Physical, Rheological and Sensory Properties of Tarhana Prepared with Two Wild Edible Plants (Trachystemon orientalis (L.) G. Don) and (Portulaca oleracea L.)

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Abstract

Tarhana is a traditional Turkish fermented soup. It is prepared with yoghurt, wheat flour, yeast, some vegetables and spices. In this study, two wild edible plants, kaldırâyak (Trachystemon orientalis (L.) G. Don) and purslane (Portulaca oleracea L.) were used to increase the dietary fiber content of tarhana, while keeping the viscosity and sensory properties in acceptable levels. Wheat flour was replaced with plants in 3 proportions (10, 20 and 30%). The fermentation activity, color, rheological and sensory properties of the tarhana products were determined. Soluble, insoluble and total dietary fiber values were determined to be 15.36, 23.04 and 38.40 g/100 g in dry weight for k Aldırayak and 7.56, 23.11 and 30.67 g/100 g in dry weight for purslane, respectively. It was determined that addition of these plants in high amounts increase the dietary fiber content but decrease the viscosity. The lightness, redness and yellowness values decreased as the concentration of added plant increased. Also, as the enrichment ratio increased, the sensory evaluation points decreased.

Keywords: Tarhana; Rheology; Dietary fiber; Portulaca oleracea L.; Trachystemon orientalis (L.); G. Don

Abbreviations: AACC: American Association of Cereal Chemists; ANOVA: Analysis of Variance; C: Control Tarhana; D: Dried; F: Fermented; NF: Nonfermented; P1: Tarhana with 10% purslane; P2: Tarhana with 20% purslane; P3: Tarhana with 30% purslane; RPM: Revolution Per Minute; SPSS: Statistical Package for the Social Sciences; T1: Tarhana with 10% kaldırâyak; T2: Tarhana with 20% kaldırâyak; T3: Tarhana with 30% kaldırâyak

Introduction

Tarhana is a popular traditional fermented food product generally used for soup making in Turkey. It is prepared by mixing yoghurt, wheat flour, yeast, and a variety of vegetables and spices (tomatoes, onions, salt, mint, paprika). The ingredients are mixed, kneaded and left for fermentation for 1-7 days, followed by drying and grinding. During fermentation, acid is produced by lactic acid bacteria and yeast, which gives tarhana an acidic and sour taste with a yeasty flavor [1].

The amount and type of ingredients used for tarhana production, as well as the processing techniques may vary among different regions in Turkey. The ratio of yoghurt to wheat flour is usually 1:1. In some regions, some amount of yoghurt may be reduced or replaced with milk, and one or more of the following ingredients may be used in the formulation: egg, soybean, corn, barley and rye flour, chickbean, lentils, cornelian cherry and baker’s yeast.

Tarhana has a high nutritional value and is considered to be a high protein food, with an average protein content of 15% [2]. Besides being a good source of vitamins such as thiamine, riboflavin and vitamin B12, tarhana also contains niacin, pantothenic and folic acid [3]. The amount and type of ingredients used in tarhana production may affect its nutritional content as well as its sensory attributes [4]. Until today, many researches have been carried out to increase the nutritional value and dietary fiber content of tarhana by adding different ingredients such as wheat germ and bran [5,6], barley, oat [7], buckwheat flour [8], soy [9-12], corn flour and carob flour [13].

The traditional definition of dietary fiber is the portions of plant foods that are resistant to digestion by human digestive enzymes; including polysaccharides and lignin. The recommended daily dietary fiber intake is 28 g/day for adult women and 36 g/day for adult men [14]. Soluble dietary fiber, which is more readily fermentable in the colon than insoluble dietary fiber, causes a shift to lower colonic pH and increases the number and changes the profile of intestinal microorganisms [15]. Health benefits of dietary fiber has been reported previously in the literature like reducing the risk for developing coronary heart disease, stroke, hypertension, diabetes, obesity, and certain gastrointestinal disorders [14,15].

