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Evaluation of Physicochemical, Nutritional and Sensory Properties of the Wet Tarhana

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Abstract
The wet tarhana is a fermented product that prepared with wheat flour, yogurt, tarhana herb (*Echiophora sibthorpiana*) and some chopped vegetables and spices. The basic difference of wet tarhana from other tarhana types is that it is prepared without a drying step. During its spontaneous fermentation process about 10 days, yogurt bacteria (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) produce several organic acids such as lactic acid and some other organic compounds. The ingredients and long fermentation process gain characteristic flavor and unique taste to the tarhana. Tarhana is similar to sourdough due to its' long spontaneous fermentation time. The aim of the study was to investigate physicochemical, nutritional and microbiological properties of wet tarhana, and to evaluate the relationships between them. For this purpose, wet tarhana samples were collected from different districts, and some physicochemical properties (pH, total acidity, dry matter, fat, and soluble ash content), antioxidant activity, phytic acid content, bioavailability, viscosity and counts of microbiota were performed. The results showed that the level of mineral digestibility was ranged from 67.22% to 88.88%, and a negative correlation was determined between mineral bioavailability and phytic acid content. The vitality of the microbiota especially lactic acid bacteria maintained during the storage period. Moreover, tarhana soups were prepared with the samples and their viscosity and sensory assessment were performed. Although the wet tarhana and soup samples had different viscosities initially, all the samples indicated pseudoplastic flow behavior. Furthermore, it was determined that the physicochemical properties of the samples affected the preference of the panelists in terms of sensorial assessment.
Keywords: tarhana, fermented products, bioavailability, viscosity
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1. Introduction

Tarhana is a traditional, fermented cereal-based food product consumed for many years in different countries. According to historical records, tarhana was first produced in Middle Asia and afterward, it spread out to different parts of the world (Özdemir, 2007). This fermented product has been consumed and called with different names in several countries. Tarhana is known as trahana in Greece, kushuk in Iraq, kishk in Egypt and tahonya/talkuna in Finland and Hungary (Hayta et al., 2002). It is prepared by mixing wheat flour, yogurt and different spices followed by fermentation for several days. The dough at the fermentation stage is called as wet Tarhana. It can be stored in a glass jar for several months. Afterwards, the dough is dried in the sun or by a dryer, thus obtained dry Tarhana (Erbaş et al., 2005). It is an important part of the daily diet as a good source of protein, minerals, and vitamins in many countries. Whereas it can be prepared with different cereal flours or spices, it can be produced and consumed dried or wet form. There are lots of tarhana types depended on its ingredients and preparation in different regions.

The wet tarhana is the traditional fermented product. The basic difference of wet tarhana from other tarhana types is that it is prepared without drying step and is stored in the glass jars. The white wheat flour, yogurt, tarhana herb (*Echiophora sibthorpiana*), Darak herb (*Anethum graveolens* L.) and optional vegetables and greens are used for the preparation of traditional wet tarhana. The tarhana herb is one of the most important ingredients that generates tarhana's unique flavor and taste. To prepare dough, all the ingredients are kneaded thoroughly and then the dough set aside for fermentation at room temperature. The fermentation process takes places around ten days. During this process, the spontaneous fermentation carries out. The compounds formed during fermentation also creates tarhana's characteristic taste and flavor. Then prepared wet tarhana is placed in the glass jars and stored in this way. Because it is not usually dried after fermentation, it protects own unique flavor and aroma which based on ingredients and formed during fermentation. Wet tarhana is generally consumed as soup.

The purpose of the present study is primarily to determine the differences between the tarhana samples obtained from different districts, to examined the change interval. Second is to investigate the relationship between bioactivity, bioavailability, physicochemical and sensory properties of the tarhana samples.

2. Material and method

The wet tarhana samples produced in the same season on August were collected from 9 different regions of

Kastamonu, Turkey; Akdoğan (T1),Azdavay (T2), Bozkurt (T3), City Center (T4), Daday (T5), Devrekani (T6), Inebolu (T7), Pehlivan (T8) and Taşköprü (T9) districts. The samples were kept in a cool place at +8 °C till to analysis. The chemicals were supplied by Merck (Germany) and Sigma (Germany).

