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Physical, chemical and sensory evaluation of gluten-free tarhana with legume hulls and flours

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RESEARCH ARTICLE

Abstract

In this study, common bean hull (CBH), faba bean hull (FBH) and chickpea hull (CH) (4, 8 and 12%) and common bean flour (CBF), faba bean flour (FBF) and chickpea flour (CF) (20, 40 and 60%) was used to replace the gluten-free flour mix (rice flour:corn starch, 50:50) in tarhana formulation. The effects of legume hulls and flours on some physical, chemical and sensory properties of tarhana were evaluated and compared with control samples. All legume hulls and flours substitution increased the ash, protein, Ca, Cu, Mg, total phenolic content (TPC) and antioxidant activity (AA) of the tarhana samples significantly ($P<0.05$). The protein content of tarhana samples increased 3.3-fold in samples substituted with legume flour (60%) compared to the control. The Ca contents of tarhana samples with CBH and CH were found to be higher than those prepared with CBF and CF. TPC of tarhana samples substituted with legume hulls and flours varied in the range from 504.79 to 1,278.94 mg GAE/kg and 614.73 to 975.87 mg GAE/kg, respectively. Tarhana samples containing 12% FBH and 60% FBF revealed the highest AA values among the samples. Legume hulls and flours decreased the brightness (L*) values of all tarhana samples. The colour of tarhana samples substituted with CBH at all replacement levels and FBF at 60% were found to be the most different from the control. The usage of FBH decreased all sensory attributes except the consistency of tarhana soups despite the high TPC and the AA of tarhana samples. Results show that it is possible to prepare gluten-free tarhana with CBH and CH (up to 8%) and CBF, FBF, CF (up to 20%) without compromising its acceptability and that legume hulls and flours are an excellent nutritional enrichment source of gluten-free tarhana.

Keywords: tarhana, gluten-free, common bean, faba bean, chickpea

1. Introduction

Celiac disease (CD) is an autoimmune disorder induced by gluten from wheat, rye, barley and some varieties of oats (Fasano *et al.*, 2003; Rosell *et al.*, 2014). CD is the most common and increasing food intolerance in the world (Gobbeti *et al.*, 2018; Lionetti *et al.*, 2015).

In addition to CD, there are other pathological symptoms related to gluten in people such as non-celiac gluten sensitivity, dermatitis herpetiformis, wheat allergy and gluten ataxia (Gobbeti *et al.*, 2018; Sapone *et al.*, 2012). CD affects approximately 1% of the world's population and highly underdiagnosed in all countries. However, the global prevalence of gluten-related disorders (CD, wheat allergy and non-celiac gluten sensitivity) is estimated to be around 5% (Caruso *et al.*, 2013; Elli *et al.*, 2015; Gobbeti *et al.*, 2018 Mustalahti *et al.*, 2010). Gluten-free diet for a lifetime is the only available, accepted and efficient treatment for these diseases (Gobbetti *et al.*, 2018; Jnawali *et al.*, 2016).

Commercially available gluten-free products, which have an important role in patients with CD and other gluten-related disorders, are frequently made with refined flours and/ or starches. Although it is important to avoid gluten in the gluten-free diet, the assessment of the nutritional quality of diet should also be considered. Gluten-free cereal products generally provide poor quality proteins, low amounts of iron, fibre, calcium, and B-vitamins (Thompson *et al.*, 2005). Therefore, these products are nutritionally inadequate and their long-term consumption may increase the risk of malnutrition. There is a strong need for the development of nutritionally complete and economical gluten-free products (Jnawali *et al.*, 2016; Vici *et al.*, 2016).

