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Effect of Hazelnut Pulp Addition on Physical and Chemical Properties of Tarhana

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ABSTRACT

In this study, hazelnut pulp was added to tarhana to increase its nutritional value. For this purpose, hazelnut oil was partially extracted by cold pressing method and hazelnut pulp was added to the tarhana formulation at varying concentrations (5, 10, 15, 20, 25 and 30%). According to the research data, as the hazelnut pulp ratio increased, pH and acidity values, redness (a*) and yellowness (b*) color values of tarhana increased, while the brightness (L*) value decreased. It was determined that the addition of hazelnut pulp increased the foaming capacity and foam stability of tarhana and decreased the viscosity values. Depending on the increase in hazelnut pulp, the protein, fat and ash ratios, total phenolic substance and antioxidant activity of tarhana also increased.

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Fındık Posasının Tarhananın Fiziksel ve Kimyasal Özelliklerine Etkisi

ÖZET

Bu çalışmada, besin değerini artırmak amacıyla tarhanaya fındık posası ilave edilmiştir. Bu amaçla fındık yağı soğuk pres yöntemi ile kısmen alınmış ve fındık posası belirli oranlarda (%5, 10, 15, 20, 25 ve %30) tarhana formülasyonuna katılmıştır. Araştırma verilerine göre fındık posası oranı arttıkça tarhananın pH ve asitlik değerleri ile kırmızılık (a*) ve sarılık (b*) renk değerleri yükselmiş, parlaklık (L*) değeri ise düşmüştür. Fındık posası ilavesinin tarhananın köpürme kapasitesini ve köpük stabilitesini arttırdığı, viskozite değerlerini düşürdüğü tespit edilmiştir. Fındık posası artışına bağlı olarak tarhananın protein, yağ ve kül oranları ile toplam fenolik madde ve antioksidan aktivitesinde de artış meydana gelmiştir.

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INTRODUCTION

Tarhana is a traditional fermented product made by combining wheat flour, yogurt, yeast, and various vegetables such as paprika, tomatoes, mint, onion, and salt, followed by fermentation, drying, and grinding. Tarhana is known and consumed under different names in many countries of the world; "Kishk" in Syria, Lebanon, and Egypt, "kushuk" in Iraq, "tahonya, talkuna" in Hungary and Netherlands, "tarhana" in Greece and "atole" in Scotland. The word tarhana was first included in the words of Kıpcak Turks in the form of tarhana in Turkish words (Çakıroğlu, 2008) but also claimed to be originated from Hittite civilization (Güveloğlu, 2019). Until recently, tarhana was primarily produced in rural areas of Türkiye. With the migration of people from rural to urban areas, and the increased participation of women in the labor force, the demand for ready-to-eat foods has increased, and traditional tarhana has taken its place among other instant soups.

The composition of tarhana changes with different formulations and varies depending on its raw material, the materials used in its production, and the variability of the production methods. Tarhana, which is usually dried and powdered, is preserved wet in some regions without drying, and it is dried as chips and consumed as a snack in others. In a study conducted by some researchers, the effects of different drying techniques such as tunnel type drying, freeze drying, microwave drying, spray drying, and hot air drying were investigated (Şengün, 2006). Koca et al. (2002) evaluated tarhana samples consisting of cow milk yogurt, soymilk yogurt, and cow and soymilk yogurt mixture in terms of pH, viscosity, color, and sensory properties. They found that the samples with added soymilk had a higher viscosity than the samples with added cow milk yogurt. Bilgiçli (2004) examined the effect of yeast *(Saccharomyces cerevisiae*), malt flour, and phytase enzyme additive on some nutritional parameters of tarhana. The mineral content, phytic acid amount, and protein bioavailability of tarhana are found to be very high, and the natural fermentation process is sufficient in this regard. In the study conducted by Gokmen (2009), the effects of adding quince to tarhana were investigated and it was found that the use of raw quince in making tarhana is more accepted in terms of acceptability scores. Additionally, tarhana is a product that is fairly rich in terms of mineral and protein content. Tarakçı et al. (2013) investigated the effect of blackberry substitution on some functional and physicochemical properties of tarhana and concluded that there was a decrease in acidity, dry matter, water holding capacity, foaming capacity and foam stability in tarhana with the addition of blackberry. They determined that the viscosity decreased with the temperature increase for all samples. Hazelnut pulp is rich in protein, ash, and fat contents (Yağcı & Göğüş, 2008) hence it is expected that inclusion of hazelnut pulp in tarhana will enhance the nutritional and functional properties of tarhana. The goal of this study was to produce a new type of tarhana by incorporating cold-pressed hazelnut pulp and adding tarhana with nutritional, functional, aroma, and structural properties.

