

Effect of quinoa, buckwheat and lupine on nutritional properties and consumer preferences of tarhana

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Received: 20 March 2018 / Accepted: 19 June 2018

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RESEARCH ARTICLE

Abstract

Tarhana, one of the Turkish traditional nutritious foods, is prepared with wheat flour, yoghurt, yeast, various vegetables and spices by some processes (kneading, fermenting, drying and grinding). The study aimed to improve tarhana's nutritional and sensorial properties using quinoa, buckwheat and lupine flour at different levels of addition to wheat flour (0 as control, 10, 20, 30 and 40%, w/w). Redness, yellowness, ash, protein, phytic acid, calcium, iron, potassium, magnesium, phosphorus, zinc contents, total phenolic content and antioxidant capacity values increased linearly ($P < 0.05$) by increasing the levels of buckwheat, quinoa and lupine flour. Highest viscosity value was found in quinoa flour added tarhana samples. Addition of lupine flour increased a^* , b^* , SI (chroma) as colour values as well as ash, protein, calcium, iron, potassium, zinc contents. Buckwheat flour addition increased ash, phytic acid, magnesium, phosphorus contents and antioxidant capacity in comparison to other flours used in tarhana samples. According to sensorial analysis, 20% quinoa flour added tarhana samples gave the highest scores from panellists according to taste, flavour, sourness and general likes. Improvement of colour of tarhana samples was determined with utilisation of lupine flour by the panellists. Consequently, 20% quinoa addition to tarhana formulation can be recommended to improve nutritional properties without adverse effects.

Keywords: tarhana, fortification, quinoa, buckwheat, lupine, antioxidant

1. Introduction

Tarhana, a traditional fermented cereal product, is produced by kneading wheat flour, yogurt, onion, yeast, and spices followed by alcohol and lactic acid fermentation, drying and grinding to the particle size of < 1 mm. Generally, yogurt bacteria (*Streptococcus thermophilus*, *Lactobacillus bulgaricus*) and baker's yeast (*Saccharomyces cerevisiae*) are used for tarhana fermentation. Thus, tarhana's characteristic sour and acidic taste is gained. After fermentation proteins, carbohydrates and lipids are hydrolysed by the action of the bacteria and a product with a high digestibility is obtained (Dağlıoğlu *et al.*, 2002; Özdemir *et al.*, 2007; Tarakçı *et al.*, 2004). During the fermentation process of tarhana, almost 95% of phytic acid content, an antinutritional agent in food, is destroyed (Bilgiçli *et al.*, 2006). Digestibility and bioavailability of minerals and proteins are affected by phytic acid due to its ability of binding minerals or proteins.

Tarhana is known and consumed under different names in many countries, indicating that tarhana has moved long distances between cultures. Among these cultures, the changes are not only in the name but also in the fermentation conditions and period, drying methods, varieties of tarhana ingredients with the development of technology.

There are many studies in the literature about tarhana. Some of these were based on traditional methods (Çekal and Arslan, 2017), while others compared different raw materials in tarhana formulation (Bilgiçli, 2009; Öner *et al.*, 1993) and different production methods (Ertaş, 2018). In some studies, microbiological, chemical (Erbaş *et al.*, 2005), and nutritional (Bilgiçli *et al.*, 2006) aspects of tarhana were investigated. In these studies, some legume and cereal flours or brans were used in tarhana in place of wheat flour for enrichment of its nutritional content. The aims of

enrichment are to block vitamin and mineral loss frequently seen in society, to counter the vitamin and mineral loss occurring during food processing, and to supplement food components that are present in small quantities in food.

Buckwheat (*Fagopyrum esculentum*) is a good source for many essential minerals, vitamins, polyunsaturated fatty acids and the flavonoid rutin (Fabjan *et al.*, 2003). Quinoa is a gluten-free grain that is rich in essential amino acids, vitamin B2, E and A, and contains more iron than any other grain (Koziol, 1990, 1992). The United Nations Food and Agriculture Organization observed that the properties of quinoa are closer to the ideal protein balance than any other common grain. Lupine (*Lupinus albus* L.), known as bitter lupine, sweet lupine and several names in Turkey (Yorgancılar, 1996), is a good source of vitamins, minerals, calcium and iron (Sator, 1983; Williams, 1979). Lupine beans contain two to three times more protein than cereals. Buckwheat, quinoa and lupine are rich in vitamins and minerals, have a low glycaemic index and can help prevent heart and some cardiovascular diseases (Hall *et al.*, 2005). Because of their high benefits these seeds are used to enrich food products all over the world.

The aim of this study was to determine nutritional and sensorial properties of tarhana made with wheat flour and partially replaced by buckwheat, quinoa and lupine flours.

2. Materials and methods

Materials

Control tarhana formulation included wheat flour, full-fat concentrated set yoghurt, bakers' yeast, peeled and chopped dry onions, tomato paste, red pepper and salt. In other formulations wheat flour was partially replaced with buckwheat, quinoa and lupine flours. Buckwheat, quinoa and lupine seeds were bought commercially and used after grinding (<500 µm).

Preparation of tarhana samples

For control tarhanas, the recipe was based on wheat flour (100 g) yoghurt (40 g), tomato paste (10 g), chopped onions (15 g), red pepper (2 g), salt (1 g) and bakers' yeast (2.5 g). Tarhana samples prepared with wheat flour (100% w/w) were used as control sample; 3 different flours (quinoa, buckwheat and lupine flour) replaced with wheat flour at 5 different levels (0, 10, 20, 30 and 40%, w/w) to prepare fifteen different tarhana formulations with two repetitions. All ingredients were mixed for 10 min with a Kenwood mixer (Chef KM330, Hampshire, UK). Tarhana dough was fermented at 30 °C for 72 h in a plastic container, and the fermented dough samples were dried at 55 °C for 48 h in a drier (Nüve FN-500, Ankara, Turkey) and then passed

through a 500 mm sieve. The results of all the experiments were given as the average of two replicates.

