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# Physical, Physicochemical and Rheological Properties of Baklava Flours Produced in Turkey

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**Abstract**

In this study, physical, physicochemical and rheological properties of 22 baklava flour samples obtained from baklava producers and flour factories with high baklava flour capacity in Konya, Gaziantep, Ankara, Izmir, Balıkesir, Isparta were determined and quality profile of baklava flour was introduced. Physical analysis such as particle size distribution and color; chemical and physicochemical properties such as ash content, protein content Zeleny sedimentation value, modified Zeleny sedimentation value, gluten content, gluten index, dried gluten, falling number, starch damage and rheological properties such as farinograph and extensograph tests were carried out. Average ash content of the samples were 0.58% (dm), protein content was 12.46% (dm), Zeleny sedimentation value was 37.6 mL, modified sedimentation value was 47.0 mL, gluten content was 29.8%, gluten index was 94.4% and water absorption was 60.4%. It was found that quality characteristics of flour samples obtained from flour factories and baklava producers changed regionally. Especially, flours obtained from Gaziantep had different physical, physicochemical and rheological properties depending on durum wheat.

**Keywords:** Special purpose flour, baklava, baklava flour quality

**Türkiye'de Üretilen Baklavalık Unların Fiziksel, Fizikokimyasal ve Reolojik Özellikleri**

**Özet**

Bu çalışmada, Konya, Gaziantep, Ankara, İzmir, Balıkesir ve Isparta'daki yüksek kapasiteli un fabrikalarından ve baklava üreticilerinden temin edilen 22 baklavalık un örneğinin fiziksel, fizikokimyasal ve reolojik özellikleri belirlenmiş ve baklavalık unun kalite profile ortaya konmuştur. Fiziksel analizlerden partikül boyutu dağılımı ve renk;, fizikokimyasal analizlerden kül, protein, Zeleny sedimentasyon, modifiye Zeleny sedimentasyon, gluten, gluten indeks, kuru gluten, düşme sayısı, nişasta zedelenmesi ve reolojik analizlerden farinograf ve ekstensograf testleri gerçekleştirilmiştir. Örneklerin ortalama kül içeriği kuru maddede %0.58, protein içeriği %12.46, Zeleny sedimentasyon değeri 37.6 mL, modifiye Zeleny sedimentasyon değeri 47.0 mL, gluten içeriği %29.8, gluten indeks %94.4 ve ortalama su kaldırması %60.4'tür. Baklava üreticileri ve fabrikalardan temin edilen un örneklerinin kalite karakteristiklerinin bölgesel değişimler gösterdiği belirlenmiştir. Özellikle, Gaziantep'ten temin edilen unlar durum buğdayı kullanımına bağlı olarak farklı fiziksel, fizikokimyasal ve reolojik özellikler göstermiştir.

**Anahtar kelimeler:** Özel amaçlı un, baklava, baklavalık un kalitesi

## Introduction

Flours used in the production of bakery products other than bread is called special purpose flour. According to the Turkish Food Codex Wheat Flour Statement (Anonymous, 2013), special purpose flour is defined as the wheat flour suitablefor the production of directly consumed products such as baklava, biscuits, cakes, phyllo, pizza, hamburger, grain bread and flours suitable for specially processed flours, flours with additives and durum clear flour. As indicated in the description, the properties suitable for the production of bakery products are not described separately for every product, but the term 'special purpose flour' is used instead of the flour appropriate for the production of more than one bakery product. However, the properties of the flour change for every bakery product. Therefore, it is important to define the properties of the flour appropriate for the production of every single bakery product. On the other hand, as there is no standardization in the properties of special purpose flours, these properties are limited with the millers' specifications.

Baklava is a well-known traditional Turkish dessert prepared from multi-layers of very thin dough that are brushed with butter, stuffed with pistachios or nuts and added with syrup (Koz et al., 2004). To the best of its knowledge, baklava is a Turkish originated dessert from Assyrians that has left a mark on Turkish, Middle East, South Asia and Balkan cuisines (Akyildiz, 2010). As mentioned above, baklava flour, which is special purpose flour, must be used for baklava production. As a result of bilateral discussions with the flour factories, it is concluded that wheat blends having high ratio of imported wheat, high quality gluten, low flour yield and having no sunn pest damage are preferred for baklava production. Toros, Ceyhan 99, Bezostaja, Zerun and Melez in Central Anatolia Region, Segittario, Adana 99, Flamura (Thrace), Bezostaja (Polatlı, Ankara), Kazakhstan wheat and Australian wheat are among the wheat varieties preferred by the millers in Turkey. By these wheat blends, it is aimed to obtain dough with high quality protein and high gluten content, high extensibility that is suitable for rolling and tolerant to mixing (Anonymous, 2010a).

