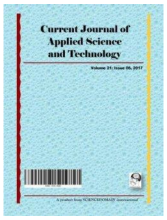


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# Physico-chemical and Sensory Properties of Tarhana Prepared from Different Cereals and Dairy Ingredients

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Author MFYH designed the study, wrote the protocol, managed the analyses of the study and managed the literature searches. Author MGEG designed the study, managed the analyses of the study, performed the statistical analysis, wrote the first draft of the manuscript and managed the literature searches. Both authors read and approved the final manuscript.*

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## ABSTRACT

Tarhana is a traditional fermented food made from cereals and yoghurt mixture and popular in some European and African countries. In this study, the effects of wheat, oat or barley flour with cow or goat yoghurt on the physico-chemical and sensory properties of Tarhana were investigated. A gradually increased in acidity of all prepared Tarhana dough samples was found during fermentation time. The acidity of Tarhana powder ranged between 0.78% for Tarhana made from oat flour and goat yoghurt to 2.12% when using barley flour with goat yoghurt. In addition, incorporated barley flour and goat yoghurt in Tarhana resulted in significant increase in total phenolic compounds and antioxidant activity being (27.23 mg GAE/g) and 47.45%, respectively. It could be stated that all

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Tarhana samples are good source of minerals especially K, Na and Mg. A significant increase in lightness (L) being 71.75 and total intensity of color being 72.46 was exhibited by Tarhana prepared from oat flour and cow yoghurt compared to all other treatments. All of Tarhana treatments were significant increase in redness (a), yellowness (b) and chroma except Tarhana samples prepared from barley flour. It could be seen that all Tarhana soups behaved as non-Newtonian fluid (pseudoplastic) whereas, the viscosity was gradually decreased with increasing the rotational speed (rpm). All of the Tarhana soups were acceptable in sensory properties except when using barley flour which need to improve their color. Tarhana soup with wheat flour and cow or goat yoghurt samples had valuable high scores in color (8.7 and 8.0), taste (8.7 and 8.7) and overall acceptability (8.9 and 8.7) and being more preferable by the panelists. It can be concluded that Tarhana supplemented with oat or barley flour can be claimed to be a good sources of minerals, phenolics as well as antioxidant activity and considered as a functional food.

*Keywords: Tarhana; oat; barley; physico-chemical; antioxidant activity; sensory parameters.*

## 1. INTRODUCTION

Tarhana is a traditional Turkish fermented cereal based food, made from wheat flour, yogurt, baker's yeast and various vegetables. After fermentation, the Tarhana dough is dried and ground [1]. Tarhana powder is generally consumed as soup at lunch and dinner [2]. The low moisture content (6–9%) and low pH (3.8–4.4) of the Tarhana powder provide bacteriostatic effect against pathogenic and spoilage organisms; and increase the shelf life where, it can be stored for 2–3 years without any deterioration [3,4]. Tarhana is considered as a good source of saccharides, proteins, minerals and some vitamins. Moreover, their preparation is inexpensive and lactic acid fermentation offers benefits like preservation, enhancement of nutritive value and sensory properties improving the quality of the product [5].

Tarhana is healthy for children, the elderly and patients [6]. It is thick-creamy, strongly flavored and it can be easily digested [2]. Fermentation is usually carried out by using yogurt bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophilus* and baker's yeast (*Saccharomyces cerevisiae*). Both lactic acid bacteria and yeast fermentation occur simultaneously during Tarhana preparation [7]. Commercially Tarhana dough was fermented with higher *Lactobacillus* spp. diversity than homemade Tarhana dough. *Lactobacillus casei* and *L. alimentarius* were identified differently from the fermentation of commercially Tarhana dough [8]. The carbohydrate, protein and lipid components of Tarhana dough are subjected to partial hydrolysis by lactic acid bacteria and yeasts during fermentation, resulting in a final product with improved digestive properties [9]. Fermentation also resulted in increase of niacin, pantothenic acid, riboflavin and folic acid contents of Tarhana [10].

Some researchers fortified, supplemented or replaced wheat flour and/or yoghurt in Tarhana by adding other cereals, legumes, wheat germ, or wheat bran to raise the biological value of Tarhana and Tarhana-like products [2]. Oat (*Avena sativa*) grain contains high amounts of polysaccharides which are extremely important group of "carbohydrates" and the main constituents of dietary fibers. Dietary fibers play an extremely important role in the nutritional benefits of "whole-grain products" especially oats [11]. The soluble fiber from oatmeal and oat bran is very effective to lower blood cholesterol and normalize blood sugar levels [12,13,14]. Barley (*Hordeum valgare*) grain gives consumers different bioactive compounds that can enhance their health because it is a major source of fiber and nutrients in the human diet. β-glucan, a cell wall component and the major fiber constituents in barley have been shown to reduce the risk of colon cancer, reduce glycemic index and lower cholesterol [15]. The beneficial effects of fiber have been ascribed to its ability to control hyperglycemia (high blood sugar), improve glucose tolerance as well as reduce serum lipids and cholesterol levels associated with cardiovascular disease in both normal and hyperlipidemia individuals [16,15].

Goat milk is very nutritious in the tropics [17]. It differs from cow milk in having buffering capacity, better digestibility, alkalinity and certain therapeutic values in medicine and human nutrition [18]. It is important for prevention of cardiovascular diseases, cancer and used for stimulation of immunity. It is recommended for infants, old and convalescent people [19].

The objective of this study was to evaluate the effects of oat or barley flours and goat milk on physico-chemical and sensory properties of Tarhana compared to traditional Tarhana which prepared from wheat flour and cow milk.