MATERIALS and METHODS

For the production of tarhana samples, wheat flour, yogurt, tomato paste, fresh yeast, mint, red pepper, tomato, salt and hazelnut samples were purchased from the market in Ordu city.

Production of Tarhana samples

Natural hazelnuts were first broken down and divided into smaller pieces in a food processor. In the cold pressed oil extraction machine, the hazelnut oil rate is reduced. In the study, 0%, 5%, 10%, 15%, 20%, 25%, and 30% Hazelnut pulps were added to tarhana samples. The formulation specified in Table 1 refers to the control group (0%). Tarhana varieties were produced in 3 replicates.

Tarhana samples used in the production of tarhana are shown in Table 1. While the hazelnut ratio increased in the product formulations, the ratio of the other inputs was kept constant. Before chopping the onions in the food processor, tomato paste, dried mint, red pepper, and salt were added, and a mixture was obtained. After the mixture was pre-baked, water was added and then cooked for a while. When the temperature of the obtained mixture decreased to 20°C, flour, yogurt, yeast, and hazelnuts were added. To ensure a homogeneous dough structure, the mixture was kneaded for 10 minutes. The prepared tarhana doughs were allowed to ferment for 30 hours at 30°C. Fermented tarhana doughs were cut into Hazelnut-sized pieces and placed on the drying tray. The fermented tarhana doughs were dried in a convection oven (Nucleon, NST-120, Ankara) at 52°C until the moisture content was 12%, ground, and pulverized.

Table 1. Standard Tarhana formulation
Çizelge 1. Standart Tarhana formülasyonu

Material	(%)	Amount (g)
Wheat Flour	50	500
Yogurt	25	250
Onion	12	120
Tomato paste	6	60
Salt	4	40
Fresh yeast	1	10
Red pepper	1	10
Dry mint	1	10

Tarhana analyses

Determination of dry matter; the drying cups were kept at 105oC for 1 hour, tared and 5 g of sample were weighed into the drying cups and then left to dry in the oven (Nucleon, NST-120, Ankara) at 105ºC until they reached a constant weight. Results are expressed in %.

Ash analyses; James's (1995) method was modified and porcelain crucibles 3 g of sample was weighed at 550±5℃ temperature until the formation of white color.

Color analyses; Color analysis of tarhana samples was performed with color measurement device (Minolta, CR-400, and Osaka, Japan).

Total fat analysis; Soxhelet extraction method was used to determine the fat content of the samples (James, 1995). The tarhana samples were boiled by distillation in the extraction apparatus (Velp Scientifica, SER 148, and Usmate, Italy).

The pH analysis; a 5 g tarhana dry sample was weighed into a beaker and the pH was measured with a digital pH meter to determine the pH (Mettler Toledo, Sevencompact S210) at 25°C (Ibanoğlu et al., 1995).

Titratable acidity analysis; titratable acidity was determined by adding 1% phenolphthalein to tarhana samples and titration with 0.1 N NaOH, and the results were determined in terms of lactic acid per 100 g sample (Ibanoğlu et al., 1999).

Protein analysis; The Kjeldahl method was used to determine the protein content (James, 1995).

Viscosity Analysis; 10 g of dry tarhana sample was weighed into a glass beaker and 150 ml of distilled water was added. The solution was cooked by stirring for 10 minutes, thereby gelatinizing the starch. The samples were poured into the sample cup of the viscometer (AND, SV-10, Tokyo, Japan) while hot (Tarakçı et al. 2013).

Water absorption capacity and oil absorption capacity; tarhana (5.0 g) was thoroughly mixed with distilled water (25 mL) or sunflower oil in 50-mL centrifuge tubes. Dispersions were stirred at 15 min intervals over a 60 min period and then centrifuged at 4000 × *G* for 20 min. Water and oil absorption capacity values were expressed as grams of water or oil absorbed per gram of tarhana (Hayta et al. 2002).

Foaming capacity and foam stability; tarhana (10 g) was dispersed in distilled water and stirred for 20 min. The mixture was centrifuged at 4000 × *G* for 20 min. The obtained supernatant was filtered (Whatman no. 1), where it was stirred for 2 minutes on high speed. The solution was slowly poured into a cylinder, and the volume of the foam was recorded after 10 s. Foaming capacity was expressed as the volume (mL) of gas incorporated per mL of solution. Foam stability was recorded as the time passed until half of the original foam volume had disappeared (Hayta et al. 2002).