Tarhana, a traditional fermented cereal product of Turkey, is mainly prepared by mixing wheat flour, yoghurt, yeast, vegetables (tomatoes, onions, peppers, parsley, etc.) and spices (mint, paprika, etc.) followed by fermentation for one to seven days, drying and grinding (Bilgiçli *et al.*, 2006a; Dağlıoğlu *et al.*, 2002). Tarhana is produced by lactic acid and yeast fermentation. During fermentation, due to hydrolysis of proteins, carbohydrates and lipids, their digestive properties are improved (Bilgiçli *et al.*, 2006b). It has an important place in the diets of infants, young children and the elderly, because it is a good source of B vitamins, minerals, organic acids and free amino acids (Dağlıoğlu, 2000; Ibanoğlu *et al.*, 1995; Kilci and Goçmen, 2014). Its low moisture content (6-9%) and pH value (3.8-4.4) have bacteriostatic effect on pathogenic microorganisms and it can be kept for l-2 years without any deterioration (Dağlıoğlu, 2000; Ibanoğlu *et al.*, 1999).

Legumes have a significant role in human nutrition all over the world. They are low in fat and are excellent sources of protein, slow release carbohydrates, dietary fibre, a variety of micronutrients and phytochemicals which help in the prevention of hormone-related cancers, such as breast and prostate cancer, heart disease. Also legumes lower the blood cholesterol and reduce the risk of neural tube defects like spina bifida in newborn babies (Mlyneková *et al.*, 2014). They contain high amounts of lysine, leucine, aspartic acid, glutamic acid and arginine, and provide well-balanced essential amino acid profiles when consumed with cereals. The use of legumes in human diet can help to alleviate the protein-calorie malnutrition problem prevalent in most developing countries (Singh and Singh, 1992). Apart from their nutritional profile, legume flours can be used as an alternative to common flours for preparing gluten-free products (Messina, 1999; Mlyneková *et al.*, 2014; Tharanathan and Mahadevamma, 2003).

Legumes have superior properties in terms of nutritional content. However there is no information about the usage of legume hulls and flours in gluten-free tarhana production. Therefore, the objective of this study was to determine the suitability of legume hulls and flours for tarhana production and to compare their effects on physical, chemical and sensory quality of the gluten-free tarhana samples and to ensure that persons with CD and gluten related disorders consumed a nutritionally adequate diet.

2. Materials and methods

Materials

The ingredients rice flour (Piyale), corn starch (Piyale), yoghurt (Sütaş), tomato paste (Öncü), onion, paprika (Bağdat), baker's yeast (Pakmaya) and salt (Salina) were purchased from local markets in Karaman, Turkey. Xanthan gum was obtained from Vatan Gıda A.Ş., Istanbul, Turkey. Common bean (*Phaseolus vulgaris* L.), chickpea (*Cicer arietinum* L.) and faba bean (*Vicia faba*) were obtained from local producers in Mersin, Turkey. In order to obtain legume hulls, legumes were soaked in hot water (~85 °C) and cold water for 30 min. and loosened shells were obtained by peeling them manually according to Kaya *et al.* (2018). For obtaining legume flours, legumes were soaked in distilled water for 12 h at room temperature, cooked in water for 30 min at 90±2 °C then dried at 60 °C for 12 h in an oven (Nüve KD-200, Ankara, Turkey,) and milled to flour with a hammer mill (Perten-3100 Laboratory Mill, Perten Instruments AB, Huddinge, Sweden) according to Demir *et al.* (2010).

Tarhana preparation

To prepare control gluten-free tarhana samples gluten-free flour mix (200 g, rice flour:corn starch 50:50), yoghurt (80 g), tomato paste (20 g), chopped onion (10 g), paprika (4 g), xanthan gum (4 g), baker's yeast (5 g), salt (2 g) and water were mixed in Kitchen-aid mixer (Artisan Series, Greenville, OH, USA) for 5 min at the highest speed. After mixing, the dough was incubated in plastic containers for 72 h at 30 °C and dried in an air convection oven (Nüve KD-200) at 55 °C for 48 h. Dried samples were ground in a hammer mill equipped with 1 mm opening screen (Bilgiçli *et al.*, 2006a). Tarhana samples containing legume hulls and flours were prepared by replacing gluten-free flour mix (rice flour:corn starch 50:50) with legume hulls at 4, 8, 12% and legume flours at 20, 40, 60% levels, respectively. The samples were stored in a glass jar (0.5 l) at room temperature until analyses.