## 2. MATERIALS AND METHODS

### 2.1 Materials

Cow and goat milk used in yoghurt preparation were kindly obtained from Agriculture and Veterinary Research and Experiments Center, Qassim University, Buraidah, Kingdom of Saudi Arabia. Starter Yo-flex culture (Yc-183) was obtained from Christian Hansen (Copenhagen, Denmark) which is a mixed strain culture (1: 1) of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. Wheat flour was obtained from Saudi Grains Organization (SAGO), Qassim region. Oat (*Avena sativa*), barley (*Hordeum valgare*) grains, tomato paste, chopped dry onion, paprika, salt and baker's yeast were purchased from the local market, Buraidah, Qassim region. Oat and barley grains were milled by using a hammer mill and sieved through 212 µm sieve then kept in refrigerator until analysis. The reagents used for the chemical analyses were of analytical grade.

### 2.2 Preparation of Tarhana Samples

Cow and goat yoghurt samples used in Tarhana processing were prepared according to the method reported by Tamime and Robisons [20]. For Tarhana preparation, wheat, oat or barley flour (400 g), cow or goat yoghurt (160 g), tomato paste (40 g), chopped dry onion (20 g), dry paprika (8 g), table salt (4 g) and baker's yeast (10 g), were mixed for 5 min using a Hobart mixer (N 50, Canada). The dough was put in the closed plastic containers and left for fermentation at 30 °C for 3 days in an incubator. The fermented doughs were divided into 2 cm diameter pieces, placed on the trays, and dried at 55°C in an air convection oven. The dried samples were milled into granulated form in a hammer mill equipped with 1 mm opening screen. Tarhana sample prepared from wheat flour and cow yoghurt considered as a control. The end-product Tarhana samples were kept in closed glass containers at room temperature [21].

### 2.3 Preparation of Tarhana Soup Samples

Tarhana soups were prepared by well mixing 5.0 g Tarhana powder sample with 100 $cm^3$ water and 1.0 g salt. After boiling for 5 min with continuous stirring, soups were cooled to 70°C for sensory evaluation and to 60°C for viscosity measurements [22].

### 2.4 Physico-chemical Properties of Tarhana

The effect of using oat or barley flour instead of wheat flour and goat yoghurt instead of cow yoghurt on physico-chemical properties of prepared Tarhana samples was investigated. Determined physical attributes of Tarhana are pH value, moisture content, water activity, color and viscosity. While the chemical properties of Tarhana samples are titratable acidity, total phenolic content, antioxidant activity and mineral contents.

#### 2.4.1 Physical properties of Tarhana

*2.4.1.1 Determination of pH*

The pH of Tarhana dough during fermentation up to 3 days and Tarhana powder samples were measured according to the method of Adeleke and Odedeji [23] using a pH meter (HANNA, HI 9025) already standardized with buffer solutions of pH 4.0 and 7.0.

*2.4.1.2 Moisture content*

Tarhana dough after fermentation period and Tarhana powder samples were analyzed for their moisture content according to the methods described in AOAC [24].

*2.4.1.3 Water activity*

Water Activity of Tarhana dough after fermentation period and Tarhana powder samples was determined using AQUA LAB (model series 3), USA by methods described by Landrock and Proctor [25]. Samples (in small plastic cups) were equilibrated against the saturated salt solution at 20°C.

*2.4.1.4 Determination of color*

Prepared Tarhana color was determined using spectrophotometer (Minolta Color Reader CR-10, Minolta Co. Ltd., Japan) according to the method described in Francis [26]. Color coordinates X, Y and Z were converted to corresponding Hunter L*, a* and b* color coordinates according to formula given by manufacturer. The chroma (C) represents color saturation or purity was calculated from C = $(a^2+b^2)1/2$ and total color intensity $(a^2+b^2+L^2)1/2$.

*2.4.1.5 Viscosity of Tarhana soup*

Viscosity of prepared Tarhana soup samples was measured using a rotational Brookfield viscometer (Brookfield DV-III ULTRA, LV spindle no: 2) at 20, 50, 80 and 100 rpm and 70°C as described by Ibanoglu et al. [27]. The results of viscosity were expressed in cP.

#### 2.4.2 Chemical properties of Tarhana

*2.4.2.1 Determination of titratable acidity*

Titratable acidity (as % lactic acid) of Tarhana dough during fermentation up to 3 days and Tarhana powder samples were analyzed determined as reported by Ling [28].

*2.4.2.2 Determination of total phenolic content*

Total phenolic content of Tarhana powder samples was measured by the Folin–Ciocalteu assay along with spectrophotometer as described by Singleton et al. [29]. Aliquots of 0.5 ml of each extracts were added to 0.5 ml of Folin-Ciocalteu reagent, followed by addition of 0.5 ml of an aqueous 20% solution of sodium carbonate. The mixture was stirred and allowed to stand for 30 min. The absorbance at 765 nm was measured using a model UV/VIS 1201 spectrophotometer (Shimadzu, Kyoto, Japan). A blank sample consisting of water and reagents was used as a reference. Gallic acid was applied as a standard, and the results were expressed as milligram gallic acid equivalent (GAE).