Colour measurement

Colour measurement of all flours was carried out with a Konica Minolta Chroma Meter (Model CR-400, Konica Minolta Sensing, Inc., Osaka, Japan) according to the CIE L*, a*, b* colour system. The parameters were recorded as: L*; lightness (black/white), a*; redness (green/red) and b*; yellowness (blue/yellow). Hue angle ($H = \tan^{-1}(b^*/a^*)$) and saturation index ($SI = \sqrt{a^{*2} + b^{*2}}$) of the samples were calculated.

Analytical methods

Proximate analysis was performed independently using standard AACC methods (AACC, 1990). The moisture contents were determined by drying the samples in a hot air oven (Nüve KD 400, Istanbul, Turkey) according to AACC method 44-12. Ash content of tarhana samples was determined according to AACC method 08-01, the protein contents of the samples were estimated from the crude nitrogen content of the samples determined by the Kjeldahl method (method 46-12) (AACC, 1990).

Nutritional analysis

Phytic acid content of powder tarhana samples and replacer flours were measured by a colorimetric method according to Haug and Lantzsch (1983). The absorbance of the solution was measured at 519 nm wavelength against distilled water. A standard curve was prepared using sodium phytate solution. Determination was conducted in triplicate.

Calcium (Ca), iron (Fe), potassium (K), magnesium (Mg), phosphorus (P) and zinc (Zn) were determined in the tarhana samples by spectroscopic method using a ICP-AES (Vista series, Varian International AG, Steinhausen, Switzerland) as described by Skujins (1998). Mineral results were expressed in mg/100 g of sample.

Total phenolic content was determined by the Folin-Ciocalteu spectrophotometric method (Beta *et al.*, 2005; Gao *et al.*, 2002) with slight modifications. The total phenolic content was measured with Hitachi-U1800 spectrophotometer (Hitachi High-Technologies, Tokyo, Japan) at 725 nm. The results were expressed as mg gallic acid equivalents per g of sample (mg GAE/g) (Gamez-Meza *et al.*, 1999; Slinkard and Singelton, 1977).

Antioxidant capacity of tarhana samples determined with TEAC and DPPH assays. TEAC method was used according to Re *et al.* (1999) with a Shimadzu UV 1240 spectrophotometer (Kioto, Japan) set at 734 nm. The results were expressed as mmol Trolox equivalent (TE)/

kg of sample. The DPPH assay followed the modified method described by Blois (1958). The antioxidant activity of the tarhana samples were evaluated based on the radical scavenging effect of the stable 1,1-diphenyl-2-picrylhydrazyl radicals (DPPH) and calculated as percent discoloration.

Viscosity

Tarhana soup was prepared with 20 g of dried tarhana powder, 300 ml water, 8 g of butter and 2 g salt and allowed to boil for 10 min over heat with constant stirring. Viscosity properties of tarhana soups were measured using a Brookfield RTV Viscometer (Brookfield RTV, Engineering Laboratories, Middleboro, MA, USA) at 100 rpm and 70 °C using a number 5 spindle. Measurements were taken after 1 min of rotation and results were recorded as centipoises (cP).

Sensory evaluation

Sensorial test was performed on prepared tarhana soup samples with 0, 10 and 20% of the three replacer flours, according to the taste, odour, colour, grittiness, sourness, and overall acceptance by a trained 25-member panel. Tarhana soups were prepared as mentioned under the viscosity test. Each tarhana soup sample was coded with three random digit numbers and the positions of the samples were randomised. The ratings were carried on a 5-point scale ranging from 5 (like extremely) to 1 (dislike extremely).

Statistical analysis

A commercial software program (JMP, version 5.0, SAS Institute, Cary, NC, USA) was used to perform statistical analyses. Data were subjected to statistical analysis by three-way analysis of variance (ANOVA).

3. Results and discussion

Analytical results

Colour properties of wheat, buckwheat, quinoa and lupine flours used in tarhana production are given in Table 1. The highest L* (lightness) (94.69) and hue angle (87.15) values among the materials used in tarhana formulation were determined with wheat flour, followed by quinoa, lupine and buckwheat flour, respectively. The highest a* (redness) value was found in buckwheat flour (3.69), highest b* (yellowness) (28.75) and chroma (28.75) values were obtained with lupine flour. Superior yellowness value of lupine seeds is due to their carotenoid pigments (beta carotene, lutein and zeaxanthin) (El-Diffrawi and Hudson, 1979; Ghezlou, 2000). The dense redness pigmentation of buckwheat is due to the dark hull (Marshall and Pomeranz, 1982). Previous studies have also shown similar results for colour values of buckwheat flour (Bilgiçli, 2008; Yarpuz, 2011).

Table 1. Colour values, chemical and nutritional properties of raw materials used in tarhana formulation.¹

