DOI: 10.29050/harranziraat.511520
Harran Tarım ve Gıda Bilimleri Derg. 2019, 23(3): 301-312

Research Article/Araştırma Makalesi

The effects of different gluten-free flours on the physical, chemical, functional and sensorial properties of tarhana

Tarhana üretiminde farklı glutensiz unların kullanılmasının tarhananın fiziksel, kimyasal, fonksiyonel ve duyusal özellikleri üzerine etkisi

Kübra TULUK[1*], **Nilgün ERTAŞ**[2]

[1]Department of Food Engineering, Faculty of Engineering, Ege University, İzmir, Turkey
[2]Department of Food Engineering, Faculty of Architecture and Engineering, Necmettin Erbakan University, Konya, Turkey

To cite this article:
Tuluk, K. & Ertaş, N. (2019). The effects of different gluten-free flours on the physical, chemical, functional and sensorial properties of tarhana. Harran Tarım ve Gıda Bilimleri Dergisi, 23(3): 301-312.
DOI:10.29050/harranziraat.511520

Address for Correspondence:
Kübra TULUK
e-mail:
kubratuluk@gmail.com

Received Date:
10.01.2019
Accepted Date:
09.05.2019

ABSTRACT

Tarhana is traditional food product containing wheat flour. Because of wheat flour contains gluten, it is forbidden for celiac patients. The aim of this study was to determine physical, chemical, functional and sensorial properties of tarhana produced from gluten-free flours instead of wheat flour. The findings in this study showed that the use of non-cereal flours such as lupin, chickpea, common bean and buckwheat flours improved the chemical properties of tarhana compared to the use of cereal flours such as wheat, corn and rice flours. The highest Mg and P values were determined with buckwheat flour. Using lupin flour gave the highest Ca, Mn, foaming capacity, water absorption capacity and emulsifying activity values in tarhana. Using corn and rice flour resulted more lighter tarhana color than the others used in tarhana. According to sensorial evaluation; using chickpea, commonbean, rice and buckwheat flours improved the overall acceptability of tarhana.

Key Words: Gluten-free, Tarhana, Non-cereal flour, Functional properties, Sensory evaluation

ÖZ

Tarhana, buğday unu içeren geleneksel bir gıda ürünüdür. Buğday unu gluten içerdiği için, çölyak hastaları tarafından tüketilmesi yasak bir gıdadır. Bu çalışmanın amacı; tarhana üretiminde buğday unu yerine farklı glutensiz unların kullanımının; tarhananın fiziksel, kimyasal, fonksiyonel ve duyusal özellikleri üzerine etkilerinin araştırılmasıdır. Çalışmanın sonuçlarına göre, tarhana üretiminde lupin, nohut, kuru fasulye ve karabuğday unu gibi tahıl olmayan unların kullanımı; buğday, mısır ve pirinç unu gibi tahıl unlarının kullanımına kıyasla kimyasal özellikleri geliştirmiştir. En yüksek magnezyum ve fosfor içeriği karabuğday ununda tespit edilmiştir. Lupin unu kullanımı; tarhanada en yüksek kalsiyum, mangan içeriği, köpük oluşturma kapasitesi, su tutma kapasitesi ve emülsiyon aktivitesi değerleri oluşturmuştur. Mısır ve pirinç unu kullanımı; diğer tarhana örneklerine göre daha açık renge sahip tarhana elde edilmesine neden olmuştur. Duyusal analiz sonuçlarına göre; tarhana üretiminde; nohut, fasulye, pirinç ve karabuğday unu kullanımı, tarhananın genel kabul edilebilirliğini arttırmıştır.

Anahtar Kelimeler: Glutensiz, Tarhana, Tahıl olmayan un, Fonksiyonel özellik, Duyusal değerlendirme

Introduction

Tarhana is a popular cereal-based traditional fermented product used in making soup in Turkey. It is produced by mixing cereal flours, yoghurt, yeast and a variety of vegetables and spices (Erkan et al., 2006) and by fermentation of the mixture for 1 to 7 days (Tangüler, 2014). After fermentation, tarhana dough is dried (Değirmencioğlu et al., 2016) and grounded to powders (Tarakçı et al., 2004; Erbaş et al., 2005). Tarhana has high nutritional value and is considered to be a good source of proteins, vitamins (B_1 and B_2) and minerals (calcium, iron, sodium, potassium, magnesium, zinc and copper) (Daglioglu, 2000). Tarhana, which is very useful for children and babies, also contributes to bone development and strengthens bones. Thanks to the lycopene contained in its body to protect against many diseases are the benefits of the tarhana. Therefore, according to İbanoğlu and İbanoğlu (1999), tarhana is widely used in human diet (Üçok et al., 2019). Due to its low pH (3.8-4.2) and low moisture content (6-9 g/100g), tarhana is an inadequate source for growing pathogens and spoilage microorganisms (İbanoğlu and İbanoğlu, 1999).

Tarhana is generally produced from wheat flour (Erkan et al., 2006). Therefore, it is not suitable for celiac people who suffered from celiac disease. Celiac disease is an autoimmune disorder induced by the ingestion of gluten proteins present in wheat, barley, and rye (Rewers, 2005). It is well known that foods produced from wheat flour contain gluten, and any kind of food which contains gluten is not safe for celiac people. Therefore, celiac people must consume a strict gluten-free diet throughout their life (Akoğlu and Oruç, 2018). The most known cereal flours used for gluten-free breads are rice (Renzetti and Arendt, 2009), sorghum and corn flours (Sciarini et al., 2012). Corn, lupin, chickpea, common bean, rice, buckwheat flours are suitable for a wide range of food applications and they can be processed into a number of palatable, nutritious food products. Han et al. (2010) studied with chickpea, green and red lentils, pinto bean, navy bean, yellow pea flour for developing gluten-free cracker snacks. Constantini et al. (2014) used common buckwheat (*Fagopyrum esculentum* Moench) and Tataryn buckwheat (*Fagopyrum tataricum* Gaertn) flours and chia flour in their study in order to enrich the nutritional value of the gluten-free breads. Despite the fact that gluten-free foods are safe for celiac people, the production of these foods in good quality is very challenging from the standpoint of consumers' acceptance. On the other hand, it is important to emphasize that the properties of food products such as healthy, nutritious, price, taste, naturality, filling, freshness, quality and cultural habits of individuals should taken into consideration when making a decision about food and nutrition (Aktaş and Özdoğan, 2016).