Rolling the dough thin, good frying and syrup absorbing are important quality parameters in baklava production. Flours with minimum 13% protein, 35% gluten, 90% gluten index, average 38 ml Zeleny sedimentation value and with 10 ml of increase in modified Zeleny sedimentation value are preferred by flour mills in order to provide these quality parameters. Although dough is used in low proportion in comparison to other ingredients in baklava production, the effects on end product quality and crispness are quite important. Therefore, to know the properties of the flour used will guide to baklava producers while deciding the flour they will supply for baklava production (Anonymous, 2010b).

Researches on flour properties of baklava are very limited. Atlı et al. (2013) investigated the effects of flour and oil quality on the properties of baklava. Baklava was made using two different flour and their blend and using clarified butter and vegetable oil. Baklava samples were evaluated in terms of syrup consistency, shape, color, brightness, smell, creaking-rustling and flavor. It was reported that except for smell, panelists gave higher scores to all parameters of baklava produced from clarified butter. Acar (2012) investigated the suitability of some wheat cultivars for baklava production. Koten et al. (2008) studied some quality characteristics of flours used for baklava and determined moisture, ash, protein, wet gluten, dry gluten, gluten index and Zeleny sedimentation value of three flours supplied from local baklava producers in South-Eastern Anatolia. In this study, some physical, physicochemical and rheological quality characteristics of baklava flour samples obtained from millers and baklava producers were determined and a quality profile for baklava flour was introduced.

## Materials and Methods

### *Materials*

12 baklava flours from flour mills having high baklava flour production capacity in Konya, Gaziantep, Ankara, Izmir, Balıkesir, Isparta and 10 baklava flours from baklava producers in Izmir and Gaziantep were obtained in 2009 and 2010 in two replications, stored in air tight containers in 15°C and rested for one month before the analysis were carried out. Results represent the average of two supply years.

Flours supplied from flour mills were randomly coded between M1-M12 and flours supplied from baklava producers were coded between P1-P10.

### *Methods*

#### *Physical analyses*

Particle size distribution of the flours was determined according to Ozkaya and Kahveci (1990) with some modifications. 100 g of flour was sieved for 5 minutes from sieves having 132, 118 and 80 µ sieve opening. Oversize and undersize materials were given in percentage. Two parallel siftings were carried out for each sample. *L*, a** and *b** values of the flours were determined by Minolta Chromameter CR-310 (Osaka, Japan) according to Ekinci (2001). Average of five parallel readings was recorded.

#### *Physicochemical and rheological analyses*

Moisture, ash and protein content of the samples were carried out according to ICC Standard No: 110/1 (Anonymous, 1982), No: 104/1 (Anonymous, 1990) and No: 105/2 (Anonymous, 1994a). Protein content was determined by multiplying the nitrogen content by 5.7. Analyses were carried out in three parallels. Zeleny sedimentation test, modified Zeleny sedimentation test and falling number were determined according to ICC Standard No: 116/1 (Anonymous, 1994b), Pinckney et al. (1957) and ICC Standard No: 107/1 (Anonymous, 1995a) respectively. Wet gluten, dry gluten and gluten index were determined according to AACC Method 38.12-02 (Anonymous, 2000). Analyses were performed in three parallels. Starch damage of the flour samples was determined according to AACC Method 76.33.01 (Anonymous, 2006) using Chopin SD-Matic. Farinograph and Extensograph tests were carried out in two parallels using AACC Method 54-21.02 (Anonymous, 1995b) and ICC Standard No: 114/1 respectively (Anonymous, 1992).

***Statistical analysis***

Results in this study were analyzed by ANOVA using SAS (Statistical Analytical Systems). The study was planned as completely randomized design and differences between the samples were determined by Fisher's LSD (Least Significant Difference) test using PROG GLM procedure (SAS, 2001).

