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PHYSICOCHEMICAL, FUNCTIONAL, SENSORY, AND RHEOLOGICAL PROPERTIES OF TRADITIONAL TARHANAS FROM THE CENTRAL ANATOLIAN REGION

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Abstract: Tarhana, produced in Anatolia using a variety of production techniques, is a traditional fermented product made from a mixture of yogurt, wheat flour, vegetables, and spices. Tarhana, with its high nutritional value, makes a positive contribution to human nutrition in terms of health. In this study, the chemical (moisture, ash, protein, fat, titratable acidity, salt, water activity, total sugar), functional (total phenolic content, total antioxidant capacity, water and fat holding capacity), viscosity and sensory properties of tarhana produced in Aksaray, Ankara, Eskişehir, Kayseri, Konya, Nevşehir and Sivas provinces of Central Anatolia region were determined. The moisture contents of the tarhana samples were found to be 17.36-7.52%, protein contents 12.62-8.88%, ash contents 7.4-3.66%, fat contents 4.23-0.81%, titratable acidity values 21.5-7.5%, pH values 5.4-4.04. The highest viscosity value was found in Sivas tarhana with 1.721 Pa.s Kayseri and Konya tarhanas had the highest total phenolic content and antioxidant capacity. In terms of sensory properties, the most admired tarhana was the tarhana from Aksaray province, and the least admired tarhana was the tarhana from Ankara province. In conclusion, when we compared the tarhana commonly consumed as soup in the Central Anatolian region, it was found that the physical and chemical properties, as well as the sensory preferences, varied regionally.

Keywords: Central Anatolia, Functional, Traditional, Tarhana

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1. Introduction

Definition of tarhana according to TS 2282: It is a food with a high nutritional value which is obtained by mixing wheat flour or cracked wheat or semolina or their mixture with yogurt, pepper, salt, dried onion, onion, tomato, herbal substances which are neutral in taste and smell, kneading and fermenting, then drying, grinding and sieving. Tarhana, which has been produced and consumed since ancient times, came to Anatolia thanks to the Turks who migrated from Central Asia. From Anatolia, tarhana spread to eastern countries such as Iran and Iraq, which were neighbors of the Ottoman Empire, and to western countries such as Hungary and Greece via Rumelia (Temiz, 2011). The names of tarhanas by country are shown in Table 1.

Tarhana is a widely consumed product group in our country due to its easy production, low cost, long shelf life, and high nutritional value. Tarhana is a food with both vegetable and animal content due to the presence of flour and yogurt in its composition (Erbaş et al., 2004). Tarhana, which is extremely rich in nutritional value, contains many minerals such as protein, calcium, iron, sodium, potassium, magnesium, zinc, and copper. In addition, it is extremely rich in group A and B vitamins and is easily digestible (Yıldırım and Güzeler, 2016). Although there is no standard method for producing tarhana, it is generally made by mixing, drying, and grinding its primary components. In tarhana made in our country, various types have been developed by incorporating a range of additional ingredients into the dough. Adding some spices (mint, thyme, dill, etc.) creates aromatic flavors in tarhana dough (Özçam, 2012). Although the amounts and types of ingredients added to tarhana dough vary, they are produced in the same stages in home and industrial production (Özdemir et al., 2007; Keşkekoğlu, 2009).

According to TS 2282, tarhana is classified into four main groups based on the raw materials used: Göce tarhana, flour tarhana, semolina tarhana, and mixed tarhana. Additionally, approximately 50 different types of tarhana are known to exist in our country (Aksu et al., 2012). Tarhana types differ according to the basic production technique or the variety of ingredients added. The different products added affect the fermentation time, and tarhana with different flavors, tastes, and smells are obtained in each region. Table 2 shows the fermentation times of tarhana produced in the different areas.