Dietary fiber is an important component of a vegetable-rich diet [16]. Kaldırâyak (Trachystemon orientalis (L.), G. Don) and purslane (Portulaca oleracea L.) are two plants that grow naturally in Turkey. The genus Trachystemon D. Don belongs to the family Boraginaceae and is represented by one species in Turkey Trachystemon orientalis (L.) G. Don. This plant is distributed in East Bulgaria and West Causia and in various habitats in the Black Sea region in Turkey. It is 30-40 cm tall, with a rhizome, it is hairy, with blue-red flowers and is perennial and herbaceous. The flowering branches, rhizomes, leaves and petals are consumed as vegetables in Turkey. This plant is known to cause diuresis and plasmapheresis [17].

Purslane (Portulaca oleracea L.) is an annual green herb with edible succulent stems and leaves, slightly acidic and spinach-like taste, leaves have an obovate to obovate form, being 1-5 cm long and 0.5-2 cm wide.
cm across, while stems are cylindrical, up to 30 cm along and 3 mm diameter. It can be consumed cut in small pieces, in raw salads, as a vegetable dish, after cooking, or after drying plant, it can be boiled into tea or soup. Purslane is a good source of compounds with a positive impact in human health [18]. The aerial parts of the plant are used in many countries as a diuretic, febrifuge, antiscorbutic, antiseptic, antisypsmodic and vermifuge [19,20].

The purpose of this study was to increase the dietary fiber content of tarhana using kaldirayak and purslane and to determine the effect of addition of these two plants to tarhana formulation on the acceptability of the products, especially in terms of viscosity and sensory properties. In this way, a healthier product will be produced while the energy value of the product is being decreased.

Material and Methods

Material

White commercial wheat flour with 13.31% moisture, 12.00% protein contents, and yoghurt made from cow milk with 87.97% moisture, 4.4% fat, 3.5% protein, 3.71 pH and 1.76% titratable acidity (as lactic acid) were used. Tomato paste was double concentrated to a content of 30%. Compressed baker’s yeast in wet form, yoghurt, wheat flour, onion, tomato paste, mint, paprika and salt were purchased from local markets in Samsun, Turkey.

The plants were cleaned, washed and oven-dried at 50 ± 2°C (FN-500, Nüve, Turkey). The dried samples were ground and mixed with flour in three ratios (10, 20 and 30%) to produce tarhana. Some properties of the plants are shown in Table 1. Tarhana without adding plants was also produced for control purpose.

Preparation of tarhana samples

Tarhana samples were prepared according to the method of Ibanoglu et al. [4] with some modifications. To prepare tarhana samples, onions were chopped. Tomato paste, paprika, onion, salt, and mint were weighed. The mixture was cooked at high heat for 30 seconds, and medium heat for 5 minutes by continuous stirring. After cooking, the samples were cooled until room temperature (about 25°C). Wheat flour (as mixed with plant powders at 10, 20 and 30% ratios), yeast and yoghurt was added to this mixture and kneaded for 10 minutes. Tarhana doughs were transferred into separate plastic containers and fermented at 30 ± 2°C for 48 hours. Each portion of fermented dough was spreaded to approximately 0.5-1 cm thickness. Samples were dried overnight in a ventilated place until constant weight was reached. Wheat flour was added to give a total content of 30%. Compressed baker’s yeast in wet form, yoghurt, wheat flour, onion, tomato paste, mint, paprika and salt were purchased from local markets in Samsun, Turkey.

In the study, tarhana with 7 different formulations were prepared, which were control group (C), tarhana with 10% “kaldirayak” (T1), tarhana with 20% “kaldirayak” (T2), tarhana with 30% “kaldirayak” (T3), tarhana with 10% purslane (P1), tarhana with 20% purslane (P2) and tarhana with 30% purslane (P3). The percentage of addition was calculated based on flour content. The trials were dried as 3 replicates.