Total phenolic analysis: the method used by Xu and Chang (2007) in the total phenolic content analysis was modified. After homogenizing 3 g of tarhana with 10 ml of water, it was placed in a 25°C water bath for 30 minutes. Samples were centrifuged at 4000 x *G* for 10 min and filtered (Whatman no.1). After adding 300µl of the filtrate into the tubes, 4300µl of water and 100 µl of Folin Ciocalteu reagent were added and waited for 2 minutes. Then 300 µl 7.5% (w/v) Na_2CO_3 solution was added to the samples. The samples were vortexed and kept in the dark for 2 hours. The absorbance of the solutions was read at 760 nm by a spectrophotometer (UV-VIS Shimadzu UV mini-1240).

Antioxidant analysis; for the antioxidant activity analysis of tarhana samples, the method used by Demirkol and Tarakçı (2018) was modified. Three grams of tarhana samples were homogenized with 10 mL of methanol and then placed in a water bath of 25°C for 30 minutes. Samples that were centrifuged at 4000 rpm for 20 min were filtered through Whatman No.1 filter paper. DPPH (1, 1-Diphenyl-2-picrylhydrazyl radical) reagent was added to 1000 µl of the obtained filtrate. At the end of the period, absorbance values of the samples were measured with spectrophotometer at 515 nm wavelength.

Statistical Analysis

One-way ANOVA method was used with Minitab 18 package program for statistical analysis of the data of the analysis results of tarhana samples with hazelnut addition. Tukey multiple comparison test was used to compare the samples, which were found to be significant as a result of variance analysis.

RESULTS and DISCUSSION

The pH values changes in Tarhana Samples

Tarhana fermentation is performed by lactic acid bacteria (LAB) (*Streptococcus thermophilus*, *Lactobacillus bulgaricus*) coming from yogurt and bread yeast (*Saccharomyces cerevisiae*), which ensure the tarhana its characteristic aroma, acidic taste, and yeast flavor (Daglıoglu, 2000; Bilgiçli and Ibanoglu, 2007). In addition to *Streptococcus thermophilus* and *Lactobacillus bulgaricus* during the fermentation of tarhana, it also reported the presence of *L Lactobacillus casei, L Lactobacillus plantarum,* and *Lactobacillus brevis* in the product (Özbilgin, 1983). As a result, the metabolites produced reduce the pH of tarhana and extend its shelf life (Koca & Tarakçı, 1997). There are significant differences between the samples when the effect of hazelnut ratio on pH is investigated. The average pH value increased as the hazelnut rate increased and the lowest pH value was determined in control tarhana with 4.77±0.11, while the highest pH value was found with 5.13±0.16 and 30% hazelnut pulp (Table 3). The effect of hazelnut ratio on the pH value of tarhana were found statistically significant ($p<0.05$). In their study on the acceptability of tarhana, Ibanoglu et al. (1995) found that the pH value of tarhana varied between 4.3-4.8. Temiz et al. (1991) reported that the pH of the tarhana made by changing the type and amount of yoghurt was between 4.0-4.3. Bilgiçli et al. (2006) stated that the final pH of the samples increased as the amount of wheat seeds and bran added to the samples increased in the measurements made in tarhana containing wheat germ and bran.

Titratable Acidity Changes in Tarhana Samples

Yeast and lactic acid bacteria used in the production of tarhana soup are responsible for acid formation during fermentation. In our research, the acidity values of tarhana samples were observed in the control samples at the lowest hours at 0.46% and at the 0th hour, and the highest acidity values were found in the samples that used 30% hazelnut pulp (Table 2). Lactic acid bacteria and yeasts (*S. cerevisiae*) explain it by converting sugars into various organic acids (Erdoğrul & Erbilir 2006; Çelik et al., 2005). The titratable acidity value increased as the hazelnut rate increased, and the lowest acidity value was determined in control When the effect of hazelnut rate on acidity is investigated, there are significant differences between the rates ($p<0.05$). This can be explained by the fact that the free fatty acids formed by hydrolysis of the oil contained in hazelnut pulp, increase the acidity of hazelnut pulp tarhana. Bilgiçli (2009) reported that the addition of buckwheat increased tarhana acidity in his study. Ertaş et al. (2009) stated that the acidity value decreased in tarhana produced by using whey instead of yogurt. Bilgiçli et al. (2005) stated that the addition of wheat germ and bran has higher titratable acidity values compared to the control tarhana sample.