Chemical analysis

AACC methods were followed to determine ash (method 08-01), protein (method 46-12) and fat content (method 30-25) of the tarhana samples (AACC, 1990). For mineral contents determination, 1 g of ground samples were put into burning cup and mixed with 15 ml of pure nitric acid and total samples were kept overnight at room temperature. Then 4 ml of per chloric acid were added to each sample and total samples were heated up to 130 °C for 5-6 h using a hot plate. After cooling the samples, 5 ml of hydrogen peroxide were added and samples were heated again until the colour is opened. After filtration and dilution, the mineral contents of samples were determined by atomic absorption spectrometer using Perkin Elmer PinAAcle 900, Waltham, MA, USA (Naghipour *et al.*, 2014).

Total phenolic content (TPC) was determined based on the Folin-Ciocalteu colourimetric method. Powdered samples (2 g) were extracted for 2 h with 10 ml solvent (methanol/HCl/water, 8:1:1, v/v/v) at room temperature (25 °C). The extracts were separated by centrifuge at 3,000 rpm for 10 min (Beta *et al.*, 2005; Gao *et al.*, 2002). For total phenol assay, 0.1 ml of aliquot extract was mixed with 1.5 ml of saturated solution of sodium carbonate and 0.5 ml of diluted Folin-Ciocalteu reagent in a test tube and it was filled with water up to 10 ml at room temperature. The mixture was allowed to stand at room temperature for 2 h and then the absorbance was measured at 760 nm by using spectrophotometer (Shimadzu UV-1800, Kyoto, Japan). TPC was expressed as milligrams of gallic acid equivalents (GAE) per kg of dry weight.

Antioxidant activity (AA) was measured using a free radical 2,2 diphenyl-1-picrylhydrazyl (DPPH), where antioxidants are allowed to react with the stable radical in a methanol solution according to the method given by Wronkowska *et al.* (2010) with some modifications. Ground samples (1 g) were extracted with 10 ml 80% aqueous methanol (10 ml) and centrifuged at 3,000 rpm for 10 min. The supernatant (100 µl) was reacted with freshly made DPPH solution (250 µl, 10 mg DPPH/25 ml 80% methanol) and 80% methanol (2 ml). The mixture was incubated in the dark at room temperature for 20 min. The absorbance was measured at 517 nm against the blank. The blank consisted of 80% methanol and the reagent solution without 80% methanolic extract added. AA was calculated as percentage of discolouration:

$$AA\% = [1 - (\text{Abs sample}_{t=20} / \text{Abs control}_{t=0})] \times 100 \quad (1)$$

Colour measurement

Colours (L*, a* and b*) of tarhana samples were measured by Minolta CR-400 (Minolta Camera, Osaka, Japan). Colour values were determined according to the CIELab colour space system, where L* corresponds to light/dark chromaticity, a* to green/red chromaticity and b* to blue/yellow chromaticity. Colour values were measured at five different points on samples. Values are the mean of five determinations.

The total colour difference ΔE (taking the control gluten-free tarhana as reference) was calculated according to Madenci and Bilgiçli (2014) as:

$$\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{1/2} \quad (2)$$

Sensory analysis

For the preparation tarhana soups, tarhana powder (20 g) was mixed with 200 ml of distilled water and simmered for 12 min over medium heat with continuous stirring. Tarhana soups were served to panellists at 50 °C in a porcelain bowl under daylight room conditions. Twenty-five untrained panellists (both males and females) were selected for evaluation. The order of presentation of samples to the panellists was randomised. Colour, taste-odour, consistency, sourness and overall acceptability of samples were rated on a 1-9 scale where 1 = dislike extremely; 2 = dislike very much; 3 = dislike moderately; 4 = dislike slightly; 5 = neither like nor dislike; 6 = like slightly; 7 = like moderately; 8 = like very much; 9 = like extremely.