Experimental design

One level response surface design (RSD) with one numeric and one categoric variables was used to determine the effect of viscosity. The numeric variable was the ratio of plant powder and the categoric variable was the type of plant powder, kaldirayak and purslane. The dependent variables were selected as viscosity and overall acceptability of the product. Uncoded and coded values of the independent variables and the experimental points are shown in Table 2.

Methods

Moisture, ash and crude fat contents of the ingredients and tarhana samples were determined according to AACC Methods [21]. Nitrogen content of the samples were determined by the Kjeldahl Method [22], and converted to protein content using a factor of 5.7 for wheat, 6.38 for yoghurt and 6.25 for plants samples. pH was determined according to the method of Ibanoglu et al. [4]. Acid formation during fermentation and in tarhana samples was determined by titrating with 0.1 N NaOH up to pH 8.1 while mixing continuously on magnetic stirrer and expressed as a percent of total lactic acid [23]. Total, soluble and insoluble dietary fiber values were determined by enzymatic-gravimetric method [24].

Color analysis

The color of tarhana samples was measured using a colorimeter (Minolta CR 400, Osaka, Japan) calibrated with a white tile (No: 19633162). The L* value indicates lightness, the a* and b* values are the chromaticity coordinates (a* from green to red; b* from blue to yellow). Tarhana samples were put into an optically flat glass dish for measurements. From the instrumental L*, a*, b* values, the color difference (ΔE) was calculated according to following equation:

\[
\Delta E = \sqrt{(L-L_0)^2 + (a-a_0)^2 + (b-b_0)^2}
\]

Rheological measurements

Tarhana powders were cooked in water for 10 min at a ratio of powder to water 0.1:1.5 (g/mL) to allow complete starch gelatinization. Viscosity was measured at 25, 45, and 60°C using the Brookfield rotational viscometer (Model DV-1+; Brookfield Engineering

Table 1: Physical and chemical properties of dried plants used in tarhana production.

<table>
<thead>
<tr>
<th>Coded levels</th>
<th>Uncoded levels</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment no</td>
<td>X1</td>
<td>X2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>+1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>-1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
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<td>5</td>
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<td>-1</td>
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<tr>
<td>6</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>+1</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>+1</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>+1</td>
</tr>
</tbody>
</table>

T: Kaldirayak, P: Purslane

Table 2: Coded and uncoded levels of independent variables for one factor design and responses.
Laboratories, Inc., Middleboro, USA) using No. 4 spindle at the different spindle speed (5, 10, 20, 30, 50, 60 and 100 rpm). The internal radius of the cylinder used for measurements was 3.25 cm. Temperature was kept constant using a thermostatically controlled water bath during the measurements. All data were taken after 30s in each sample. Data were analysed using power law model Eq.(2) [25]. Shear rate was calculated as Eq. (3) and Eq. (4) [26].

\[ \eta_a = k \gamma^{n-1} \]  
\[ SRC = 2WRb^2Rc^2/\pi X^2[Rc^2-Rb^2] \]  

\[ W = 2\pi N/60 \]  

Where: \( \eta_a \) is the viscosity in mPa.s; \( \gamma \) is shear rate in s\(^{-1}\), \( k \) consistency index in mPa.s\(^n\), \( n \) is flow behavior index (dimensionless).

The obtained data were statistically evaluated by analysis of variance (ANOVA), using SPSS 16 programme. Differences in samples were tested for statistical significance at \( p<0.05 \) level. Duncan’s multiple range test was used to differentiate between the mean values.

### Statistical analysis

The following equation was used to express viscosity (mPa.s) and overall acceptability of the soups (Y) as a function of the coded independent variables, where \( X_1 \) and \( X_2 \) represent the code of ratio of plant powder and plant type, respectively.

\[ Y = a_0 + a_1X_1 + a_2X_2 + a_{12}X_1X_2 \]  

DesignExpert 8.0.7.1 was used to perform regression analysis and determine the optimum ratio and plant type.