2.1 Enumeration of lactic acid bacteria (LAB) and yeast

Microbial properties of wet tarhana samples were analyzed in terms of yeast, aerobic and anaerobic lactic acid bacteria. To enumeration of LAB, a 10g sample was transferred to 90mL 0.1% peptone water and homogenized with a stomacher (Isolab, Germany). Microbial suspensions were plated from appropriate dilutions and incubated as follows: Man-Rogosa and Sharp Agar (MRS, Merck, Germany) for *Lactobacillus* spp. incubated at 37 °C for 48 h, M17 Agar (Merck, Germany) for *Streptococcus* and *Lactococcus* spp. incubated at 30 °C for 48h., yeast extract glucose chloramphenicol agar (YGC, Merck, Germany) for total yeasts incubated at 25 °C for 48h, respectively.

2.2 Physicochemical properties

For the measurement of pH, the sample and distilled water were mixed (1:9, w/v) by ultra turrax (IKA, T25, Germany) until a homogeneous mixture was obtained, the pH was then measured. The mixture was titrated with 0.1N sodium hydroxide, and total titratable acidity (TTA) was calculated (Rizzello et al. 2016).The color profile of the samples was determined using a colorimeter (Minolta,CM3600d, Osaka, Japan.) Lightness, L^* (100= White; 0= Black), a^* (+, Red; -, Green) and b^* (+, Yellow; - Blue) values were measured. The measurement was performed on five different points and mean values were calculated (Torrieri et al., 2014). The fat, ash and moisture contents were determined according to AACC approved methods (Moisture No: 44-15A, Ash No: 08-03, Fat No: 30-25).

2.3 Nutritional properties

For in-vitro mineral digestibility (MD%) tarhana samples (1g) were incubated with 25 mL of pepsin solution (2 g pepsin +1L hydrochloric acid 0.03 N) at 37°C for 3h. The samples were filtered by ashless filter paper. The pellet and filter paper were burned together in the furnace and the ash value was calculated. The digestible mineral content was obtained with their differences. The MD value (%) was obtained by using the following equation (1) (Hayta and Hendek Ertop, 2017):

$$MD\ \% = \frac{DigestibleMineralContent}{TotalMineralContent} x100 \quad (1)$$

For determination of phytic acid content, the seed samples were grounded and the phytic acid extraction was carried out by adding 10mL 0.2 N hydrochloric acid to 0.5 g and placed on the horizontal shaker at room temperature for 24 h. The phytic acid was analyzed in the protocol as described by Haug and Lantzsch (1983). For antioxidant activity, the extraction was carried out according to Banu et al.(2010). Antioxidant activity was determined by the method described by Karamac et al.(2002) with minor modification, as inhibition % using the α,α diphenyl-β-picrylhydrazyl (DPPH) radical scavenging assay. In the study, 0.040 mL extract was mixed with 2.5 mL of methanol and a methanolic solution of DPPH (1mM, 0.300 mL) was then added.

2.4 Viscosity

The viscosity (cp) measurements were performed on the samples (Fungilab Expert L viscometer, USA- spindle No. 7). The measurement was directly carried out at the wet tarhana samples. For the tarhana soups to viscosity measurement, the wet tarhana samples were diluted to 10% dry solids content with water before measurements (Fungilab Expert L viscometer, USA- spindle No. 4). The temperature was kept constant at 50 °C during measurements (Erbaş et al., 2005). All readings were taken after 1min. Viscosity values were measured at different rotational speeds for the wet tarhana samples (5, 10, 15, 30 and 60 rpm) and for the soup samples (10, 30, 60 and 90 rpm) the procedure conducted by Mitschka (1982) was used.

2.5 Sensory assessment

For the sensory analysis, tarhana soup samples were prepared by the wet tarhana samples were diluted to 10% dry solids content with tap water. The soup samples were heated gently while stirring until they boiled, then they were simmered for 5 min and finally cooled to 70 °C. Sensory analysis was taken place with 18 students and academic staff whose ages ranged from 20-30 in Kastamonu University Faculty of Engineering and Architecture (Muir et. al., 2000). The intensities of the various sensory characteristics of the samples were evaluated by the panelists. The samples were labeled randomly with three-digit numerical codes and then given to the panelists, who evaluated the intensities of attributes for each sample. The intensities (taste, color, odor, consistency, sourness, pungency, general acceptability) were scored using a seven-point hedonic scale (Meilgaard et al., 1991). Seven means extreme perceptible and zero means imperceptible. The results were presented statistically (Table 4).