	Wheat flour	Buckwheat flour	Quinoa flour	Lupine flour
L* (lightness)	94.69±0.06 ^a	74.44±0.18 ^d	89.34±0.06 ^b	83.54±0.04 ^c
a* (redness)	-1.16±0.00 ^d	3.69±0.07 ^a	-0.57±0.01 ^c	-0.16±0.06 ^b
b* (yellowness)	9.25±0.09 ^d	18.91±0.01 ^b	12.03±0.02 ^c	28.75±0.04 ^a
SI (chroma)	9.32±0.09 ^d	19.27±0.03 ^b	12.04±0.02 ^c	28.75±0.04 ^a
Hue angle	87.15±0.07 ^a	78.96±0.20 ^d	82.71±0.07 ^b	80.32±0.11 ^c
Moisture (%)	11.17±0.01 ^b	11.29±0.00 ^a	10.85±0.01 ^c	5.80±0.01 ^d
Crude ash (%)	0.55±0.00 ^c	2.05±0.00 ^a	2.02±0.02 ^a	4.16±0.04 ^b
Protein (%)	12.58±0.18 ^c	13.80±0.01 ^b	12.98±0.05 ^c	40.05±0.14 ^a
Phytic acid (mg/100 g)	153.30±2.97 ^d	1,556.09±2.97 ^a	905.10±2.97 ^c	995.09±2.97 ^b
Ca (mg/100 g)	29.06±0.13 ^d	30.04±0.16 ^c	49.55±0.19 ^b	365.12±0.25 ^a
Fe (mg/100 g)	1.52±0.03 ^b	2.89±0.04 ^a	3.53±0.69 ^a	3.98±0.09 ^a
K (mg/100 g)	119.02±1.82 ^d	404.16±4.14 ^c	748.66±2.57 ^a	729.29±4.09 ^b
Mg (mg/100 g)	44.27±0.79 ^c	235.95±1.83 ^a	32.77±1.48 ^d	124.64±1.19 ^b
P (mg/100 g)	138.93±3.38 ^c	433.89±2.62 ^a	392.62±3.10 ^b	380.57±3.30 ^b
Zn (mg/100 g)	0.92±0.03 ^d	2.21±0.04 ^b	1.71±0.05 ^c	5.17±0.06 ^a
TPC (mg GAE/g)	54.44±5.75 ^c	157.25±3.54 ^a	103.50±2.65 ^b	39.44±3.98 ^c
TEAC (mmol TE/kg)	0.291±0.00 ^a	0.464±0.03 ^a	0.370±0.00 ^a	0.396±0.15 ^a
DPPH (%)	67.83±0.55 ^c	95.00±0.47 ^a	74.78±0.31 ^b	72.11±1.10 ^b

¹ Means followed by the same letter within a row are not significantly different ($P < 0.05$). TPC = total phenolic content; TEAC = Trolox equivalent antioxidant capacity; DPPH = α -diphenyl- β -picrylhydrazyl.

Chemical and nutritional properties of raw materials used in tarhana formulation are given in Table 1. The highest ash content (4.16%) was obtained with lupine flour, due to its high mineral content (Kohajdová *et al.*, 2011). The highest protein content was determined with lupine flour which may offer a more sustainable alternative to soya. The amount of protein (40.05%) of lupine flour was found 2.90 times higher than buckwheat flour (13.80%), 3.09 times higher than quinoa flour (12.98%) and 3.18 times higher than wheat flour (12.58%). Phytic acid is known as an antinutritional factor which chelates minerals and prevents it to be bioavailable for humans (Bilgiçli, 2002). When the phytic acid contents of the raw materials were examined, the highest phytic acid content was determined with buckwheat flour (1,556.09 mg/100 g), followed by lupine flour (995.09 mg/100 g) and quinoa flour (905.10 mg/100 g), respectively. The lowest content of phytic acid was determined with wheat flour (153.30 mg/100 g). These results were in agreement with Bilgiçli (2008), Iglesias-Puig *et al.* (2014), and Doxastakis *et al.* (2001). Despite their disadvantages (antinutritional factor), phytic acid is useful for health benefits. Phytic acid supports colon health by lowering blood sugar, and decreasing digestion of starch (Yoon *et al.*, 1983). Phytic acid is a well-known antioxidant of natural origin. Iron binding increases antioxidative activity by reducing lipid peroxidation and free radical formation (Bohn *et al.*, 2008).

Mineral contents of raw materials used in tarhana samples are also given in Table 1. In the raw materials, the highest Ca content (365.12 mg/100 g) was found in lupine flour; it was 12.15 times higher than buckwheat flour (30.04 mg/100 g), 7.37 times higher than quinoa flour (49.55 mg/100 g) and 12.56 times higher than wheat flour (29.06 mg/100 g). In terms of Fe content, there was no statistical difference ($P>0.05$) between buckwheat flour (2.89 mg/100 g), quinoa flour (3.53 mg/100 g) and lupine flour (3.98 mg/100 g). The lowest Fe content was found in wheat flour (1.52 mg/100 g). Lupine flour gave the highest Ca and Zn content, buckwheat flour had the highest Mg and P content, and quinoa flour showed the highest Mg content.

Total phenolic content and antioxidant activity values of raw materials of tarhana samples are also shown in Table 1. The highest total phenolic content was found in buckwheat flour (157.25 mg GAE/g), followed by quinoa flour (103.50 mg GAE/g), wheat flour (54.44 mg GAE/g) and lupine flour (39.44 mg GAE/g). Results of TEAC analysis of raw materials were between 0.291 and 0.464 mmol TE/kg with no statistical differences ($P>0.05$) between in these results. According to DPPH analysis, the highest value was found in buckwheat flour. There was no statistical difference ($P>0.05$) between lupine flour and quinoa flour, while the lowest level was found in wheat flour. Buckwheat is an important source of quercetin, rutin and other flavonoids. Rutin plays important role in inhibiting low-density lipoprotein (LDL)

peroxidation and antioxidant activity (Jiang *et al.*, 2007; Zielińska *et al.*, 2007a,b). Its antioxidant activity mainly due to its radical scavenging activity.