### Results and Discussion

#### Changes in pH and titratable acidity

Changes in \( \text{pH} \) and titratable acidity of the samples before and after fermentation were given in Table 3. Changes during the fermentation period were given in Figures 1 and 2.

As seen in Table 3, the \( \text{pH} \) and titratable acidity of tarhana samples before fermentation and after fermentation and drying were statistically different \( (p<0.05) \). Among the fermented products, control group had the lowest \( \text{pH} \), while the highest \( \text{pH} \) was seen for the samples enriched with 30\% purslane. It was seen that \( \text{pH} \) decreased slightly during fermentation and this \( \text{pH} \) change decreased as the plant concentration in the samples increases. Moreover, it was determined that \( \text{pH} \) continued to decrease during drying, which indicates that fermentation continued during this process. The drying temperature was appropriate for the activity of lactic acid bacteria which originate from yoghurt. As the plant ratio increased, the titratable acidity increased although \( \text{pH} \) remained high. This arose from the buffering power of the plants.

Kose and Cagindi [27] determined the titratable acidity of tarhana samples produced from wheat, rye, maize and soy flour as 1.5-1.7\%; and Erkan et al. [1] determined the titratable acidity and \( \text{pH} \) of tarhana produced from wheat and barley flour as 1.2-1.6\% and 4.59-4.81, respectively. In their study to produce tarhana by adding wheat germ
and bran, Bilgicli et al. [28] determined the total acidity as 1.73-3.76% and pH as 4.25-5.10; and reported that as the wheat germ and bran ratio increased, the acidity increased while pH decreased. Bilgicli [8] determined that the acidity of tarhana samples produced by adding buckwheat flour in different ratios to the wheat flour were higher than that of the control group (tarhana prepared from 100% wheat flour). The acidity was 2% in the control group, whereas it increased to 2.12% and 2.18% in parallel with the ratio of the buckwheat flour added. Celik et al. [6] produced tarhana by adding 0, 20 and 40 % bran to wheat flour and fermented the samples for six days. They determined the pH of the control group as 4.37, while it was 6.21 and 6.74 for the 20% and 40 % bran added samples, respectively. Caglar et al. [13] determined the titratable acidity of the tarhana samples produced by adding different ratios of carob flour as between 1.12% ile 1.87%. They determined the acidity value of the samples enriched with carob flour to be higher than that of control group (tarhana prepared from 100% wheat flour), and as the ratio of carob flour increased, the acidity also increased significantly.

Titratable acidity values of our dried tarhana samples were determined to be in accordance with those of Kose and Cagindi [27], Erkan et al. [1] and Caglar et al. [13], but lower than those of Bilgicli et al., [28] and Bilgicli [8]. The pH values of the samples were generally lower than those of Erkan et al., [1], Bilgicli et al., [28] and Celik et al., [6].

**Color properties of Tarhana**

The changes in color properties of tarhana samples before and after fermentation were given in Table 4, and the color values of dried tarhana samples were given in Table 5.

It was seen that color values change depending on the concentration of added plants, and this change was statistically significant (p<0.05). As seen from Table 4, the lightness, redness and yellowness values decreased as the concentration of added plant increased for both fermented and nonfermented samples.