2.6 Statistical analysis

The average values of measurements are reported together with standard deviations. Analysis of variance (ANOVA) was used to evaluate the significant difference with performed using SPSS 18.0.0 software. Tukey test was used to determine significant differences (p<0.05).

3. Results and Discussion

3.1 Enumeration of lactic acid bacteria and yeast

The aerobic and anaerobic LAB and yeast numbers of each sample are demonstrated in Table 1. The number of microorganisms changed according to the sample type. There is no growth was observed in T7 sample by means of all microorganisms. The anaerobic LAB didn't grow in T3, T4, and T9 samples. Generally, 10^3-10^6 cfu/g yeast, 10^3-10^6 cfu/g aerobic LAB and 10^5- 10^6 cfu/g anaerobic LAB were detected in the tarhana samples. Lactic acid and other metabolites of aerobic and anaerobic lactic acid bacteria generate tarhanas unique flavor. Additionally increasing acidity during fermentation extends the shelf life of tarhana. Because of that number of LAB and yeast are important. 10^3 -10^5 cfu/g aerobic LAB and 10^4-10^5cfu/g anaerobic LAB and 10^5 cfu/g yeast were detected in the six different wet tarhana samples, in a previous study conducted by Hendek Ertop and Atasoy (2018). Wet tarhana has more microbial load than dry tarhana. Continuing fermentation generates an increase in acidity during the storage period. This case causes more intense flavor and taste in wet tarhana products.

3.2 Physicochemical properties

pH values of tarhana samples ranged from 3.56-4.26. As indicated in Table 2, T4 had the highest pH value 4.26. Its followed by the T2 with 4.24. The lowest value 3.56 belong to T7. In accordance with these results, while T7 had the highest acidity value 27.0, T5 had the lowest one with 9.45. In Turkish Tarhana Standard TS 2282 report that the acidity of tarhana must range from 10 to 35. So all the samples except T5 are in accordance with the standard by means of acidity. Coşkun (2006) measured pH values of tarhana samples from Thrace region 3.30, 3.69 and 4.12 and total acidity 16.86, 13.98, 9.56. In another study, the pH and total acidity of six different tarhana samples were reported between 4.0-4.5 and 4.6-5.7 respectively (Hendek Ertop and Atasoy, 2018). Tamer et al. (2007) measured between 1.7 and 40.7 of the 21 different type tarhana's acidity. Ingredients in the formulation, microbiota of tarhana, duration of the fermentation process, production condition and storage period can affect the acidity of tarhana product.

According to statistical analysis, all samples indicated similar moisture content (p>0.05). It was found that all the samples contained as much moisture as nearly half of their mass. T7 had the highest moisture content 57.45% and T4 had the lowest value with 49.22%. Tamer et al. determined the moisture content of frozen non-dried tarhana from Afyon province as 66.40%. Hendek Ertop and Atasoy (2018) determined that the moisture content was in the range of 49.2-57.5% in different tarhana doughs. Wheat flour and yogurt, two main ingredients of tarhana, are thought to cause different moisture contents of tarhana samples. While T8 had the highest fat content with 4.77% T1 had the lowest with 0.74%.

Table 1. Number of aerobic LAB (cfu/g), anaerobic LAB (cfu/g) and yeast (cfu/g)

Tarhana sample	Aerobic LAB (cfu/g)	Anaerobic LAB (cfu/g)	Yeast (cfu/g)
T1	42.10^5	78.10^5	43.10^3
T2	11.10^6	40.10^6	26.10^4
T3	34.10^4	-	24.10^3
T4	50.10^5	-	72.10^3
T5	11.10^3	27.10^6	28.10^4
T6	24.10^5	12.10^6	30.10^6
T7	-	-	-
T8	95.10^5	15.10^6	76.10^5
T9	56.10^4	-	30.10^3

a-g: Means with different superscripts in the same column are significantly different ($p<0.05$)

Table 2.pH, acidity (Lactic Acid%), moisture content (%), fat content (%)