Table 2. The pH, titratable acidity and color values of tarhana samples*
Çizelge 2. Tarhana örneklerinde pH, titre edilebilir asitlik ve renk değerleri

Samples	pH	Titratable acidity	*L**	*a**	*b**
FK	4.77±0.11^{g}	0.58±0.09^{g}	56.35±0.03^{a}	-1.23±0.11^{d}	30.73±0.46^{e}
F5	4.83±0.12^{f}	0.60±0.08^{f}	55.93±0.02^{b}	0.90±0.06^{c}	31.98±0.03^{d}
F10	4.90±0.13^{e}	0.63±0.09^{e}	54.71±0.02^{c}	1.45±0.04^{b}	32.20±0.10^{d}
F15	4.98±0.12^{d}	0.66±0.11^{d}	50.71±0.08^{d}	1.50±0.02^{b}	32.86±0.04^{c}
F20	5.02±0.13^{c}	0.69±0.11^{c}	49.73±0.05^{e}	1.55±0.02^{b}	33.68±0.04^{b}
F25	5.06±0.14^{b}	0.71±0.12^{b}	49.36±0.08^{f}	1.99±0.01^{a}	33.90±0.02^{b}
F30	5.13±0.16^{a}	0.74±0.12^{a}	47.73±0.09^{g}	2.01±0.01^{a}	34.74±0.02^{a}

Different superscript letters in the same column indicate a significant difference between the samples ($p<0.05$).
FK: 0%; F5: 5%; F10: 10%; F15: 15%; and F20: 20% hazelnut pulp containing tarhana samples

Color Changes in Tarhana Samples

In this system, L (brightness), a* (redness) and b* (yellowness) values are measured. The results of L* value in the samples of tarhana soup are given in Table 2. The effect of hazelnut ratio on L* value was statistically significant ($p<0.05$). When the L* values were examined, it was observed that as the ratio of hazelnut pulp increased, its brightness decreased. Hayta et al. (2002) demonstrated that there were significant differences in the color measurements of tarhana samples between the drying methods used in their study of the effect of drying methods on the functional properties of tarhana, suggesting that industrial microwave drying could be an alternative to classical drying methods. Bilgiçli (2009) investigated Tarhana with buckwheat flour and discovered that as the rate of buckwheat flour increased, the L* value decreased compared to control samples. L* values were determined between 71.72 and 78.51 in the study conducted by Erkan et al. (2006). According to the studies, it was observed that the L* value of tarhana supplemented with hazelnut pulp was lower.

Variance analysis results of a* values for tarhana soups are given in Table 2. The effect of hazelnut pulp ratio on a* value was statistically significant ($p<0.05$). With the control sample, it was determined that there were significant differences in a* values of hazelnut pulp tarhana ($p<0.05$). In control samples, the mean a* value, which is -1.23±0.11, increases with increasing hazelnut ratio, and the highest a* value is determined in tarhana as +2.01±0.01 for 30% hazelnut pulp. In the study conducted by Erkan et al. (2006), the use of barley in tarhana was investigated and stated that a values, ranged from +3.14 to +6.46. In their study on the use of different flours in tarhana, Köse et al. (2002) discovered a value of a ranging from +14.41 to +18.72. In our study, a value was found lower than other studies.

The effect of hazelnut pulp ratio on b* value of tarhana soups was found statistically significant ($p<0.05$). In control samples, the average b value of 30.73±0.46 increased as the hazelnut ratio increased and the highest b* value was determined in tarhana with 30% hazelnut pulp as34.74±0.02. (Table 3). Ertaş et al (2009) stated that in their study on the use of whey concentrate in tarhana, the b value ranged between 20.59 and 24.28. In the study conducted by Üçok et al (2019), quinoa flour was used in the production of tarhana and stated that the b values increased as the rate of quinoa flour increased (28.06-34.57). The b* values obtained in our study are higher than those of Ertaş et al. (2009) and are similar to those found by Üçok et al. (2019).