Statistical analysis

The analysis of variance (ANOVA) was performed using the Statistical software JMP 5.0.1 (SAS Institute, Cary, NC, USA). The comparison of the means was made by using Student's t comparison test. Significant differences were based on $P<0.05$.

3. Results and discussion

Chemical properties of gluten-free tarhana samples

Some chemical properties of gluten-free tarhana samples are presented in Table 1 and Table 2. The ash content of the tarhana samples prepared with common bean hull (CBH; 12%), faba bean hull (FBH; 12%) and common bean flour (CBF; 60%) was found to be the highest among the samples. The protein content of the tarhana samples increased 3.3-fold as expected in the highest CBF, faba bean flour (FBF) and chickpea flour (CF) ratios. This increase was 1.76 times in the samples substituted with chickpea hull (CH) at the highest enrichment ratio.

Similar results were found in the studies performed by Bilgiçli *et al.* (2011), Demir *et al.* (2010), Jayasena *et al.* (2010), Tazrart *et al.* (2016) and Zucco *et al.* (2011). Tiwari and Singh (2012) reported that the endosperm (cotyledon) constitutes the major portion of the pulse grain and thus make the highest contribution to the protein content.

Legumes have been an important source of protein and calories for many populations around the world (Martínez *et al.*, 2003). In addition to increased protein content, the combination of cereals with legumes provides better overall essential amino acid balance (Gómez *et al.*, 2008, Livingstone *et al.*, 1993; Zucco *et al.*, 2011).

The fat contents of the tarhana samples containing legume hulls were not statistically different from each other, whereas the samples containing 60% CF gave the highest

Table 1. Some chemical properties of tarhana samples prepared with legume hulls.[1,2]

	Ratio (%)	Ash (%)	Protein (%)	Fat (%)	Total phenolic content (mg GAE/kg)	Antioxidant activity (%inhibition)
Control	0	2.56±0.03f	4.15±0.14f	1.41±0.24a	473.12±4.3ı	21.18±0.25ı
CBH	4	2.88±0.01cd	5.11±0.22e	1.45±0.13a	558.84±7.6f	26.94±0.41g
	8	3.12±0.04b	5.87±0.10d	1.51±0.18a	581.53±4.0e	32.41±0.13f
	12	3.29±0.03a	6.53±0.18c	1.55±0.20a	687.58±3.1d	37.50±0.40c
FBH	4	2.83±0.04de	5.89±0.26d	1.41±0.16a	819.13±6.7c	36.74±0.13d
	8	3.11±0.02b	6.51±0.15c	1.45±0.23a	983.82±4.8b	38.49±0.40b
	12	3.27±0.01a	6.97±0.13ab	1.47±0.28a	1,278.94±7.0a	46.28±0.11a
CH	4	2.78±0.04e	6.48±0.13c	1.54±0.24a	504.79±5.9h	25.46±0.54h
	8	2.91±0.03c	6.85±0.21bc	1.62±0.31a	537.99±6.3g	31.80±0.38 f
	12	3.07±0.01b	7.30±0.14a	1.68±0.11a	582.17±3.4e	35.68±0.24e

[1] Results are dry-weight basis. The means with the same letter in column are not significantly different (P<0.05).
[2] CBH = common bean hull; CH = chickpea hull; FBH = faba bean hull.

Table 2. Some chemical properties of tarhana samples prepared with legume flours.[1,2]

