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A COMPARISON OF INDUSTRIAL AND HOMEMADE BULGUR IN TURKEY IN TERMS OF PHYSICAL, CHEMICAL AND NUTRITIONAL PROPERTIES

Article Highlights  
• Bulgur is a perfect food in terms of high nutritional value, keeping quality, healthy and low cost  
• Bulgur is produced industrially and homemade in villages by farmers who grow durum wheat, in Turkey  
• Depending on the applied process, physical, chemical and nutritional properties of bulgur can vary  
• Dehulling process in industrial production causes the mineral elements to be thrown with the shell  
• All bulgur samples contained lower amount of heavy metals as cadmium and lead than JECFA limits

Abstract  
Determination of functional and nutritional properties of bulgur is of paramount importance for the growth of healthy generations. In this study, physical, chemical, nutritional and sensorial qualities of bulgur produced at the industrial, homemade and laboratory scale in Turkey were determined and the results were compared. The ash content of bulgur samples was determined between 1.04 and 1.81%, the total protein contents of the samples were found between 11.90 and 14.47%. Evaluation of nutritional status of bulgur; the total phenolic contents value varied 449.82 to 1047.09 µg/g, the phytic acid values were found between 422.14 and 1173.56 mg/100 g. The mineral contents of the samples were analyzed, and all the bulgur samples contained lower amounts of cadmium and lead than JECFA limits. Homemade bulgur samples had a more aromatic taste and smell than industrially produced bulgur samples, and also industrially produced bulgur samples had lighter color than homemade bulgur.

Keywords: bulgur, industrial producing, homemade, mineral, phytic acid, Turkey.

Bulgur is a semi-finished food product that is usually obtained by cleaning, cooking and drying under sunlight or in high drying towers, then pearl ing by friction, grinding and then sifting according to size of durum wheat (Triticum durum) [1, 2]. It has been one of the most important food products of Turkish people in Anatolia for over 3000 years. Mostly hard wheat, especially durum wheat, is preferred for bulgur production. Durum wheat is the hardest of all wheat varieties and used in making products such as pasta and bulgur due to its high protein, high gluten strength and uniform golden color.

The general composition of bulgur includes: 9-12% water, 10-16% protein, 1.2-1.5% fat, 76-78% carbohydrates, 1.2-1.4% ash and 1.1-1.3% fiber. Protein, calcium, iron, B1 vitamin and niacin contents of bulgur are higher from the cereal products like bread and pasta, and also protein, calcium and iron contents of bulgur are higher than wheat. Many nutrients leach out of wheat, but nutrients are absorbed back
into the grain during the bulgur production. Losses of water-soluble nutrients like vitamins are prevented. Bulgur digestibility increases due to coagulated protein and gelatinized starch. The excess nitrogenous substances are caused by the hard structure of starch fused with protein. This is a desirable feature in bulgur because of resistance to insect, mites and microorganisms, and long shelf life [3-5]. Also, bulgur is a natural food because no chemicals or additives are used in processing.

Differences in the processing of bulgur and properties of wheat used in bulgur production are among factors that can affect the quality. Today, two types of bulgur production systems are used in Turkey: Antep type and Karaman (Mut) type production [6]. The Antep type bulgur production involves cleaning, cooking, drying, tempering, debranning and cracking in disc mill or hammer mill. The Karaman type bulgur production involves cleaning, cooking, drying, longer tempering of dried wheat, debranning, re-drying and milling process by stone mill. In Karaman, cooking and milling processes of bulgur vary from plant to plant. The most important difference is that the cooking process is done with steam and not with water. The main advantages of steam are higher degradation of phytic acid and higher absorption of nutrients. Due to the steam cooking process, more water absorption of bulgur occurs during cooking. In some companies, stone mills are used instead of metal mills, and companies argue that bulgur produced with stone mills is better tasting. In bulgur production, a modified color sorting system line is used due to the fact that color is an important visual quality parameter for bulgur [7]. In recent years, it has accelerated efforts to achieve yellow colored bulgur according to consumer demand [8]. Mechanical yellowing process (pearling of the wheat) is peeled more bran content than normal process and color materials are removed from bulgur. Pearling step is used in industrial production, while homemade production not contains this step. There are advantages like attractive bulgur color, as well as disadvantages like falling bulgur yields from 80-85% to 70-72%, increased labor cost, increased additionally machinery and building costs. But also this process has disadvantages for consumer like reduced nutrient absorption due to decrease the amount of cellulose and minerals that useful for the health of human body [9].