Viscosity changes in tarhana samples

Viscosity is a measure of the resistance of a fluid to flow under surface tension and is one of the main parameters for semi-liquid foods (Bourne, 2002). Norquist et al. (2012) examined the properties of gluten after its interaction with enzymatic hydrolysis or heat and markedly decreased viscosity with increasing frequency of hydrolysis. It inhibits the interactions between starch molecules by limiting the swelling of starch with its high-water absorption feature. Thus, it affects the viscosity of starch (Türksoy, 2018). The viscosity measurement results for tarhana pulp samples are shown in Table 3. The lowest viscosity value was measured containing 10.24 cp and 30% hazelnut pulp, while the highest viscosity was determined in control samples at 149.56 cp. According to the results obtained, it is seen that the viscosity value decreases as the hazelnut ratio increases. Viscosity is an indicator of the resistance of fluidity to followability. Viscosity changed inversely with the addition of hazelnut pulp. The lowest viscosity value was determined to be 24.67 cp in for samples containing 30% hazelnut pulp, while the highest was determined to be 105.08 cp in for control samples. With the addition of hazelnut pulp, increased fat content, reduced starch and gluten content, and loss of fermentation are thought to cause a significant reduction in baked tarhana viscosity. In their study on the use of quinoa flour in the production of tarhana, Üçok et al. (2019) discovered that the viscosity decreased as the quinoa was added, and the viscosity values of tarhana samples ranged between 42.04 cp and 138.26 cp. Çağlar et al. (2012) reported that the viscosity of carob tarhana samples increased with the addition of carob, with results ranging from 98.4 to 117.65. Anıl et al. (2016) measured the viscosities of corn flour and baked corn flour tarhana and determined that the average viscosity value in baked corn flour was 4.13cp, while it was 121.35cp in non-baked corn flour samples. Current findings are compatible with the aforesaid study results.

Generally, molecules move more comfortably with increasing temperature, and viscosity decreases due to the decrease between intermolecular friction and thus hydrodynamic forces (Davis, 1995) and Çelik et al. (2005). In the study conducted by Ibanoğlu and Ibanoğlu (1998), the rheological properties of some traditional soups were determined, and it stated that the viscosity decreased with temperature. Heating can break down molecular entanglement and bonds stabilize the molecular structure and cause a decrease in viscosity. As the temperature increases, instability of protein-protein and protein-water interactions occurs, leading to a decrease in viscosity (Hayta et al., 2002).

Table 3. Viscosity, water-holding capacity, foaming capacity and foam stability values in tarhana*
Tablo 3. Tarhanada viskozite, su tutma kapasitesi, köpürme kapasitesi ve köpük stabilite değerleri

Hazelnut ratio (%)	Viscosity (cp)	Water holding capacity (ml g^{-1})	Foaming capacity (ml ml^{-1})	Foam stability (min.)
FK	105.08±27.58^{a}	0.74±0.02^{a}	0.01±0.01^{f}	0.01±0.02^{g}
F5	89.01±19.14^{b}	0.72±0.11^{a}	0.35±0.01^{e}	0.35±0.03^{f}
F10	78.19±18.04^{c}	0.85±0.07^{a}	0.67±0.01^{d}	0.85±0.02^{e}
F15	55.15±13.74^{d}	0.82±0.08^{a}	0.78±0.01^{c}	1.20±0.15^{d}
F20	43.47±11.49^{e}	0.73±0.10^{a}	0.92±0.03^{b}	1.56±0.05^{c}
F25	37.39±10.13^{f}	0.76±0.04^{a}	0.99±0.02^{a}	1.81±0.07^{b}
F30	24.67±7.47^{g}	0.70±0.06^{a}	1.03±0.02^{a}	2.26±0.13^{a}

Different superscript letters in the same column indicate a significant difference between the samples ($p<0.05$).
FK: 0%; F5: 5%; F10: 10%; F15: 15%; and F20: 20% hazelnut pulp containing tarhana samples.

Water holding capacity

Water holding capacity is considered as an important functional feature in viscous foods such as bakery products, and sauces (Hayta et al., 2002). Many parameters such as the size and shape of starch granules, the distribution of protein aggregates and pH, temperature, salt content have a significant effect on the water holding capacity (Muir et al., 2000). Proteins have a higher water holding capacity at pH values above and below the isoelectric point. The salt concentration below 1% increases the water retention capacity of the proteins. The water retention capacities of the proteins generally decrease with increasing temperature (Fennema, 1985). The analysis results regarding the water holding capacity are shown in Table 4. The lowest water holding capacity was 0.70 ml g^{-1} and 30% hazelnut pulp, the highest 0.85 ml g^{-1} and 10% hazelnut pulp samples. Hayta et al. (2002) reported that in their study on various drying techniques, the water holding capacity, drying, tunnel dryer and home-type microwave drying techniques were superior in industrial microwaves.