	Ratio (%)	Ash (%)	Protein (%)	Fat (%)	Total phenolic content (mg GAE/kg)	Antioxidant activity (%inhibition)
Control	0	2.56±0.03j	4.15±0.14e	1.41±0.24f	473.12±4.3h	21.18±0.25ı
CBF	20	2.96±0.03ı	10.86±0.44d	1.67±0.17ef	614.73±4.1g	42.34±0.31g
	40	3.77±0.04d	12.28±0.28c	1.90±0.34def	630.35±2.6f	51.86±0.42e
	60	4.38±0.01a	13.87±0.31a	2.35±0.25cd	631.33±5.5f	56.41±0.10c
FBF	20	3.05±0.04h	10.33±0.35d	1.98±0.13def	831.65±4.2c	53.64±0.33d
	40	3.47±0.01f	12.14±0.23c	2.07±0.24de	943.87±5.0b	68.93±0.55b
	60	4.13±0.04c	13.71±0.31a	2.20±0.37cde	975.87±3.8a	77.14±0.20a
CF	20	3.20±0.03g	10.34±0.20d	2.70±0.41c	672.27±3.4e	40.15±0.18h
	40	3.68±0.04e	12.94±0.14b	3.55±0.23b	675.28±4.8e	50.39±0.25f
	60	4.24±0.02b	13.98±0.27a	4.17±0.17a	768.06±7.4d	57.04±0.42c

[1] Results are dry-weight basis. The means with the same letter in column are not significantly different (P<0.05).
[2] CBF = common bean flour; CF= chickpea flour; FBF= faba bean flour.

amount of fat among the samples prepared with legume flours. Fat content in the range from 6.67 to 8.69% has been reported for 10 cultivars of yellow chickpea (*C. arietinum* L.), grown in the same climatic area (Rossi *et al.*, 1984). Similarly, chickpea has been reported to have more fat content than beans such as kidney bean, black bean, lima bean, etc. (Tiwari and Singh, 2012).

Compared to the control samples, legume hulls and flours significantly increased (P<0.05) the TPC of gluten-free tarhana samples. Tarhana samples prepared with FBH (12%) and FBF (60%) were the richest in terms of TPC. The AA values of the tarhana samples increased significantly (P<0.05) with the increasing amount of legume hulls and flours in the formulation. The AA of tarhana samples with legume hulls ranged from 25.46 to 46.28% and the highest AA was obtained in the tarhana samples prepared with FBH at the maximum enrichment ratio for legume hulls.

Tarhana samples containing FBF at the level of 60% revealed the highest AA (77.14%) among the legume flour substituted samples. The majority of phenolic compounds found in the seeds of the legumes are found in the seed coat and legumes which have dark seed coats, such as soybean, broad beans, faba beans, lentils, and peas, have high AA mainly due to the proanthocyanidins (Dueñas *et al.*, 2004; Moïse *et al.*, 2005).

Legume seed coats, often referred to as hulls, are rich sources of polyphenolics and natural antioxidants (Moïse *et* *al.*, 2005). The distribution of phenolics in pulses is different in cotyledon and seed coat. Generally, non-flavonoid phenolic compounds are located in the cotyledon while flavonoids are found in seed coat (Tiwari and Singh, 2012). In another study, Boudjou *et al.* (2013) studied the faba bean and lentil for their phenolics content and antioxidant and anti-inflammatory activities of legume fractions and reported that the antioxidant values consistently decreased in the following order: cotyledon > whole > hull for all legumes. Numerous epidemiological studies have shown a correlation between the consumption of foods containing high content of phenolics (such as fruits, vegetables, legumes, wine, etc.) and foods with high antioxidants values and reduced incidence of various diseases such as cancer and cardiovascular diseases (Dueñas *et al.*, 2004; Hughes *et al.*, 1997; Kris Etherton *et al.*, 2002).

Compared to the control, the use of legume hulls and legume flours in gluten-free tarhana formulation increased significantly (P<0.05) the Ca, Cu and Mg contents (for legume hulls) and all mineral contents (for legume flours) of tarhana samples, respectively (Table 3 and Table 4). At the maximum enrichment ratio (12%) of CBH, FBH and CH, the increases were 1.78, 1.25 and 1.67 fold for Ca, 1.15, 1.32 and 1.38 fold for Fe, 3.40, 2.40 and 1.80 fold for Cu and 2.24, 2.35 and 2.05 fold for Mg, respectively. The use of CBF, FBF and CF in gluten-free tarhana formulation (60%) increased Ca, Fe, Cu and Mg contents by 1.34, 1.24 and 1.31 times (Ca), 5.45, 6.15 and 6.28 times (Fe), 6.20, 6.80 and 4.00 times (Cu), 2.63, 2.69 and 2.56 times (Mg), respectively.