Beyşehir Tarhana: This type of tarhana is made by preparing buttermilk from strained yogurt, to which butter, milk, water, and wheat are gradually added (Coşkun, 2014). In tarhana production, buttermilk is made from strained yogurt, transferred to copper kettles, and heated. Wheat (göce) is added to the heated buttermilk with continuous stirring and cooking. The wheat used should be thinner than bulgur (Anonymous, 2020a). Butter is then added to the mixture and left to cool. Depending on the consistency of the dough obtained, buttermilk, water, or milk is added. When the dough reaches the desired consistency, it is shaped and dried on reeds (Kahraman, 2009).

Table 1. Tarhana names according to countries (İbanoğlu et al., 1999)

Countries	Nomenclature
Syria, Egypt, Lebanon	Kishk
Iraq	Kushuk
Hungary	Tahonya
Finland	Talkuna
Greece	Trahana
Scotland	Atole
Albania	Trahana and trahan
Macedonia	Tarana
Bulgaria	Trahan and tarhana

Table 2. Fermentation times of tarhanas produced in the central Anatolian region

Region	Fermentation Time (days)	References
Sivas	2-5	Gürdaş, 2002
Ankara/Beypazarı	6-7	Anonymous, 2023
Kırşehir	3-5	Anonymous, 2020a
Aksaray	2	Anonymous, 2019
Nevşehir	1-7	Yıldırım and Güzeler, 2016
Eskişehir	1	Anonymous, 2020b
Kayseri	7	Anonymous, 2022

Sivas Tarhana: It is known that various fruits from the province of Sivas, such as apples, pears, and quince, are added to the local tarhana (Gürdaş, 2002). Sivas tarhana is mostly made with yogurt. Yogurt or buttermilk is added to the pre-cooked yogurt and mixed until it thickens. It is dried on fences in the form of flat round balls or balls with a hole in the middle (gilik). This tarhana, called tarhana with additives, is soaked and left to soften before it is prepared as soup (Üçer, 2006).

Kayseri Tarhana: After washing the durum wheat to be used in the production of tarhana, water and salt are added and boiled. Chickpeas are added to the boiling paste, and the mixture is kneaded. Once the salt ratio is balanced, the yogurt flour mixture prepared beforehand is added to the kettle. The mixture is cooked until it reaches a thick consistency. The dough is left to rest and left to dry (Anonymous, 2022).

Ankara Tarhana: This type of tarhana, which originating from the province of Ankara, is made in many districts using different techniques. In Çamlıdere tarhana, the wheat is first sorted and washed and then ground into semolina. The yeast used in Çamlıdere tarhana is sourdough. Yeast, salted yogurt, and wheat are mixed and kept for 3 days, then wrapped in cloths and dried (Anonymous, 2023).

Eskişehir Tarhana: The yogurt used to make tarhana is salted and filtered in bags. Onions are fried in vegetable oil in a cauldron, and milk is added after adding a little water. Göce (ground wheat) is added to the boiling cauldron with constant stirring, and the mixture is left to simmer. The strained yogurt is mixed with the egg. The cooked wheat and yogurt are mixed and kneaded like dough. The dough is left to rest for a day, then cut into small pieces and dried (Anonymous, 2020b).

Nevsehir Tarhana: Onion, tomato, capia pepper, red pepper, coriander, parsley, and garlic are added as vegetables in this tarhana from Nevsehir province. After all the vegetables are cooked, pre-cooked chickpeas are added. After the mixture has cooled, it is mashed, yogurt and flour are added and left to ferment. The fermented tarhana dough is placed on a clean cloth. As the tarhana dries, it is rubbed by hand, and powdered tarhana is obtained by drying it (Anonymous, 2020c).

Aksaray Tarhana: Tarhana, which is specific to the province of Aksaray, is made by kneading yogurt, flour, mint, red and green pepper, and finely chopped onion into a smooth dough. The dough is covered with a cloth and left to ferment. The longer the fermentation time, the sourer the tarhana will taste, while the shorter the fermentation time, the sweeter the tarhana will taste. When the dough has reached the desired taste, it is placed on cloths and dried (Anonymous, 2019).