While water-holding capacity was determined as 0.74±0.02 (ml g^{-1}) in samples without hazelnut pulp, it was found to be 0.85±0.07 (ml g^{-1}) in samples with10% hazelnut pulp, indicating 14% increase (Table 3). It has been reported that the water holding capacity may increase by approximately 10%. As a reason for this increase, it has been observed that some hydrophobic groups in the protein are reduced by denaturation, and water is needed for protein hydrolysis (Fennema, 1985). The lowest water holding capacity was determined in samples using 30% hazelnut pulp (0.70 ± 0.06 ml $^{g-1}$). With the addition of hazelnut pulp, the proportional decrease in the amount of starch in the formulation of tarhana can have an effect on water absorption.

In the study conducted by Çelik et al. (2005), the effect of yeast on the functional properties and quality of tarhana was investigated. The water retention capacity, which is one of the important functional features of yeast added samples, has decreased. Aktaş (2018) has observed a regular increase in water absorption values as the dandruff substitution rate in tarhana samples increased and the water absorption values of the samples without dandruff added was 0.58 ml g^{-1}, while the water absorption average of the samples with bran added was 15%. The values indicated that the average increased by 44.8% to 0.84 ml g^{-1}. This parameter is 0.62-0.65 46 ml g^{-1}, according to the study performed by Tarakçı et al. (2013) in tarhana. The results obtained in our study show similarities with other studies.

Foaming Stability and Foam Capacity

Foam is defined as a two-phase system consisting of air cells separated by a thin layer of liquid and bubbled air in a liquid (Makri et al., 2005). Fermentation can cause significant or undesirable changes in the foaming properties of grain-based foods (İbanoğlu & İbanoğlu, 1999). The foaming capacity results of tarhana samples are given in Table 3. The foaming capacity results were determined to range from 0.00 to 1.06 (ml ml^{-1}). As hazelnut pulp ratio increased, foaming capacity increased. While the foaming capacity of the control samples averaged 0.01±0.01 (ml ml^{-1}), tarhana with 30% hazelnut pulp was determined as 1.03±0.02 (ml ml^{-1}) and the difference between them was found statistically significant ($p<0.05$). Proteins play an active role in foaming, and the fact that hazelnut is a protein-rich food has led to increased foaming capacity in tarhana.

Çağlar et al. (2012) reported in their study that the foaming capacity of tarhana increased with the addition of carob, with the highest foaming capacity of 0.91 ± 0.01 ml ml^{-1} in tarhana samples containing 8% carob. Bilgiçli (2008) discovered that complete replacement of wheat flour with buckwheat flour increased the foaming capacity from 0.750 ± 0.06 (ml ml^{-1}) to 1.91 ± 0.11 (ml ml^{-1}). The foaming capacity values recorded in this study were found compatible with other studies.

The presence and clustering of proteins as a thin layer on the foam surface is effective in improving foam stability. The stability increases as the small molecules formed by the hydrolysis of the proteins spread much better at the liquid-air interface. With fermentation, the protein molecule is broken down and results in an increase in the foam stability of compounds with smaller molecules (Ibanoğlu & Ibanoğlu, 1999). According to the results of foam stability given in Table 4, foam stability varies between 0.00 and 2.47 minutes. The effect of hazelnut pulp ratio on foam stability value was found statistically significant ($p<0.05$). While the foam stability in the control samples was 0.01±0.02 on average, this value was determined as 2.26±0.13 on the tarhana samples with 30% hazelnut pulp (Table 3.) and the difference between them was found to be statistically significant ($p<0.05$). High foam stability is due to the surfactant properties of continuous phase soluble proteins (Kaur and Singh, 2007). Hayta et al. (2002) reported that the foam stability varied between 1.37-6.17 min depending on the type of drying method, while Gokmen (2009) found this value as 0.35 min in tarhana. The results of foam stability obtained in our study are similar to other studies.