<table>
<thead>
<tr>
<th>Samples</th>
<th>NF-F</th>
<th>F-D</th>
<th>NF-D</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.75 ± 0.78</td>
<td>18.43 ± 2.20</td>
<td>42.14 ± 2.04</td>
</tr>
<tr>
<td>T1</td>
<td>1.75 ± 1.19</td>
<td>23.37 ± 0.27</td>
<td>32.85 ± 1.01</td>
</tr>
<tr>
<td>T2</td>
<td>4.75 ± 1.51</td>
<td>28.36 ± 1.71</td>
<td>31.30 ± 0.45</td>
</tr>
<tr>
<td>T3</td>
<td>6.78 ± 0.64</td>
<td>26.95 ± 0.41</td>
<td>30.89 ± 0.41</td>
</tr>
<tr>
<td>P1</td>
<td>2.08 ± 0.61</td>
<td>20.58 ± 4.79</td>
<td>34.04 ± 1.91</td>
</tr>
<tr>
<td>P2</td>
<td>3.51 ± 1.55</td>
<td>26.10 ± 0.66</td>
<td>31.54 ± 1.39</td>
</tr>
<tr>
<td>P3</td>
<td>4.10 ± 1.35</td>
<td>26.54 ± 0.05</td>
<td>30.85 ± 0.64</td>
</tr>
</tbody>
</table>

*Significantly different in each group (p<0.05). C:Control, T:Kaldirayak, P:Purslane. 1,2 and 3 represent 10, 20 and 30% enrichment, respectively.

**Table 4:** Color properties of dried tarhana samples.

As seen from Table 5, the lightness, redness and yellowness values of dried tarhana samples decreased as the concentration of added plant increased. Color changed slightly during fermentation, however, increase in lightness value was observed as a result of the effect of the removal of water during drying. In order to determine the effect of fermentation and drying on color, total color difference values (ΔE) of the samples were calculated and given in Table 6.

As seen from Table 6, the change in color after fermentation is slight but statistically important (p<0.05). The effect of drying process was greater than that of fermentation for both control and plant added samples. The color values changed as a result of drying and further grinding due to O3 in the surrounding air. The lightness values increased especially as a result of removal of water and grinding and this had a great effect on ΔE values.

**Rheological behavior**

Viscosity values of tarhana samples produced by adding different amounts of plants were determined at different temperatures at 20 rpm. The results were given in Table 7.

It was seen that as the temperature increased, viscosity values decreased. Viscosity changes due to the type and concentration of plant added were found to be significant (p<0.05). Generally, viscosities of the control samples and the samples enriched with 10% and 20% kaldirayak were determined to be the highest, whereas those of the samples enriched with 30% kaldirayak and 30% purslane were the lowest at 3 different temperatures. Increase in viscosity was expected due to the increase in soluble dietary fiber content with the addition of plants, however, insoluble dietary fiber content also increased, which caused the viscosity to decrease. As seen from Table 7, viscosities of
tarhana samples with 10% and 20% kaldirayak were not statistically different from the control group (p>0.05).

Table 8 provides the regression coefficients obtained by fitting the experimental data to the second order response models for viscosity and overall acceptability. Two-factor interaction models were selected to express both responses. For overall acceptability, the model was not significant, therefore, the optimum levels were evaluated in terms of viscosity. For viscosity, the R2 value was 0.7233; which indicated that about 27.67% of the total variations were not satisfactorily explained by the model. The model F-value of 15.80 implied the model is significant. There were only a 0.30% chance that "Model F-Value" this large could occur due to noise. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. Ratio of 9.299 indicated adequate signals. The model can be used to navigate the design space. The optimum level and type of plant were determined as 10% kaldirayak, with a desirability of 0.943. This level of addition of kaldirayak led to a viscosity of 710.64, which was close to the control samples; and an overall acceptability of 8.4. For purslane, the optimum level of addition was also given as 10%, but with a desirability of 0.682.

The rheological properties of soups are important as they primarily affect the sensory quality, and hence, consumer preference. Those properties can be influenced by some of the added ingredients [30]. The dietary fiber content is one of the properties that affect the viscosity. Viscous dietary fibers such as gums, pectins, psyllium and β-glucan thicken when they are mixed with liquids. Insoluble fiber particles may also affect viscosity measurement, however they are not the primary factor which affect viscosity [31]. The dietary fiber content of kaldirayak was determined to be twice that of purslane (Table 1), however, the viscosity differences in tarhana samples enriched with kaldirayak and purslane were not that much.