*2.4.2.3 Measurement of antioxidant activity (DPPH free radical scavenge)*

The ability of the Tarhana powder extracts to scavenge DPPH free radicals was determined by the method described by Blois [30]. Aliquots (100 µl) of each extracts were mixed with 2.9 ml of 0.1 mM DPPH in methanol. The control samples contained all the reagents except the extract. The absorbance at 517 nm was measured after 30 min of incubation at room temperature. The remaining DPPH free radical was determined by absorbance measurement against methanol blanks. The percentage scavenging effect was calculated from the reduction of absorbance against control (DPPH radical solution in methanol without sample) using the following equation: Scavenging activity (%) = $[(Ab_{control} - Ab_{sample})/Ab_{control}] \times 100$

*2.4.2.4 Determination of minerals in Tarhana samples*

The mineral contents of the prepared Tarhana samples, including potassium (K), sodium (Na), manganese (Mn), ferrous (Fe), cupper (Cu), zinc (Zn), cadmium (Cd) and lead (Pb) elements were determined using an Atomic Absorption Flame Emission Spectrophotometer (Perkin-Elmer Model AA-6200 from Shimadzu 7000, Japan) as reported by AOAC [24].

### 2.5 Sensory Evaluation of Tarhana Soup

Sensory evaluation of prepared Tarhana soups was performed by using ten member panels of food science and human nutrition department staff, Qassim University. A 9-hedonic scale from 1 (dislike extremely) to 9 (like extremely) was used to evaluate color, odor, taste, consistency and overall acceptance according to method described by Isik and Yapar [31]. The coded samples were served to the panelists at random to guard against bias.

### 2.6 Statistical Analysis

Data were expressed as the means ± SE. Statistical analysis was carried out using the PROC ANOVA followed by Duncan's Multiple Range Test with $p \leq 0.05$ being considered statistically significant to compare between means according to Snedecor avd Cochran [32]. All procedures were triplicate using Statistical Analysis System program [33].

## 3. RESULTS AND DISCUSSION

### 3.1 Changes in pH and Development of Acidity of Tarhana

Acidity formed by acidic fermentation in Tarhana dough is important factor for sensory properties of Tarhana soup as well as the keeping qualities of Tarhana powder since the low pH makes Tarhana unattractive to pathogenic and spoilage microorganisms. Changes in pH of Tarhana dough during fermentation periods up to 3 days and Tarhana powder are shown in Figs. 1. and 2., respectively. It could be observed that pH of Tarhana dough samples ranged from 4.84 to 4.47 confirming fact that the typical pH range for Tarhana-like products is 4–5 [34]. Gradually decrease in pH and increase in acidity of all Tarhana dough treatments were observed from first to third day of incubation at 30°C. At zero time, the highest pH value 4.84 was given by

Tarhana with barley flour and cow yoghurt followed by 4.79 for Tarhana with oat flour and goat yoghurt, while the lowest pH values was 4.69 for both recorded by Tarhana prepared from wheat flour with goat yoghurt and oat flour with cow yoghurt, respectively. At the end of fermentation period, Tarhana with wheat flour and goat yoghurt had the lowest pH value being 4.47 (Fig. 1). These changes in pH value may be attributed to increasing digestible substrates in the Tarhana dough as a result of amylolytic activity during the fermentation period [35]. The main reason of pH reduction in Tarhana dough was production of acids by baker's yeast and lactic acid bacteria of yoghurt in the formulation during fermentation [36]. Tarhana powder prepared from oat flour and goat yoghurt exhibited significant ($p \leq 0.05$) increase in value of pH (5.58) compared to other samples, while the lowest pH value (4.34) was given by Tarhana powder prepared from barley flour and goat yoghurt as shown in Fig. (2).

Titratable acidity (as lactic acid) of Tarhana dough treatments and Tarhana powder was determined and the obtained results are illustrated by Figures (3) and (4), respectively. After one day of fermentation, significant increase in acidity for Tarhana dough prepared from barley flour with cow or goat yoghurt were 0.76 and 0.77%, respectively. The same trend was continuous during fermentation period, in addition the acidity level of Tarhana dough containing wheat flour and cow yoghurt was increased significantly ($p \leq 0.05$) at the end of fermentation period (third day) which reached to 0.95% followed by 0.90% for Tarhana dough prepared from barley flour with goat yoghurt. The increase in the acidity followed by a decrease in pH value may be due to the fermentation of sugars and formation of organic acids by lactic acid bacteria of yoghurt and baker's yeast [3]. The rapid increase in acidity of Tarhana dough minimizes the impact of spoilage bacteria, whereas lactic acid fermentation can be suppressed in the slowly acidified medium by butyric bacteria activity [37]. Acidity levels of the final powder Tarhana samples ranged between 0.78% (the lowest level) for Tarhana with oat flour and goat yoghurt and 2.12% (the highest level) for Tarhana sample with barley flour with goat yoghurt. These results are compatible with results of pH determination for Tarhana dough and final product. Kilci and Gocmen [1] reported that significantly increase in acidity of Tarhana was found with the addition levels of oat flour and steel cut oat at the rate of 40% accounting for 1.20% and 1.23%, respectively. Kivanc and Funda [38] found that during fermentation period of Tarhana up to seven days, the acidity was increased from 1.10 to 3.25% and the pH decreased from 5.22 to 4.13.