There are studies in the literature that have investigated the properties of tarhana from different regions. In the study conducted by Güler (1993), the nutritional composition of 10 different tarhana samples from Adana, Hatay, and Maraş provinces was analysed. Moisture 13.1-18.8%, total acidity 9.0-17.5%, ash 2.0-8.0%, starch 41.6-56.4%, protein 17.2-21.9%, sugar 4.7%, salt 0.7-0.9% and fat 1.3-9.6% were determined. In the study in which the chemical composition of 21 different tarhana samples collected from the provinces of Afyonkarahisar, Burdur, Bolu, Eskişehir, Kütahya, and Tekirdağ was analysed, it was reported that the moisture, ash, salt, protein, fat, and acidity contents of the samples were between 9. 35-66.4%, 1.36-9.40, 0.62-9.01, 6.77-28.55, 0.43-15.78 and 1.7-4.7%, respectively (Tamer et al., 2007). In the study conducted by Soyyiğit (2004), 27 different home-made flour tarhana in Isparta region were analysed and pH 3.61-4.86, acidity 4.91-36.62%, moisture 8.46-15.38%, fat 1.35-7.90%, protein 12.79-21.58%, salt 1.29-12.43% and ash content 1.63-13.19% were determined. Several studies have investigated the properties of tarhana produced in different regions. These include 51 traditional homemade tarhanas from Edirne, Kırklareli, and Tekirdağ provinces (Coşkun, 2002), 13 different tarhanas from Kahramanmaraş province (Yörükoğlu and Dayısoylu, 2016), homemade tarhanas from Bilecik, Zonguldak, Eskişehir, Kütahya, Van, Afyon, İstanbul and Ankara provinces (Funda, 2009), commercially produced tarhanas from Konya province (Bilgicli et al., 2006) and tarhanas from different regions of Antalya province (Erbaş et al., 2003).

It is important to determine the quality and technological characteristics of traditional/commercial tarhanas produced with different methods and raw materials in different regions of Türkiye to ensure standard production conditions, sustainability, and marketing. In the literature review, there are studies on tarhanas produced in different provinces. However, studies that analyse and compare tarhanas regionally are limited. Additionally, no studies have focused on determining the viscosity properties of traditional tarhanas. This study aimed to evaluate the chemical, functional, sensory, and rheological properties of traditional tarhanas produced in several provinces within the Central Anatolia region.

2. Materials and Methods

2.1. Material

Ten different tarhana samples were obtained from local producers in Ankara, Konya, Kayseri, Sivas, Eskişehir, Nevşehir, and Aksaray provinces in Central Anatolia. Tarhana samples were stored in sealed glass containers in a refrigerator at +4 °C in an odourless environment until analysis. The chemicals used were of analytical grade and were purchased from Sigma (Sigma Chemical Company, MO, USA) and Merck (Merck KGaA, Darmstadt, Germany).

2.2. Chemical Analysis

The moisture and ash content of tarhana samples were determined using AACC standard methods 44-01.01 and 08-01.01, respectively (AACC, 2004). Total nitrogen was determined by micro-Kjeldahl (AOAC, 2000) and crude fat by the Ankom method (AOCS, 2005). Total sugar content was determined spectrophotometrically by the phenol-sulphuric acid method using the xylose standard (Dubois et al., 1956). The colour of the samples was measured using a Minolta Chroma Meter (CR-300 Minolta Japan).

2.3. Titration of Acidity

To 10 g of tarhana sample, 50 mL (20 °C) of 67% neutralised ethyl alcohol was added and stirred at 150 rpm for 5 minutes. The mixture is then filtered through filter paper, and 10 mL of the filtrate is titrated with 0.1 N NaOH solution (Anonymous, 2004).

2.4. pH

5 g of tarhana sample was homogenised in 50 mL of distilled water. The pH was then measured using a pH meter (WTW inolab, Germany).