Colour properties of tarhana samples

Colour is one of the main properties that influences acceptability of food. The colour of tarhana samples were determined; the L^* , a^* and b^* values are indications of lightness, redness, and yellowness, respectively. Colour results of tarhana samples are shown in Table 2. The average L^* , a^* , b^* , chroma and hue angle values of samples were 77.53 ± 3.64 , 8.54 ± 2.18 , 27.81 ± 3.92 , 29.05 ± 4.39 and 73.70 ± 2.97 , respectively. According to the results, quinoa flour added tarhana samples gave higher L^* (lightness) and hue angle values and lower redness, yellowness and chroma values than the other replacer flours added tarhana formulations. Lupine flour added samples showed the highest redness, yellowness and chroma values while the quinoa flour added tarhana samples showed the lowest. It was determined that as the usage level of the buckwheat and lupine flours increased, the lightness value decreased. In contrast to this, when the usage level of the quinoa flours increased, the lightness value increased. When L^* value of raw materials was examined, it was seen that the L^* values of wheat flour were higher than those of buckwheat, quinoa and lupine flours. For this reason, it was thought that decreasing the wheat flour ratio causes a decrease of the L^* value. Similar results were reported by Bilgiçli (2002) and Chevallier *et al.* (2000). The highest a^* colour value (12.06) was found in 40% lupine flour added tarhana samples. These results were in agreement with Maghaydah *et al.* (2013) and Bilgiçli and Levent (2014), who reported an increase in the red colour of samples associated with increasing levels of lupine flour. The highest b^* colour value (34.19) was also found in 40% lupine flour added samples. The fact that lupine flour is dominated by a high yellow colour, the addition of lupine flour to tarhana increased the colour value of b^* . Pollard *et al.* (2002) and Yarpuz (2011) studied the effect of colour characteristics of lupine flour added bread and reported that the addition of 10-30 g/100 g lupine flour into bread increased the yellowness (b^*) value compared to control samples.

Nutritional evaluation of tarhana samples

Crude ash, protein and phytic acid values of the tarhana samples are shown in Table 3. The highest ash content was found in 40% lupine flour added samples (2.46%). Tarhana produced with quinoa had significantly lower amounts of ash compared with buckwheat and lupine flour added tarhana samples. In addition, investigated buckwheat and lupine flour added tarhana samples had higher ash content than quinoa flour added tarhanas due to high mineral content of buckwheat (Baljeet *et al.*, 2010) and lupine seeds. It was found that as the amount of replacer flours

Table 2. Colour values of tarhana samples.¹

Replacer flours	Usage level (%)	L*	a*	b*	SI (chroma)	Hue angle
Buckwheat flour	0	79.48±0.65 ^a A	8.74±0.30 ^b A	28.95±0.28 ^a A	30.24±0.18 ^a A	73.20±0.69 ^b A
	10	79.15±0.57 ^a A	4.64±0.00 ^c B	23.16±0.18 ^c B	23.62±0.17 ^c B	78.67±0.08 ^a B
	20	76.08±0.01 ^b B	8.77±0.08 ^b B	26.82±0.07 ^b B	28.57±0.40 ^b B	71.64±0.24 ^{bc} B
	30	74.05±0.21 ^c B	9.12±0.01 ^b B	27.34±0.03 ^b B	28.54±0.36 ^b B	71.02±0.76 ^{bc} A
	40	69.61±0.20 ^d C	10.29±0.23 ^a B	28.73±0.32 ^a B	30.52±0.38 ^a B	70.30±0.20 ^c B
Quinoa flour	0	79.34±0.45 ^c A	8.29±0.43 ^{ab} A	28.96±0.43 ^a A	30.12±0.53 ^a A	74.04±0.56 ^c A
	10	80.50±0.01 ^{bc} A	3.81±0.14 ^d C	21.30±0.01 ^d C	22.57±0.14 ^c C	80.28±0.31 ^a A
	20	80.73±0.05 ^b A	7.32±0.06 ^{bc} C	22.25±0.11 ^c C	26.04±0.16 ^b C	73.68±0.03 ^c A
	30	81.06±0.29 ^b A	7.12±0.16 ^c C	24.77±0.10 ^b C	25.82±0.07 ^b C	73.98±0.33 ^c A
	40	83.74±0.20 ^a A	8.61±0.02 ^a C	25.14±0.06 ^b C	21.80±0.00 ^c C	77.78±0.06 ^b A
Lupine flour	0	79.34±0.46 ^a A	8.29±0.13 ^e A	28.96±0.35 ^d A	30.12±0.38 ^d A	74.04±0.05 ^a A
	10	76.58±0.04 ^b B	9.11±0.07 ^d A	30.57±0.01 ^c A	31.90±0.01 ^c A	73.40±0.13 ^a C
	20	75.76±0.69 ^{bc} B	10.69±0.10 ^c A	32.50±0.12 ^b A	34.30±0.20 ^b A	71.40±0.34 ^b B
	30	74.35±0.07 ^{cd} B	11.15±0.02 ^b A	33.79±0.01 ^a A	35.57±0.01 ^a A	71.79±0.03 ^b A
	40	73.34±0.09 ^d B	12.06±0.05 ^a A	34.19±0.06 ^a A	36.26±0.07 ^a A	70.56±0.04 ^c B
Minimum-maximum		69.61-83.74	3.81-12.06	21.30-34.19	21.80-36.26	70.30-80.28
Mean ± std		77.53±3.64	8.54±2.18	27.81±3.92	29.05±4.39	73.70±2.97

¹ Values followed by different superscript letters (series 'a-d') within each column (indicating differences among average of tarhana samples at same replacer flours with different usage levels of replacer flours), by different uppercase letters (series 'A-C') within each column (indicating differences among average of tarhana samples at different replacer flours with same usage levels of replacer flours) are significantly different at $P<0.05$.