## 3.2 Moisture Content and Water Activity of Tarhana

Moisture content (%) and water activity of Tarhana dough after fermentation and Tarhana powder are tabulated in Table (1). It was clear that Tarhana dough prepared from barley flour and goat yoghurt had the highest moisture content (46.92%) followed by 45.79% in case of Tarhana dough made from barley flour and cow yoghurt, while the lowest moisture content (39.34%) was recorded by Tarhana dough with wheat flour and cow yoghurt. This result may be

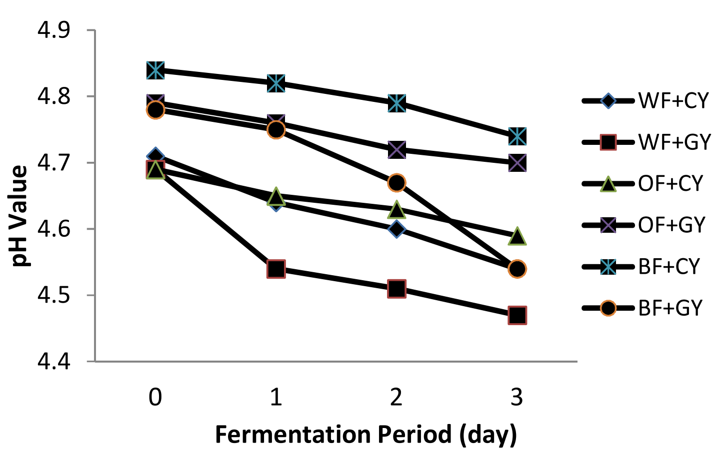


**Fig. 1. Changes in pH of Tarhana dough during fermentation period**

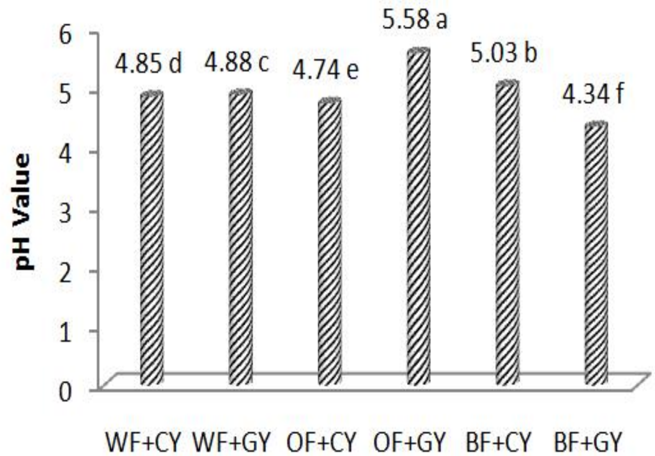


**Fig. 2. pH values of Tarhana powder prepared from various ingredients**

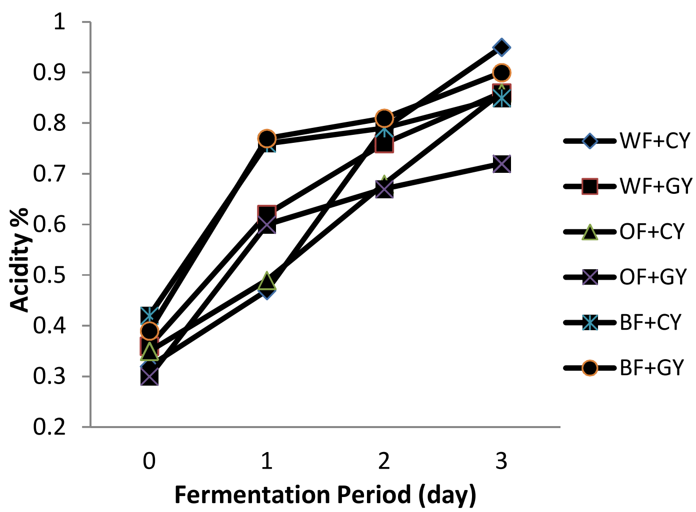


**Fig. 3. Acidity development in Tarhana dough during fermentation period**

attributed to the high ability of barley flour to bind more water and contains high moisture content, whereas barley flour contains more level of β-glucan which is major fiber constituents in barley.

Water activity ranged between 0.977 and 0.955 for all Tarhana dough samples. Tarhana is often dried after fermentation to decrease the moisture content below 10% to prevent caking and microbial spoilage [39]. According to the Turkish Standards Institution, the maximum moisture content in Tarhana should not be higher than 10%. High moisture content may lead to multiplication of the spoilage organisms in the end product and decrease in its shelf life [40].

Regarding to moisture content of Tarhana powder, significant ($p \leq 0.05$) increase was found in moisture content (6.27%) which prepared using wheat flour and goat yoghurt followed by (6.11%) for Tarhana powder with wheat flour and cow yoghurt. On the other hand, using barley flour and goat yoghurt resulted in significant ($p \leq 0.05$) decrease in moisture content (4.03%) when compared to other treatments. The same trend was noticed in water activity which ranged from 0.232 for wheat flour and goat yoghurt to 0.145 for oat flour and goat yoghurt. Drying process was found statistically significant on the water content of the samples. Karagozlu et al. [41] stated that water content of Tarhana continued to decrease after grinding due to increasing the surface area of Tarhana granules.