2.5. Salt Analysis

The tarhana samples were filtered through ashless filter paper (Whatman No:42). The pink colour was removed with 0.1 N H_2SO_4 solution after a few drops of 1% phenolphthalein were dropped on the filtrate. The neutralised filtrate was titrated with 0.1 N $AgNO_3$ solution until a brick red colour was obtained, and the % salt content was determined using the following Equation 1 (Anonymous, 2010).

$$\% \text{ Salt} = V \times mEq \times F \times 100 / m \quad (1)$$

V: Amount of 0.1 N $AgNO_3$ solution used in the titration, mL

mEq: Millivalent weight of NaCl, 0.0585 g

F: Factor of $AgNO_3$ solution

m: Sample quantity (g)

2.6. Water Activity

The a_w values of the samples were measured using an Aqua Lab Model Series 3TE (USA) water activity meter set at 20 °C (Hughes et al., 2002).

2.7. Analysis of Total Phenolics and Total Antioxidant Capacity

Tarhana samples were weighed at 1 g and extracted with 20 mL acidified methanol (methanol/hydrochloric acid/distilled water, 8:1:1, v/v) at room temperature (24±1 °C) for two h in a shaking water bath. The extracts obtained were centrifuged at 3000 rpm for 10 min. The collected extracts were used to determine the total phenolic content and total antioxidant capacity (Beta et al., 2005).

The total phenolic content of tarhana was determined using 2 N Folin-Ciocalteu phenol reagent according to the method of Singleton and Rossi (1965). 2 N 100 µL Folin-Ciocalteu phenol reagent, 100 µL extract or 100 µL standard gallic acid solutions, 2.3 mL distilled water and 1 mL 7% aqueous sodium carbonate solution were mixed and kept at room temperature for 2 h. The absorbance was measured at a wavelength of 750 nm, and the results were reported as being "gallic acid equivalent" (Cingöz, 2018).

The total antioxidant capacity values of the samples were determined by two methods. The ferric reducing antioxidant power (FRAP) was determined according to the method developed by Benzie and Strain (1996). The samples were mixed with the obtained FRAP working solution and kept in the dark for 30 min. At the end of the time, the absorbance values were recorded at 593 nm in a spectrophotometer, and the results were expressed as "Trolox equivalent." The determination of antioxidant capacity by the DPPH (2,2-diphenyl-1-picrylhydrazyl) method was performed according to the method described by Brand-Williams et al. (1995). 1.95 mL of 100 µM DPPH was added to 50 µL of extract or Trolox standard solutions (50 µL), mixed and allowed to stand for 10 min. The absorbance values were then read at 517 nm, and the results were expressed as 'Trolox equivalent.'

2.8. Viscosity

20 g of tarhana sample was mixed with 200 mL of water and boiled over medium heat for 12 minutes with continuous stirring. The whole mass was homogenised for 1 min with ultraturax before measurement. Then, the viscosity of the soup was measured with a viscometer

(IKA Rotavisc me-vi, Seoul, Korea) at 100 rpm at 60 °C using Mil no:5 (Bayrakçı and Bilgiçli, 2015). To maintain the measurement temperature at 60 °C, silicone tubing was wrapped around the outside of the measurement vessel, and 60 °C water was circulated through the tubing.

2.9. Water and Oil Holding Capacity

A 5.0 g tarhana sample was weighed into 50 mL centrifuge tubes; 25 mL of water and 25 mL of sunflower oil were added to assess water and oil holding capacities, respectively The mixture was mixed for 60 minutes and then centrifuged (20 minutes, 4.000×g). The water and oil holding capacities were expressed as the amount (grams) of water or oil absorbed per gram of tarhana (Bayrakçı and Bilgiçli, 2015).

2.10. Sensory Analysis

Sensory evaluations were carried out according to TS 5525, method 2.2.4, with a 1-5 point scale (1=least liked, 5=most liked) using the scoring method of descriptive analysis methods. Taste, odour, consistency and general flavour characteristics of the samples served as soup were evaluated by 15 panelists.