Table 3. Crude ash, protein and phytic acid values of tarhana samples.¹

Replacer flours	Usage level (%)	Ash (%)	Protein ² (%)	Phytic acid (mg/100 g)
Buckwheat flour	0	1.40±0.00 ^e A	14.61±0.12 ^c A	28.40±1.41 ^d A
	10	1.56±0.05 ^d A	15.77±0.23 ^b B	35.69±2.97 ^d A
	20	1.84±0.01 ^c A	15.54±0.10 ^b B	48.29±2.97 ^c A
	30	2.01±0.01 ^b A	15.60±0.02 ^b B	65.09±2.97 ^b A
	40	2.26±0.03 ^a B	16.39±0.06 ^a B	77.69±2.97 ^a A
Quinoa flour	0	1.36±0.04 ^b A	14.38±0.07 ^b A	26.97±2.52 ^c A
	10	1.54±0.08 ^{ab} A	15.57±0.00 ^a B	25.19±0.00 ^c B
	20	1.69±0.07 ^a A	15.25±0.52 ^{ab} C	31.49±2.97 ^{bc} A
	30	1.72±0.07 ^a B	15.32±0.45 ^{ab} B	39.89±2.97 ^{ab} B
	40	1.82±0.04 ^a C	14.63±0.01 ^{ab} C	48.29±2.97 ^a B
Lupine flour	0	1.36±0.01 ^e A	14.52±0.14 ^c AB	25.26±0.01 ^d A
	10	1.52±0.02 ^d A	19.68±0.23 ^b A	31.49±2.97 ^d AB
	20	1.77±0.02 ^c A	19.81±0.18 ^b A	46.19±0.00 ^c A
	30	2.03±0.03 ^b A	20.88±0.50 ^a A	60.89±2.97 ^b A
	40	2.46±0.01 ^a A	21.28±0.50 ^a A	73.49±2.97 ^a A
Minimum-maximum		1.36-2.46	14.38-21.28	25.19-77.69
Mean ± standard deviation		1.75±0.32	16.62±2.43	44.29±17.54

¹ Values followed by different superscript letters (series 'a-d') within each column (indicating differences among average of tarhana samples at same replacer flours with different usage levels of replacer flours), by different uppercase letters (series 'A-C') within each column (indicating differences among average of tarhana samples at different replacer flours with same usage rates of replacer flours) are significantly different at $P<0.05$.

² Protein = $N \times 6.25$.

increased, also the ash content of tarhana increased. Similar results have been reported by Bojnanska *et al.* (2009) and Bilgiçli (2002). Because of the differences in ingredients, the nutritional value of tarhana samples varies greatly. Protein contents of tarhana samples ranged from 14.38 to 21.28% w/w. The protein content increased more in lupine flour added samples than in other replacer flours added samples. The protein content of tarhana samples increased significantly ($P<0.05$) when the levels of lupine and buckwheat flour increased. When the protein contents of the raw materials were compared, the protein content of replacer flours was higher than that of wheat flour.

Phytic acid, a component naturally found in legumes and grains, reduces the bioavailability of minerals by forming mineral complexes that are necessary for human nutrition (Bilgiçli, 2002). Phytic acid is widely used as a nutritional supplement due to its antioxidant properties (Higuchi, 2014). In contrast with this positive feature of phytic acid has been regarded as an antinutritional factor because it forms complexes with metal cations (Ca^{+2} , Zn^{+2} , and Fe^{+2}) and reduces their bioavailability. Phytic acid values of buckwheat, quinoa and lupine flour added tarhana samples were investigated and phytic acid contents of replacer flours added tarhana samples was found higher than the control group (0% replacer flours). The quinoa flour added tarhana samples gave lower phytic acid values than the other replacer flours. It was seen that the increasing usage level

of replacer flours also increased the phytic acid content of tarhanas (Table 3). This situation could be explained by the higher phytic acid content of replacer flours than wheat flour.

Mineral contents, such as Ca, Fe, K, Mg, P and Zn contents of tarhana samples were determined with inductively coupled plasma atomic emission spectrometry (ICP-AES), were given in Table 4. According to results, the highest Ca content were found in lupine flour added tarhana samples than followed by quinoa and buckwheat flour added tarhana samples, respectively. Buckwheat flour addition to tarhana formulation gave the lowest Ca, Fe and K, and the highest Mg and P content. The Fe contents of quinoa and lupine flour added tarhana samples were not statistically different ($P>0.05$) and higher than those of buckwheat flour added tarhana samples. While the level of quinoa flour were increased Mg contents of samples were decreased. This situation could be explained by the higher Mg content of wheat flour than the quinoa flour. Demir (2015), studied the effect of quinoa flour on the mineral contents of couscous and reported that the addition of quinoa flour increased the Zn, Fe, Ca, K, Mg and P contents of utilised couscous samples compared to control group. The highest Zn content was found in lupine flour added samples. While the level of replacer flours increased, Ca, Fe, K, P contents of tarhana samples increased. The quinoa flour addition in tarhana formulation did not show a significant difference ($P>0.05$)