There are about 500 bulgur factories in Turkey and the current annual production capacity is 1,125,000 t in terms of production volume. Turkey took the top spot with 1,125,000 tons bulgur production and 500 bulgur factories in the year of 2005. Today that number is expressed as 278 factories with 630,000 t capacity. But the decline in the number of factories has not led to the production decline. Despite the decline in the number of factories, findings also show increased production capacity in existing factories. With 300,000 tons of annual production and 20 bulgur factories, USA and Canada were in the second place while Middle East countries were in third place with 120,000 tons and 15 bulgur factories [10]. The main bulgur producers are in Gaziantep, Karaman, Çorum, Mardin and Urfa in Turkey. Although it is made from the same material (durum wheat), bulgur production is 2.5 times higher than production of pasta. The average annual consumption of bulgur is 12 kg per person [4,11].

In this study, industrially and homemade produced bulgur products in Turkey are collected from the market, and physical, chemical, nutritional and sensorial properties are compared to each other and with laboratory scale bulgur.

EXPERIMENTAL

Materials

In order to perform this study, fifteen samples of bulgur were analyzed, twelve bulgur samples from an industrial and four from homemade sources in Turkey. For comparison, laboratory scale bulgur sample was produced and investigated in this study as well. The total number of samples of this study was 34 with 2 replications. The wheat used to produce the laboratory bulgur sample was obtained from Selva Inc. All the collected samples were stored in a cool and dry place until they were analyzed.

Homemade bulgur samples were collected from villages. During the production of homemade bulgur, wheat was washed in cool water for removing the dust and soil particles and water was discarded, wheat was cooked with water (2 or 3 times the amount of wheat) until there is not any white area on cooked wheat, and spread on sheets for sun-drying in open air, bran of the wheat was removed by wooden hammers called dibek, after which the wheat was cracked in stone mills and stored in a cool and dry place.

According to industrial and homemade bulgur production in Turkey, the region of Central Anatolia, the cultivar of Triticum durum L. cvs. C1252 and Triticum durum Desf. cv. Kızıltan-91 are used, in the region of Southeast Anatolia, the varieties of Svevo (Triticum durum Desf.), burgos (Triticum durum Desf.) and zenit (Triticum durum Desf.) are mostly used in bulgur production.
Laboratory bulgur production

Laboratory bulgur samples were produced using Antep type bulgur method with some modifications. Wheat samples (2 kg, *Triticum durum* L. cvs. C1252) free from cracks, dust and other foreign materials were soaked in distilled water (1:5) for 5 h, and then cooked in the autoclave (Hirayama HV-50, Saitama, Japan) at 121 °C for 20 min with distilled water (1:2). Cooked wheat samples were dried at 50±5 °C to 10% moisture content in the oven (Nüve FN-500, Ankara, Turkey). The dried wheat seeds were tempered with 2% additional water by mixing for 10 min, and then milled into coarse grist with disk mill (Inovamer, Mersin, Turkey). All the cracked material was passed through a 3.55 mm sieve and over 1.6 mm sieve, and aspirated to remove bran material.

Physical attributes

Thousand kernel weights were obtained by weighting in grams of 1000 seeds, using an electronic balance weighting to 0.001 g accuracy. 1000 kernel volume values were determined using the water displacement method. Length, width and thickness values of wheat were measured using a digital caliper (0.01 mm precision, Muititoyo 0.001mm, Japan). The sphericity (\( \frac{\text{length} \times \text{width} \times \text{thickness}}{\text{height}} \)) and diameter ratio (length/width) of wheat kernels were calculated. The color of the wheat kernels and bulgur samples were evaluated by measuring the \( L^* \), \( a^* \) and \( b^* \) values using a Hunter Lab Color QUEST II Minolta CR-400 (Minolta Camera, Co., Ltd, Osaka, Japan). The hue angle (\( \tan^{-1} (\frac{b^*}{a^*}) \)) was calculated from \( a^* \) and \( b^* \) values.

