

Influence of lupin (*Lupinus albus L.*) yoghurt on mineral content and functional properties of tarhana

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RESEARCH ARTICLE

Abstract

Tarhana is a fermented cereal-yoghurt-vegetable based product that contains high amounts of protein, mineral and vitamin. In this research, lupin yoghurt (LY) was produced from fermented lupin milk, and replaced with cow's milk yoghurt up to 100% (w/w) level in tarhana formulation. LY substitution increased protein content of final product from 13.12% up to 14.87%. The redness (a*), yellowness (b*) and hue values of tarhana samples changed significantly ($P < 0.05$) with LY usage. Tarhana samples prepared with 100% LY had the lowest a* and b*, and the highest hue values. Tarhana containing high amounts of LY had rich copper, iron, manganese and zinc contents compared to control tarhana. Especially manganese content of the tarhana increased up to 177 times with LY substitution. While LY over 25% level improved the functional properties such as foaming capacity, water absorption capacity and emulsifying activity of tarhana samples, foaming stability was negatively affected by LY substitution. Colour, taste, consistency, sourness and overall acceptability scores decreased at high substitution levels of LY.

Keywords: functional properties, lupin milk, lupin yoghurt, nutritional properties, tarhana

1. Introduction

Tarhana is a popular traditional fermented food in Turkey. It is known as 'trahana' in Greece, 'khisk' in Egypt, Syria and Jordan, 'kushuk' in Iraq and 'talkuna' in Hungary and Finland (İbanoğlu *et al.*, 1999; Youssef, 1990). Generally tarhana process contains mixing of ingredients (wheat flour, yoghurt, tomato paste, onions, salt and spices) to obtain tarhana dough, 1-7 days dough fermentation (with or without baker's yeast), drying of dough below 10% moisture level and grinding into ~1 mm particle size (Bilgiçli, 2009a; İbanoğlu *et al.*, 1995; Özbilgin, 1983). Tarhana is generally consumed in the form of thick soup, and sometimes as chips or cracker which was prepared by drying of tarhana dough as thin plate-shaped. Tarhana is important foodstuff especially for children and patients due to high amounts of B vitamins, minerals, organic acids and free amino acids content (Dağlıoğlu, 2000). Tarhana contains approximately 10.2% moisture, 16.0% protein, 60.9% carbohydrate, 5.4% fat, 1.0% fibre, 3.8% salt and 6.2% ash contents (values

are average of 134 different tarhana samples) (Siyamoğlu, 1961). In some research, wheat flour or yoghurt in tarhana formulation have been replaced with different ingredients for nutritional enrichment or technological improvement of tarhana samples. For this purpose, different legumes, cereals, pseudo cereals, brans, fibres, dairy products or by-products and soy yoghurt (Bilgiçli, 2009a,b; Bilgiçli *et al.*, 2006; Koca *et al.*, 2002; Özbilgin, 1983; Tarakçı *et al.*, 2004; Türker and Elgün, 1995) have been used in tarhana formulations. Dairy ingredients such as milk, whey, whey concentrate and yoghurt are incorporated into cereal products commonly because of their nutritional and functional benefits (Ertaş *et al.*, 2009; Kenny *et al.*, 2000).

Lupin is a valuable ancient leguminous plant which is a very good source of protein (containing 25-40%) and oligosaccharides (7-17%). Lupin and its milling products can be used as potential source for fortified foodstuff and dietetic food (Erickson, 1985; Sujak *et al.*, 2006). Lupin seeds are also good source of lipids, dietary fibres, minerals,

alkaloids, phenolic compounds and vitamins for human nutrition (Błaszczak *et al.*, 1994; Gulewicz *et al.*, 2002; Kinghorn and Balandrin, 1984; Martinez-Villaluenga *et al.*, 2006; Zielinska *et al.*, 2008). Lupin utilisation is limited due to the presence of alkaloids of the quinolizidine group and bitter compounds (Michael, 2002, 2003; Torres *et al.*, 2002; Wysocka and Brukwicki, 1998). After the long debittering processes including boiling and soaking, lupin seeds can be edible. Lupin flour can be mixed with wheat flour to improve the nutritional value of food products due to their potential to increase protein content (Hall and Johnson, 2004; Torres *et al.*, 2006). Lupin flour has been used in bakery products (Guemes-Vera *et al.*, 2008; Mubarak, 2001), biscuits (Gammere, 1995), pasta and crisps (Lampart-Szczapa *et al.*, 1997), milk substitutes and also as main food component for vegetarians. Lupin flour replacement with cereal flour improves the texture, flavour and often colour of bakery products (Dervas *et al.*, 1999).