2.11. Statistical analysis

The results were obtained in 2 parallel three replicates. SPSS statistical computer software (SPSS, Inc., Chicago, IL, USA) was used to analyse the results, which are presented as mean±standard deviation. The values obtained in the experiments were evaluated by Duncan's multiple comparison test (Genç and Soysal, 2018).

3. Results and Discussion

The chemical analysis results of tarhana samples from Ankara, Konya, Kayseri, Eskişehir, Nevşehir, Aksaray, and Sivas provinces of the Central Anatolia region are presented in Table 3. The moisture content ranged from 17.36% in Ankara (the highest) to 7.52% in Nevşehir (the lowest). Four tarhana samples exceeded the upper limit of 10% moisture contents specifieed in TS 2282, and 3 different tarhana samples did not exceed this limit. In a study of tarhana enriched with oat bran and sugar beet fibre, the moisture content of the samples was reported to be between 9.5% and 13.9%. It was reported that the moisture content did not vary proportionally with the amount of fibre added (Karaman, 2020). Yücecan et al. (1988) found the moisture content of 15 tarhana samples from different regions of our country to be 9-12.1%. They reported that the moisture content of 134 tarhana samples varied between 6.4-13.9% (Siyamoğlu, 1961). The highest ash value of 7.40% belongs to Eskişehir province, and the lowest value of 3.66% belongs to Sivas province. The percentage of husk in cereals has a significant effect on the ash content. The aleurone layer and the peripheral layers of the endosperm in wheat grains added to the tarhana composition contain high amounts of ash. The amount of ash is high in samples using whole wheat flour (Aktaş, 2018). In the study that included the determination of chemical and microbiological conditions of tarhanas of Kahramanmaraş province, the ash content was determined to be between 3.46-5.35% (Dayısoylu et al., 2003). The highest titratable acidity of 21.50% was found in Nevşehir tarhana, and the lowest acidity of 7.50% was found in Aksaray province. The acidity of tarhana (Table 3) was reported to be in the range of 10-35 according to TS 2282 tarhana standard (Anonymous, 2004). The acidity values of 27 domestic tarhanas from the Isparta region were between 4.91-36.62% (Soyyiğit, 2004). In another study, the total acidity values of 16 commercial tarhana samples were measured between 9.65-28.00% (Göçmen et al., 2003). The highest pH value of 5.40 was found in Aksaray tarhana and the lowest pH value of 4.04 was found in Nevşehir. There is no value for pH in the TS 2282 standard, and values of 3.8-4.2 are accepted as the optimum range in the literature (Dağlıoğlu, 2000). Another factor affecting the shelf life of food is water activity. If the water activity exceeds certain limits, undesirable conditions such as mold may occur in the products (Özçam, 2012). The highest water activity was 0.66 in Aksaray tarhana, and the lowest was 0.40 in Konya tarhana. A significant correlation was found between the moisture content of the tarhana samples and the water activity value. In a study, water activity values of 22 domestic tarhanas were reported in the range of 0.28-0.63 (Çağındı et al., 2016).