Chemical and nutritional properties

Wheat and bulgur samples were analyzed in triplicate for their moisture (method 44-19), crude ash (method 08-01), crude protein (method 46-12), crude fat (method 30-25) using standard methods [12]. The mineral element contents of the samples were determined by inductively coupled plasma spectroscopy, ICP-AES (Vista series, Varian International AG, Switzerland) according to method by [13]. Total phenolic content (TPC) was determined using the Folin-Ciocalteau method [14] as modified by [15]. Total phenolic results were expressed as μg gallic acid equivalents per g sample. Phytic acid was determined by the method described by [16].

Sensory properties

Bulgur samples were boiled in water (1:2) at 100±2 °C. After all the boiling water was absorbed, 25 g bulgur sample was served to the panelists at approximately 40 °C in identical glass containers. Sensory analyses of bulgur samples were conducted by twelve panelists. The attributes selected were: hardness, taste, chewiness, color and smell. Bulgur characteristics were rated on a 1-5 scale: 1 - dislike extremely; 3 - acceptable and 5 - like extremely.

Statistical analysis

JMP statistical package software program (version 5.0.1.a, SAS Institute. Inc. Cary, NC, USA) was used to perform statistical analyses. Tukey honestly significant difference test were performed to establish the significance of differences among samples. Significance was accepted at \( p < 0.01 \) throughout the analysis.

RESULTS AND DISCUSSION

Analytical results

The mean length, width and thickness values of wheat used in bulgur production on a laboratory scale were measured as 7.43, 3.15 and 2.81 mm. Sphericity and diameter ratio of wheat sample (*T. durum* L. cvs. C1252) were 4.04 and 2.37, respectively. Thousand kernel weight and 1000 kernel volume values of wheat which determine the marketing price were measured as 45.44 g and 70.0 ml, respectively. Similar results have been reported by some researchers [17,18]. \( L^* \), \( a^* \) and \( b^* \) values of durum wheat ranged between 45.55 to 49.15 in terms of \( L^* \) values, between 7.47 to 8.67 in terms of \( a^* \) values, between 16.34 to 17.50 in terms of \( b^* \) values [19].

Chemical bulgur properties

Table 1 shows the chemical and nutritional results obtained in this study. Those average values that resulted in significant differences at \( p < 0.01 \) as revealed by ANOVA analysis have been marked with an asterisk. Table 1 also shows the minimum and maximum values of chemical and nutritional components of bulgur produced at the industrial, homemade and laboratory scale. The mean moisture content of the industrial bulgur samples (11.5%) was higher than homemade bulgur (9.7%). The mean moisture content of the laboratory bulgur sample was 9.2%. The moisture content in bulgur is an important parameter for trade and storage. The amount of water in grain depends on the relative humidity and temperature of the storage place. According to the Turkish Food Codex Communiqué of bulgur, the maximum moisture content of bulgur should be as 13%. But moisture content of two bulgur samples (13.15 and 14.07%) produced industrially were higher than this
Table 1. Chemical and nutritional composition of industrially, homemade and laboratory scale manufactured bulgur samples; mean values were significantly different (P < 0.01) between homemade and industrial samples; LMB: laboratory made bulgur