Functional properties such as foaming capacity, foaming stability, water and oil retention, solubility, viscosity, emulsification are important especially for process design and sensory quality of foods (Kinsella and Whitehead, 1989). Functional properties of tarhana can be affected by tarhana ingredients, fermentation process, drying methods, heating temperatures, heating time, heating type and storage (Bilgiçli, 2009a; Boye *et al.*, 1997; Çağlar *et al.*, 2013; Çelik *et al.*, 2005; Gökmen, 2010; Hayta *et al.*, 2002; İbanoğlu, 1999; İbanoğlu *et al.*, 1995; Solak and Akin, 2011). The aim of this study was to determine the effect of lupin yoghurt (LY) on the nutritional, functional and sensory properties of tarhana samples.

2. Materials and methods

Materials

Tarhana ingredients (wheat flour, yoghurt, tomato paste, chopped onions, dried and hot pepper, compressed yeast and salt) were purchased from local markets in Konya, Turkey. The yoghurt which is used for control sample was made of cow's milk. Lupin seeds were purchased from local market as traditionally debittered. Traditional debittering process contains heat treatments at 60-70 °C for 90 min in water and subsequent soaking for 4 days (soaking water is refreshed four or five times during the soaking period) to remove alkaloids. For lupin flour production, the hulls of the lupin seeds were removed manually, and the caryopsis dried at 65 °C in an oven for 8 h. After drying, the samples were milled by a hammer mill (Falling Number-3100 Laboratory Mill; Perten Instruments AB, Huddinge, Sweden) equipped with an 0.5 mm opening screen to obtain lupin flour.

Preparation of cow's and lupin milk yoghurts

LY was prepared according to Koca *et al.* (2002) with some modification. First, lupin milk was made to prepare LY. 80 g lupin flour was blended with 400 ml hot water and the mixture was kept for 15 min at 90-95 °C. Then this mixture was cooled to 44 °C to obtain lupin milk. On the other side dry matter content of cow's milk was increased by 2% milk powder addition. Milk powder added milk was heated with to 90 °C for 30 min. Then it was cooled to 44 °C like lupin milk. Concentrated cow's milk and lupin milk were mixed in defined proportions (0:100, 25:75, 50:50, 75:25 and 100:0), and these mixtures were incubated at 42 °C with 0.03% yoghurt culture addition for 4 h. After the incubation process, yoghurt samples were kept in a refrigerator until use in tarhana production.

Preparation of tarhana samples

To prepare the control tarhana sample, wheat flour (400 g), yoghurt (160 g), tomato paste (40 g), chopped onions (20 g), dried and hot pepper (8 g), yeast (10 g), salt (4 g) and distilled water were used. The ingredients of each lot were mixed for 5 min in a Hobart mixer (Hobart N50; Hobart, Toronto, Canada) and left for fermentation in closed plastic containers at 30 °C for 72 h. The fermented dough was divided into 2 cm diameter pieces by hand, placed on aluminium trays and dried at 55 °C for 48 h in an air convection oven. The dried samples were ground into granulated form in a hammer mill equipped with an 1 mm opening screen. Tarhana samples were kept in closed glass containers at room temperature until used. The tarhana samples that were substituted with LY were likewise prepared. In these samples cows' milk yoghurt was substituted with LYs' in tarhana formulation.

Some chemical and physical analyses

The AACC methods were used for the determination of moisture, ash and protein contents of the samples (AACC, 1990). The mineral contents were determined by an inductively coupled plasma atomic emission spectrometer (Vista series; Varian International AG, Zug, Switzerland) as explained by Bubert and Hagenah (1987).