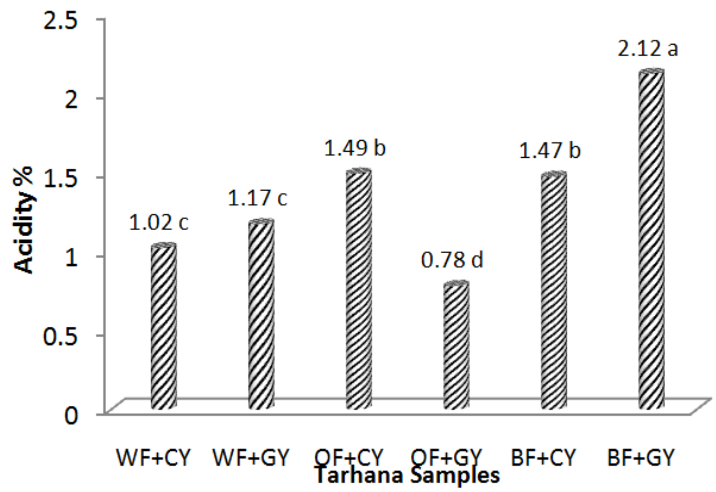


**Fig. 4. Acidity (LA %) of Tarhana powder prepared from various ingredients**

Water content of powder Tarhana was 5.8% at the end of the 8-day of manufacturing period. Ekinci [42] found that the water content of Tarhana dough was 70.0%, and final water content was 10.0% at the end of the manufacturing process. Low moisture content (6–10%), low pH (3.5–5.0), and presence of the components like organic acids, bacteriocins, etc. formed during fermentation period have a bacteriostatic effect on pathogens and spoilage microorganisms during long term storage (1–2 years) and enhanced the shelf life of Tarhana [2].

### 3.3 Color Parameters of Tarhana Powder

Color of Tarhana powder is an important characteristic for consumer preference and it depends on physicochemical parameters of used raw materials. The lightness (L*), redness (a*), yellowness (b*), total intensity and chroma for Tarhana powder were measured and the data are found in Table (2) and illustrated by Fig. (5). It could be observed that Tarhana made from oat flour and cow yoghurt exhibited significant (p≤0.05) high in lightness being 71.75 and total intensity of color being 72.46 compared to all other treatments, while the lowest lightness (66.56 and 65.71) and lowest total intensity (67.33 and 66.50) was given by Tarhana with wheat flour and cow or goat yoghurt, respectively. It is normally expected that, increase in darkness in Tarhana powder affected the panelists negatively in sensory evaluation.

All of Tarhana treatments were significant (p≤0.05) increased in redness (ranged from 10.32 to 10.08), yellowness (ranged from 30.41 to 29.81) and chroma (ranged from 32.12 to 31.38) except Tarhana samples prepared from barley flour with cow or goat yoghurt. These results were comparable with those by Cagindi et al. [43] as they concluded that redness of Tarhana was increased due to higher amounts of tomatoes and red pepper in recipes of the samples. In addition, these samples had higher antioxidant activity and total phenolic content.

**Table 1. Moisture content and water activity of Tarhana dough at the end of fermentation period and Tarhana powder**

| Treatments | Tarhana dough | | Tarhana powder | |
|---|---|---|---|---|
| | Moisture (%) | Water activity | Moisture (%) | Water activity |
| Wheat flour with cow yoghurt | 39.34 ± 0.04$^{e}$ | 0.962 ± 0.01$^{c}$ | 6.11 ± 0.01$^{b}$ | 0.221 ± 0.01$^{b}$ |
| Wheat flour with goat yoghurt | 42.56 ± 0.35$^{d}$ | 0.955 ± 0.00$^{d}$ | 6.27 ± 0.05$^{a}$ | 0.232 ± 0.00$^{a}$ |
| Oat flour with cow yoghurt | 43.97 ± 0.27$^{c}$ | 0.977 ± 0.01$^{a}$ | 4.61 ± 0.02$^{c}$ | 0.160 ± 0.00$^{c}$ |
| Oat flour with goat yoghurt | 41.64 ± 0.44$^{d}$ | 0.972 ± 0.01$^{ab}$ | 4.42 ± 0.04$^{d}$ | 0.145 ± 0.03$^{d}$ |
| Barley flour with cow yoghurt | 45.79 ± 0.36$^{b}$ | 0.968 ± 0.02$^{b}$ | 4.44 ± 0.03$^{d}$ | 0.153 ± 0.02$^{cd}$ |
| Barley flour with goat yoghurt | 46.92 ± 0.33$^{a}$ | 0.972 ± 0.03$^{ab}$ | 4.03 ± 0.03$^{e}$ | 0.151 ± 0.05$^{d}$ |

*Data are the mean ± SE, n = 3,*
*Means having the same letter within each property are not significant difference at p≥0.05*

Differences in Tarhana color could be due to the different raw or cooked vegetables like tomatoes, onions, and green pepper with spices (mint, paprika) were used in the preparation. The changes in color also may be attributed to the Maillard reaction formation during the drying process [44]. Color of Tarhana changed slightly during fermentation, however, increase in lightness value was observed as a result of the effect of the removal of water during drying [45].

### 3.4 Viscosity Determination of Tarhana Soups

The rheological properties are very important parameters of Tarhana soup in terms of palatability and consumer acceptability. Apparent viscosity (cp) of Tarhana soup samples prepared by using different sources of cereals and dairy at different rotational speeds 20, 50, 80 and 100 rpm with temperature 70 °C were determined and the results are shown by Figure 6. It could be seen that viscosity of all tested samples was gradually decreased with increasing the rotational speed indicated that all prepared Tarhana soups samples behaved as shear thinning as the viscosity decreased. Geankoplis [46] reported that decrease in the apparent viscosity with increasing the shear rate indicated that the Tarhana soup was behaving as non-Newtonian fluid (shear thinning or pseudoplastic). These results are close to that reported by Erbas et al. [44] who stated that the flow behavior index of Tarhana soup was (0.39), so that it behaved as a pseudoplastic liquid. Çelik et al. [36] found that Tarhana soup with or without wheat bran exhibited pseudoplastic behavior at a temperature range from 35° to 70°C.