Protein Changes in Tarhana Samples

It is a low-quality protein source since it contains small amounts of amino acids such as flour, lysine, methionine, and threonine, which are the main components of tarhana. As the other main component, yogurt, these amino acids are present, so flour and yogurt in tarhana complement each other in terms of essential amino acids and are a source of higher quality protein. Many researchers have attempted to enrich tarhana with various protein sources due to the fact that vegetable proteins derived from wheat flour are more intense than animal proteins and have a lower bioavailability. Since the lactic acid bacteria in yoghurt in the composition of tarhana pre-digest the nutrients such as protein, carbohydrate, and fat in the environment, the digestibility and nutritional properties of tarhana increase (Bilgiçli & Türker, 2004). Table 4 shows the protein content of tarhana samples. The lowest protein content was found to be 12. 21% in the control tarhana sample, while the highest protein content was found in the sample containing 30% hazelnut pulp. The hazelnuts ratio effect on protein amount in tarhana samples was found statistically significant ($p<0.05$). As the hazelnut pulp rate increased, the protein amount of tarhana increased. While the average protein amount of the control samples was 12.211±0.2%, it was determined as 15.117±0.08% in the samples containing 30% hazelnut pulp (Table 5). In the study conducted by Bilgiçli and Türker (2004), it was discovered that the total protein amount increased as the yeast additive ratio increased, with the total protein amount in yeast-free samples having the lowest value with 15.019%, and the yeast additive yielding the highest total protein amount with 17.050%. Köse and Çağındı (2002) determined that protein content ranged between 8.8 and 22.5% in their study on the use of different flours in tarhana. Erkan et al. (2006) stated that in their study by adding barley to the tarhana formulation, the protein ratio varies between 10.1 and 15.9. In our study, the protein ratio in tarhana increased by 23.8% when 30% hazelnut pulp was added. As seen in table, hazelnut pulp contains a higher rate of protein than wheat flour. This difference is also reflected in the tarhana produced. In other words, as the hazelnut pulp ratio increased in tarhana samples, the protein content also increased.

Ash Changes in Tarhana Samples

Food ash is the inorganic part that remains after the combustion of organic matter. When organic matter is burned, water and CO_2 are formed, leaving the mineral-containing inorganic part. Minerals are obtained from plants, water and animal foods. Most minerals are found in foods due to organic matter (protein, fat, carbohydrate). The ash contents of the tarhana samples are given in Table 4. Control tarhana had the lowest ash content of 1.191 %, while tarhana with 30% hazelnut pulp had the highest protein rate of 1.778%. As the hazelnut pulp rate increased, the ash amount of tarhana increased. The average amount of ash in the control samples was 1.22 ± 0.02%, while the amount of ash in the 30% hazelnut pulp added tarhana was 1.73 ± 0.04% and the difference was found to be statistically significant ($p<0.05$). The ash amount of the tarhana samples varies depending on the substances used in its formulation and the amount of these substances. In their study on cranberry tarhana, Koca et al. (2006) discovered that the ash rate ranged from 1.75 to 3.96%. In a study by Tamer et al. (2007), they stated that the ash rate of tarhana is between 1.36% and 9.4%. Bilgiçli et al. (2006) found that the ash content of tarhana increased with the addition of wheat seeds, reaching 3.26% with the addition of 50% wheat seeds; the ash content was the lowest in the control tarhana (1.36%). Dağcı et al. (2008) used soy yoghurt, which was obtained by processing soybeans, in the formulation of tarhana. They determined the ash content of the tarhana obtained to be 0.56%. The results obtained in this study Koca et al. (2006) and Tamer et al. (2007), however, Bilgiçli et al. (2006) and Dağcı et al. (2008) was found to be higher than the findings. This is due to the fact that the ash content of the ingredients in the formulation varies. As seen in the table, hazelnut pulp contains a higher rate of ash than wheat flour. This rate was reflected in the produced tarhana and as the rate of hazelnut pulp increased, the amount of ash increased.

Fat Changes in Tarhana Samples

Hazelnut contains 60-70% oil. Fatty acids with various functions and benefits are found in the composition of the oils for our organism. Hazelnut oil constitutes approximately 83% of the composition of fatty acids, oleic acid, and 12% of linoleic acid (Akdere, 2003). Table 4 shows the results of the amount of oil found in the tarhana samples. While the amount of oil in control tarhana was determined to be 2.39 %, the highest oil rate was determined to be 11.4 % for 30 percent% hazelnut pulp added tarhana. As hazelnut pulp ratio increased, the oil concentration of tarhana increased. While the average amount of oil in the control samples was 2.42±0.03%, it was 11.30±0.10% for the hazelnut pulp added tarhana, and the difference was found to be significant ($p<0.05$). Ertaş et al (2009) reported that oil concentrations ranged between 0.87% and 6.33% in their study on the use of whey concentrate in tarhana. Ibanoğlu et al (1995) found the fat content of tarhana between 3.7% and 5.6%. Koca and Tarakçı (1997) investigated the use of corn flour and whey in tarhana and found that the fat content was between 2.49% and 5.51% in their study. In our study, a higher rate of oil was detected than other study findings. The reason for this is the fat content of hazelnut pulp in the Table 4. This rate was reflected in the tarhana produced and the amount of oil increased as hazelnut pulp rate increased.