Table 4. Mineral contents of tarhana samples (mg/100 g).¹

Replacer flours	Usage level (%)	Calcium	Iron	Potassium	Magnesium	Phosphorus	Zinc
Buckwheat flour	0	103.35±0.21 ^c A	2.50±0.01 ^e A	401.00±5.66 ^e A	52.60±0.42 ^e A	251.00±2.83 ^e A	0.85±0.01 ^e A
	10	106.57±1.89 ^{bc} C	2.67±0.01 ^d A	503.30±0.99 ^d B	76.47±1.79 ^d A	309.28±2.16 ^d A	1.0±0.03 ^d B
	20	109.11±0.23 ^{ab} C	2.89±0.02 ^c B	599.43±3.43 ^c C	102.92±1.89 ^c A	361.06±2.06 ^c A	1.11±0.01 ^c B
	30	110.98±0.48 ^a C	3.12±0.01 ^b B	703.01±2.81 ^b C	126.42±1.39 ^b A	418.68±2.01 ^b A	1.23±0.02 ^b B
	40	112.48±0.33 ^a C	3.35±0.00 ^a B	804.10±5.52 ^a C	150.55±1.77 ^a A	470.71±1.85 ^a A	1.33±0.00 ^a A
Quinoa flour	0	105.10±0.71 ^e A	2.43±0.04 ^e A	401.50±0.71 ^e A	53.30±0.57 ^a A	253.50±2.12 ^e A	0.85±0.04 ^a A
	10	115.74±0.80 ^d B	2.89±0.02 ^d A	621.06±2.74 ^d A	53.65±1.77 ^b B	301.02±1.39 ^d A	0.94±0.01 ^a B
	20	123.78±1.44 ^c B	3.30±0.04 ^c A	832.87±2.64 ^c A	51.61±0.98 ^{ab} C	349.05±2.76 ^c A	1.0±0.01 ^a B
	30	130.93±0.81 ^b B	3.70±0.02 ^b A	1,051.18±1.17 ^b A	49.92±0.68 ^{bc} C	392.07±2.92 ^b B	1.07±0.01 ^a C
	40	137.43±0.75 ^a B	4.10±0.01 ^a A	1,266.99±1.44 ^a A	48.33±0.52 ^c C	443.09±2.71 ^a B	0.65±0.70 ^a A
Lupine flour	0	104.75±0.07 ^e A	2.46±0.04 ^e A	401.25±1.06 ^e A	52.85±0.35 ^e A	253.50±3.54 ^e A	0.84±0.01 ^e A
	10	231.08±1.81 ^d A	2.91±0.08 ^d A	615.06±4.16 ^d A	64.77±1.45 ^d B	299.39±2.27 ^d A	1.27±0.02 ^d A
	20	358.13±1.38 ^c A	3.26±0.02 ^c A	822.86±3.02 ^c B	74.26±0.91 ^c B	344.78±3.13 ^c A	1.67±0.03 ^c A
	30	483.27±1.88 ^b A	3.67±0.03 ^b A	1,031.67±3.29 ^b B	83.30±0.28 ^b B	389.18±2.58 ^b B	2.03±0.00 ^b A
	40	603.77±4.19 ^a A	4.06±0.03 ^a A	1,239.48±2.15 ^a B	93.78±0.59 ^a B	431.57±0.80 ^a B	2.42±0.01 ^a A
Minimum-maximum		103.35-603.77	2.43-4.10	401.00-1,266.99	49.92-150.55	251.00-443.09	0.84-2.42
Mean ± standard deviation		195.76±155.49	3.15±0.54	752.98±284.96	75.65±30.48	351.19±71.02	1.22±0.49

¹ Values followed by different superscript letters (series 'a-d') within each column (indicating differences among average of tarhana samples at same replacer flours with different usage levels of replacer flours), by different uppercase letters (series 'A-C') within each column (indicating differences among average of tarhana samples at different replacer flours with same usage levels of replacer flours) are significantly different at $P<0.05$.

on zinc values with increasing replacer flours level. Yıldız (2012) studied the effect of buckwheat flour and lupine flour on the mineral contents of gluten-free biscuits and reported that the addition of buckwheat and lupine flour increased the Ca, Cu, Fe, Mg, K, Mn, P and Zn minerals contents of biscuits.

Total phenolic content

Total phenolic content of the samples was determined, and results were found between 60.69-232.25 mg GAE/g (Table 5). According to the results, the highest phenolic content was found in the samples with quinoa flour. It was found that the increasing replacer flours in the tarhana formulation increased the phenolic content. When total phenolic contents of raw materials were examined, buckwheat and quinoa flour were higher than wheat and lupine flour (Table 1). The total phenolic content of the insoluble-bound fraction of the grain might be altered by the various food processing methods of grain-based food products, such as kneading, baking, fermenting, drying, etc. (Okarter, 2012). The bioactive properties and health benefits might be positively or negatively affected due to this situation (Abdel-Aal and Rabalski, 2013; Nguyen *et al.*, 2015). Siger *et al.* (2011) examined the total phenolic substance quantities of different lupine species and found values between 491.51-731.14 mg GAE/100 g. Alvarez-

Jubete *et al.* (2009) studied buckwheat, quinoa and wheat flours added breads and total phenolic contents of these breads was found as buckwheat > quinoa > wheat.

Antioxidant capacity

Antioxidant capacity methods have been generally divided into two categories: as hydrogen atom transfer (HAT) reaction and as electron transfer (ET) reaction-based methods. Total phenol content was measured using the Folin-Ciocalteu Reagent, Trolox equivalent antioxidant capacity (TEAC), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging capacity assay was considered under the methods utilising the ET mechanism (MacDonald-Wicks *et al.*, 2006; Prior *et al.*, 2005), although they are classified under the methods utilising both ET and HAT mechanisms by Prior *et al.* (2005). TEAC measures the antioxidant capacities of substances with compared to Trolox standard. DPPH is a dark coloured powder, acting as a free radical and a trap (scavenger) for other radicals. Antioxidant capacities of tarhana samples are given in Table 5.

TEAC method

The TEAC method was applied to determine antioxidant capacities of tarhana samples. The antioxidant capacities of tarhanas were found between 0.17-0.55 mmol TE/kg as

Table 5. Total phenolic content and antioxidant capacity of tarhana samples.¹

Replacer flours	Usage level (%)	TPC (mg GAE/g)	Antioxidant capacity TEAC (mmol TE/kg)	Antioxidant capacity DPPH (%)
Buckwheat flour	0	70.50±2.83 ^c A	0.31±0.00 ^{ab} B	73.17±0.40 ^c A
	10	79.13±4.42 ^c AB	0.17±0.14 ^b A	73.94±0.38 ^c A
	20	103.50±1.77 ^b B	0.37±0.00 ^{ab} A	80.78±0.79 ^b A
	30	117.56±1.33 ^b B	0.45±0.01 ^{ab} A	84.22±1.10 ^a A
	40	142.25±4.42 ^a B	0.48±0.00 ^a A	85.56±0.63 ^a A
Quinoa flour	0	73.85±0.49 ^d A	0.32±0.01 ^b A	73.74±0.73 ^{cd} A
	10	60.69±1.33 ^d B	0.25±0.05 ^b A	72.39±0.39 ^d A
	20	147.56±0.44 ^c A	0.27±0.02 ^b B	76.94±0.86 ^c A
	30	232.25±8.84 ^a A	0.31±0.02 ^b B	82.06±1.49 ^b A
	40	203.82±3.09 ^b A	0.55±0.01 ^a A	86.56±0.47 ^a A
Lupine flour	0	73.82±0.10 ^d A	0.32±0.00 ^a A	73.32±0.04 ^a A
	10	89.13±1.77 ^c A	0.22±0.01 ^a A	73.44±2.51 ^a A
	20	91.00±1.77 ^c C	0.26±0.02 ^a B	74.61±1.49 ^a A
	30	100.06±3.09 ^b B	0.33±0.02 ^a B	76.72±0.71 ^a A
	40	106.94±2.21 ^a C	0.35±0.14 ^a A	77.95±0.39 ^a B
Minimum-maximum		60.69-232.25	0.17-0.55	72.39-86.56
Mean ± std		112.80±48.94	0.33±0.11	77.69±4.88