Although the usage ratio is lower, legume hulls (CBH and CH) resulted in a greater increase in the Ca content of tarhana samples than legume flours (CBF and CF). Fe, Cu

Table 3. Mineral contents of tarhana samples prepared with legume hulls.[1,2]

	Ratio (%)	Ca (mg / 100 g)	Fe (mg / 100 g)	Cu (mg / 100 g)	Mg (mg / 100 g)
Control	0	54.38±1.39h	0.40±0.03e	0.05±0.007d	17.92±0.44j
CBH	4	74.52±1.47e	0.43±0.01de	0.08±0.003c	22.40±0.37h
	8	87.44±1.70c	0.45±0.02de	0.12±0.010b	31.80±0.13e
	12	96.90±2.01a	0.46±0.06cde	0.17±0.008a	40.18±0.24b
FBH	4	57.00±1.64h	0.48±0.04bcd	0.08±0.006c	30.25±0.31f
	8	62.67±2.31g	0.50±0.01abcd	0.09±0.008c	37.90±0.48c
	12	67.84±0.71f	0.53±0.05ab	0.12±0.003b	42.08±0.27a
CH	4	82.66±1.91d	0.52±0.02abc	0.08±0.004c	19.10±0.48ı
	8	87.80±0.88bc	0.53±0.01ab	0.08±0.001c	25.50±0.51g
	12	91.04±1.43b	0.55±0.03a	0.09±0.004c	36.81±0.42d

[1] Results are dry-weight basis. The means with the same letter in column are not significantly different (P<0.05).
[2] CBH = common bean hull; CH = chickpea hull; FBH = faba bean hull.

Table 4. Mineral contents of tarhana samples prepared with legume flours.[1,2]

	Ratio (%)	Ca (mg / 100 g)	Fe (mg / 100 g)	Cu (mg / 100 g)	Mg (mg / 100 g)
Control	0	54.38±1.39g	0.40±0.03f	0.05±0.007h	17.92±0.37h
CBF	20	68.89±0.92bcd	0.69±0.06e	0.16±0.006f	38.33±0.28f
	40	70.71±1.27abc	1.49±0.04d	0.24±0.011d	43.30±0.17d
	60	72.67±2.11a	2.18±0.01b	0.31±0.008b	47.08±0.33b
FBF	20	64.62±1.64e	0.64±0.03e	0.16±0.006f	45.80±0.23c
	40	66.20±1.90de	1.45±0.04d	0.26±0.007c	46.92±0.38b
	60	67.53±1.53cde	2.46±0.07a	0.34±0.003a	48.25±0.16a
CF	20	60.63±1.73f	0.66±0.03e	0.11±0.003g	34.90±0.49g
	40	66.98±1.40de	1.69±0.06c	0.15±0.001f	41.10±0.35e
	60	71.16±1.03ab	2.51±0.01a	0.20±0.013e	45.81±0.20c

[1] Results are dry-weight basis. The means with the same letter in column are not significantly different (P<0.05).
[2] CBF = common bean flour; CF= chickpea flour; FBF= faba bean flour.

and Mg contents of the legume flour substituted tarhana samples were found to be richer. The increase in the Mg value of the legume hull substituted tarhana samples is close to the increase in the Mg content of the legume flour substituted samples. Similarly, Kaya *et al.* (2018) reported that pulse hulls are rich sources of Ca and Mg. It is reported that the seed coat of pulses is rich in minerals such as calcium, magnesium, iron, zinc, potassium and copper (Tiwari and Singh, 2012). It is reported that the reaction to gluten by celiac patients leads to malabsorption of important nutrients such as iron, folic acid, calcium, fat soluble vitamins, etc. (Feighery, 1999). Therefore, it is important for celiac patients to consume rich mineral foods.