<table>
<thead>
<tr>
<th>Component</th>
<th>Industrial (I)</th>
<th>Homemade (H)</th>
<th>LMB</th>
<th>Contrast (I-H) diff.</th>
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<td>SD</td>
<td>Max</td>
<td>Min</td>
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<td>14.1</td>
<td>9.2</td>
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<tr>
<td>Crude Ash (%)</td>
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<td>1.60</td>
<td>1.04</td>
</tr>
<tr>
<td>Crude Protein (%)</td>
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<td>0.49</td>
<td>13.3</td>
<td>11.9</td>
</tr>
<tr>
<td>Crude Fat (%)</td>
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<td>0.26</td>
<td>1.76</td>
<td>0.78</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>354.1</td>
<td>5.4</td>
<td>361.9</td>
<td>345.0</td>
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<tr>
<td>Phytic acid (mg/100 g)</td>
<td>712.3</td>
<td>233.6</td>
<td>1153.9</td>
<td>422.1</td>
</tr>
<tr>
<td>Total Phenolic Content (µg/kg)</td>
<td>662.9</td>
<td>173.1</td>
<td>968.0</td>
<td>449.8</td>
</tr>
<tr>
<td>Ca (mg/100 g)</td>
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<td>3.64</td>
<td>30.9</td>
<td>20.1</td>
</tr>
<tr>
<td>Fe (mg/100 g)</td>
<td>1.89</td>
<td>0.40</td>
<td>2.68</td>
<td>1.51</td>
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<td>K (mg/100 g)</td>
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<td>24.7</td>
<td>400</td>
<td>328</td>
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<td>15.0</td>
<td>102.4</td>
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<td>0.45</td>
<td>2.51</td>
<td>0.89</td>
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<td>6.65</td>
<td>59.6</td>
<td>40.7</td>
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<td>P (mg/100 g)</td>
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<td>40.5</td>
<td>382</td>
<td>250.9</td>
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<tr>
<td>Zn (mg/100 g)</td>
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<td>0.58</td>
<td>3.21</td>
<td>1.20</td>
</tr>
<tr>
<td>Cu (mg/kg)</td>
<td>4.08</td>
<td>0.24</td>
<td>4.41</td>
<td>3.57</td>
</tr>
<tr>
<td>Cd (mg/kg)</td>
<td>0.05</td>
<td>0.02</td>
<td>0.09</td>
<td>0.01</td>
</tr>
<tr>
<td>Pb (mg/kg)</td>
<td>0.09</td>
<td>0.11</td>
<td>0.31</td>
<td>0.00</td>
</tr>
</tbody>
</table>

level (13%). In Karaman type production, due to the tempering process of the cooked and dried wheat, and at the later stages without additional drying process, moisture problems can occur, which is the likely reason for the high moisture content. In a previous study, bulgur from five different companies was investigated and the total moisture contents of the bulgur samples were determined in the range of 11.1 to 13.4%, and the average moisture content of the bulgur was 12.4% [20]. The mean ash content in the analyzed bulgur samples produced industrially, homemade and laboratory scale was found as 1.25, 1.49 and 1.69%, respectively. The average ash contents found in bulgur were within the range of 0.86 to 1.80% described by some researchers [20-22]. The average values of ash contents were lower in the industrial bulgur samples than in homemade samples, because of the better separation of wheat bran from bulgur during bulgur production. The pearling step in industrial production allows more bran separation from the wheat compared to the homemade, because the de-branning step is not adequately performed in homemade bulgur production. Also, de-branning or pearling of wheat could not be adequately performed by laboratory scale bulgur production. Therefore, laboratory scale bulgur had high ash content. Protein content is expressed as a percentage of dry matter. Bulgur samples produced by industrial producers, homemade and laboratory scale ranged between 11.9-13.3%, 12.8-14.5% and 13.9%, respectively. Similar results (14.72%) have been observed previously [21]. Homemade bulgur samples gave the highest protein content. Homemade bulgur is made with hard durum wheat with high protein content. Bulgur produced from different wheat varieties showed significant differences in the amount of protein in previous study [22]. These differences can result from factors such as areas where wheat is grown, the amount of fertilizer in the soil, and annual rainfall [23]. Furthermore, the average amount of protein content of bulgur samples produced by any method in Turkey gave higher values than the minimum level of protein in bulgur described by Communiqué of Bulgur (11%) [24]. The protein content of bulgur samples increased course granulation to fine, peeled shell to unpeeled shell, and also stated that removal of the aleurone layer by peeling reduces the amount of protein in other study [25]. Similar results were observed by previous researchers and they found that the protein content of barley ranged between 9.8-11.4%, in barley bulgur, protein content was constant throughout the bulgur process [26]. The fat contents showed levels in the order of 0.78-1.76%, 0.96-1.12% and 1.75% in those manufactured using industrial procedures, homemade and laboratory scale, respectively. The energy values, expressed as a kcal of dry matter,
were statistically similar, with values of around 345.0-361.9 kcal, 350.1-375.8 kcal and 364.8 kcal respectively, in the industrial, homemade and laboratory scale bulgur. The highest mean energy value was determined with bulgur produced as homemade.