**Table 2. Effect of using oat or barley flour with cow or goat yoghurt on color attributes of Tarhana powder**

| Treatments | Color attributes | | | | |
|---|---|---|---|---|---|
| | *L** | *a** | *b** | Total intensity | Chroma |
| Wheat flour with cow yoghurt | 66.56 ± 0.01$^{d}$ | 10.16 ± 0.13$^{a}$ | 29.81 ± 0.10$^{a}$ | 67.33 ± 0.02$^{c}$ | 31.49 ± 0.14$^{a}$ |
| Wheat flour with goat yoghurt | 65.71 ± 0.75$^{d}$ | 10.20 ± 0.16$^{a}$ | 30.12 ± 0.37$^{a}$ | 66.50 ± 0.71$^{c}$ | 31.80 ± 0.31$^{a}$ |
| Oat flour with cow yoghurt | 71.75 ± 0.74$^{a}$ | 10.08 ± 0.09$^{a}$ | 30.19 ± 0.24$^{a}$ | 72.46 ± 0.73$^{a}$ | 31.83 ± 0.19$^{a}$ |
| Oat flour with goat yoghurt | 68.56 ± 0.43$^{bc}$ | 10.32 ± 0.03$^{a}$ | 30.41 ± 0.26$^{a}$ | 69.33 ± 0.43$^{b}$ | 32.12 ± 0.24$^{a}$ |
| Barley flour with cow yoghurt | 69.36 ± 0.23$^{b}$ | 4.76 ± 0.02$^{b}$ | 23.05 ± 0.01$^{c}$ | 69.52 ± 0.23$^{b}$ | 23.54 ± 0.01$^{c}$ |
| Barley flour with goat yoghurt | 67.47 ± 0.71$^{cd}$ | 5.02 ± 0.02$^{b}$ | 23.83 ± 0.25$^{b}$ | 67.65 ± 0.70$^{c}$ | 24.35 ± 0.24$^{b}$ |

*L: Lightness, a: Redness, b: Yellowness Data are the mean ± SE, n = 3,*
*Means having the same letter within each property are not significant difference at p≥0.05*

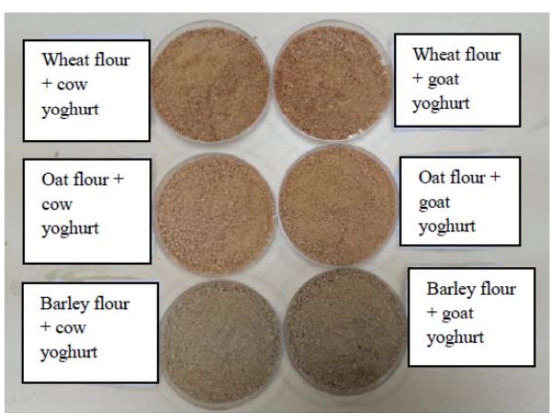


**Fig. 5. Color of Tarhana powder prepared from various ingredients**

The highest viscosities were recorded by Tarhana soups prepared from wheat flour with cow yoghurt (from 269.9 to 113.4 cp) and with goat yoghurt (from 262.4 to 92.1 cp) when increased the speed from 20 to 100 rpm, respectively. It may be due to the majority of wheat starch granules are fully swollen and physically interacting with others causing increased viscosity. On the other side, Tarhana soups produced by using barley flour with cow or goat yoghurt exhibited lower viscosity (from 153.0 to 56.7 cp) and (195.0 to 68.7 cp), respectively when increased the speed from 20 to 100 rpm than other samples. These results are in agreement with Koca et al. [45] as they stated that viscosity of Tarhana samples changed due to the type and concentration of plant added. Variations in the peak viscosity of Tarhana samples could be attributed to starch granules swelling, which are affected by the amylose-lipid complex, amylose/amylopectin ratio and contents [47].

## 3.5 Bioactive Compounds in Tarhana Powder

Some of thermal processing techniques such as baking, steaming, autoclaving, extrusion, drying, roasting have shown the potential to enhance the extractability of phenolic compounds from the materials [48]. These processes cause some physical and chemical changes due to protein denaturation, starch gelatinization, components interactions, and browning reactions. These changes result in improved sensory properties, antioxidant properties, increased nutrient availability and inactivation of enzyme inhibitors [49].

The effect of using oat and barley flour instead of wheat flour, and goat yoghurt instead of cow yoghurt on total phenolic compounds and antioxidant activity of prepared Tarhana was studied and the results are shown in Table (3). It could be observed that Tarhana powder containing barley flour and goat yoghurt exhibited significant ($p \le 0.05$) increase in total phenolic compounds being 27.23 mg GAE/g followed by 15.18 mg GAE/g for Tarhana sample with barley flour and cow yoghurt compared to control and other samples. Also, Tarhana sample prepared with oat flour had valuable total phenolic content. The same trend was noticed regarding to antioxidant activity, whereas, significantly highest ability in radical scavenging activity (47.45%) was recorded by Tarhana sample made from barley flour and goat yoghurt followed by 45.54% in case of Tarhana sample made using barley flour and cow yoghurt when compared to control and other treatments. These findings are in agreement with Kilci and Gocmen [50] who mentioned that Tarhana supplemented with steal cut oat might be considered as rich sources of phenolic compounds and showed higher antioxidant activities than control, this can be attributed to the rich antioxidant capacities of steal cut oat. Degirmencioglu *et al*. [51] found that the total phenolic content gradually increased with the addition of oat flour to Tarhana, but significantly higher total phenolic content was found in oven dried samples at 55 $^{o}$C as compared with other methods. Data also revealed that control Tarhana prepared from wheat flour and cow yoghurt, and Tarhana with wheat flour and goat yoghurt had the lowest antioxidant activity being 33.25 and 34.44%, respectively.