The instrument was operated with a radiofrequency power of 0.7-1.5 kW (1.2-1.3 kW for axial); plasma gas flow rate of 10.5-15 l/min (radial), 15 l/min (axial); auxiliary gas flow rate of 1.5 l/min; viewing height of 5-12 mm; copy and reading time of 1-5 s (maximum of 60 s); and copy time of 3 s (maximum of 100 s).

pH of tarhana samples was measured by a digital pH meter (WTW pH 315; WTW, Weilheim, Germany) in a mixture of tarhana sample (5 g) and distilled water (100 ml). Fermentation loss was calculated according to the following equation:

Fermentation loss (%) = $100 \times ((a \times b) - (c \times d)) / (a \times b)$ (1)

Where a is the weight of tarhana dough before fermentation (g); b is the dry matter ratio of tarhana dough before fermentation (%); c is the total weight of ground dry tarhana (g); and d is the dry matter ratio of ground dry tarhana (%).

Colour measurement

Colour of the samples was measured using a Minolta Chroma Meter CR-400 (Minolta, Osaka, Japan). Colour values (L^* , a^* and b^*) were determined according to the CIE Lab colour space system. The instrument was calibrated with a white reference tile before the measurements. Hue angle ($\tan^{-1} b^*/a^*$) was calculated using a^* and b^* values.

Functional properties

Water absorption capacity and oil absorption capacity

Tarhana powder (5.0 g) and distilled water (25 ml) or sunflower oil (25 ml) were put into 50 ml centrifuge tubes and mixed thoroughly, and then stirred at 15 min intervals over a 60 min period. Mixture was centrifuged at $4,000 \times g$ for 20 min. Water and oil absorption capacity values were expressed as ml of water or oil absorbed per gram of tarhana (Hayta *et al.*, 2002).

Foaming capacity and foam stability

Tarhana powder (10 g) was stirred with distilled water for 20 min, then centrifuged at $4,000 \times g$ for 20 min. After filtration of the supernatant, it was poured into a Waring blender (model 8011 E; Waring Products, New Hartford, CT, USA) and whipped for 2 min at high-speed setting. The volume of the foam was recorded after 10 s by the aid of a measuring cylinder. Foaming capacity was expressed as the volume (ml) of gas incorporated per ml of solution. Foam stability was recorded as the time passed until the half of the original foam volume had disappeared (Hayta *et al.*, 2002).

Emulsifying activity

Tarhana powder (10 g) was dispersed in distilled water and stirred (20 min) and centrifuged at $4,000 \times g$ (20 min). Equal volumes of supernatant and sunflower oil were mixed and homogenised for 5 min at low-speed setting in a Waring blender. The homogenised mixture was transferred into a measuring cylinder. Emulsifying activity was expressed as % volume of the emulsified layer in total volume of the mixture (Hayta *et al.*, 2002).

Sensory analysis

Sensory analyses were conducted on tarhana soups. For preparation of soup, 50 g tarhana powder (dry basis) was mixed with 500.0 ml distilled water and boiled for 5 min over medium heat with constant stirring. Sensory evaluation for tarhana soups was made by 17 panellists in terms of colour, taste, odour, consistency, sourness, grittiness and overall acceptability using a 5-point scale (1 = dislike extremely and 5 = like extremely). The samples were coded with numbers and served to the panellists at random to guard against bias.

Statistical analysis

TARIST (Version 4.0; Ege University, İzmir, Turkey) software was used to perform the statistical analyses. Differences in samples due to substitution of LY were tested for statistical significance at $P=0.05$ level.