	Acidity (Lactic Acid%)	pH	Moisture (%)	Fat (%)	Color		
					L^*	a^*	b^*
T1	21.15±0.22^{c}	3.92±0.01^{b}	49.55±0.55^{b}	0.74±0.08^{f}	72.33±0.21^{d}	7.60±0.14^{c}	31.20±0.46^{c}
T2	13.05±0.09^{e}	4.24±0.02^{a}	49.47±0.21^{b}	3.53±0.16^{b}	82.33±0.21^{a}	0.62±0.14^{g}	21.23±0.46^{e}
T3	21.20±0.13^{c}	3.74±0.00^{c}	54.57±0.18^{ab}	1.23±0.13^{e}	71.75±0.50^{d}	6.19±0.38^{e}	28.56±0.52^{d}
T4	24.30±0.21^{b}	3.57±0.02^{d}	49.22±0.02^{b}	1.35±0.22^{e}	68.96±1.32^{g}	11.40±0.22^{b}	33.97±0.73^{b}
T5	9.45±0.18^{f}	4.26±0.00^{a}	50.35±0.43^{b}	1.33±0.19^{e}	75.70±0.20^{c}	8.32±0.14^{c}	30.78±0.12^{c}
T6	19.60±0.10^{cd}	3.94±0.02^{b}	53.6±0.27^{ab}	2.30±0.09^{c}	71.33±0.49^{de}	13.87±0.55^{a}	37.12±0.82^{a}
T7	27.00±0.00^{a}	3.56±0.01^{d}	57.45±0.19^{a}	2.36±0.14^{c}	80.15±0.26^{b}	1.64±0.18^{f}	21.74±0.21^{e}
T8	18.00±0.05^{d}	3.97±0.01^{b}	50.90±0.21^{b}	4.77±0.39^{a}	70.54±0.40^{ef}	7.97±0.60^{c}	31.46±0.46^{c}
T9	24.10±0.13^{b}	3.70±0.00^{c}	54.97±0.06^{ab}	1.99±0.10^{d}	70.26±0.33^{f}	7.11±0.33^{d}	33.37±0.63^{b}

a-g: Means with different superscripts in the same column are significantly different (*p<0.05*)

According to the statistical analyzes performed, there was a significant difference ($p<0.05$) between the fat contents of the samples. As it can be seen from the Table 2, T3, T4, and T5 had the similar fat contents. T2 and T8 had the higher values than other samples. Dağlıoğlu (2000) reported that fat content of different tarhana samples changes in the range of 1.6-18.2% depending on the content of tarhana. In the previous studies, tarhana sample made with wheat flour had the 3.40% fat while the samples made with barley flour had 3.39% fat content. (Erkan et al., 2006).The fat content of the tarhana related to the ingredients used in the formulation and the yogurt type is one of the most influent factors. T2 and T8 samples got the highest score from the sensory analysis in terms of taste and odor parameter shown in Table 4. Therefore it can be said that the fat content has a positive effect on taste and odor properties. Color analyses results had shown in Table 2. T2 had the highest lightness value (L^*) 82.33 while T4 had the lowest one with 70.26. T6 had the highest a^* and b^* values and T2 had the lowest a^* and b^* values. Erkan (2006) measured the L^*, a^*, b^*values of tarhana made with wheat flour 75.06, 6.46 and 20.12 respectively. Results of the color analysis showed that the type and amount of spices and vegetables in formulations creates a significant difference between the appearance of samples.

3.3 Nutritional properties

In previous studies in different fermented foods, it was determined that the natural fermentation or yeast fermentation was made increased the amount of digestible mineral matter and led to an increase in the amount of digestible ash (Sripriya et al., 1997; Toufeili et al., 1999; Elyas et al., 2001; Dhingra and Jood 2001). The mineral digestibility also known as bioavailability of the samples were found (Table 3) statistically significant ($p<0.05$).According to the results, the Mineral Digestibility value of the samples ranged from 88.88% to 67.22%.