**Table 1.** Particle size distribution (%) of baklava flour samples

| | >132µ | 132-118µ | 118-80µ | <80 µ |
|---|---|---|---|---|
| M1 | 14.01$^{b}$ | 8.65$^{a}$ | 37.23$^{abcd}$ | 40.13$^{h}$ |
| M2 | 10.30$^{d}$ | 5.95$^{abcdef}$ | 35.40$^{abcde}$ | 48.36$^{efg}$ |
| M3 | 7.01$^{g}$ | 3.27$^{fgh}$ | 34.07$^{bcdef}$ | 55.66$^{bcd}$ |
| M4 | 7.39$^{fg}$ | 5.20$^{cdefgh}$ | 37.07$^{abcd}$ | 50.34$^{defg}$ |
| M5 | 8.63$^{e}$ | 4.45$^{defgh}$ | 33.85$^{bcdef}$ | 53.07$^{cdef}$ |
| M6 | 12.16$^{c}$ | 5.80$^{abcdefgh}$ | 32.94$^{cdef}$ | 49.11$^{efg}$ |
| M7 | 5.44$^{ij}$ | 5.05$^{cdefgh}$ | 33.8$^{bcdef}$ | 55.72$^{bcd}$ |
| M8 | 6.73$^{gh}$ | 6.42$^{abcde}$ | 34.63$^{abcdef}$ | 52.24$^{cdef}$ |
| M9 | 3.65$^{lm}$ | 6.95$^{abcd}$ | 38.63$^{ab}$ | 50.78$^{defg}$ |
| M10 | 8.63$^{e}$ | 5.69$^{abcdefgh}$ | 35.26$^{abcde}$ | 50.43$^{defg}$ |
| M11 | 8.12$^{ef}$ | 4.56$^{defgh}$ | 39.50$^{a}$ | 47.83$^{fg}$ |
| M12 | 5.41$^{ijk}$ | 5.63$^{bcdefgh}$ | 38.30$^{ab}$ | 50.68$^{defg}$ |
| P1 | 5.64$^{hi}$ | 3.65$^{efgh}$ | 37.95$^{abc}$ | 52.78$^{cdef}$ |
| P2 | 4.34$^{kl}$ | 3.88$^{efgh}$ | 34.57$^{abcdef}$ | 57.22$^{bc}$ |
| P3 | 3.16$^{m}$ | 2.89$^{gh}$ | 30.32$^{ef}$ | 63.64$^{a}$ |
| P4 | 4.41$^{jkl}$ | 3.45$^{efgh}$ | 37.84$^{abcd}$ | 54.31$^{cde}$ |
| P5 | 3.11$^{m}$ | 2.825$^{h}$ | 32.63$^{def}$ | 61.43$^{ab}$ |
| P6 | 4.64$^{ijkl}$ | 7.67$^{abc}$ | 33.54$^{bcdef}$ | 54.17$^{cde}$ |
| P7 | 20.43$^{a}$ | 8.53$^{ab}$ | 30.98$^{ef}$ | 40.07$^{h}$ |
| P8 | 14.76$^{b}$ | 5.245$^{cdefgh}$ | 35.14$^{abcde}$ | 44.86$^{gh}$ |
| P9 | 19.66$^{a}$ | 5.85$^{abcdefg}$ | 29.47$^{f}$ | 45.4$^{gh}$ |
| P10 | 4.33$^{kl}$ | 3.88$^{efgh}$ | 34.57$^{abcdef}$ | 57.23$^{bc}$ |
| Mean | 8.27 | 5.25 | 34.89 | 51.59 |
| LSD | 1.10 | 2.90 | 5.16 | 5.93 |
| p value | <.001 | 0.0123 | 0.0313 | <.001 |

In a column, means with the same letter are not different from each other (p<0.05), M: samples obtained from flour mills, P: samples obtained from baklava producers

## Results and Discussion

Particle size distribution of the baklava flour samples were given in Table 1. 86.48% of baklava flour mass was under the sieve having 118 µ sieve opening. Baklava flour mass under the sieve having 80 µ sieve opening ranged between 45.0 – 55.0% with an average of 51.59%. M1, P7, P8 and P9 (flours supplied from Gaziantep) had the lowest percentage retained under 80 µ sieve and did not differ from each other (p>0.05). In contrast, percentage of flour over 132 µ for M1, P7, P8 and P9 was remarkably higher than the other baklava flours and these flours were different (p<0.05) from other baklava flours.