3. Results and discussion

Properties of some raw materials

Wheat and lupin flours were analysed for their chemical content and colour values. Moisture, ash and protein contents were found to be 10.2, 0.51 and 10.9% for wheat flour and 8.5, 1.95 and 35.4% for lupin flour, respectively (data not shown). Copper, iron, magnesium, manganese, phosphorus and zinc (Cu, Fe, Mg, Mn, P and Zn) content of wheat flour were 0.37, 1.3, 39.5, 0.37, 255.3 and 1.13 mg/100 g, respectively. Cu, Fe, Mg, Mn, P and Zn content of lupin flour was found to be 1.05, 4.9, 95.3, 172.9, 498.7 and 3.95 mg/100 g, respectively (data not shown). Lupin flour showed higher ash, protein and mineral content than wheat flour. Chemical compositions and mineral content of the wheat and lupin flours were similar to findings given by Bilgiçli (2009a), Martinez-Villaluenga *et al.* (2006) and Levent and Bilgiçli (2011a). The L^* , a^* , b^* and hue values of wheat and lupin flours were found to be 95.02 and 88.00, -1.89 and -1.53, 11.22 and 26.52, -80.46 and -86.71, respectively (data not shown). A high b^* value of lupin flour gives a yellowish colour to food products as egg substitution.

pH and fermentation loss of tarhana samples

pH and fermentation loss of tarhana samples are given in Table 1. Optimal fermentation is important for functional and sensorial properties of tarhana. The highest LY substitution levels resulted in lower pH and higher fermentation loss than other substitution levels. During the 72 h tarhana fermentation process, high sugar content of lupin flour (Erbaş *et al.*, 2005) might increase the fermentation activity in tarhana dough at 100% LY substitution level. High fermentation activity decreased pH and increased the fermentation loss which important

Table 1. pH, fermentation loss and colour values of tarhana samples substituted with lupin yoghurt¹.

LY level (%) ²	pH	Fermentation loss (%)	L*	a*	b*	Hue
0	4.71±0.11 ^a	12.52±0.01 ^b	80.6±0.17 ^a	7.71±0.03 ^{ab}	34.0±0.37 ^{ab}	77.2±0.18 ^b
25	4.63±0.10 ^a	12.33±0.27 ^b	81.1±0.18 ^a	7.40±0.20 ^b	33.1±0.13 ^b	77.4±0.37 ^b
50	4.59±0.01 ^a	12.41±0.07 ^b	79.4±0.38 ^a	8.44±0.41 ^a	33.5±0.03 ^a	75.8±0.65 ^c
75	4.57±0.07 ^{ab}	12.31±0.08 ^b	80.5±0.20 ^a	4.44±0.30 ^c	27.4±0.34 ^c	80.7±0.72 ^a
100	4.38±0.01 ^b	13.11±0.07 ^a	81.9±0.47 ^a	3.26±0.17 ^d	22.7±0.24 ^d	81.8±0.33 ^a

¹ Means with different superscripts in the same column are significantly different ($P<0.05$).
² LY = lupin yoghurt.

in terms of dry matter loss. Bilgiçli (2009a) reported that fermentation loss values of tarhana ranged between 9.06 and 23.27% with the addition of 0-100% buckwheat flour in tarhana formulation.

Colour values of tarhana samples

Colour values of tarhana samples are shown in Table 1. L* values of tarhana samples did not change significantly ($P>0.05$) with LY substitution. Tarhana samples containing 100% LY had the lowest a* and b* values but the highest hue values. Pollard *et al.* (2002) reported that the substitution of wheat flour with lupin flour decreased the darkness of the crust and the crumb colour of bread. Lupin flour substitution generally increases the b* values of cereal products and give a yellowish and attractive colour to the end product. Levent and Bilgiçli (2011b) found significant increase in crust and the crumb yellowness of cake substituted with lupin flour (0-40%). In contrast to these findings, LY substitution decreased yellowness of the end product in the present study. This situation might be caused by physical and chemical changes during long fermentation process (72 h) of tarhana.

Chemical properties of tarhana samples

Protein and mineral content of the tarhana samples are given in Table 2. As expected, rich protein content of LY also increased the protein amount of the end product tarhana from 13.12 up to 14.87%. LY substitution at 100% levels increased Cu, Fe, Mn and Zn contents of the tarhana samples from 0.12, 0.80, 0.02 and 0.56 mg/100 g (control) to 0.21, 0.90, 3.54 and 0.66 mg/100 g, respectively. While the P content of the samples decreased with LY substitution, Mg content did not change significantly ($P>0.05$). The decrease in the P content of the samples may be due to the low P content of lupin yoghurt compared to that of cow's milk yoghurt. The increases in the Mn content at 25-100% LY substitution levels was found to be 36-177 times higher than that of control tarhana samples. These increases in Mn are very remarkable. High Mn contents of lupin seeds and its products has been reported in the literature (Levent and Bilgiçli, 2011a; Yorgancılar and Bilgiçli, 2012).