Table 3.Total ash, digestible ash, mineral digestibility (%) and inhibition (%) of tarhana samples

Tarhana sample	Total ash (%)	Digestible ash (%)	Mineral digestibility (%)	Inhibition (%)
T1	1.54±0.02^{c}	1.35±0.01^{c}	87.63±0.92^{a}	45.54±0.00^{bc}
T2	1.11±0.03^{d}	0.75±0.02^{d}	67.22±1.06^{d}	27.71±1.98^{d}
T3	1.34±0.09^{cd}	1.10±0.02^{cd}	81.72±1.21^{c}	36.30±3.30^{cd}
T4	1.05±0.03^{d}	0.71±0.02^{d}	67.34±0.02^{d}	47.26±0.00^{bc}
T5	1.52±0.06^{c}	1.23±0.00^{c}	80.78±0.02^{c}	36.25±4.03^{cd}
T6	1.76±0.02^{bc}	1.50±0.01^{bc}	85.06±0.55^{b}	49.57±0.00^{abc}
T7	2.12±0.00^{b}	1.88±0.03^{b}	88.88±1.19^{a}	43.48±3.53^{bc}
T8	2.52±0.03^{a}	2.18±0.06^{a}	86.67±0.63^{a}	61.16±2.04^{a}
T9	2.65±0.01^{a}	2.17±0.04^{a}	81.85±1.12^{c}	55.52±2.22^{ab}

a-g: Means with different superscripts in the same column are significantly different (*p<0.05*)

The phytic acid forms the complexes with the minerals which are required for the body and it decreases the bioavailability of them (Lopez et al., 2002). However, phytase enzyme which is one of the most important metabolites of LAB provides degradation of the phytic acid in the grain and cereal products such as tarhana, sourdough which are fermented products. Therefore, the phytic acid content of the tarhana samples was determined and the relation between the phytic acid (mg/100g) and mineral digestibility (%) was evaluated with correlation as statistically. In this study, the negative correlation was determined between them, and the R^2 was found 0.85.In a study about the effects of the contributions of yeast, malt flour and phytase enzyme on the bioavailability of protein and mineral contents which was carried out in tarhana, it was determined that the level of mineral digestibility, 68.32%, increased up to 82.07% after fermentation (Bilgiçli et al., 2006).

The DPPH radical inhibition (%) values of the samples were found statistically significant ($p<0.05$). This result can be explained by the different content of the tarhana formulation of the samples. For example, the rate

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of the bran content of the flour used in tarhana formulation could be an effect. It is known that high extraction rate in flours affects the antioxidant capacity (Liukkonen et al.,2003; Rizzello et al.,2012). Moreover, the increase in antioxidant activity resulting from fermentation can be explained by different biochemical and metabolic events. The metabolisms of LAB facilitate lipid oxidation during fermentation. It is known that homofermentative lactobacillus increases the lipid oxidation (Vermeulen et al.,2007). It is also likely that formation of the bioactive peptides as a result of the interaction between acidification and proteolysis took place by the fermentation may contribute antioxidant effect. It was ascertained that some selected LAB produced antioxidative peptides during sourdough fermentation (Coda et al.,2012).

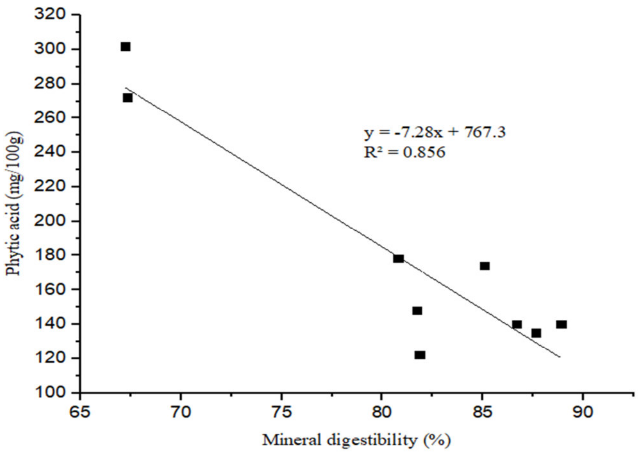
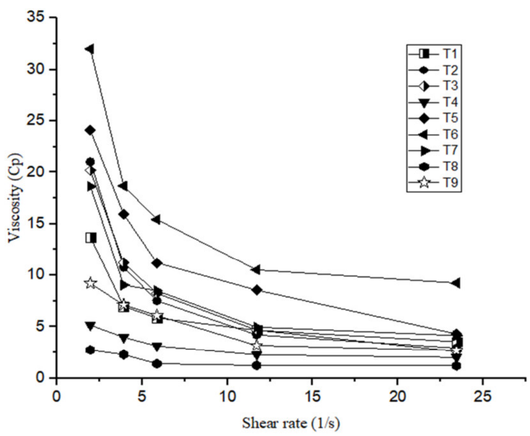
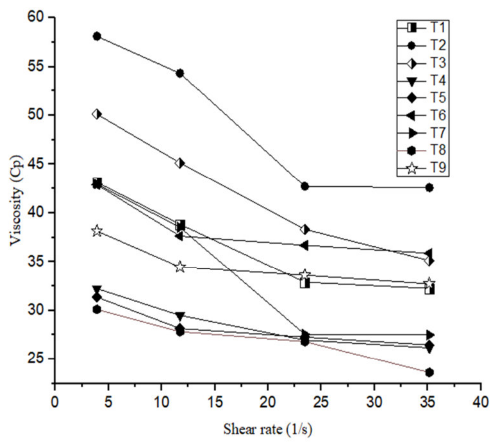