Total Phenolic Changes in Tarhana Samples

Phenolic compounds are substances which contain one or more hydroxyl groups, including functional derivatives attached to an aromatic ring. Phenolics are the most active natural antioxidants, and they achieve their antioxidant effects by binding free radicals, chelating metals, and inhibiting lipoxygenase enzyme. Phenolic compounds are the most important group of water-soluble antioxidants (Güleşçi & Aygül, 2016). Besides being rich in fat components, hazelnut is known to be a rich source of phenolic components with antioxidant potential. Table 4 shows the results of the total amount of phenolic substances found in tarhana samples. While the amount of phenolic substance was determined in control samples with the lowest 1.598 mgGAE g^{-1}, the highest amount of phenolic substance was determined in 2.178 (mgGAE g^{-1}) tarhana sample with 30% hazelnut pulp. As the hazelnut pulp ratio increased, the total phenolic content of tarhana increased. While the average amount of phenolic substance belonging to the control samples was 1.64±0.01(mg GAE g^{-1} sample), it was determined as 2.15±0.00 (mg GAE g^{-1} sample) in the samples using 30% hazelnut pulp and the difference was statistically significant ($p<0.05$). Demir (2018) stated that the total phenolic content of tarhana samples varied between 714.31±14.13 and 1521.08±15.65 (mg GAE/100g). Değirmencioğlu et al. (2016) investigated the effect of different drying methods (sun drying, oven drying, microwave drying) on total phenolic substance content and antioxidant activity in tarhana enriched with oat flour in various proportions, and determined that total phenolic content of the samples dried in kiln dryers at 55 °C was high. Kılcı and Göçmen (2014) added 10, 20, 30 and 40% oat crushing instead of wheat flour in the form of tarhana. They stated that the content of phenolic substances increased as it increased. In our study, the amount of phenolic substance increased as the hazelnut ratio increased. The reason for this is that hazelnut contains high levels of phenolic substances as seen in Table 4. The findings differed from those of previous studies. This is due to the fact that the tarhana ingredients contain varying amounts of phenolic substances.

Antioxidant Activity Changes in Tarhana Samples

Single electron parts that are not paired in atomic or molecular structures are called “free oxygen radicals”. These molecules, which can easily exchange electrons with other molecules, are also called “reactive oxygen particles”. These radicals interact easily with other molecules in the cell, causing oxidative stress. Oxidative stress causes damage to essential cell components and causes various ailments related to age. Nutrition with foods with high antioxidant content is important to protect against the effect of free radicals. Antioxidants in foods are “substances that have low concentrations compared to oxidizable substrates and prevent or delay oxidation of substrates” (Becker et al., 2004; Çağatay & Kayalı, 2006; Sönmez et al., 2010).

As the rate of hazelnut pulp increased, the antioxidant activity of tarhana increased (Table 4). While the antioxidant activity of the control samples was 0.15±0.01 (mgTroloxE g^{-1}), it was determined as 0.42±0.00 (mg TroloxE g^{-1}) in the samples containing 30% hazelnut pulp and the difference was statistically significant ($p<0.05$). Bilgiçli et al. (2006) determined the total antioxidant amount between 10.93-22.44 (mMol TroloxE g^{-1}) in his study with the addition of wheat germ and bran to tarhana. In the study conducted by Özmen (2011), different legume flours were used in the production of tarhana and the total amount of antioxidants were determined to be between 42.50 and 55.18 (mMol trolox g^{-1}). The reason for this is that hazelnut contains high levels of antioxidants as seen in Table 4. The results obtained were found different from other studies. This is due to the fact that the ingredients in tarhana contain antioxidant substances in varying proportions.

CONCLUSIONS

The addition of hazelnut pulp was found to have a significant effect on viscosity, foaming capacity and foam stability, but not on water holding capacity. The addition of hazelnut pulp causes a decrease in viscosity of tarhana, while foam stability and capacity increased. Hazelnut pulp contains a higher amount of phenolic substances than wheat flour. It was observed that with the increase of fermentation and hazelnut pulp, the total amount of phenolic substance increased together with the total antioxidant values. With this study, it was possible to present a food product with high antioxidant, phenolic, mineral, and protein content to social individuals who are more conscious about nutrition and health.

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Author contributions

MNO and ZT have designed the study and collected the data. MNO and ZT wrote the article, and critically reviewed by ZT. The authors contributed equally to the article.

Conflict of interest statement

Authors have declared no conflict of interest.

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