Comprehensive literature searching showed that there were inadequate studies about the utilization of corn, lupin, chickpea, common bean, rice in tarhana production. Therefore, the aim of this study was to develop an enriched formulation for gluten-free tarhana, which might be a good alternative with its higher nutritional value for the celiac people. For this purpose, corn, lupin, chickpea, common bean, rice and buckwheat flours were used for the gluten-free tarhana production.

Materials and methods

Materials

Commercial type wheat flour (WHF) and corn flour (CRF) were obtained from local markets in Konya, Turkey. Lupin flour (LPF), chickpea flour (CPF), common bean flour (CBF), rice flour (RCF) and buckwheat flour (BWF) were obtained by milling the seeds. These flours were used as main ingredients in the tarhana production. The other ingredients for the tarhana production were pepper paste (22 g/100g total dry solids), medium sized of onions, mint (in powder form) and paprika (in powder form).

Preperation of tarhana samples

The tarhana samples (WHF tarhana (WHT as control sample), CRF tarhana (CRT), LPF tarhana (LPT), CPF tarhana (CPT), CBF tarhana (CBT), RCF tarhana (RCT) and BWF tarhana (BWT)) were produced at laboratory scale. The following formulation was used in the tarhana production: 400 g flour, 160 g yoghurt, 40 g pepper paste, 20 g chopped onions, 8 g hot pepper, 10 g baker's yeast and 4 g salt. These ingredients were mixed with 100 ml of water using a Kenwood mixer (Chef KM330, Hampshire, UK) for 5 min.

Emulsifiers, hydrocolloids, protein isolates of different sources should be used in dough formulas instead of gluten to achieve desired rheological properties during dough making (Masure et al., 2016). The gums are super sticky thickening agent that can be used as a replacement for gluten, and do not contain gluten, so they are safe for celiac patients and any other wheat and gluten intolerances. In the production of gluten-free tarhana samples, 1.5 g/100g guar gum was used for each production. After mixing, tarhana dough was fermented at 30°C for 3 days in an incubator. The pH of the dough was controlled continously and the fermentation was ended at pH of 4. The dough was also kneaded six-times by hand for 12 h. Then, the fermented dough was dried in trays in an air oven (Ozkoseoglu PFS-9, Turkey) at 55ºC for 48 h up to 10% moisture content (w/w, d.b.). The dried tarhana samples were ground and sieved to a particle size smaller than 1 mm screen opening.

Chemical properties

The moisture, ash and protein (Factor; N × 5.70 for cereal flours; N × 6.25 for non-cereal flours) contents of samples were determined according to AACC Methods of 44-15A, 08-01 and 46-12, respectively (AACC, 2000). The mineral contents of tarhana samples were determined by an Inductively Coupled Plasma-Atomic Emission Spectrometers (ICP-AES) (Vista series, Varian International AG, Switzerland) as explained by Bubert and Hagenah (1987).

Functional Properties

Water absorption capacity and oil absorption capacity

Five grams of tarhana powder was thoroughly mixed with 25 ml of distilled water to determine water absorption capacity or sunflower oil to determine oil absoption capacity in separately centrifuge tubes. The dispersion was stirred at 15 min intervals over a 60 min period and then centrifuged at 4000 × g for 20 min. The supernatant volume was measured. The water or oil volume absorbed by tarhana powder was determined. Water and oil absorption capacity values were expressed as mL of water or oil absorbed by per gram of tarhana sample (Hayta et al., 2002).

Foaming capacity and foam stability

Ten grams of tarhana powder was dispersed in 25 ml distilled water and stirred for 20 min. The dispersion was centrifuged at 4000 × *g* for 20 min. Supernatant was filtered (Whatman No. 1) and transferred into a Waring blender and whipped for 2 min at high-speed (Hi-20,800 rpm) The solution was poured into a measuring cylinder, and the volume of the foam was recorded after 10 sec. The foaming capacity was expressed as the volume (ml) of gas incorporated per mL of solution. The foam stability was recorded as the time (min) passed until the half of the original foam volume (ml) had disappeared (Hayta et al., 2002).

Emulsifying activity

Ten grams of tarhana powder were dispersed in 25 ml distilled water at 25°C and stirred for 20 min and then the solution was centrifuged at 4000 × *g* for 20 min. Sunflower oil were mixed with equal volumes of supernatant and homogenized for 5 min at low-speed (Low-15,800 rpm) in a Waring blender. The homogenized mixture was transferred into a measuring cylinder. The emulsifying activity was expressed as percent volume of the emulsified layer in total volume of the mixture (Hayta et al., 2002).

Color measurement

A colorimeter (Minolta Chroma Meter CR-400, Minolta, Osaka, Japan) was used to determine the Hunter lab colours by measuring *L** (100=white; 0=black), *a** (+, red; -, green) and *b** (+, yellow; -, blue). The instrument was calibrated with illuminate D65 as reference before the measurements.

Sensory analyses

Tarhana soups, prepared from tarhana powders were subjected to sensory evaluation. To determine the sensory properties of tarhana soup, 25 g tarhana powder (dry basis) was mixed with 250 ml water (10°C) and simmered for 10 min with constant stirring. Tarhana were evaluated by 25 panelists (14 men and 11 women). The soups were filled to porcelain bowl at 50°C and served to panelists under daylight room conditions. Colour, taste, stickiness, sourness, grittiness and overall acceptability of tarhana soup were evaluated using 9 point hedonic scale with “1” being “dislike extremely”, “2” being “dislike very much”, “3” being “dislike moderately”, “4” being “ dislike slightly”, “5” being “neither like or nor dislike”, “6” being “like slightly”, “7” being “like moderately”, “8” being “like very much” and “9” being “like extremely”.

Statistical analyses

The data obtained in the present study were subjected to analysis of variance (ANOVA) using the software of Statistical Package for the Social Sciences–SPSS 15.0 (2006, SPSS Inc., USA). The mean values were compared using Tukey HSD Post Hoc Test (P<0.05). All experiments were performed in triplicate.