Functional properties of tarhana samples

Functional properties of tarhana samples are summarised in Table 3. Tarhana samples containing 75-100% LY had significantly higher foaming capacity values compared to the other tarhana samples ($P<0.05$). This higher foaming

Table 2. Chemical properties of tarhana samples substituted with lupin yoghurt¹.

LY level (%) ²	Protein ³ (%)	Cu (mg/100 g)	Fe (mg/100 g)	Mg (mg/100 g)	Mn (mg/100 g)	P (mg/100 g)	Zn (mg/100 g)
0	13.12±0.03 ^e	0.12±0.01 ^c	0.80±0.03 ^b	43.78±0.89 ^a	0.02±0.01 ^e	252.6±2.11 ^a	0.56±0.03 ^b
25	13.53±0.03 ^d	0.13±0.01 ^{bc}	0.82±0.03 ^b	42.71±0.64 ^a	0.72±0.11 ^d	231.1±1.29 ^b	0.57±0.01 ^b
50	13.91±0.07 ^c	0.15±0.01 ^b	0.83±0.04 ^{ab}	42.51±0.45 ^a	1.83±0.04 ^c	208.4±1.85 ^c	0.61±0.02 ^{ab}
75	14.55±0.06 ^b	0.18±0.01 ^a	0.86±0.01 ^{ab}	43.40±0.92 ^a	2.73±0.01 ^b	187.4±1.78 ^d	0.62±0.04 ^{ab}
100	14.87±0.07 ^a	0.21±0.01 ^a	0.90±0.00 ^a	41.89±0.76 ^a	3.54±0.07 ^a	167.8±2.18 ^e	0.66±0.01 ^a

¹ Means with different superscripts in the same column are significantly different ($P<0.05$). Protein and mineral values are dry matter basis.
² LY = lupin yoghurt.
³ Protein = N × 6.25.

Table 3. Some functional properties of tarhana samples substituted with lupin yoghurt¹.

LY level (%) ²	Foaming capacity (ml/ml)	Foaming stability (min)	Water absorption capacity (ml/g)	Oil absorption capacity (ml/g)	Emulsifying activity (%)
0	0.36±0.11 ^d	3.18±0.01 ^a	0.652±0.01 ^c	0.80±0.08 ^a	87.14±0.76 ^b
25	0.70±0.04 ^c	2.57±0.03 ^b	0.672±0.03 ^{bc}	0.70±0.18 ^a	87.06±0.51 ^b
50	0.94±0.03 ^b	1.92±0.01 ^c	0.724±0.01 ^{abc}	0.70±0.17 ^a	90.00±0.00 ^a
75	1.37±0.03 ^a	1.33±0.00 ^d	0.755±0.00 ^{ab}	0.80±0.14 ^a	90.63±0.71 ^a
100	1.43±0.07 ^a	0.97±0.04 ^e	0.799±0.04 ^a	0.90±0.00 ^a	90.00±0.00 ^a

¹ Means with different superscripts in the same column are significantly different ($P<0.05$).

² LY = lupin yoghurt.