## 3.6 Minerals Content of Tarhana Samples

Minerals content of prepared powder Tarhana samples were determined on a dry weight basis and the obtained results are shown in Table (4). It was noticed that K, Na and Mg were the highest minerals levels in all Tarhana samples which ranged between 13282.0 to 7444.0 mg kg$^{-1}$, 9650.0 to 5171.8 mg kg$^{-1}$ and 1521.1 to 831.4 mg kg$^{-1}$, respectively. Generally differences between control Tarhana (made from wheat

**Table 3. Total phenolic content and antioxidant activity of Tarhana powder samples**

| Treatments | Total phenolic compounds (mg GAE/g) | Antioxidant activity (%) |
|---|---|---|
| Wheat flour with cow yoghurt | 12.14 ± 0.07$^{c}$ | 33.25 ± 0.93$^{c}$ |
| Wheat flour with goat yoghurt | 11.73 ± 0.03$^{d}$ | 34.44 ± 0.13$^{c}$ |
| Oat flour with cow yoghurt | 13.93 ± 0.02$^{b}$ | 36.07 ± 0.15$^{b}$ |
| Oat flour with goat yoghurt | 14.46 ± 0.16$^{b}$ | 37.69 ± 0.11$^{b}$ |
| Barley flour with cow yoghurt | 15.18 ± 0.03$^{b}$ | 45.54 ± 0.13$^{a}$ |
| Barley flour with goat yoghurt | 27.23 ± 0.05$^{a}$ | 47.45 ± 0.17$^{a}$ |

*Data are expressed as means ± SE (n = 3). Mean values in the same column within each parameter bearing the same superscript do not differ significantly (P > 0.05)*

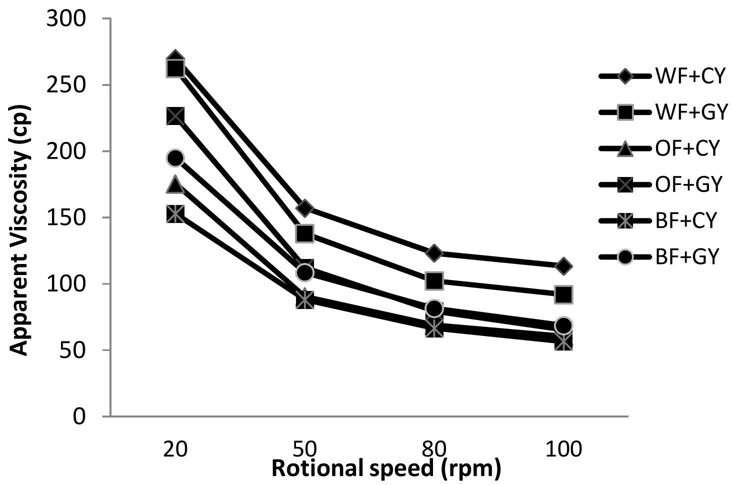


**Fig. 6. Viscosity-rotational speed (rpm) relationship of Tarhana soup samples at 70°C**

flour and cow yoghurt) and other Tarhana samples in minerals levels were associated with the type of flour and yoghurt added. The levels of Cu in Tarhana samples were within the range of 15.15–10.30 mg $kg^{-1}$. Copper is necessary for the formation of hemoglobin as it is a component of enzymes which needed for metabolism of Fe and is required for the function of over 30 proteins in the body [52]. Addition of oat flour with cow or goat yoghurt to Tarhana caused increased of Mn levels (47.99 and 42.24 mg $kg^{-1}$), respectively compared to control and other Tarhana samples. These data are in agreement with Kilci and Gocmen [53] as they reported that Mn concentrations of samples supplemented with oat flour up to 40% were significantly higher than control. The human body contains a total of 10–40 mg of manganese. Manganese is the metal activator for pyruvate carboxylase and it activates various enzymes like some other divalent metal ions [54]. Bilgiçli et al. [55] stated that Tarhana is a good source of total minerals (Ca, Mg, and K) with favorable bioavailibities (Ca, Mg, Zn, and K). The fermentation with Bakery yeast with increasing acidity causes an increase in total amounts of minerals and proteins as a result of phytic acid fermentation loss. Availability of minerals from Tarhana very high, because phytates were mostly decomposed during fermentation which provides optimum pH for enzymatic degradation of phytates presented in cereals in the form of complexes with divalent cations such as iron, zinc, calcium and magnesium [56].

### 3.7 Sensory Evaluation of Tarhana Soup Samples

Sensory characteristics are an important indicator of potential consumer preferences. Differences in sensory quality attributes of Tarhana soup prepared with wheat flour and cow yoghurt (as a control sample) and other treatments produced by oat or barley flours instead of wheat flour and goat yoghurt instead of cow yoghurt are presented in Table (5). Data