Results and discussion

The moisture, ash and protein contents of flour samples are presented in Table 1. Although, no significant difference in the moisture content was found between WHF, LPF, CPF, CBF and BWF, a slight decrease was observed between LPF, CBF and BWF when compared to WHF descriptively. However, CRF had the highest moisture content among the flours. The ash contents of the samples were found to be between 0.54–4.11 g/100g. No significant difference in the ash content was found between LPF, RCF and BWF. While WHF had the lowest ash content (0.54 g/100g), CBF had the highest ash content (4.11 g/100g) among the samples (Table 1). Brigide et al (2014) reported that common bean showed an ash content ranging from 4.1 to 4.82%. Our findings in line with the observations realized by Türksoy (2018) who indicated that CBF (3.90 g/100g) had the higher ash content than WHF (0.60 g/100g). De Almeida Costa et al. (2006) found that the ash content of CBF was 3.80 g/100g in their study. The protein contents of flours ranged from 9.35 to 34.83 g/100g. LPF had the highest protein content when compared with the other flours used in this study.

Table 1. Proximate composition of cereal and non-cereal flours used in tarhana production

Çizelge 1. Tarhana üretiminde kullanılan unların yaklaşık bileşimleri

	Moisture (g/100g) *Nem*	Ash (g/100g) *Kül*	Protein* (g/100g) *Protein*
WHF *BU*	9.95 ± 0.12^{cd}	0.54 ± 0.04^{e}	10.72 ± 0.14^{d}
CRF *MU*	14.68 ± 0.41^{a}	1.26 ± 0.08^{d}	10.31 ± 0.05^{d}
LPF *LU*	9.37 ± 0.03^{d}	2.02 ± 0.09^{c}	34.83 ± 0.04^{a}
CPF *NU*	10.26 ± 0.08^{c}	2.51 ± 0.13^{b}	18.03 ± 0.11^{b}
CBF *FU*	9.87 ± 0.21^{cd}	4.11 ± 0.24^{a}	17.67 ± 0.19^{b}
RCF *PU*	11.22 ± 0.09^{b}	1.64 ± 0.03^{cd}	9.35 ± 0.52^{e}
BWF *KU*	9.56 ± 0.08^{d}	1.97 ± 0.04^{c}	12.54 ± 0.41^{c}

Data are expressed as mean values ± standard deviations (n=2); mean values within the same column with different superscripts are significantly different (P<0.05); the letter ‘‘a’’ denotes the highest value. WHF: wheat flour (as control sample); CRF: corn flour; LPF: lupin flour; CPF: chickpea flour; CBF: common bean flour; RCF: rice flour; BWF: buckwheat flour.

*N × 5.70 for cereal flours; N × 6.25 for non-cereal flours.

Çizelgedeki değerler analizlerde elde edilen sonuçların ortalama değerleridir; analizi yapılan örnek sayısı 2’dir (n=2); aynı sütundaki farklı üst indis harfler sonuçlar arasında istatistiksel bakımdan fark olduğunu göstermektedir (P<0.05); “a” harfi en yüksek değeri ifade etmektedir. BU: buğday unu (kontrol örneği); MU: mısır unu; LU: lupin unu; NU: nohut unu; FU: fasulye unu; PU: pirinç unu; KU: karabuğday unu.

*N × 5.70 tahıl unları için; N × 6.25 tahıl olmayan unlar için.

The protein content of the tarhana is increased when a legume flour substituted with the wheat flour. Because legume flours have higher protein content compared to wheat flour. Besides, mixing of the legumes and cereals ensure the better combination which provides maximum benefit from the essential amino acids (Zucco et al., 2011). Paraskevopoulou et al. (2010) stated that legumes can be successfully incorporated into the baked products for enrichment in regard to protein composition. Han et al. (2010) studied about the developing of gluten-free cracker by incorporation of chickpea flour, and they reported that the cracker containing chickpea flour was advanced to a trading scale processing test.

The chemical properties of the tarhana samples are presented in Table 2. The moisture content of CRT, LPT, CPT, CBT was found to be significantly ($P<0.05$) higher than the control sample (WHT). No significant difference was found in the moisture contents among WHT, RCT and BWT samples. As seen from the Table 2, CBT has the highest ash content (4.74 g/100g) among the samples. This finding was probably due to the high ash content of CBF (Table 1). Even though, no significant differences in ash contents were observed among WHT, CRT and RCT, the ash contents of CRT and RCT were found to be slightly lower than WHT. We found that the protein content of CRT, LPT, CPT, CBT and BWT were significantly higher than WHT and RCT. The peak value of protein content was observed in LPT. This is an expected finding, because the LPF has the highest protein content among the flour samples.

RCT had the lowest protein content among tarhana samples. Herken and Aydın (2015) found that use of carob flour in the production of tarhana samples caused an increase in ash content and a decrease in protein content. They stated that statistically significant increase was determined in ash content with the increasing substitution level of carob flour. In a previous study, Daglioğlu (2000) stated that moisture, protein and ash contents of different types of tarhana were varied between 6.4-13.9% (w/w), 12.0-29.9% (w/w) and 1.4-14.2% (w/w), respectively. It is clearly observed that the moisture, protein and ash contents of tarhana were effected the substitution of different types of flour in tarhana formulation.

The mineral contens of tarhana samples are given in Table 2. There is a significant differences ($P<0.05$) found in Ca, Fe, K, Mg, Mn, P and Zn contents of tarhana samples. In general tarhana is known its high nutritional value and is considered to be a good source of calcium, iron, sodium, potassium, magnesium, zinc and copper minerals. But using lupine, common bean and chickpea flour in tarhana formulation gave higher Ca content; than control tarhana sample. WHT and BWT samples gave similar Ca contents. The peak value of the Ca content was found in LPT sample. Additionally, CBT has the second highest Ca content among the tarhana samples. The highest and the second highest Fe contents were found in CPT and WHT samples, respectively. The Fe contents of the other tarhana samples were found to be lower than CPT and WHT, and varied between 0.09-0.74 mg/100g. The K contents of tarhana samples were found to be significantly different from each other and ranged between 247.60-1406.10 mg/100g. The highest K content was determined in CBT and the lowest K content was found in LPT sample. In comparison with the use of WHF, the use of CRF, LPF, CPF, CBF and BWF significantly increased the Mg content of tarhana. However, we found that no significant difference between Mg contents of WHT and RCT. The very significant increase in Mg content of tarhana was found with the use of BWF. It was reported that the substitution of buckwheat flour with wheat flour in tarhana formulation increased ash, protein, fat, cellulose, K, Mg and P contents (Bilgiçli, 2009). The remarkable finding in our study was related with Mn content of tarhana samples. The Mn content of LPT had very high value (48.77 mg/100g) compared to the other tarhana samples. The Mn contents of tarhana samples except LPT sample were found to be between 0.12-1.20 mg/100g.