capacity values among tarhana samples may be caused by the higher protein contents of LY in tarhana formulations. Previous studies of Alamanou and Doxastakis (1995), Dervas *et al.* (1999) and Hojila-Evangelista *et al.* (2004) reported that lupin proteins show good water and fat binding, emulsifying and foaming capacity. In the present study, control tarhana exhibited the highest foam stability, while tarhana samples containing 100% LY had the lowest foam stability. Some researchers reported that the amount of protein, degree of denaturation, pH, temperature, tarhana concentration, whipping time and processing methods have an effect on good foaming and its stability (İbanoğlu and İbanoğlu, 1998; Kinsella, 1979). The water absorption capacity is an important functional property especially in viscous foods (Hayta *et al.*, 2002; Sosulski *et al.*, 1976). Water absorption capacity values changed significantly with LY substitution ($P<0.05$). Improvement in the water binding capacity with the addition of lupin flour up to 10% was reported by Kohajdova *et al.* (2011). The oil absorption capacity of tarhana samples ranged from 0.70 to 0.90 ml/g (Table 3). The difference of oil absorption capacity between the tarhana samples was found to be not significant ($P>0.05$). Tarhana samples containing 50, 75 and 100% LY gave higher emulsifying activity values than the control and samples containing 25% LY. These higher

emulsifying effects may be due to the interaction of lupin proteins and lipids.

Sensory properties

Sensory properties of tarhana samples are given in Table 4. LY substitution significantly affected all sensorial properties of tarhana samples ($P<0.05$). The lowest colour score was obtained with 100% LY substitution. While the taste of the tarhana samples was more liked by the panellists when the samples contained up to 50% LY, the odour values of the tarhana samples decreased when the samples contained 100% LY. Tarhana containing 100% LY gained the lowest consistency score in the sensory evaluation. Bilgiçli (2009a) reported that tarhana viscosity/consistency decreased with the addition of buckwheat flour because of a decrease in starch, gluten, and fermentation loss in the end product. In the present study, sourness and grittiness scores of the samples containing 75 or 100% LY decreased compared to the samples with 25% LY. The highest LY substitution level caused lower overall acceptability scores compared to tarhana samples containing 0, 25 or 50% LY. The results show that the use of 25% LY in tarhana formulation has a positive effect on the sensory properties, whereas 75-100% LY decreases some sensory scores compared to control tarhana.

Table 4. Sensory properties of tarhana samples substituted with lupin yoghurt¹.

LY level (%) ²	Colour	Taste	Odour	Consistency	Sourness	Grittiness	Overall acceptability
0	4.72±0.40 ^a	3.83±0.35 ^{ab}	4.86±0.21 ^a	4.00±0.35 ^{ab}	3.76±0.34 ^{ab}	4.13±0.18 ^{ab}	4.36±0.20 ^{ab}
25	4.65±0.21 ^{ab}	4.63±0.52 ^a	4.75±0.00 ^a	4.87±0.18 ^a	4.50±0.00 ^a	4.86±0.21 ^a	4.80±0.00 ^a
50	4.27±0.33 ^{abc}	4.61±0.21 ^a	4.07±0.62 ^{ab}	4.50±0.35 ^a	3.76±0.34 ^{ab}	4.13±0.53 ^{ab}	4.27±0.33 ^{ab}
75	3.08±0.60 ^{bc}	3.34±0.58 ^{bc}	3.59±0.58 ^{ab}	3.21±0.41 ^{bc}	3.34±0.58 ^b	3.38±0.18 ^b	3.58±0.59 ^{bc}
100	2.81±0.98 ^c	2.26±0.34 ^c	3.27±0.69 ^b	2.59±0.58 ^c	2.96±0.41 ^b	3.50±0.00 ^b	2.84±0.59 ^c

¹ Means with different superscripts in the same column are significantly different ($P<0.05$).

² LY = lupin yoghurt.

4. Conclusions

Recently, different minor or major ingredients such as cereal, legume, bran, wheat germ, dietary fibres, pseudo cereals, different types of dairy products or by-products, and soy yoghurt have been used in tarhana formulation to replace flour or yoghurt to improve some properties of tarhana. In our study, we used LY to substitute the cow's milk yoghurt to prepare tarhana with improved chemical, functional and sensory properties compared to the control. High substitution levels of LY improve the nutritional contents of tarhana in terms of protein, minerals (Cu, Fe, Mn and Zn) and functional properties, such as foaming capacity, water absorption capacity and emulsifying activity. On the other hand, a significant decrement was observed in the P content of the samples with LY substitution ($P < 0.05$). LY can be used in tarhana formulation up to a substitution level of 50%, whereas higher substitution levels have an adverse effect on some sensorial properties of tarhana.

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