Figure 1.Correlation between mineral bioavailability(%) and phytic acid (mg/100 g) content

3.4 Viscosity

It is known that one of the parameters used for determining quality in Tarhana samples is the viscosity. Starch has a significant effect on the viscosity properties of foods. The formation of a viscous, consistent structure in Tarhana originates from the thickener feature of starch. It has been reported that fats and proteins also affect viscosity like starch (Anıl, 2016; Kıtan, 2017). Varying viscosity values depending on different shear rates are shown in Figure 2. Whereas samples show the similar flow behavior, the viscosity of samples quite different. While T6 has the highest viscosity, T8 has the lowest viscosity for wet tarhana. According to the graphs A and B, when the share rate increase, viscosity decreased for all of the tarhana and soup samples. Many liquid or semi-solid food samples exhibit a variation in their viscosity as a response to increasing shear rates, so they are called non-ideal or non-Newtonian fluids. All of the tarhana samples in this study showed the non-Newtonian flow behavior. Non-Newtonian fluids are also classified as "Pseudoplastic (Shear thinning) fluids" when there is a decrease in viscosity against the applied shear rates. As shown in Figure 2, the samples in this study showed Pseudoplastic behavior because their viscosities decreased in response to the increase in shear rate applied. The decrease in viscosity as the shear rate was increased may be related to the decreased alignments of constituent molecules of the tested food system. It was reported that shear-thinning behavior could be expected in the milk products since weak physical bonds, electrostatic, and hydrophobic interactions affect the rheology (Alpaslan and Hayta, 2007).





(a) (b)

Figure 2.Viscosity of the wet tarhana samples (a) and soups (b) measured in centipoises (cp) vs. shear rate (1/s)

3.5 Sensory Assessment

It was determined that all samples have a similar profile with some differences. As indicated in Table 4, T8 sample received the highest score and T9 sample received the lowest score. The results showed that T2 got the highest consistency value. This opinion could be that due to the highest fat content of the sample (Table 2). The results of the pungency and sourness feature of the samples were found similar. The correlation between both attributes was found R^2=0.815. The fermentation carried out in tarhana production and continued along shelf life was associated with microbiota and its metabolites. So it clearly influenced the organic acid content, pH and TTA levels. The LAB synthesizes lactic acid by the homofermentation of hexoses, and lactic acid, acetic acid, ethanol and CO_2 by the heterofermentation of hexoses (Olapade and Adetuyi, 2007). Especially organic acid content of the fermented products such as tarhana and sourdough can affect the taste and odor. The color of the T2 and T7 soup samples had the lowest score. This case could be associated with that their tarhana samples had lowest $a*$ value. By this result, it can be said that less redness character of wet tarhana created an undesirable appearance for the soup.