Table 2. Certain chemical properties of tarhana produced using cereal and non-cereal flours
Çizelge 2. Tarhana üretiminde kullanılan unların bazı kimyasal özellikleri

	Moisture (g/100g) *Nem*	Ash (g/100g) *Kül*	Protein* (g/100g) *Protein*	Ca (mg/100g) *Ca*	Fe (mg/100g) *Fe*	K (mg/100g) *K*	Mg (mg/100g) *Mg*	Mn (mg/100g) *Mn*	P (mg/100g) *P*	Zn (mg/100g) *Zn*
WHT *BT*	6.70 ± 0.06^{c}	2.01 ± 0.11^{d}	16.01 ± 0.04^{f}	39.71 ± 0.30^{d}	1.74 ± 0.07^{b}	360.90 ± 1.12^{e}	36.01 ± 0.88^{f}	0.44 ± 0.01^{d}	210.93 ± 2.81^{d}	0.55 ± 0.03^{d}
CRT *MT*	7.76 ± 0.04^{b}	1.87 ± 0.03^{d}	22.75 ± 0.11^{c}	26.82 ± 1.02^{f}	0.09 ± 0.01^{e}	384.00 ± 1.74^{d}	41.11 ± 0.91^{e}	0.12 ± 0.03^{e}	196.94 ± 2.35^{e}	0.58 ± 0.06^{d}
LPT *LT*	8.47 ± 0.08^{a}	2.92 ± 0.14^{c}	35.04 ± 0.17^{a}	215.88 ± 0.72^{a}	0.55 ± 0.10^{cd}	247.60 ± 2.62^{g}	67.93 ± 1.19^{d}	48.77 ± 0.08^{a}	391.68 ± 2.45^{ab}	2.35 ± 0.04^{a}
CPT *NT*	8.32 ± 0.03^{a}	3.55 ± 0.18^{b}	27.91 ± 0.13^{b}	87.86 ± 0.75^{c}	3.17 ± 0.11^{a}	1044.90 ± 2.28^{b}	96.44 ± 1.30^{c}	1.20 ± 0.03^{b}	306.77 ± 2.40^{c}	1.15 ± 0.06^{c}
CBT *FT*	7.95 ± 0.07^{b}	4.74 ± 0.03^{a}	21.83 ± 0.06^{d}	126.93 ± 0.88^{b}	0.74 ± 0.08^{c}	1406.10 ± 2.26^{a}	117.89 ± 1.07^{b}	0.89 ± 0.06^{c}	385.30 ± 3.03^{b}	1.52 ± 0.01^{b}
RCT *PT*	6.78 ± 0.04^{c}	1.71 ± 0.17^{d}	10.64 ± 0.04^{g}	33.68 ± 0.69^{e}	0.12 ± 0.01^{e}	315.00 ± 1.73^{f}	33.41 ± 0.96^{f}	0.50 ± 0.04^{d}	208.64 ± 2.35^{d}	0.77 ± 0.06^{d}
BWT *KT*	6.81 ± 0.10^{c}	3.00 ± 0.04^{c}	17.23 ± 0.30^{e}	41.68 ± 0.91^{d}	0.35 ± 0.11^{de}	622.70 ± 2.25^{c}	128.52 ± 1.27^{a}	0.94 ± 0.03^{c}	396.98 ± 2.31^{a}	1.23 ± 0.08^{c}

Data are expressed as mean values ± standard deviations (n=2); mean values within the same column with different superscripts are significantly different (P<0.05); the letter ''a'' denotes the highest value. WHT: wheat tarhana (as control sample); CRT: corn tarhana; LPT: lupin tarhana; CPT: chickpea tarhana; CBT: common bean tarhana; RCT: rice tarhana; BWT: buckwheat tarhana.
*, N × 5.70 for cereal flours; N × 6.25 for non-cereal flours.

Çizelgedeki değerler analizlerde elde edilen sonuçların ortalama değerleridir; analizi yapılan örnek sayısı 2'dir (n=2); aynı sütundaki farklı üst indis harfler sonuçlar arasında istatistiksel bakımdan fark olduğunu göstermektedir (P<0.05); "a" harfi en yüksek değeri ifade etmektedir. BT: buğday unu ile üretilen tarhana (kontrol örneği); MT: mısır unu ile üretilen tarhana; LT: lupin unu ile üretilen tarhana; NT: nohut unu ile üretilen tarhana; FT: fasulye unu ile üretilen tarhana; PT: pirinç unu ile üretilen tarhana; KT: karabuğday unu ile üretilen tarhana.
**, N × 5.70 tahıl unları için; N × 6.25 tahıl olmayan unlar için.*

Yorgancilar et al. (2009) stated that lupin has higher Mn content and they found that the Mn content of lupin was 111,38 mg/100g. Therefore, in our study, the addition of lupin flour caused an increase in Mn content of tarhana between all the samples tested. It was observed that the P contents of LPT, CBT and BWT were found to be significantly higher than other tarhana samples. The LPT has the highest Zn content (2.35 mg/100g) among the tarhana samples. The Zn contents of the other tarhana samples were found to be varied between 0.55-1.52 mg/100g. Trugo et al. (2016) stated that lupin seed was a good source of Zn with values in the range 3.0–18.0 mg/100g. It is possible to say that the substitution of different types of flour in tarhana enhanced the mineral content of all the tarhana samples tested. However, CF and RF substitution of tarhana did not caused a noticeably increase as compared to other tarhana samples. The Recommended Daily Allowances (RDA) are 130 mg of magnesium, 800 mg of calcium, 1.5 g of manganese, 500 mg of phosphorus and 5 mg of zinc for 4-8 years old children (RDA, 2018). When 100g (dry matter) of tarhana containing 100% lupin flour is consumed, 52.25% of RDA for Mg, 26.98% of RDA for Ca, 3.25% of RDA for Mn, 78.33% of RDA for P, and 47% of RDA for Zn were taken by the children body.