**Nutritional properties**

According to ANOVA results, bulgur varieties as a variation source significantly affected the phytic acid values \((p < 0.01)\). The phytic acid contents found in the bulgur were within the range of 422.1-1153.9 mg/100 g for the industrial bulgur samples, within the range of 852.7-1173.6 mg/100 g for homemade bulgur. The average content in phytic acid was higher in the samples of laboratory produced bulgur \((1533.8 \text{ mg/100 g})\). This fact may be justified, probably, by high fiber content of un-separated wheat bran in laboratory and homemade bulgur production. In bulgur produced industrially, separation of wheat bran was efficient, which was proven with lower ash content. Some investigators studied bulgur samples and determined the phytic acid content of raw, cooked wheat and bulgur samples ranged between 872-1124 mg/100 g; 845-1126 mg/100 g; and 681-941 mg/100 g \([27]\). Phytic acid content decreased in the range of 18.9-33.9% during the bulgur production in another study \([28]\). In literature, decreases of phytic acid were explained by the phytic acid change in the aleurone layer, as well as the contamination of germ layer \([26]\). The 0.5 mm sieve material \((düğürçük)\) of bulgur represents nutritional riches with significant ash, fat, cellulose and phytic acid content. When phytic acid and phytate breaks down, it indicates a significant mineral usefulness. On the other hand, phytic acid is an important functional food with its anticancer and antioxidant properties \([29]\). The mean values of total phlopicolic content \((449.8-968.0 \mu g/100 g)\) in the industrially produced and 632.6-1047.1 \(\mu g/100 g\) in homemade) were the same as those determined in bulgur samples \([20]\). These values were higher than those previously observed with wheat samples \((50.1 \text{ to 56.2 mg gallic asit/100 g})\) by other authors \([30]\). From the results obtained in this study and from those previously reported, it can be deduced that compared to the wheat samples, bulgur samples gave high values of total phenolic content. As a result of thermal processes, cellulosic compounds and cell walls broken and thus bound form phenolic will remain free \([31]\). Some researchers stated that thermal effects lead to an increase in phenolic compounds \([32]\). Also, the color was highly significant for bran phenolic contents. In literature, the hue angle values and phenolic contents were negatively correlated \([33]\). In this study, similar negative correlation was found with hue angle and total phenolic content. Therefore, homemade bulgur samples had lower hue angle values and gave higher total phenolic content than industrially produced bulgur. The calcium content of industrially produced, homemade and laboratory scale bulgur samples were varied between 20.1 to 30.9 mg/100 g, 34.6 to 49.5 mg/100 g and 56.8 mg/100 g, respectively. The mean iron values of industrial, homemade and laboratory scale bulgur were 1.89, 2.99 and 5.85 mg/100 g, respectively. The mean potassium content of industrially produced and homemade bulgur samples were determined as 363 and 378 mg/100 g, respectively. The content of magnesium of bulgur produced industrially, homemade and laboratory scale ranged between 60.2 and 102.4 mg/100 g, 106.5 and 126.3 mg/100 g and 127 mg/100 g, respectively. In another study, the amount of magnesium of bulgur was determined as 211.6 mg/100g \([21]\). Magnesium levels in wheat significantly \((p < 0.05)\) reduced with bulgur processing was observed by some researchers \([34]\). The average manganese content was 1.36 mg/100 g in the bulgur sample produced industrially in Turkey. Average manganese values of homemade produced bulgur sample were higher than industrially produced \((1.98 \text{ mg/100 g})\) and the highest values obtained with laboratory scale bulgur samples \((5.70 \text{ mg/100 g})\). Similar calcium and iron contents of 360 and 31 ppm of dry matter have been described for bulgur samples \([35]\). Homemade and laboratory produced bulgur samples were investigated in terms of chemical properties that homemade bulgur samples contain 612 ppm calcium and 24.8 ppm iron, 17.6 ppm zinc, 1084 ppm magnesium, and also bulgur samples produced laboratory condition contain 604 ppm calcium and 24.6 ppm iron, 18.4 ppm zinc, 1100 ppm magnesium were determined by some researchers \([34]\). The average sodium content of industrially produced and homemade bulgur samples were 52.2 and 48.9 mg/100 g, respectively. Laboratory scale produced bulgur sample gave the highest sodium \((65.83 \text{ mg/100 g})\) content. Phosphorus content ranged from 250.9-382.0 mg/100 g in bulgur samples that produced industrially in Turkey. Phosphorus content of homemade bulgur was found between 295.1-412.2 mg/100 g. Homemade and laboratory scale bulgur samples \((407.27 \text{ mg/100 g})\) gave higher phosphorus content than industrially produced bulgur. It was previously determined that the changes of phosphorus and magnesium content between 338 and 380 mg/100 g; between 84 and 107 mg/100 g, in barley respectively \([26]\). When barley processed to bulgur, phosphorus and magnesium content reduced to 294-342 mg/100 g to 90-100
mg/100 g, respectively [26]. Zinc content changed between 1.20-3.21 mg/100 g in industrially bulgur, between 1.34-4.74 mg/100 g in homemade bulgur, laboratory scale produced bulgur sample gave 4.15 mg/100 g zinc content. The higher portion of mineral elements found in a kernel of wheat is contained in the wheat germ, husk or bran and the least amount in endosperm. For this reason, high mineral content consisting of homemade wheat gave higher amount of mineral content than industrially produced bulgur. According to the World Health Organization, heavy metals like Pb, Cd and Ni accumulated by plants in toxic forms should be controlled in food systems [36]. Heavy metals will finally damage the health of living organism by food [37]. Therefore, the determination of heavy metal contents in foods systems becomes important. The content of copper of industrially produced, homemade and laboratory scale bulgur, expressed as mg/kg with values of around 4.08, 5.08 and 5.37, respectively. The cadmium content of bulgur produced of industrially produced, homemade and laboratory scale ranged between 0.01 and 0.09 mg/kg, 0.02 and 0.08 mg/kg and 0.08 mg/kg, respectively. Whereas JECFA [38], permit levels up to 0.1 mg/kg, the recommended limit for Cd in cereal grains including wheat and rice, bran and germ. It was clear that there was no risk with respect to the concentrations of cadmium in bulgur. The average lead content of industrially produced, homemade and laboratory scale bulgur samples were 0.09, 0.00 and 0.02 mg/kg, respectively. The maximum lead level permitted for cereal grains is 0.2 mg/kg [38]. Lead content of homemade produced bulgur sample was not determined. It was clear from the results that there was no risk with respect to the concentrations of lead in bulgur.

