70-9.40 $g.g^{-1}$). Instant chickpea flour exhibited SW value 3.30 $cm^3.g^{-1}$, which was similar than that reported for heat treated cowpea flours (2.31 – 4.63 $cm^3.g^{-1}$) by Enwere and Ngoddy (1986), whereas Wang and Toews (2011) determined remarkable higher values of SW for chickpea fibre fractions (7.70 - 9.40 $cm^3.g^{-1}$).

EC is defined as the ability of the flour to emulsify oil (Kaur and Singh, 2005). It was concluded that fine wheat flour did not form emulsion. The EC of chickpea flour represented 45.0 $cm^3.100\ cm^{-3}$. Comparable EC values were recorded by Siddiq et al. (2010) for black bean flour (45.6 $cm^3.100\ cm^{-3}$). On the other hand, higher values were measured by Kaur and Singh (2005) in different chickpea flours (from 58.2 to 68.8 $cm^3.100\ cm^{-3}$). The higher EC of legumes might be due to the dissociation and partial unfolding of globular proteins, leading to exposure of hydrophobic amino acid residues, which consequently increased the surface activity and adsorption at the oil and water interface. Moreover, interaction between proteins and carbohydrates in legume flours may also impact the EC (Ma et al., 2011). ES provides a measure of the ability of the protein to impart strength to the emulsion to resist changes to its structure (e.g., coalescence, creaming, flocculation or sedimentation) over a defined time period (Boye et al., 2010a). ES of chickpea flour was found lower (12.8 - 68.8 $cm^3.100\ cm^{-3}$) as was recorded for various bean flour (45.60-60.50 68.8 $cm^3.100\ cm^{-3}$) by Siddiq et al. (2010). Further, it was found that chickpea flour showed FC 40.0 $cm^3.100\ cm^{-3}$. Similar FC values were showed for various bean flours (37.40-49.6 $cm^3.100\ cm^{-3}$) by Siddiq et al. (2010), but Mortuza and Tzen (2008) showed higher FC (44.3-63,5 $cm^3.100\ cm^{-3}$) for various beans flours. Lower values of FC could be due to inadequate electrostatic repulsions, lower solubility and hence excessive protein-protein interaction (Butt and Batool, 2010).

An important index of gelling capacity is the LGC which may be defined as the lowest concentration required to formation a self-supporting gel (Boye et al., 2010b). Gelation properties observed for the used flour at different concentrations (0-20 %) are shown in Table 3. It was concluded that complete gelation of instant chickpea was observed at 6 %. Our results are identical to those reported by Sanjeewa et al. (2010) for *Kabuli* XN variety of chickpea flour and Olalekan and Bosede (2010) for jack bean and cowpea flours, but Kaur et Singh (2005) and Butt and Batool (2010) determined higher LGC values for flours obtained from different cultivars of chickpea harvested in India (≥ 10 %) and various legume protein isolates (≥ 14 %). Variations in different legume flours may be ascribes to the ratios of different constituents, such as proteins, carbohydrates and lipids, in different legume flours, suggesting that interactions between such components may also have a significant role in functional properties (Kaur et al., 2007).

Table 3. The least gelation concentration of chickpea flour.

	Concentration of chickpea flour (%)									
	2	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
fine wheat flour	-	-	±	±	±	±	+	+	+	+
instant chickpea flour	±	±	+	+	+	+	+	+	+	+

No gelling (−), complete gelling (+), or partial gelling (±).

Physical properties of crackers

Data on physical properties of crackers as affected by incorporation of chickpea flour are presented in Table 4. Incorporation of instant chickpea flour reduced volume index of crackers from 1.37 (control sample) to 1.33 cm (samples with 30 % of chickpea flour). The statistically relevant differences were observed between control crackers and crackers enriched with 30 % level of chickpea flour. Similar decreasing in volume index was also described in study of Gómez et al. (2008) and Hemeda and Mohamed (2010) for cakes incorporated with various levels of chickpea flour. It was also observed that the density of crackers supplemented by 20 and 30 % levels of instant chickpea flour was significantly higher ($p = 0.05$) that than in control sample.

Table 4. Physical properties of chickpea-enriched crackers.