Drying methods, fermentation, storage, drying temperatures, drying time, drying type and different tarhana ingredients have important effect on the functional properties of tarhana (Bayrakçı and Bilgiçli, 2015). It was reported that poor functional properties of food ingredients was related to its low solubility in aqueous systems (Wu, 2001). Table 3 represents the certain functional properties (foaming capacity, foaming stability, water absorption capacity, oil absorption capacity and emulsifying activity) and the colour values (L*, a*, b*) of tarhana samples. According to Table 3, we can state that the use of LPF in tarhana production exhibits higher values for foaming capacity, water absorption capacity, oil absorption capacity and emulsifying activity. This finding was mostly due to the higher protein content of LPF. Kohajdova et al. (2011) reported that the addition of LPF up to 10% (w/w) caused an important increase in water absorption capacity. Sosulski et al. (1976) , Hayta et al. (2002), and Ertaş et al., (2014) reported that water absorption capacity had crucial effects on the functional properties of viscous foods. Alamanou and Doxastakis (1995), Dervas et al. (1999), Hojilla Evangelista et al. (2004) stated that lupin protein has good water absorption, fat binding, emulsifying and foaming capacity.

According to process design, sensory quality and consumer acceptability functional properties are important parameters. In the present study, it is observed that the peak value of foaming stability was found in RCT (5.28 min), followed by CRT (4.28 min) and WHT (3.18 min), however, the foaming stability values of the rest of tarhana samples were varied between 0.40-1.23 min. Hamada (2000) stated that the foaming properties of rice protein are similar to albumin from egg white. However, in contrast to our finding, Bilgiçli (2009) reported that the substitution of 100% BWF with the wheat flour caused a significant increase in foaming stability of tarhana. Low foaming formation probably due to the having inadequate balance between hydrophobicity and hydrophilicity as stated by Damadoran (1997). In a previous study of İbanoğlu and İbanoğlu (1999), foaming stability and foaming capacity of tarhana were affected by the tarhana concentration, whipping time and processing methods.

Bolontrade et al. (2016) reported that the foams prepared at acidic pH were stable than the alkaline pH and also reported that soluble fractions of protein showed grater stability than the total protein.

Table 3. Color values and certain functional properties of tarhana produced using cereal and non-cereal flours
Çizelge 3. Tarhana üretiminde kullanılan unların bazı fonksiyonel özellikleri ve renk değerleri

	Functional properties *Fonksiyonel özellikler*					Colour values *Renk değerleri*		
	Foaming capacity (mL mL^{-1}) *Köpük oluşturma kapasitesi*	Foaming stability (min) *Köpük stabilitesi (dk)*	Water absorption capacity (mL g^{-1}) *Su tutma kapasitesi*	Oil absorption capacity (mL g^{-1}) *Yağ tutma kapasitesi*	Emulsifying activity (%) *Emülsiyon aktivitesi*	L*	a*	b*
WHT *BT*	0.37 ± 0.01^{d}	3.18 ± 0.07^{c}	0.92 ± 0.05^{d}	0.63 ± 0.04^{abc}	100 ± 0.00^{a}	81.35 ± 0.33^{c}	6.17 ± 0.51^{c}	31.14 ± 0.61^{b}
CRT *MT*	0.46 ± 0.02^{c}	4.28 ± 0.14^{b}	1.28 ± 0.07^{c}	1.00 ± 0.00^{a}	99 ± 1.41^{a}	85.67 ± 0.21^{a}	1.60 ± 0.34^{f}	28.36 ± 0.27^{c}
LPT *LT*	1.02 ± 0.01^{a}	0.90 ± 0.07^{d}	2.67 ± 0.04^{a}	0.93 ± 0.11^{ab}	100 ± 0.00^{a}	81.15 ± 0.45^{c}	2.92 ± 0.45^{e}	20.11 ± 0.06^{d}
CPT *NT*	0.29 ± 0.03^{e}	1.23 ± 0.06^{d}	1.48 ± 0.01^{c}	0.63 ± 0.09^{abc}	99.5 ± 0.71^{a}	81.01 ± 0.40^{c}	4.28 ± 0.24^{d}	28.71 ± 0.35^{c}
CBT *FT*	0.58 ± 0.02^{b}	0.40 ± 0.10^{e}	1.82 ± 0.01^{b}	0.50 ± 0.14^{c}	74.5 ± 0.71^{c}	73.55 ± 0.52^{d}	8.06 ± 0.16^{b}	31.57 ± 0.45^{b}
RCT *PT*	0.28 ± 0.01^{ef}	5.28 ± 0.11^{a}	1.29 ± 0.05^{c}	0.70 ± 0.14^{abc}	93 ± 1.41^{b}	83.62 ± 0.21^{b}	6.71 ± 0.45^{c}	33.41 ± 0.06^{a}
BWT *KT*	0.22 ± 0.01^{f}	1.21 ± 0.08^{d}	2.00 ± 0.16^{b}	0.52 ± 0.11^{bc}	91 ± 1.41^{b}	67.03 ± 0.45^{e}	9.97 ± 0.34^{a}	31.70 ± 0.27^{b}

Data are expressed as mean values ± standard deviations (n=2); mean values within the same column with different superscripts are significantly different (P<0.05); the letter ‘‘a’’ denotes the highest value. L*: lightness; +a*: redness; -a*: greenness; +b*: yellowness; -b*: blueness. WHT: wheat tarhana (as control sample); CRT: corn tarhana; LPT: lupin tarhana; CPT: chickpea tarhana; CBT: common bean tarhana; RCT: rice tarhana; BWT: buckwheat tarhana.