¹ Values followed by different superscript letters (series 'a-d') within each column (indicating differences among average of tarhana samples at same replacer flours with different usage levels of replacer flours), by different uppercase letters (series 'A-C') within each column (indicating differences among average of tarhana samples at different replacer flours with same usage levels of replacer flours) are significantly different at $P < 0.05$. TPC = total phenolic content; TEAC = Trolox equivalent antioxidant capacity; DPPH = α -diphenyl- β -picrylhydrazyl.

shown in Table 5. According to the results, the antioxidant capacity of buckwheat flour added tarhanas were higher than that of lupine and quinoa flour added tarhanas. Buckwheat is an important source of quercetin, rutin and other flavonoids, and rutin plays important role in antioxidant activity (Jiang *et al.*, 2007). Antioxidant capacity of lupine flour added tarhana samples was not statistically ($P>0.05$) different from each other in terms of increasing flour levels. The highest TEAC values were found in the 40% replacer flour tarhana groups. Therefore, the replacer flours in tarhana formulation had higher antioxidant capacity values than tarhana samples without any replacer flours (control). Alvarez-Jubete *et al.* (2009) investigated the pseudocereals quinoa and buckwheat as potential healthy ingredients for improving the nutritional quality of gluten-free breads and found the antioxidant capacities of these bread samples as buckwheat > wheat > quinoa. Saharan *et al.* (2017) found a positive correlation between total phenolic and flavonoid content with antioxidant activity. Role of α -amylase, xylanase and β -glucosidase enzymes in release of polyphenols and antioxidants during solid state fermentation of cereals was justified by a linear correlation obtained between total phenolic and flavonoid contents with enzyme activities.

DPPH method

Antioxidant capacities of tarhana samples were also investigated using the DPPH analysis method. Results showed between 72.39-86.56% of DPPH scavenging activity. Average antioxidant capacity of samples was found as $77.69 \pm 4.88\%$ (Table 5). When antioxidant capacities of replacer flours were examined, increasing levels of buckwheat and quinoa flours in tarhana formulation resulted in increased antioxidant capacity values. Increasing lupine flour in tarhana formulation showed statistically similar ($P>0.05$) values. This situation can be explained by Table 1. Replacer flours gave higher antioxidant capacities (TEAC and DPPH) than wheat flour, so higher antioxidant capacity values of tarhana samples than control group were found with replacer flours addition to tarhana formulation.

Sedej *et al.* (2011) studied on gluten-free crackers made with buckwheat and whole buckwheat flour and compared these gluten-free crackers with wheat and whole wheat flour crackers. According to results of DPPH analysis, antioxidant capacities of buckwheat and whole buckwheat flour crackers were higher than wheat and whole wheat flour crackers.

Viscosity

Viscosity results of cooked tarhana samples are given in Figure 1 and ranged from 11.88 to 28.89 cP. Buckwheat and quinoa flours added cooked tarhana samples showed higher viscosity values than lupine flour added cooked tarhana samples. An increase in the levels of replacer flours

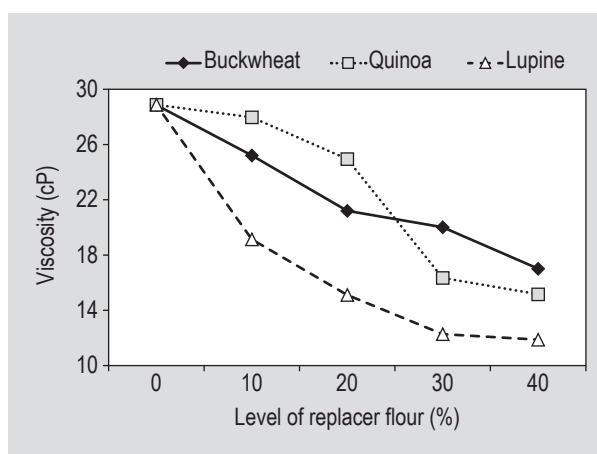


Figure 1. Viscosity values of tarhana samples.

caused a decrease in the viscosity values of the tarhana samples, and also viscosity values of replacer flours added samples were lower than control samples. Bilgiçli (2008) studied tarhana samples made with wheat and buckwheat flour at different (0, 20, 40, 60, 80 and 100%) levels and analysed the viscosity values of the samples. In that study, an increased buckwheat flour level in tarhana formulation caused a decrease in the viscosity values of cooked tarhana samples. While the viscosity value of control group (100% wheat flour) tarhana sample was 1,470 cP, the viscosity of 100% buckwheat flour added tarhana sample was 130 cP. It was thought that lower viscosity values could be expected, when surfactant property of fat and viscosity lowering effect of water are considered. Thus, when the proportion of replacer flour increases, the decreasing gluten content and the starch ratio causes the viscosity to decrease. The difference in viscosity results obtained in this present study and reported in literature could be due to the fat and water content of cooked tarhana samples. The different type and content of ingredients and different processes affects the properties of tarhana reported by some researchers (Brennan *et al.*, 2013; De Noni and Pagani, 2010).