**Color properties**

Lightness (L*), redness (a*), yellowness (b*) and hue angle values are given in Table 2. The average L* value of industrially produced and homemade bulgur samples ranged between 52.48-75.16 and 45.52-80.44, respectively. Laboratory scale produced bulgur sample gave the lowest L* value (45.52). Lightness values of industrially produced bulgur samples showed wide range, this is maybe due to the effective pearling processes or wheat varieties of using in bulgur production. In general, homemade produced bulgur samples have been found to lighter than industrially produced bulgur in Turkey. The highest redness values were determined in laboratory scale bulgur samples, but the highest yellowness values were obtained with industrially produced bulgur samples. In Southeast Anatolia, durum wheat cultivars as svevo, burgos and zenit are major dominating varieties and used in bulgur production and this cultivars possessing high yellow pigmentation. Therefore, industrial bulgur samples gave highest yellowness values due to the wheat cultivar used in production. Also, the pearling step in industrial production allows more bran separation from the wheat. The average hue angle values of industrially produced, homemade and laboratory scale bulgur samples were 86.51, 82.79 and 79.03, respectively. Bulgur was produced from siyez and durum wheat, and found the average values of L*, a* and b* as 38.02, 7.30, 15.02 in uncooked siyez bulgur and as 46.54, 5.60, 19.25 in durum bulgur, respectively [39].

In the villages, homemade bulgur is produced by traditional cooking, but in industrial production autoclaving is used. High pressure and temperature applied in autoclave cooking results in darkening of bulgur color, which are undesirable. Also, cooking in autoclave resulted in a more significant decrease on

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**Table 2. Color and sensorial properties of industrially, homemade and laboratory scale manufactured bulgur samples; mean values were significantly different (P < 0.01) between homemade and industrial samples; LMB: laboratory made bulgur**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Industrial (I)</th>
<th>Homemade (H)</th>
<th>LMB</th>
<th>Contrast (I-H) diff.</th>
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<td></td>
<td>Mean</td>
<td>SD</td>
<td>Max</td>
<td>Min</td>
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<tr>
<td>L*</td>
<td>58.04</td>
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<td>a*</td>
<td>1.48</td>
<td>1.29</td>
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<tr>
<td>b*</td>
<td>25.84</td>
<td>2.48</td>
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<td>Hue angle</td>
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<td>3.86</td>
</tr>
</tbody>
</table>
vitamins as thiamin, niacin, pantothenic acid, pyridoxine, and riboflavin, when compared with traditional cooking. It is well known that autoclaving is the best method to reduce the antinutritional factor in the cooking methods. Despite this, autoclaving gave non-clumped and non-deformed grains. Drying temperature is the factor that affects the bulgur quality. In homemade production, it is dried under the sun, but it in industrial production drying is carried out in hot air flow. Higher temperatures cause irreversible darkening and opaqueness of bulgur color.