Nymann et al. [32] determined the total dietary fiber as 2.8-12.1% and soluble fiber as 1.3% in wheat flour. In their study towards determining the dietary fiber content of various cereals, Da Silva and Ciocca [33] determined the total, insoluble and soluble dietary fiber content as 14.90 g/100 g, 12.67 g/100 g and 2.23 g/100 g, respectively in wheat. Dietary fiber is highly found in the bran fraction of wheat. As the bran is separated, the dietary fiber content of wheat decreases. In this study, the average total, insoluble and soluble dietary fiber content in control group tarhana samples were determined as 3.38 ± 0.33 g/100 g, in dry weight, 3.03 ± 0.09 g/100 g in dry weight and 0.35 ± 0.27 g/100 g in dry weight, respectively. Both the soluble and insoluble dietary fiber content of plants used in the study were high (Table 1), therefore, utilization of these plants in tarhana production increased the dietary fiber content of the product considerably. As compared to the control group, when tarhana was enriched with these two plants by 10%, the insoluble dietary fiber content increased by 1.8, and the soluble dietary fiber content increased by 5.5 for kaldirayak, and 2.3 for purslane.

Tarhana soup with or without plants at 25, 45 and 60°C temperatures was properly described by the power law method, with the soups showing a shear thinning behavior (n<1). Flow behavior indices for tarhanas prepared with plants were lower than those for control samples. It was reported by some researchers [34] that tarhana soup exhibited pseudoplastic behaviour.

Bilgici et al. [28] determined that the cooked viscosity of tarhana soups decreased with the addition of wheat germ/bran. Since starch is the main component responsible for the cooked viscosity of tarhana soup and the wheat germ/bran practically contains no starch, starch concentration has been decreased by the addition wheat germ/bran. Bilgicli [8] determined that buckwheat flour addition over 20% decreased the viscosity of tarhana, and stated that this decrease was due to the decreasing starch and gluten content. Celik et al. [6] also reported that viscosities of tarhana samples enriched with wheat bran were lower than that of control.

All tarhana samples analysed in this work exhibited pseudoplastic behaviour. Typical example of this behavior for tarhana soups at 60°C is presented in Figure 3.

As seen from Figure 3, the viscosity of all samples decreased with increasing shear rate. Yilmaz et al. [30] explained the reason for this behaviour as the disentangling of long chained molecules by increasing shear rate, which allows to overcome the intermolecular resistance to flow (Table 9).

Consistency index, k, is an indicator of the viscous nature of food system. Table 9 indicates that the consistency index changed with plant ratio and decreased with increasing the temperature from 25 to 60°C. Yilmaz et al. [30] reported that higher k values show a more viscous nature because of the increase in fluidity in tarhana soup. The n values ranged from 0.36 to 0.52 under different plant ratios and temperature, which shows the pseudoplastic behaviour of soup samples. These values showed no consistent trend as influenced by plant ratio and temperature, which was in accordance with the report by Yilmaz et al. [30].

In their study to examine the effect of 4 different drying techniques on functional properties of tarhana, Hayta et al. [35] determined that

![Figure 3: Viscosity-shear rate relationship for tarhana samples at 60°C.](https://www.jfoodprocesstechnol.com/content/6/5/443)

Table 8: Model parameters for predicting the responses. R2 = Coefficient of determination, Adj. R2 = Adjusted coefficient of determination, F = F-value, Sig F = Significance level, S.E. = Standard error, Adeq precision = Adequate precision, C = Control, T1 = Kaldirayak, T2 = Purslane, P1 = P. vulgaris, P2 = P. orientalis, P3 = P. oleracea, Y = Response, a = Intercept term, X1 = % of Kaldirayak, X2 = % of Purslane, nX1X2 = Interaction term.