Table 3. Physicochemical analysis results of tarhana samples

Samples	Moisture (%)	Ash (%)	Titration acidity (%)	pH	Water activity (a_w)	Protein (%)	Fat (%)	Salt (%)	Total Sugar (mg xylose/100 g tarhana)
Ankara	$17.36±0.00^{a}$	$5.36±0.01^{c}$	$8.75±0.01^{f}$	$5.28±0.00^{b}$	$0.43±0.02^{d}$	$11.64±0.06^{c}$	$1.12±0.05^{d}$	$5.82±0.02^{b}$	$12.79±0.19^{c}$
Konya	$12.38±0.02^{c}$	$4.49±0.05^{e}$	$11.00±0.20^{d}$	$4.70±0.12^{cd}$	$0.40±0.11^{d}$	$11.22±0.17^{d}$	$0.81±0.11^{e}$	$4.25±0.05^{d}$	$15.58±0.95^{a}$
Kayseri	$7.55±0.01^{f}$	$4.63±0.11^{e}$	$20.00±0.03^{b}$	$4.12±0.05^{e}$	$0.57±0.04^{c}$	$12.19±0.13^{b}$	$1.65±0.04^{b}$	$4.48±0.04^{c}$	$15.60±0.60^{ab}$
Eskişehir	$16.64±0.00^{b}$	$7.40±0.04^{a}$	$10.50±0.21^{de}$	$4.85±0.08^{c}$	$0.75±0.00^{a}$	$8.88±0.08^{f}$	$1.27±0.03^{c}$	$8.21±0.11^{a}$	$14.93±0.29^{b}$
Nevşehir	$7.52±0.03^{f}$	$5.17±0.04^{d}$	$21.50±0.08^{a}$	$4.04±0.10^{e}$	$0.45±0.06^{d}$	$11.57±0.04^{c}$	$4.23±0.04^{a}$	$4.17±0.12^{d}$	$16.21±1.17^{a}$
Aksaray	$11.55±0.01^{d}$	$5.48±0.02^{b}$	$7.50±0.06^{g}$	$5.40±0.00^{a}$	$0.66±0.01^{b}$	$10.42±0.01^{e}$	$0.91±0.12^{e}$	$5.86±0.08^{b}$	$9.66±0.30^{d}$
Sivas	$7.98±0.00^{e}$	$3.66±0.04^{f}$	$12.30±0.11^{c}$	$4.76±0.10^{c}$	$0.54±0.03^{c}$	$12.62±0.01^{a}$	$1.63±0.02^{b}$	$2.30±0.01^{e}$	$15.36±0.92^{b}$

a,b= Means marked with different letters in the same column are statistically different ($P<0.05$).

The protein content of the tarhana samples ranged from 8.88 to 12.62%, the fat content from 0.81 to 4.23%, the salt content from 2.30 to 8.21%, and the total sugar content from 9.66 to 16.21 mg xylose/100 g tarhana (Table 3). According to the tarhana standard, the protein content should be at least 12% (in dry matter), and tarhanas from Sivas and Kayseri met the standard (Anonymous, 2004). It was reported that the protein values of 27 domestic tarhanas in the Isparta region were in the range of 21.58-12.79% (Soyyiğit, 2004). The fat content of the tarhana samples ranged from 0.81 to 4.23% (Table 3). The fat ratio of all samples was statistically different (P<0.05). The use of oil in the production of tarhana, differences in the ingredients and the presence of fat or non-fat yogurt in the composition cause differences in the fat ratio. There are studies in the literature that have measured the fat ratios of different tarhanas. In a study conducted on 15 home tarhanas and five commercial tarhanas from different regions of Türkiye, the fat ratios of commercial tarhanas were found to be in the range of 3.05-3.56%, while those of home tarhanas were found to be in the range of 0.45-4.97% (Esimek, 2010). In a similar study, 22 pieces of home tarhanas and 14 pieces of commercial tarhanas were examined, and the fat content was reported to be in the range of 0.21-7.00% for commercial tarhanas and 0.25-4.12% for home tarhanas (Çağındı et al., 2016). In other studies in which the fat content of tarhana samples was determined, the % fat ratio was found to be in the range of 0.39-30.2 (Siyamoğlu, 1961; Çolakoğlu and Bilgir, 1977; Yücecan et al., 1988). The salinity of the tarhana samples ranged from 2.30 to 8.21% (Table 3). While Nevşehir and Konya tarhana samples were statistically similar in terms of salt content (P<0.05), other tarhana samples were different. The highest salt content was found in Eskişehir province and the lowest in Sivas province. It can be seen that the differences in salt content vary according to the diversity of tarhana composition. Salt contents of Maraş tarhana samples were reported in the range of 3.30 to 5.59% (Yörükoğlu, 2012), salt contents of tarhana samples collected from 21 different regions were reported in the range of 0.62 to 9.01% (Tamer et al., 2007), and salt contents of 96 tarhana samples collected from different regions were reported in the range of 0.32 to 6.64% (Ersoy Ömeroğlu et al., 2023). The total sugar content of tarhana samples was found to be in the range of 9.66-16.21 mg xylose/100 g tarhana. The total sugar contents of tarhana samples from Konya, Kayseri, and Nevşehir provinces were statistically similar (P<0.05). No study was found in the literature search that determined the total sugar content of tarhana samples. To estimate the GI values of tarhana samples, it is useful to know the total sugar content.