**Table 4. Effect of different cereals and dairy sources on minerals content of Tarhana samples**

| Samples | Mineral content (mg $Kg^{-1}$ db) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Na** | **K** | **Ca** | **Mg** | **Fe** | **Zn** | **Cu** | **Mn** |
| Wheat flour + cow yoghurt | 9650.00 | 13282.00 | 50.65 | 1506.55 | 98.35 | 23.26 | 11.97 | 23.57 |
| Wheat flour + goat yoghurt | 5905.00 | 8376.00 | 45.05 | 1431.40 | 59.86 | 13.53 | 10.30 | 18.13 |
| Oat flour + cow yoghurt | 5171.80 | 7444.00 | 30.00 | 1341.85 | 65.94 | 21.86 | 11.35 | 42.24 |
| Oat flour + goat yoghurt | 5787.40 | 10295.75 | 24.90 | 1521.10 | 79.95 | 24.94 | 10.83 | 47.99 |
| Barley flour + cow yoghurt | 5369.25 | 11729.95 | 21.10 | 1369.10 | 85.52 | 17.33 | 15.15 | 23.37 |
| Barley flour + goat yoghurt | 7182.00 | 13218.70 | 37.80 | 1531.65 | 57.68 | 16.62 | 12.63 | 21.58 |

**Table 5. Sensory characteristics of Tarhana soup prepared from different raw materials**

| Treatments | Sensory attributes | | | | |
|---|---|---|---|---|---|
| | Color (9) | Odor (9) | Taste (9) | Consistency (9) | Overall acceptability (9) |
| Wheat flour with cow yoghurt | 8.7 ± 0.15[a] | 8.3 ± 0.15[a] | 8.7 ± 0.17[a] | 8.0 ± 0.14[a] | 8.9 ± 0.11[a] |
| Wheat flour with goat yoghurt | 8.0 ± 0.16[b] | 8.4 ± 0.13[a] | 8.7 ± 0.30[a] | 7.4 ± 0.27[a] | 8.7 ± 0.18[a] |
| Oat flour with cow yoghurt | 7.4 ± 0.17[c] | 8.6 ± 0.23[a] | 7.6 ± 0.29[b] | 7.6 ± 0.31[a] | 8.1 ± 0.25[b] |
| Oat flour with goat yoghurt | 7.5 ± 0.14[c] | 8.7 ± 0.15[a] | 7.3 ± 0.16[b] | 7.6 ± 0.25[a] | 8.0 ± 0.30[b] |
| Barley flour with cow yoghurt | 5.4 ± 0.19[d] | 7.4 ± 0.31[b] | 6.9 ± 0.28[b] | 8.0 ± 0.07[a] | 7.3 ± 0.15[c] |
| Barley flour with goat yoghurt | 5.2 ± 0.23[d] | 7.2 ± 0.30[b] | 6.7 ± 0.27[b] | 7.7 ± 0.16[a] | 6.5 ± 0.27[d] |

*Data are the mean ± SE, n = 10, Mean values in the same column bearing the same superscript do not differ significantly (P ≤ 0.05)*

revealed that Tarhana soup with wheat flour and cow or goat yoghurt samples had significant ($p \leq 0.05$) high scores in color (8.7 and 8.0), taste (8.7 and 8.7) and overall acceptability (8.9 and 8.7) and being more preferable by the panelists. On the other hand, no significant ($p \geq 0.05$) differences were observed in odor of Tarhana soup when wheat or oat flours with cow or goat yoghurt was used in the preparation, in addition no significant ($p \geq 0.05$) differences between all selected Tarhana soup samples in consistency which ranged from 8.0 to 7.4. As expected, the panelists gave the lowest scores for Tarhana soup samples containing barley flour with cow or goat yoghurt in color (5.4 and 5.2) and total acceptability (7.3 and 6.5), respectively compared to other treatments. These results may be attributed to poor redness (a) and yellowness (b) colors of Tarhana powder prepared using barley flour in the formula (Table 4 and Fig. 5) where it was found high correlation between color and acceptability of Tarhana. These results are in agreement with Kilci and Gocmen [53] who stated that supplementation of oat flour into Tarhana did not cause any undesirable taste or odor and resulted in acceptable soup properties. Panelists emphasized a sweet taste in the soups as the oat flour increased. Magala et al. [5] found that Tarhana dough fermented for 144 h showed higher sensory attributes than samples fermented for 72 h, as well as control sample reached the highest overall acceptability due to highest values of taste, odor and consistency.

## 4. CONCLUSION

It could be concluded that with increasing the fermentation time of all Tarhana dough treatments up to three days, decreased pH and increased acidity. Acidity (organic acids) formed by the fermentation of sugars by lactic acid bacteria of yoghurt and baker's yeast is important for sensory acceptability of Tarhana soup and to extend shelf life of Tarhana powder. The radical scavenging activity was highest for Tarhana prepared with barley flour and goat yoghurt which exhibited significant increase in total phenolic compounds and antioxidant activity accounting for 27.23 mg GAE/g and 47.45%, respectively followed by barley flour and cow yoghurt compared to control and other samples. The highest K, Na and Mg levels were observed in all Tarhana samples and the differences in minerals levels between control Tarhana and other Tarhana samples were attributed to the type of flour and yoghurt added. Tarhana samples were significantly high in redness, yellowness and Chroma except Tarhana samples prepared from barley flour. Gradually decreased in viscosities in all Tarhana soups was found with increasing the rotational speed which indicated that the Tarhana soups samples were behaving as non-Newtonian fluid. Utilization of oat flour and goat yoghurt in Tarhana preparation resulted in acceptable soup properties in terms of the sensory properties. Slightly decrease in color and acceptable of Tarhana was observed with using barley flour which could be compensated by the health benefits of barley flour. The oat flour is good alternatives to wheat flour with cow or goat yoghurt in preparation of Tarhana with their higher nutritional benefits and considered as functional food. Further studies are needed to improve the sensory properties of Tarhana incorporated with barley flour.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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