<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient</th>
<th>Viscosity</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>a0</td>
<td>550.47</td>
<td>7.45</td>
</tr>
<tr>
<td>X1 (type of plant)</td>
<td>a1</td>
<td>-14.67</td>
<td>-0.17</td>
</tr>
<tr>
<td>X2 (plant ratio)</td>
<td>a2</td>
<td>-115.50**</td>
<td>-0.75**</td>
</tr>
<tr>
<td>X1X2</td>
<td>a12</td>
<td>30</td>
<td>0.035</td>
</tr>
<tr>
<td>R²</td>
<td></td>
<td>0.8877</td>
<td>0.5417</td>
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<tr>
<td>F</td>
<td></td>
<td>15.8</td>
<td>2.36</td>
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<td>Sig F</td>
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<td>0.003</td>
<td>0.1702</td>
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<tr>
<td>S.E.</td>
<td></td>
<td>49.48</td>
<td>0.82</td>
</tr>
<tr>
<td>Adeq precision</td>
<td></td>
<td>9.299</td>
<td>3.532</td>
</tr>
</tbody>
</table>

*Y = a0 + a1X1 + a2X2 + a12X1X2
*Significant at p ≤ 0.05
**Significant at p ≤ 0.01

Table 8: Response model constants and regression analysis for viscosity and overall acceptability. **Significant at p ≤ 0.01. *Significant at p ≤ 0.05.
the values of consistency index, k, of the samples range from 15.0 cP to 30.3 cP and the flow behavior index, n, range from 0.25 to 0.55. They also determined that the consistency index decreased with increasing temperature. They indicated that heating may rupture molecular entanglement and bonds, which stabilizes the molecular structure and results with a decrease in viscosity. Another reason was indicated as the destabilization of protein-protein and protein-water interactions with the temperature increase, which leads to decrease in viscosity.

Ertas et al. [36] determined the n and k values of tarhana samples prepared by adding different ratios of whey as 0.22-0.34 and 25640-44720 cP. They reported that whey addition caused decrease in viscosity depending on ratio, below 25% being inadequate, and above 25% excess amount.

### Sensory properties of Tarhana

Sensory evaluation of the samples is given in Table 10. Plant ratio significantly (p<0.05) affected all the sensorial properties negatively. Control tarhana got the highest points in all parameters. The scores of T1 samples for color, consistency, odor and flavor were not statistically different than the control group (p>0.05). All sensory points were the lowest for the samples which include 30% plant (Table 10).

As the sensory points of tarhanas are considered, the ones enriched 10% with plants were evaluated with high scores in terms of appearance and color, whereas the ones enriched 30% were low. In terms of consistency values, control group as well as the ones enriched 10% and 20% with kaldırayak and 10% purslane were evaluated with the highest scores. Tarhanas enriched with 10% kaldırayak and purslane were evaluated as the highest in terms of odor and flavor scores, whereas samples enriched with 30% plant were the lowest. The general acceptability scores were in parallel with the other sensory properties.

In general, as the enrichment ratio increased, the sensory evaluation points and general acceptability decreased. Especially samples enriched 30% with plants were evaluated with sensory points of 5-6, which were the lowest scores. On the other hand, sensory evaluation scores of samples enriched 10% were close to those of the control group.

### Conclusion

Recently, products enriched with dietary fiber are of great interest. In this study, it was aimed to enrich a traditional product with 2 wild plants, kaldırayak and purslane. These two plants were added to the tarhana formulation in 3 different ratios and the change in dietary fiber content in the final product, as well as physical and sensory properties of the products were determined. As high amount of plant is added to the formulation, the dietary fiber content of the product increased considerably, however, the viscosity values decreased. Moreover, addition of these two plants into tarhana did not affect the overall acceptability of the product significantly. As the viscosity values were evaluated by RSD, the optimum formulation was obtained with 10% kaldırayak.

### Acknowledgement

This study was supported by Ondokuz Mayis University, Project Management Office (Project No: PYO.MUH.1901.10.01).

### References