One of the primary factors influencing consumer food preferences is the presence of desirable colour attributes (Cingöz, 2018). Bulk images of tarhana samples collected from different provinces of Central Anatolia are shown in Figure 1. L* values of tarhana samples range between 72.34-81.41, a* values varied between 0.31-9.64, and b* values range between 17.69-42.27 (Table 4). It was found that the products used in the composition of the samples, such as tomato, pepper paste, hot red pepper, red pepper powder, and tomato paste were effective on the color values. Köse and Çağındı (2002) found L* values between 52.71-63.03, a* values between 14.41-18.72, b* values between 33.41-44.14, Esimek (2010) found L* values between 60.6-85.6, a* values between 0.00-19.2 and b* values between 7.30-30.40, Çağındı et al. (2016) reported L*, a* and b* values between 54.61-88.57,-0.14-28.10 and 1.43-52.88 respectively.

Table 4. Colour analysis results of tarhana samples

Samples	L*	a*	b*
Ankara	78.39±0.48^{b}	1.49±0.17^{d}	25.85±0.61^{e}
Konya	75.94±1.08^{c}	9.34±0.53^{a}	42.27±1.01^{a}
Kayseri	79.65±1.09^{b}	8.29±0.27^{b}	36.62±0.94^{b}
Eskişehir	72.34±1.03^{d}	9.64±0.54^{a}	34.11±0.91^{c}
Nevşehir	81.41±0.63^{a}	0.88±0.15^{e}	17.69±0.74^{f}
Aksaray	72.91±0.59^{d}	3.17±0.21^{c}	30.36±0.92^{d}
Sivas	76.61±1.08^{c}	0.31±0.17^{f}	26.29±0.93^{e}

a,b= Means marked with different letters in the same column are statistically different (P<0.05).

The total phenolic content and total antioxidant capacity of tarhana samples were analysed and the results are presented in Table 5. The total phenolic content of tarhana samples was 131.40-337.40 mg GAE/100 g, and the total antioxidant capacity was 28.05-40.97 µM TE/100 g (FRAP) and 60.31-62.45 µM TE/100 g (DPPH). The results of phenolic content and antioxidant activity of all samples were statistically different (P<0.05). Kayseri tarhana stands out with the highest total phenolic content. In the study where tarhana samples from different regions were analysed, it was reported that the total phenolic content varied between 572.47-1851.83 µg GAE/g (Esimek, 2010).

Table 5. Total antioxidant capacity and total phenolic content analysis results of tarhana samples

Samples	Total phenolic content (mg GAE/100 g tarhana)	Total antioxidant capacity	
		FRAP (µM TE/100g)	DPPH (µM TE/100g)
Ankara	174.73±3.41^{d}	37.00±0.25^{c}	61.44±0.42^{b}
Konya	231.73±3.12^{b}	40.97±0.08^{a}	61.44±0.11^{b}
Kayseri	337.40±3.12^{a}	37.01±0.31^{c}	60.61±0.19^{c}
Eskişehir	153.73±2.80^{e}	30.73±0.09^{e}	62.42±0.15^{a}
Nevşehir	131.40±3.44^{f}	28.05±0.10^{f}	62.45±0.06^{a}
Aksaray	140.40±6.18^{f}	31.17±0.10^{d}	62.42±0.21^{a}
Sivas	218.07±6.09^{c}	38.55±0.31^{b}	60.31±0.12^{c}

a,b= Means marked with different letters in the same column are statistically different (P<0.05).