Colour values of gluten free tarhana samples

Colour is an important quality factor for dry and soup form of tarhana. Colour values of tarhana samples are given in Table 5. The usage of legume hull and legume flour generally decreased the lightness or brightness (L*) values of tarhana samples. The lowest L* values were observed in samples containing 12% FBH, 8, 12% CH and 60% FBF. Kaya *et al.* (2018) studied the addition of green lentil, red lentil, faba bean and pea hulls to the noodle formulation and reported that the lightness (L*) values of noodle samples showed a general tendency to decrease with increasing pulse hull substitution excluding pea hull. The highest enrichment ratio of CH and CBF at (12 and 60%, respectively) gave the highest a* values among the tarhana samples. The highest b* was obtained with samples prepared with CH (12%) and CF (60%). These results agree with those obtained by Demir *et al.* (2010), who observed that usage of cooked CF in erişte formulation resulted in darker and more yellowish colour. The instrumentally measured colour modifications can be considered as noticeable when the total colour difference (ΔE) values are higher than 2 (Savadkoohi *et al.*, 2014). ΔE values were >2 in all gluten-free tarhana samples except for 4% FBH and CH. The highest ΔE values were observed in samples containing CBH at all enrichment ratios and 60% FBF meaning that the colour of CBH (at all ratios) and 60% FBF enriched samples were the most different from the control.

Sensory analysis

Sensory properties of gluten-free tarhana samples were evaluated in terms of colour, taste-odour, consistency, sourness and overall acceptability (Figure 1 and Figure 2). The acidic and sour taste is main characteristic properties of tarhana. The use of FBH resulted in a further decrease in

Table 5. Colour values of tarhana samples.[1,2]

	Ratio (%)	L*	a*	b*	*ΔE*
Legume hulls					
Control	0	78.76±0.39c	10.05±0.10b	33.60±0.27b	–
CBH	4	82.31±0.43a	8.14±0.18fg	30.03±0.33ef	5.38±0.24 a
	8	81.57±0.32ab	7.95±0.15g	29.70±0.29f	5.25±0.35 a
	12	81.31±0.27b	7.10±0.12h	29.81±0.25ef	5.44±0.18 a
FBH	4	78.96±0.32c	8.82±0.12d	32.40±0.22c	1.73±0.11e
	8	77.38±0.47d	8.59±0.17de	30.80±0.28d	3.45±0.28 c
	12	76.42±0.34e	8.35±0.15ef	30.39±0.30de	4.32±0.14 b
CH	4	78.31±0.44c	9.45±0.16c	32.36±0.31c	1.45±0.27e
	8	76.90±0.37de	9.60±0.21c	32.19±0.26c	2.38±0.20 d
	12	76.32±0.28e	10.46±0.18a	34.93±0.34a	2.81±0.35 d
Legume flours					
Control	0	78.76±0.39b	10.05±0.10g	33.60±0.27d	–
CBF	20	80.75±0.27a	9.59±0.15h	28.86±0.21h	5.17±0.14d
	40	76.57±0.36c	12.40±0.12c	32.41±0.33e	3.43±0.18e
	60	71.42±0.47ef	14.97±0.23a	34.93±0.27c	8.94±0.33bc
FBF	20	75.33±0.32d	9.45±0.14h	29.84±0.33g	5.13±0.09d
	40	70.72±0.25f	10.51±0.16f	30.60±0.28f	8.59±0.50c
	60	67.37±0.36g	10.92±0.12e	30.68±0.35f	11.79±0.21a
CF	20	76.79±0.34c	10.12±0.16g	32.16±0.30e	2.44±0.12f
	40	76.24±0.21c	11.59±0.20d	35.82±0.21b	3.69±0.16e
	60	72.01±0.38e	13.49±0.18b	39.22±0.25a	9.43±0.31b

[1] The means with the same letter in column are not significantly different for legume hulls and legume flours (P<0.05).

[2] CBF = common bean flour; CBH = common bean hull; CF = chickpea flour; CH = chickpea hull; FBF = faba bean flour; FBH = faba bean hull.