**Table 2.** *L*, a*, b** values of baklava flour samples

| | *L** | *a** | *b** |
|---|---|---|---|
| M1 | 92.56$^{h}$ | -6.10$^{j}$ | 20.77$^{a}$ |
| M2 | 94.01$^{cdef}$ | -4.58$^{a}$ | 12.32$^{k}$ |
| M3 | 94.66$^{abc}$ | -5.25$^{fgh}$ | 14.48$^{fg}$ |
| M4 | 93.82$^{def}$ | -4.87$^{bc}$ | 13.93$^{ghi}$ |
| M5 | 94.81$^{ab}$ | -5.06$^{cdefg}$ | 13.04$^{jki}$ |
| M6 | 93.08$^{gh}$ | -4.80$^{ab}$ | 13.85$^{ghi}$ |
| M7 | 94.15$^{bcd}$ | -5.16$^{defgh}$ | 13.44$^{hij}$ |
| M8 | 93.36$^{fg}$ | -5.04$^{bcdefg}$ | 15.54$^{de}$ |
| M9 | 93.97$^{cdef}$ | -5.19$^{efgh}$ | 15.16$^{ef}$ |
| M10 | 93.80$^{def}$ | -4.93$^{bcd}$ | 13.92$^{ghi}$ |
| M11 | 95.18$^{a}$ | -4.99$^{bcde}$ | 14.07$^{gh}$ |
| M12 | 94.64$^{abc}$ | -5.27$^{gh}$ | 14.20$^{gh}$ |
| P1 | 94.96$^{a}$ | -5.12$^{cdefg}$ | 12.87$^{jk}$ |
| P2 | 93.90$^{def}$ | -4.98$^{bcde}$ | 14.59$^{fg}$ |
| P3 | 94.09$^{cde}$ | -4.98$^{bcde}$ | 14.24$^{gh}$ |
| P4 | 93.84$^{def}$ | -5.02$^{bcdef}$ | 14.32$^{fgh}$ |
| P5 | 94.99$^{a}$ | -5.17$^{defgh}$ | 13.41$^{hij}$ |
| P6 | 94.96$^{a}$ | -5.16$^{defgh}$ | 12.87$^{jk}$ |
| P7 | 93.50$^{defg}$ | -5.40$^{h}$ | 17.15$^{bc}$ |
| P8 | 93.73$^{defg}$ | -5.74$^{i}$ | 17.62$^{b}$ |
| P9 | 93.40$^{efg}$ | -5.39$^{h}$ | 16.35$^{cd}$ |
| P10 | 93.50$^{defg}$ | -5.03$^{bcdefg}$ | 14.43$^{fg}$ |
| Mean | 94.04 | -5.14 | 14.66 |
| LSD | 0.71 | 0.25 | 0.91 |
| p value | <.001 | <.001 | <.001 |

In a column, means with the same letter are not different from each other (p<0.05).

As a result of the bilateral discussions with the baklava producers in Gaziantep, it was found out that flours used in Gaziantep baklava production contained 70-80% durum wheat flour. Durum wheat flour is preferred as it provides crisp baklava production. During bilateral discussions with the flour mills in the other cities, it was stated that hard bread wheat was used in baklava flour production. Flours obtained from Gaziantep had higher oversize material due to durum wheat use in formulation.