Çizelgedeki değerler analizlerde elde edilen sonuçların ortalama değerleridir; analizi yapılan örnek sayısı 2’dir (n=2); aynı sütundaki farklı üst indis harfler sonuçlar arasında istatistiksel bakımdan fark olduğunu göstermektedir (P<0.05); “a” harfi en yüksek değeri ifade etmektedir. L: aydınlık derecesi; +a*: kırmızılık; -a*: yeşillik; +b*: sarılık; -b*: mavilik. BT: buğday unu ile üretilen tarhana (kontrol örneği); MT: mısır unu ile üretilen tarhana; LT: lupin unu ile üretilen tarhana; NT: nohut unu ile üretilen tarhana; FT: fasulye unu ile üretilen tarhana; PT: pirinç unu ile üretilen tarhana; KT: karabuğday unu ile üretilen tarhana.*

In the present study, the foaming capacity of CRT, LPT and CBT were found significantly higher than control sample (WHT). According to Cherry and McWatters (1981), this phenomena most probably results from the higher protein content and protein molecules at the interface (İbanoğlu and İbanoğlu, 1997). We determined that water absorption capacity values of CRT, LPT, CPT, CBT, RCT and BWT were found to be higher than that of WHT (P<0.05). We found that the oil absorption capacity values of tarhana samples ranged between 0.52-1.00 mL/g, and the peak values of oil absorption capacity values were found in CRT (1.00 mL/g) and LPT (0.93 mL/g), respectively. Kohajdova et al. (2011) reported that the addition of LPF up to 10% (w/w) caused an important increase in water absorption capacity. Sosulski et al. (1976), Hayta et al. (2002), and Ertaş et al. (2014) reported that water absorption capacity had crucial effects on the functional properties of viscous foods. The use of CBF and BWF caused a decrease in the oil absorption capacity compared to the control sample. Bayrakçı and Bilgiçli (2015) reported that oil absorption capacity was not affected negatively by the substitution of resistant starch into the tarhana formulation. Moreover, oil absorption capacity values of tarhana samples containing different ratio of resistant starch were similar or higher compared to the control tarhana. In our study, we determined the emulsifying activity values of WHT, CRT, LPT and CPT were varied between 99-100% with no significant difference (P<0.05). Similarly, no significant difference was found in emulsifying activity values of RCT (93%) and BWT (91%). The lowest value of emulsifying activity was determined in CBT (74.5%) among the tarhana samples. Additionally, emulsifying activity values of RCT, BWT and CBT were found to be significantly lower than those of WHT, CRT, LPT, CPT (P<0.05). These findings could be explained by the high ionic strength of CBT as similar to a previous study by Wu (2001), who reported that high ionic strength reduced the emulsifiying activity. Ertaş et al. (2014) found that different ratio of lupin yoghurt (made with lupin milk) substitution into tarhana caused an increase in the emulsifying activities of tarhana samples. Çağlar et al. (2013) found that the substitution of carob flour increased the emulsifying activity of the tarhana.

Colour is an important quality factor for the acceptance of tarhana by the consumer. Traditionally, there are many types of tarhana produced with the substitutuion of various ingredients in Turkey. Owing to the different cereals, legumes, dairy products, vegetables and seasoning in dough formulation, tarhana samples have a great variety of colour properties (Bayrakçı and Bilgiçli, 2015). The colour values of the tarhana samples are given in Table 5, and they were expressed by Hunter L*, a*, b* values corresponding to lightness, redness and yellowness, respectively.

In our study, we found that L* value of CRT was higher than other tarhana samples (P<0.05). The second highest L* value was observed in RCT. No significant differences were observed in L* values among WHT, LPT and CPT. In our study, BWT had the lowest L* value among tarhana samples. Bilgiçli (2009) reported that the increasing substitution level of buckwheat flour with the wheat flour caused a significant decrease in L* value.

Considering the a* value, we can state that the use of CRF, LPF and CPF in tarhana production caused a significant decrease in a* value compared to control tarhana (P<0.05). No significant difference was found in a* values between WHT and RCT. However, the use of CBF and BWF caused a significant increase in a* value of tarhana compared to control (P<0.05). It is well known that the colour of lupin flour is yellow. However, it is very interesting that the b* value of LPT sample was found to be lowest compared to other tarhana samples in our study.

Sensorial evaluation of tarhana samples is given in Figure 1. Different types of flours affected all sensorial properties of tarhana samples. Statistically significant differences (P<0.05) were observed in colour, taste, stickiness, sourness, grittiness and overall acceptability. All of the soups prepared with gluten-free flours and control (wheat tarhana) sample were comparable in terms of the sensorial properties. Using CPF and BWF in tarhana formulation gave higher colour scores tahan the other gluten-free flours. Panellist stated that CPF, CBF, RCF and BWF addition in tarhana formulation gave higher taste scores compared to the control sample. All gluten-free flours showed similar and higher stickiness scores than control. Panellists gave the lowest sourness scores to CRT added tarhana sample, also the highest grittiness scores to BWF added tarhana sample. When compared all sensorial properties evaluated by panelists, we clearly can state that the use of CPF, CBF, RCF and BWF in tarhana production showed better sensorial properties compared to other flours.