Figure 1. Sensory scores of gluten-free tarhana samples containing legume hulls.

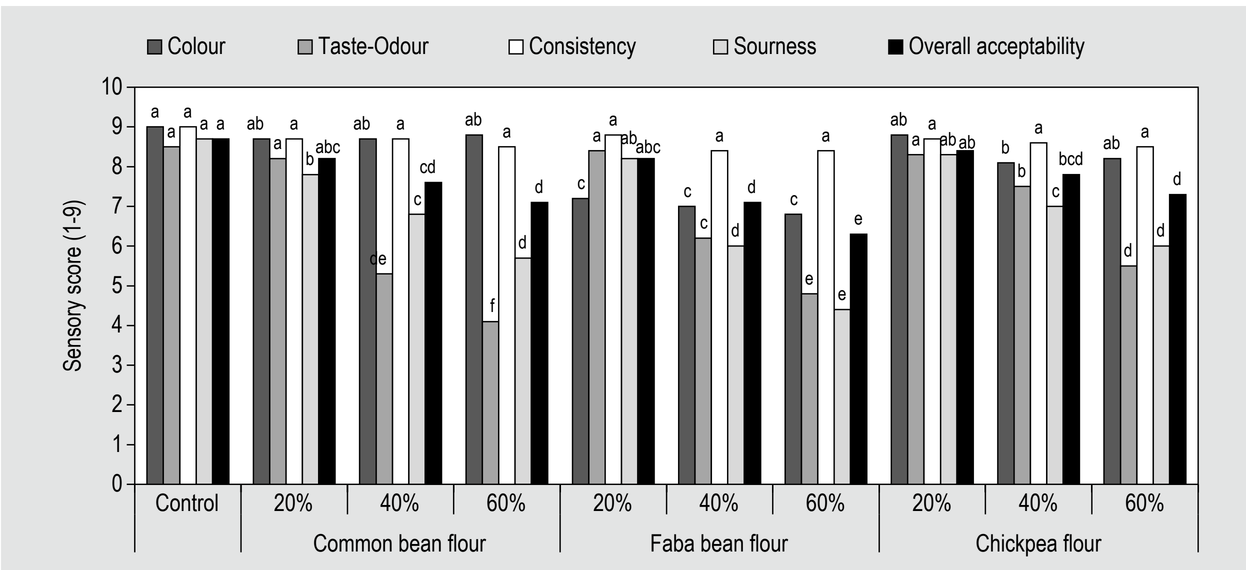

Figure 2. Sensory scores of gluten-free tarhana samples containing legume flours.

sensory attributes of tarhana samples compared to CBH and CH. All the tarhana samples with legume hulls and flours provided similar results in soup consistency. Generally, tarhana samples including 20% CBF, FBF and CF had similar sensory scores with control. The use of CBF and FBF at 40 and 60% reduced the taste-odour, sourness and overall acceptability scores of tarhana samples. However, tarhana samples supplemented with 40% CF yielded better results in terms of taste-odour scores than CBF and FBF at the same enrichment ratio. Sensory analysis result revealed that the use of up to 8% CBH and CH, 20% CBF, FBF and CF in gluten-free tarhana formulation resulted in acceptable soup properties.

4. Conclusions

In this study, legume hulls (CBH, FBH and CH) and flours (CBF, FBF and CF) were used in gluten-free tarhana formulation. Legume hulls significantly increased the ash, protein, Ca, Cu, Mg, TPC and AA of tarhana samples ($P<0.05$). Compared to the control, legume flours also enriched the Fe content of the samples. According to the usage level, the rate of increase in the protein content of the legume flour-substituted samples was found to be about 2 times that of the legume hull substituted samples. Legume hulls and flours substitution decreased the brightness values (L*) of tarhana samples significantly ($P<0.05$). Tarhana samples produced with FBH gained lower colour, taste-odour, sourness and overall acceptability scores than tarhana samples with CBH and CH. Tarhana samples with 8% CBH, CH and with 20% CBF, FBF and CF had high scores from the panellists.

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