Table 4. Sensory analysis results

	Taste	Color	Odour	Consistence	Sourness	Pungency	General Acceptability	Total
T1	4.29±0.52^{b}	4.43±0.19^{ab}	4.71±0.23^{bc}	4.00±0.22^{bc}	5.43±0.51^{a}	5.86±0.17^{a}	4.86±0.20^{ab}	33.04±0.29^{d}
T2	5.86±0.30^{a}	2.57±0.65^{b}	6.10±0.28^{ab}	6.57±0.15^{a}	5.37±0.30^{a}	5.29±0.12^{ab}	6.00±0.16^{a}	37.76±0.28^{bc}
T3	4.88±0.28^{ab}	5.13±0.31^{a}	5.63±0.22^{ab}	5.25±0.39^{abc}	5.00±0.11^{a}	5.00±0.20^{ab}	5.38±0.19^{ab}	36.25±0.24b^{c}
T4	5.80±0.02^{a}	5.57±0.16^{a}	5.43±0.37^{abc}	5.14±0.41^{abc}	5.89±0.24^{a}	6.00±0.84^{a}	5.00±0.36^{ab}	38.83±0.34^{b}
T5	5.14±0.14^{ab}	5.00±0.21^{a}	6.00±0.13^{ab}	5.71±0.29^{ab}	4.57±0.21^{a}	5.14±0.28^{ab}	5.57±0.21^{ab}	37.13±0.21^{c}
T6	5.00±0.21^{ab}	4.75±0.09^{ab}	4.00±0.27^{cd}	4.25±0.37^{bc}	5.13±0.46^{a}	5.38±0.14^{ab}	4.88±0.44^{ab}	33.39±0.28^{d}
T7	4.13±0.33^{b}	4.13±0.82^{ab}	4.00±0.09^{cd}	3.63±0.76^{bc}	5.38±0.24^{a}	5.58±0.33^{ab}	4.38±0.29^{bc}	31.23±0.41^{e}
T8	5.89±0.19^{a}	6.14±0.17^{a}	6.43±0.51^{a}	5.57±0.33^{ab}	5.71±0.09^{a}	5.43±0.37^{ab}	6.14±0.21^{a}	41.31±0.27^{a}
T9	3.86±0.16^{b}	4.86±0.54^{a}	3.00±0.23^{d}	3.29±0.27^{c}	4.00±0.61^{a}	4.29±0.21^{b}	3.29±0.20^{c}	26.59±0.32^{f}

4. Conclusion

In this study, microbial, physicochemical, nutritional and sensory properties of wet tarhana collecting from the different regions of Kastamonu province were evaluated and compared. The relationships between these properties of tarhana were evaluated. The physicochemical properties changed in a wide range. The main properties were the acidity due to spontaneous fermentation exhibited clearly effect on the taste and odor properties of the samples. With this study, the effects of tarhana fermentation on nutritional and bioactive qualities of the samples were evaluated. The tarhana fermentation which had long period affected the bioavailability, antinutrient content, antioxidant activity, and microbial vitality. Nowadays, consumers prefer food types that are produced with unrefined, fermented and healthy raw material. In this respect, it is thought that the wet tarhana was an alternative fermented product that respected the consumer preferences. Furthermore, It may be suggested to the production of the wet tarhana with the different whole grain flours, and evaluation of nutritional properties, as a result of this study.

References

AACC (2000). Approved methods of the American Association of Cereal Chemists, 8th edition AACC International, St. Paul

Anonymous (1981). Tarhana Standard, Standard No 2282. Turkish Standardization Institute, Ankara (in Turkish)

Anıl, M., Durmuş, Y. & Tarakçı, Z. (2016). Viscosity comparison of corn flour and kiln-dried corn flour tarhana substituted with different gums. *Ordu Univ. J. Sci.* 6 (2), 128-135

Banu, I., Vasilean, I. & Aprodu, I. (2010). Effect of lactic fermentation on antioxidant capacity of rye sourdough and bread. *Food Sci. Technol. Res.,* **16**,571 – 576

Bilgicli, N., Elgun, A. & Turker, S.(2006). Effects of various phytase sources on phytic acid content, mineral extractability and protein digestibility of tarhana**.** *Food Chem.,* **98**,329–337

Coda, R., Rizzello, C.G., Pinto, D. & Gobbetti, M. (2012). Selected lactic acid bacteria synthesize antioxidant peptides during sourdough fermentation of cereal flours. *Appl. Environ. Microbiol.,* 78,1087–1096

Coşkun, F. (2003). Tarhana ve beslenme yönünden önemi. Gıda ve Yem Bilimi Teknolojisi. **3** (2), 46-49

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

Dhingra, S. & Jood, S. (2001). Organoleptic and nutritional evaluations of wheat breads supplemented with soybean and barley flour. *Food Chem*. **77,** 479-488