	Volume index (cm)	**Density ($g.cm^3$)**	**Thickness (T, mm)**	**Width (W, mm)**	**Spread ratio (W/T)**
Control	1.37 ± 0.11	0.70 ± 0.03	0.38 ± 0.05	4.44 ± 0.03	11.68 ± 0.07
			Substitution level (%)		
10	1.40 ± 0.06	0.74 ± 0.02	0.38 ± 0.04	4.43 ± 0.12	11.66 ± 0.04
20	1.39 ± 0.10	0.78 ± 0.04*	0.39 ±0.07*	4.41 ± 0.05*	11.08 ± 0.06*
30	1.33 ± 0.05*	0.84 ± 0.05*	0.41 ±0.03*	4.40 ± 0.08*	10.73 ± 0.05*

* indicates a statistically significant differences ($p = 0.05$)

In general, thickness, width and spread ratio were affected by the increase in the level of chickpea flour in the crackers. As the level of replacement increased above 10 %, the chickpea flour showed remarkable impact on the thickness of crackers. Previous studies of Eissa et al. (2007) Bose and Shams-Ud-Din (2010) also showed increasing in thickness for biscuits and crackers supplemented by chickpea and kidney pea or navy and pinto bean flours, respectively. Addition of chickpea flour to cracker also resulted in reduced width of final products. The same effect was observed by Zucco et al. (2011) and Tiwari et al. (2011) when the various legume flours were added to cookies and biscuits. Results of this study also indicated that the addition of chickpea flour adversely affected spread ratio of supplemented crackers. Reduction of spread ratio was significant with increasing level of chickpea flour above 10 %. Results of this study are in concordance with those reported earlier by Hegazy and Faheid (1990), Bose and Shams-Ud-Din (2010) and Tiwari et al. (2011) who recorded decreasing of spread ratio for chickpea and pigmeon pea flours substituted cookies or biscuits. Zucco et al. (2011) described a decrease in spread with increased protein in the cookies. The higher protein level for chickpea flour used in this study (Table 1) may have contributed to the reduced spread ratio. The reduced spread ratio could be due to competition for water between legume flour and wheat flour for dough consistency (Tiwari et al., 2011).

Table 5. Sensory evaluation of chickpea flour enriched crackers.

Substitution level (%)	**0**	**10**	**20**	**30**
		Odour		
grain	5.00 ± 0.10	3.58 ± 0.06*	3.27 ± 0.05*	2.24 ± 0.03*
leguminous	0.00 ± 0.00	2.20 ± 0.04*	2.54 ± 0.10*	3.46 ± 0.05*
		Taste		
grain	4.90 ± 0.11	3.22 ± 0.08*	3.02 ± 0.12*	2.40 ± 0.06*
leguminous	0.10 ± 0.02	2.91 ± 0.02*	4.01 ± 0.06*	4.31 ± 0.02*
bitter	0.00 ± 0.00	0.20 ± 0.01*	0.62 ± 0 02*	1.01 ± 0.02*
		Structure		
hardness	1.00 ± 0.02	1.68 ± 0.11*	1.95 ± 0.03*	2.65 ± 0.11*
porosity	4.50 ± 0.30	3.50 ± 0.10*	3.02 ± 0.10*	2.80 ± 0.20*
		Overall acceptability		
	99.90 ± 2.30	97.90 ± 1.10	98.20 ± 0.80	95.30 ± 0.30*

* indicates a statistically significant differences (p = 0.05)

Sensory evaluation of crackers

Sensory evaluation of chickpea flour supplemented crackers is presented in Table 5. Addition of chickpea flour to crackers significantly (p = 0.05) reduced grain odour and taste and increased leguminous odour and taste. Furthermore, it was found that crackers containing chickpea flour showed a slightly enhanced bitter taste. Similar findings were observed by Tiwari et al. (2011) for biscuits incorporated with pigeon pea flours. The results also showed that cracker with chickpea flour were significantly harder than control crackers (without chickpea flour). Similar results were reported by Tiwari et al. (2011) who suggested that the increase in hardness of pigeon pea flour enriched biscuits is mainly due to higher proportion of proteins. Eissa at al. (2007) concluded that legume flours could be incorporated up to 10 % level in the formation of biscuits without affecting their sensory quality. On the other hand, Guadagni and Delpha (2006) indicated that up to 50 % of some legume products could be added without significant loss in palatability. In this study it was stated that replacement of fine wheat flour by 10 and 20 % levels of chickpea flour no affected significantly overall acceptability of crackers.

Conclusion

Generally, it can be concluded that the instant chickpea flour was characterised high protein (20.64 %), fat (5.95 %) and ash (2.88 %) content and relatively low starch content (47.83 %). Successful performance of legume flours as food ingredients depends on the functional characteristics and sensory qualities that they impart to the end-product (Adebowale and Lawal, 2004; Kaur et al., 2007). Chickpea flour was characterised by good water holding capacity and low water retention capacity and swelling capacity. Moreover, chickpea flour also showed good emulsifying capacity and foaming capacity.

It has been observed that chickpea flour addition at higher levels (20-30 %) significantly affected density, width, thickness and spread ratio of final products. On the other hand, volume index was remarkable affected only at 30 % substitution of fine wheat flour.

Moreover, it was evaluated that incorporation of chickpea flour reduced porosity and grain taste and odour of crackers, whereas leguminous taste and odour, bitter taste and hardness of crackers were increased. Also, it was observed that overall acceptability of crackers did not show significant differences between control sample (fine wheat flour based crackers) and crackers, in which 10 and 20 % of fine wheat flour was replaced by chickpea flour.