Tarhana, one of the traditional products, is usually consumed by making soup. Therefore, the rheological properties of tarhana in the cooked state are important. The viscosity values and functional properties of tarhana samples are presented in Table 6. Viscosity is a recognised measure of the consistency of liquid foods such as soups. The viscosity values of the samples were found to vary between 1.447-1.721 Pa.s. While Sivas tarhana had the highest viscosity value, Konya tarhana had the lowest viscosity value. The viscosity values of all the samples were statistically different ($P<0.05$). The decrease in viscosity value in products such as soups is considered to be an indicator that the product has become thicker / darker, and the consistency of tarhana soups is a situation demanded by consumers. The water and oil holding capacity, which is one of the important criteria in the cooking stage, is also related to the composition. Water and oil holding values are similar to viscosity. It was found that Sivas tarhana had the highest water and oil holding capacity, and Konya tarhana had the lowest. The results of the sensory analysis of tarhana samples by 15 semi-trained panelists are presented in Table 7. Aksaray and Eskişehir tarhanas had the highest rating, while Ankara tarhanas had the lowest overall rating. Aksaray, Eskişehir and Sivas tarhanas received the highest scores in terms of taste and aroma, which is one of the most important sensory criteria of food.

Table 6. Rheological and functional properties of tarhana samples

Samples	Viscosity (Pa.s)	Water holding capacity (g/g)	Oil holding capacity (g/g)
Ankara	1.503±0.018^{d}	0.93±0.03^{e}	1.88±0.03^{e}
Konya	1.447±0.014^{e}	0.90±0.01^{f}	1.82±0.01^{f}
Kayseri	1.666±0.032^{b}	1.11±0.02^{b}	2.24±0.02^{b}
Eskişehir	1.512±0.011^{d}	0.95±0.02^{e}	1.92±0.04^{d}
Nevşehir	1.586±0.016^{c}	0.99±0.01^{d}	2.00±0.01^{c}
Aksaray	1.605±0.023^{c}	1.02±0.01^{c}	2.06±0.05^{c}
Sivas	1.721±0.021^{a}	1.18±0.03^{a}	2.38±0.04^{a}

a,b= Means marked with different letters in the same column are statistically different ($P<0.05$).

Table 7. Sensory analysis results of tarhana samples

Samples	Colour	Taste and Aroma	Odour	Sourness	Consistency	Overall Rating
Ankara	2.21	2.64	2.79	3.29	2.75	2.76
Konya	2.89	3.29	3.43	2.71	3.75	3.26
Kayseri	2.82	2.64	3.71	2.36	3.86	3.23
Eskişehir	3.82	3.39	3.75	2.96	4.04	3.71
Nevşehir	3.93	3.21	3.46	2.64	3.57	3.54
Aksaray	4.43	3.43	3.36	3.04	3.86	3.75
Sivas	3.25	3.32	3.39	3.86	3.86	3.43

Figure 1. Tarhana samples from central Anatolian region.

4. Conclusion

In this study, the chemical, functional, rheological, and sensory properties of tarhana from Aksaray, Eskişehir, Nevşehir, Sivas, Konya, Kayseri, and Ankara provinces of Central Anatolia region were determined. It was found that the tarhana of each region has different characteristics due to the differences in the raw materials used in tarhana production, production conditions, and methods. All these values are similar to those found in studies of tarhana. Except for the moisture values, the other parameters are within the accepted TSE criteria. This study will guide future research on traditional tarhana and address gaps in the literature. It also provides valuable insights into the standard commercial production of traditional tarhanas. Furthermore, this study serves as a reference for books, almanacs, and other publications related to traditional tarhana.

Author Contributions

The percentages of the authors' contributions are presented below. All authors reviewed and approved the final version of the manuscript.

	A.C.	Z.E.
C	50	50
D	100	
S	100	
DCP	50	50
DAI	20	80
L	50	50
W	80	20
CR	80	20
SR	80	20
PM	100	

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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