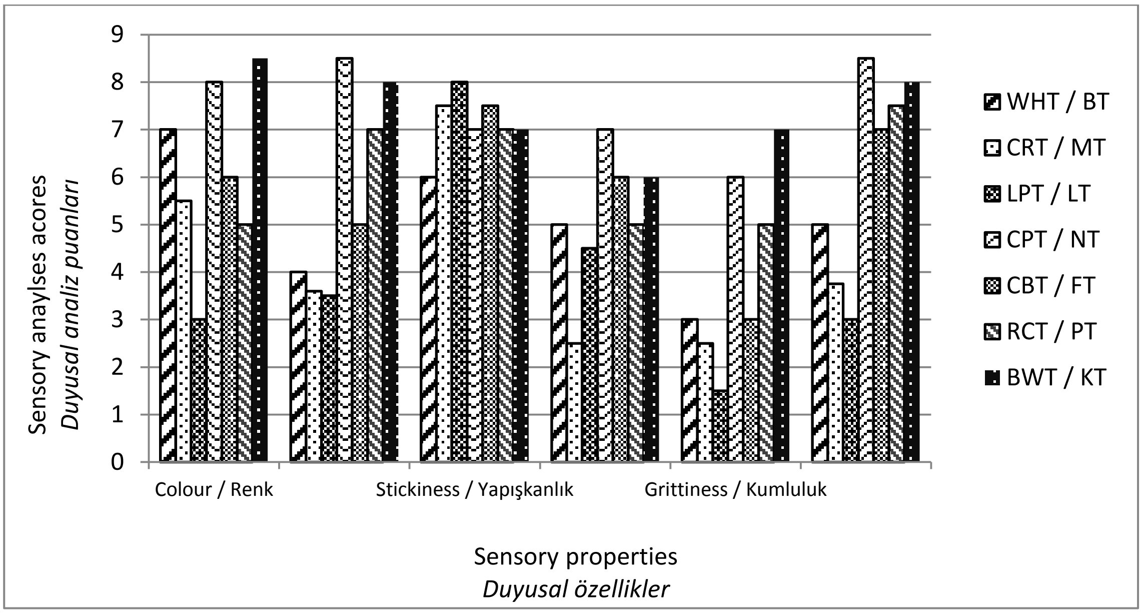

Figure 1. Sensorial properties of tarhana samples (WHT: wheat flour tarhana (as control sample); CRT: corn flour tarhana; LPT: lupin flour tarhana; CPT: chickpea flour tarhana; CBT: common bean flour tarhana; RCT: rice flour tarhana; BWT: buckwheat flour tarhana.

Şekil 1. Tarhana örneklerinin duyusal özellikleri (BT: buğday unu ile üretilen tarhana (kontrol örneği); MT: mısır unu ile üretilen tarhana; LT: lupin unu ile üretilen tarhana; NT: nohut unu ile üretilen tarhana; FT: fasulye unu ile üretilen tarhana; PT: pirinç unu ile üretilen tarhana; KT: karabuğday unu ile üretilen tarhana.

Conclusions

Wheat flour as the main ingredient is traditionally used in tarhana production. The people who suffer from celiac disease are obliged to consume gluten-free products. Therefore, there has been increasing interest in replacing common gluten-free formulations made from non-wheat flours. This study was organized to determine certain physical, chemical, functional and sensorial properties of tarhana containing gluten-free flours such as CRF, LPF, CPF, CBF, RCF and BWF.

In our study, the use of different cereal and non-cereal flours affected each of the chemical and functional properties of tarhana samples significantly. Our findings showed that the use of LPF, CPF, CBF and BWF (non-cereal flours) improved the chemical properties of tarhana when compared to the use of WHT, CRF and RCF (cereal flours). Using LPF improved the functional properties such as foaming capacity, water absorption capacity and emulsifying activity.

Since tarhana is a food product, of course its sensorial properties are very important from the standpoint of consumer acceptability. When we evaluate the results obtained from sensory analyses, the remarkable finding in this study that the use of CPF, CBF, RCF and BWF in tarhana production improved the overall acceptability scores of tarhana samples, but using LPF and CRF in tarhana formulation caused unfavourable effects in the final product.

Acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. However, we have written our manuscript by using a part of a bachelor dissertation. Additionally, our study was secured by patent by TÜRK PATENT (TURKISH PATENT AND TRADEMARK OFFICE). However, a registration number has not been given to the aforementioned patent by TÜRK PATENT, yet. The reference number of the patent: 2012/03914.

References

AACC, (2000). AACC Approved methods (10th ed.). American Association of Cereal Chemists International, St. Paul, MN.

Akoğlu, A., & Oruç, M. (2018). Metabolic food intolerances. *Harran Journal of Agricultural and Food Science*, *22*(2), 284-295.

Aktaş, N., & Özdoğan, Y. (2016). Food and nutrition literacy. *Harran Journal of Agricultural and Food Science*, *20*(2), 146-153.

Alamanou, S., & Doxastakis, G. (1995). Thermoreversible size selective swelling polymers as a means of purification and concentration of lupin seed proteins (Lupinus albus ssp. Graecus). *Food Hydrocolloids*, *9*(2), 103-109.

Bayrakçı, H.A., & Bilgiçli, N. (2015). Influence of resistant starches on chemical and functional properties of tarhana. *Journal of Food Science and Technology*, *52*(8), 5335-5340.

Bilgiçli, N. (2009). Effect of buckwheat flour on chemical and functional properties of tarhana. *LWT - Food Science and Technology*, *42*, 514-518.

Brigide, P., Canniatt-Brazaca, S.G., & Silva, M.O. (2014). Nutritional characteristics of biofortified common beans. *Food Science and Technology Campinas*, *34*(3), 493-500.

Bolontrade, A.J., Scilingo, A.A., & Añón, M.C. (2016). Amaranth proteins foaming properties: Film rheology and foam stability - Part 2. *Colloids and Surfaces B: Biointerfaces*, *141*, 643-650.

Bubert, H., & Hagenah, W.D. (1987). Detection and measurement: Inductively coupled plasma emission spectroscopy. New York, Wiley-Interscience Publication.

Cherry, J. P., & McWatters, K. H. (1981). Whippability and aeration. In *Protein Functionality in Foods*, ed. J. P. Cherry, Vol. *147*, pp. 149–176. ACS Symposium Series. American Chemical Society, New York.

Çağlar, A., Erol, N., & Elgün, M.S. (2013). Effect of carob flour substitution on chemical and functional properties of tarhana. *Journal of Food Processes and Preservation*, *37(*5), 670-675.

Costantini, L., Lukšič, L., Molinari, R., Kreft, I., Bonafaccia, G., Manzi, L., & Merendino, N. (2014). Development of gluten-free bread using tartary buckwheat and chia flour rich in flavonoids and omega-3 fatty acids as ingredients. *Food Chemistry, 165*, 232-240.

Daglioğlu, O. (2000). Tarhana as a traditional Turkish fermented cereal food. Its recipe, production and composition. *Nahrung*, *44*(2), 85-88.

Damodaran, S. (1997). Food Proteins: An Overview: Food Proteins and Their Applications. USA, CRC Press.

De Almeida Costa, G.E., da Silva Queiroz-Monici, K., Pissini Machado Reis, S.M., & de Oliveira, A.C. (2006). Chemical composition, dietary fibre and resistant starch contents of raw and cooked pea, common bean, chickpea and lentil legumes. *Food Chemistry*, *94*, 327-330.

Değirmencioğlu, N., Gürbüz, O., Herken, E.N., & Yıldız, A.Y. (2016). The impact of drying techniques on phenolic compound, total phenolic content and antioxidant capacity of oat flour tarhana. *Food Chemistry*, *194*, 587-594.