Acknowledgement

This work was supported by project: Program for supporting of young researchers No. 6409 (from Rectorate STU Bratislava, Division for science and research).

References

Abdel-Aal EM, Youssef MM, Shehata AA, El-Mahdy AR (1987) Alexandria J. Agric. Res., 32: 179–189

Adebowale KO, Lawal OS (2004) Food Res Inter., 37: 355-365

Arab EAA, Helmy IMF, Bareh GF (2010) J American Sci., 6: 1055-1072

Bose D, Shams-Ud-Din M (2010) J Bangladesh Agril. Univ., 8: 147-152

Boye J, Aksay S, Roufik S, Ribéreau S, Mondor M, Farnworth E, Rajamohamed SH (2010a) Food Res. Inter., 43: 537-546

Boye J, Zare F, Pletch A (2010b) Food Res Inter., 43: 414-431.

Butt MS, Batool R (2010) Pak. J. Nutr., 9: 373-379

Coda R, Rizzello, CG, Gobbetti M (2010) Inter. J. Food Microbiol., 137: 236-245

Eissa H, Hussein AS, Mostafa BE (2007) Polish J. Food Nutr. Sci., 57: 487-496

Enwere NJ, Ngoddy PO (1986) Trop. Sci., 26: 223-232

Faheid SMM, Hegazi NA (1991) Egypt J. Food Sci., 19: 147–159

Gómez M, Oliete B, Rosell CM, Pando V, Fernández M (2008) LWT – Food Sci. Technol., 41: 1701-1709

Goñi I, Valentín-Gamazo C (2003) Food Chem., 81: 511-515

Guadagni DG, Delpha V (2006) J. Food Sci., 37: 774-777

Han J, Janz JAM, Gerlat M (2010) Food Res. Inter., 43: 627 – 633

Hatzikamari, M, Yiangou, M, Tzanetakis, N, Litopoulou-Tzanetaki E (2007) Inter. J. Food Microbiol ., 116: 37-43

Hemeda HM, Mohamed EF (2010) Eur. J. Appl. Sci., 2: 44-50

Hegazy NA, Faheid SM (1990) Nahrung, 34: 835-841

Ibanoğlu Ş, Ibanoğlu E, Ainsworth P (1999) Food Chem. 64: 103-106

Ionescu A, Aprodu I, Daraba A, Gurau G, Baciu C, Nichita A (2009) The Annals Univer. Dunarea de Jos Galati, 33: 16-27

Kaur M, Sandhu KJ, Singh N (2007) Food Chem., 104: 259-267

Kaur M, Singh N (2005) Food Chem., 91: 403-411

Klamczynska B, Czuchajowska Z, Baik BK (2001) Inter. J. Food Sci. Technol., 36: 563–572

Ma Z, Boye JI, Simpson BK, Prasher SO, Monpetit D, Malcolmson L (2011) Food Res. Inter. (in press) DOI: 10.1016/j.foodres.2010.12.017

Meng X, Threinen D, Hansen M, Driedger D (2010) Food Res Inter., 43: 650-658

Mortuza MG, Tzen JTC (2008) J. Sci. Food Agric., 89: 1277-1283

Olalekan AJ, Bosede BF (2010) J Energ. Trends Eng. Appl. Sci., 1: 89-95

Pollard NJ, Stoddard FL, Popineau Y, Wrigley CW, Macritvhie F (2002) Cereal Chem., 79: 662-669

Raghavendra SN, Rastogi NK, Raghavarao, KSMS, Tharanathan RN (2004) Food Res. Technol., 218: 563-567

Sanjeewa WGT, Wanasundara JPD, Pietrasik Z, Shand PJ (2010) Food Res Inter., 43: 617-626

Shirani G., Ganesharanee R (2009) J. Food Eng., 90: 44-52

Siddiq M, Ravi R, Harte JB, Dolan KD (2010) LWT-Food Sci. Technol., 43: 232-237

Simsek S, Tulbek MC, Yao Y, Schatz B (2009) Food Chem., 115: 832-838

Tharanathan RN, Mahadevamma S (2003) Trends Food Sci. Technol., 14: 507-518.

Tiwari BK, Brennan CS, Jaganmohan R, Surabi A, Alagusundaram K (2011) LWT-Food Sci. Technol., 44: 1533-1537

Wang N, Toews R (2011) Food Res Inter., (in press) DOI: 10.1016/j.foodres.2011.03.012

Wood JA (2009) J. Cereal Sci., 49: 128-133

Zucco F, Borsuk Y, Arntfield SD (2011) LWT-Food Sci. Technol., (in press) DOI: 100.1016/j.lwt.2011.06.007