Sensorial evaluation

Sensory analyses of samples were applied to the level of 0, 10, 20% replacer flours added tarhana samples. The maximum addition of 20% buckwheat flour gave darker colour and dislike taste and odour values, so replacement rates of 30 and 40% were not used for sensorial analysis. Average organoleptic values of tarhana samples were assessed on a 5 points scale. They ranged from 4.00 to 4.95 for flavour, from 4.05 to 4.95 for odour, from 3.90 to 4.95 for colour, from 4.20 to 4.90 for grittiness, from 3.90 to 4.85 for sourness, and from 4.35 to 4.91 for overall acceptability (Figure 2). In sensory terms; the highest odour, flavour, sourness, overall acceptability and the lowest grittiness scores were given for 20% quinoa flour added tarhana sample. Tarhana samples with 20% lupine flour added gave the highest colour

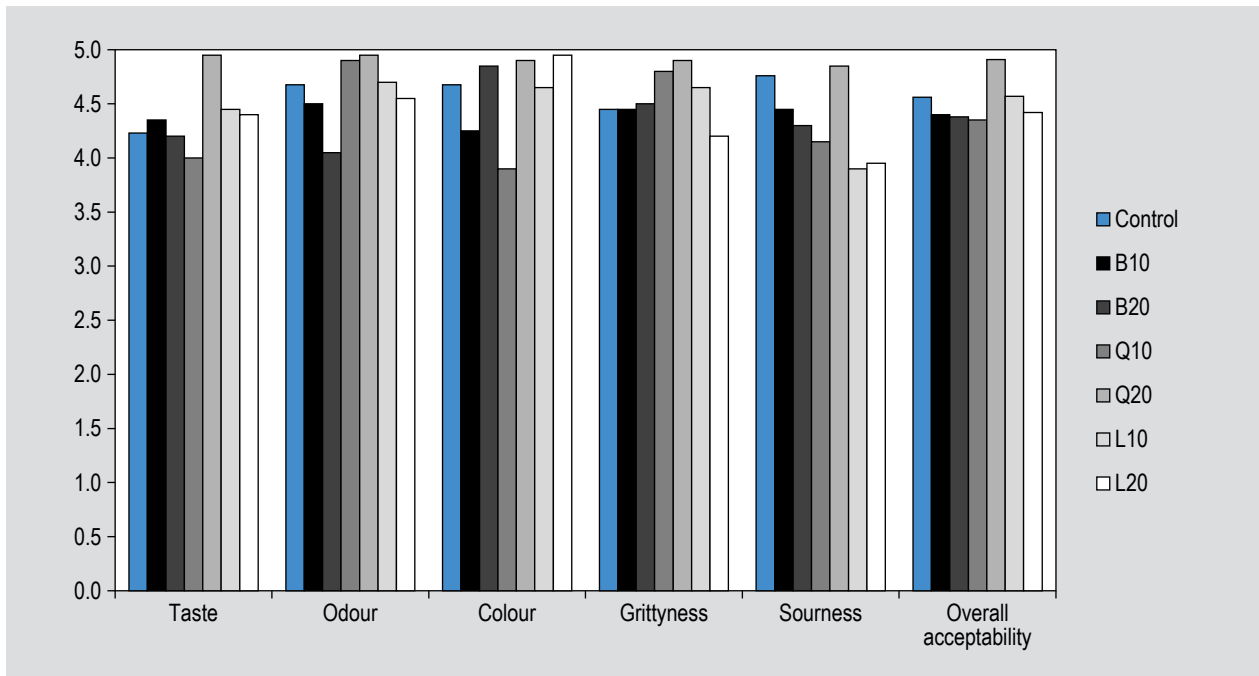


Figure 2. Sensorial properties of tarhana samples. C = control tarhana; B10 = 10% buckwheat flour added tarhana; B20 = 20% buckwheat flour added tarhana; Q10 = 10% quinoa flour added tarhana; Q20 = 20% quinoa flour added tarhana; L10 = 10% lupine flour added tarhana; L20 = 20% lupine flour added tarhana.

score. The general conclusion of panellists was that 20% quinoa flour added tarhana sample could be suggested for consumption. Yildiz (2012) studied the effect of buckwheat and lupine flour on the sensory evaluation of gluten-free biscuits and addition of more than 10% buckwheat flour and more than 20% lupine flour into biscuits produced negative effects on appearance, brittleness, taste, smell and overall acceptability reported by panellists.

4. Conclusions

In this study, to improve the nutritional and sensorial properties of tarhana, the possibilities of using buckwheat flour, quinoa flour or lupine flour in tarhana formulations at 0, 10, 20, 30 and 40% ratios were investigated. The addition of quinoa flour gave higher lightness (L^*) value, hue angle value, total amount of phenolic content, Fe and K amount of tarhana samples compared to other replacer flours. Lupine flour addition increased the amounts of a^* , b^* and SI (chroma) colour values and ash, protein, Ca and Zn contents of tarhana samples. Overall, the increase in the level of replacer flours caused a decrease in viscosity values of cooked tarhana soups, and an increase in ash, protein, phytic acid, Ca, Fe, K, P minerals, and antioxidant capacity. Increasing the level of replacer flours improved the nutritional properties of tarhana samples. Antioxidant capacities of samples were observed as buckwheat > quinoa > lupine flour added tarhana samples. According to the sensorial evaluation performed by panellists, 20% quinoa flour added tarhana samples were the most admired samples

in terms of taste, smell, sourness and general acceptability parameters, while the most admired tarhana sample in terms of colour contained 20% lupine flour.

In conclusion, to improve the nutritional and sensorial properties of tarhana – produced either industrial or home-made – quinoa and lupine flour can be easily added to the tarhana formulation. Although buckwheat flour has been highly effective in enhancing nutritional properties, it has not been appreciated much by panellists due to the unique and unwanted taste and odour of buckwheat. Consequently, 20% quinoa addition to tarhana formulation can be recommended to improve the nutritional properties without adverse effects in sensorial properties.

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