Sensorial properties

According to the variance analysis results, bulgur samples were statistically significant in hardness, cohesiveness and taste values \((p < 0.01)\). When hardness values assessing by panelists, samples crushed between the teeth in the mouth and perceived feeling of hardness was scored. A lower hardness scores represent the perceived of hardness, and higher scores represent desirable hardness feelings. Industrially produced bulgur samples gave lower hardness values than homemade bulgur samples. Homemade bulgur samples represent desirable hardness values; it may be due to the wheat properties used in bulgur making. Lower scores in terms of cohesiveness in industrially produced bulgur were observed. This might be due to the showing tendency of adhesion between the teeth in mouth. All bulgur samples (industrially, homemade and laboratory scale) were preferred for taste, showing mean scores of 4.03; 4.61 and 4.00, respectively. Yellow color of bulgur produced industrially positively affected the panelists. Industrially produced bulgur samples gave higher color scores than homemade and laboratory scale. The best odor scores of bulgur were observed with homemade bulgur. Panelists emphasized that darker bulgur samples were harder but better tasting than lighter samples. In terms of general acceptability, homemade produced bulgur samples showed higher odor and taste scores than industrially produced samples.

CONCLUSION

Industrially produced bulgur samples gave an attractive brighter yellow color than homemade bulgur samples. Homemade bulgur samples showed higher energy values than industrially produced bulgur. In terms of nutritional properties, industrially produced bulgur contained lower phytic acid content than homemade bulgur due to the effective pearling step of wheat. The total phenolic content reached maximum level in laboratory scale bulgur samples; this was followed by homemade bulgur. Higher nutritional mineral content and also lower heavy metal were observed with homemade bulgur samples. In terms of sensory characteristics, homemade bulgur samples showed more pleasant fragrance and taste than industrially produced bulgur. Homemade bulgur samples got more appreciation than industrially produced bulgur in terms of general acceptability by panelists.

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REFERENCES

[18] N. Yürür, Z.M. Turan, S. Çakmakçı, A research on the effects of some bread and durum wheat varieties on
efficiency and adaptability in Bursa condition, Turkey Grain Symposium, Bursa, 1987, pp. 59-68


[20] Z. Tacer, Istanbul Teknik University, Institute of Science Department of Food Eng, Master’s Thesis, 2008, p. 79


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STRUČNI RAD

POREĐENJE FIZIČKIH, HEMIJSKIH I NUTRITIVNIH SVOJSTAVA INDUSTRIJSKOG I DOMAĆEG BULGURA U TURSKOJ

Određivanje funkcionalnih i nutritivnih svojstava bulgura (pilav) je od najveće važnosti za zdrave generacije. U ovom radu, određen je fizički, hemijski, nutritivni i senzorni kvalitet bulgura proizvedenih industrijski, u domaćinstvu i laboratoriji u Turskoj, a zatim je poređen njihov kvalitet. Sadržaj pepela u uzorcima bulgura je bio između 1,04 i 1,81%, a ukupni sadržaj proteina između 11,90 i 14,47%. Evaluacija nutritivnog statusa bulgura je ukazala na sadržaj ukupnih fenola 449.82 do 1047.09 mg/g i sdržaj fitinske kiseline pronađene između 422.14 i 1173.56 mg/100 g. Sadržaj minerala (kadmijum i olovo) u uzorcima bulgura je bio i manji propisanog maksimuma. Uzorci domaćeg bulgura imali su bolji aromatični ukus i miris nego industrijski proizvedeni. Industrijski proizvedeni uzorci bulgura su imali svetliju boju od domaćeg bulgura.

Ključne reči: bulgur, industrijski proizveden bulgur, domaći bulgur, minerali, fitinska kiselina, Turska.