Elyas, S.H.A., El Tinay, A.H., Yousif, N.E. & Elsheikh, E.A.E. (2001). Effect of naturel fermentation on nutritive value and *in vitro* protein digestibility of perl millet. *Food Chem*.,**78** (1),75- 79

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 Sci. Technol.*,**38**(4), 409-416

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

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

Hayta, M. & Hendek Ertop, M. (2017). Optimization of sourdough bread ıncorporation into wheat bread by response surface methodology: bioactive and nutritional properties. *Int. J. Food Sci.Technol*.,**52** (8), 1828-1835

Haug, W. & Lantzsch, H.J.(1983). Sensitive method for the rapid determination of phytate in cereals and cereal products. *J. Sci. Food Agric.*,**34**, 1423-1426

Hendek Ertop, M. & Atasoy, R. (2018). Bioavailability, microbiologic and bioactive properties of tarhana produced with alternative cereals and legumes, Ecology Symposium 2018, Kastamonu, Turkey

İbanoğlu, E. & İbanoğlu, Ş. (1999). Foaming properties of white wheat flour-yoghurt mixture as affected by fermentation. *J. Cereal Sci.*,**30**, 71–77

Karamach, M., Amarowıcz, R., Weıdner, S., Abe, S. & Shahıdı, F. (2002). Antioxidant activity of Rye caryopses and embryos extracts. *Czech J. of Food Sci.,* **20***,*209–214

Kıtan, S. (2017). Glutensiz tarhana üretiminde kinoa (C*henopodium quinoa*) kullanımı. MSc thesis. Institute of science, Ondokuz Mayıs University, Samsun.

Liukkonen, K.H.,Katina, K., Wilhelmson, A., Myllymaki, O., Lampi, A.M., Kariluoto, S., Piironen, V., Heinonen, S.M., Nurmi, T., Adlercreutz, H., Peltoketo, A., Pihlava, J.M., Hietaniemi, V. & Poutanen, K. (2003). Process-induced changes on bioactive compounds in whole grain rye. *Proc. Nutr. Soc.,***62***,*117–122

Meilgaard, M., Civille, GV. & Carr, BT. (1991). Sensory Evaluation Techniques, CRC Press, Boca Raton

Muir, DD., Tamime, AY. & Khaskheli, M. (2000). Effect of processing conditions and raw materials on the properties of khisk. 2. Sensory profile and micostructure. *LWT. Food Sci Technol.*,**33**, 452-461.

Olapade, A. & Adetuyi, D.O., (2000). Comparison of different methods of producing bambara (*Voandzeia subterranean* L. *Thou*) flours for preparation of ‘moin-moin’.*Niger. Food J*., **25**,150-157.

Özbilgin, S., (1983). The chemical and biological evaluation of tarhana supplemented with chickpea and lentil. Ph. D. Thesis. Cornell University, Ithaca

Özdemir, S., Göçmen, D. & Yıldırım Kumral, A. (2007). A traditional Turkish fermented cereal food: Tarhana. *J. Food Rev. Int.*,**23**,107-121

Rizzello, C.G., Coda, R., Mazzacane, F., Minervini, D. & Gobbetti, M. (2012). Micronized by-products from debranned durum wheat and sourdough fermentation enhanced the nutritional, textural and sensory features of bread. *Food Res. Int.*, **46***,*304-313

Sripriya, G., Antony, U. & Chandra, T.S. (1997). Changes in carbonhyrates, free amino acids, organic acids, phytate and HCl extractibility of minerals during germination and fermentation of finger millet. *Food Chem*.,**58** (4), 345-350

Tamer, C.E., Kumral, A., Asan, M. & Sahin, I. (2007). Chemical compositions oftraditional tarhana having different formulations. *J Food Process Preserv*, **31**,116–26

Toufeili, I., Melki, C., Shadarevian, S. & Robinson, R.K. (1999). Some nutritional and sensory properties of bulgur and whole wheat-meal kishk (a fermented milk-wheat mixture). *Food Qual. Prefer.,***10**, 9-15

Vermeulen, N., Czerny, M., Gänzle, M.G., Schieberle, P. & Vogel, R.F. (2007). Reduction of (E)-2-nonenal and (E, E)-2,4-decadienal during sourdough fermentation. *J. of Cereal Sci.,* **45***,*78-87