Dervas, G., Doxastakis, G., Hadjisavva-Zinoviadi, S., & Trianta, N. (1999). Lupin flour addition to wheat flour doughs and effect on rheological properties. *Food Chemistry*, *66*, 67-73.

Erbaş, M., Certel, M., & Uslu, M.K. (2005). Microbiological and chemical properties of tarhana during fermentation and storage as wet–sensorial properties of Tarhana soup. *LWT - Food Science and Technology*, *38*, 409-416.

Erkan, H., Çelik, S., Bilgi, B., & Köksel, H. A. (2006). A new approach for the utilization of barley in food products: Barley tarhana. *Food Chemistry*, *97*(1), 12-18.

Ertaş, N., Bilgiçli, N., Özcan, S., & Sarı, Ş. (2014). Influence of lupin (Lupinus albus L.) yoghurt on mineral content and functional properties of tarhana. *Quality Assurance of Safety Crops and Food, 6*(4), 395-401.

Hamada, J.S. (2000). Characterization and functional properties of rice bran proteins modified by commercial exoproteases and endoproteases. *Journal of Food Science*, *65*(2), 305-310.

Han, J., Janz, J.A.M., & Gerlat, M. (2010). Development of gluten-free cracker snacks using pulse flours and fractions. *Food Research International*, *43*(2), 627-633.

Hayta, M., Alpaslan, M., & Baysal, A. (2002). Effect of drying methods on functional properties of tarhana: a wheat flour-yogurt mixture. *Journal of Food Science*, *67*(2), 740-744.

Herken, E.N., & Aydin, N. (2015). Use of carob flour in the production of tarhana. *Polish Journal Of Food And Nutrition Sciences*, *65*(3), 167-174.

Hirawan, R., Ser, W.Y., Arntfield, S.D., & Beta, T. (2010). Antioxidant properties of commercial, regular- and whole-wheat spaghetti. *Food Chemistry*, *119*(1), 258-264.

Hojilla-Evangelista, M.P., Sessa, D.J., & Mohamed, A. (2004). Functional properties of soybean and lupin protein concentrates produced by ultrafiltration-diafiltration. *Journal of American Oil Chemical Society*, *81*(12), 1153-1157.

İbanoğlu, Ş., & İbanoğlu, E. (1997). The effect of heat treatment on the foaming properties of tarhana, a traditional Turkish cereal food. *Food Research International*, *30*(10), 799-802.

İbanoğlu, Ş., & İbanoğlu, E. (1999). Rheological properties of cooked tarhana, a cereal-based soup. *Food Research International*, *32*(1), 29-33.

Kohajdová, Z., Karovičová, J., & Schmidt, Š. (2011). Lupin composition and possible use in bakery - A review. *Czech Journal of Food Science*, *29*(3), 203-211.

Masure, H.G., Fierens, E., & Delcour, J.A. (2016). Current and forward looking experimental approaches in gluten-free bread making research. *Journal of Cereal Science*, *67*, 92-111.

Mazzeo, M.F., Bonavta, R., Maurano, F., Bergamo, P., Siciliano, R.A., & Rossi, M. (2013). Biochemical modifications of gliadins induced by microbial transglutaminase on wheat flour. *Biochimica et Biophysica Acta*, *1830*, 5166-5174.

Paraskevopoulou, A., Provatidou, E., Tsotsiou, D., & Kiosseoglou, V. (2010). Dough rheology and baking performance of wheat flour-lupin protein isolate blends. *Food Research International*, *43*(4), 1009-1016.

Recommended Daily Allowances: RDA Chart | RDA Table. http://www.healthsupplementsnutritionalguide.com/recommended-daily-allowances/ Accessed 23 January 2018.

Renzetti, S., & Arendt, E.K. (2009). Effects of oxidase and protease treatments on the breadmaking functionality of a range of gluten-free flours. *European Food Research and Technology*, *229*(2), 307-317.

Rewers, M. (2005). Epidemiology of Celiac Disease: What are the Prevalance, Incidence, and Progression of Celiac Disease? Gastroenterology, *128*, 47-51.

Sciarini, L.S., Ribotta, P.D., León, A.E., & Pérez, G.T. (2012). Incorporation of several additives into gluten free breads: Effect on dough properties and bread quality. *Journal of Food Engineering*, *111*(4), 590-597.

Sosulski, F., Humbert, E.S., Bui, K., & Jones, J.D. (1976). Functional properties of rapeseed flours, concentrates and isolate. *Journal of Food Science*, *41*(6), 1349-1352.

Tangüler, H. (2014). Traditional Turkish fermented cereal based products: Tarhana, boza and chickpea bread. *Turkish Journal of Agricultural and Food Science and Technology*, *2*(3), 144–149.

Tarakçı, Z., Dogan, I.S., & Koca, A.F. (2004). A traditional fermented Turkish soup, tarhana, formulated with corn flour and whey. *International Journal of Food Science and Technology*, *9*(4), 455-458.

Trugo, L.C., Von Baer, E., & Von Baer, D. (2016). Lupin Breeding. In: Smithers G (ed) Reference Module in Food Science, Elsevier, United Kingdom, *2*, 174-182.

Türksoy, S. (2018). Determination of chemical, functional and rheological properties of whole legume flours. *The Journal of Food, 43*(1), 78-89.

Üçok, G., Cankurtaran, T., & Demir, M.K. (2019). Usage of quinoa flour in traditional tarhana production. *Harran Journal of Agricultural and Food Science, 23*(1), 22-30.

Wu, Y.V. (2001). Emulsifying activity and emulsion stability of corn gluten meal. *Journal of Science of Food and Agriculture, 81*(13), 1223-1227.

Yorgancilar, M., Atalay, E., & Babaoğlu, M. (2009). Mineral content of debittered white lupin (Lupinus albus L.) seeds. *Selçuk Journal of Agriculture and Food Sciences*, *23*(50), 10-15.

Zucco, F., Borsuk, Y., & Arntfield, S.D. (2011). Physical and nutritional evaluation of wheat cookies supplemented with pulse flours of different particle sizes. *LWT - Food Science and Technology*, *44*(10), 2070-2076.