**Table 3.** Physicochemical properties of baklava flour samples

| | Ash (% dm) | Protein (% dm) | Z.S. (mL) | M.Z.S. (mL) | Gluten (%) | Gluten Index (%) | Dry Gluten (%) | F.N (sec) | Starch Damage (%) |
|---|---|---|---|---|---|---|---|---|---|
| M1 | 0.655$^{bc}$ | 12.96$^{bc}$ | 23.9$^{i}$ | 27.8$^{i}$ | 29.7$^{def}$ | 93.2$^{ab}$ | 10.5$^{def}$ | 530$^{b}$ | 5.8$^{a}$ |
| M2 | 0.579$^{def}$ | 12.67$^{cdef}$ | 44.6$^{abc}$ | 53.8$^{bcd}$ | 29.2$^{ef}$ | 98.0$^{a}$ | 9.8$^{fgh}$ | 418$^{def}$ | 5.1$^{cdef}$ |
| M3 | 0.506$^{h}$ | 12.30$^{defgh}$ | 40.9$^{cde}$ | 52.1$^{cde}$ | 29.8$^{def}$ | 98.3$^{a}$ | 10.0$^{efgh}$ | 414$^{ef}$ | 4.7$^{efg}$ |
| M4 | 0.553$^{efg}$ | 12.10$^{fgh}$ | 37.6$^{efg}$ | 46.6$^{ef}$ | 26.7$^{gh}$ | 95.5$^{a}$ | 9.5$^{h}$ | 409$^{ef}$ | 4.4$^{g}$ |
| M5 | 0.575$^{ef}$ | 12.91$^{bc}$ | 38.9$^{def}$ | 46.8$^{ef}$ | 30.2$^{bcdef}$ | 98.1$^{a}$ | 10.5$^{de}$ | 501$^{bc}$ | 4.7$^{efg}$ |
| M6 | 0.690$^{ab}$ | 12.06$^{gh}$ | 35.4$^{fg}$ | 42.1$^{fg}$ | 29.8$^{def}$ | 90.4$^{abc}$ | 10.2$^{efg}$ | 473$^{bcde}$ | 4.8$^{defg}$ |
| M7 | 0.543$^{fgh}$ | 12.72$^{cde}$ | 43.5$^{abcd}$ | 53.9$^{bcd}$ | 30.0$^{cdef}$ | 98.5$^{a}$ | 10.9$^{bcd}$ | 492$^{bc}$ | 5.0$^{cdefg}$ |
| M8 | 0.599$^{de}$ | 13.89$^{a}$ | 45.9$^{ab}$ | 64.2$^{a}$ | 33.5$^{a}$ | 94.4$^{ab}$ | 11.5$^{ab}$ | 487$^{bc}$ | 4.9$^{defg}$ |
| M9 | 0.578$^{def}$ | 13.30$^{b}$ | 47.9$^{a}$ | 59.7$^{ab}$ | 32.3$^{abc}$ | 95.1$^{a}$ | 11.6$^{a}$ | 531$^{b}$ | 4.9$^{defg}$ |
| M10 | 0.577$^{def}$ | 11.18$^{i}$ | 30.3$^{h}$ | 41.0$^{fg}$ | 25.6$^{h}$ | 97.9$^{a}$ | 8.5$^{i}$ | 445$^{cdef}$ | 4.5$^{fg}$ |
| M11 | 0.564$^{ef}$ | 12.80$^{bcd}$ | 33.2$^{gh}$ | 37.1$^{gh}$ | 29.5$^{def}$ | 97.9$^{a}$ | 10.0$^{efgh}$ | 536$^{b}$ | 4.8$^{defg}$ |
| M12 | 0.506$^{gh}$ | 12.08$^{gh}$ | 39.3$^{def}$ | 54.1$^{bcd}$ | 28.9$^{efg}$ | 98.9$^{a}$ | 9.5$^{gh}$ | 509$^{bc}$ | 4.9$^{defg}$ |
| P1 | 0.573$^{ef}$ | 12.54$^{cdefg}$ | 38.8$^{ef}$ | 55.4$^{bcd}$ | 31.9$^{abcd}$ | 92.3$^{ab}$ | 10.7$^{cde}$ | 486$^{bcd}$ | 5.8$^{ab}$ |
| P2 | 0.544$^{fgh}$ | 12.58$^{cdefg}$ | 41.0$^{cde}$ | 57.4$^{bc}$ | 29.3$^{ef}$ | 96.8$^{a}$ | 10.7$^{cde}$ | 510$^{bc}$ | 5.2$^{abcde}$ |
| P3 | 0.541$^{fgh}$ | 12.60$^{cdefg}$ | 41.3$^{bcde}$ | 49.2$^{de}$ | 30.4$^{bcdef}$ | 94.1$^{ab}$ | 10.9$^{bcd}$ | 513$^{bc}$ | 5.2$^{abcde}$ |
| P4 | 0.540$^{fgh}$ | 13.08$^{bc}$ | 41.0$^{cde}$ | 54.8$^{bcd}$ | 30.9$^{bcde}$ | 90.6$^{abc}$ | 11.2$^{abc}$ | 492$^{bc}$ | 5.2$^{bcdef}$ |
| P5 | 0.538$^{fgh}$ | 12.63$^{cdefg}$ | 39.3$^{def}$ | 50.4$^{de}$ | 29.9$^{cdef}$ | 90.9$^{abc}$ | 10.4$^{def}$ | 515$^{b}$ | 5.6$^{abc}$ |
| P6 | 0.538$^{fgh}$ | 12.15$^{efgh}$ | 44.5$^{abc}$ | 60.1$^{ab}$ | 30.5$^{bcdef}$ | 96.1$^{a}$ | 10.2$^{def}$ | 416$^{ef}$ | 5.5$^{abcd}$ |
| P7 | 0.629$^{cd}$ | 11.23$^{i}$ | 25.0$^{i}$ | 31.3$^{hi}$ | 28.2$^{fg}$ | 93.9$^{ab}$ | 9.8$^{fgh}$ | 607$^{a}$ | 4.9$^{cdefg}$ |
| P8 | 0.718$^{a}$ | 11.76$^{hi}$ | 24.0$^{i}$ | 28.3$^{i}$ | 29.8$^{def}$ | 85.7$^{bc}$ | 10.0$^{efgh}$ | 511$^{bc}$ | 4.9$^{defg}$ |
| P9 | 0.668$^{abc}$ | 11.41$^{i}$ | 24.0$^{i}$ | 28.3$^{i}$ | 29.6$^{def}$ | 82.8$^{c}$ | 9.8$^{fgh}$ | 499$^{bc}$ | 4.9$^{defg}$ |
| P10 | 0.553$^{efg}$ | 13.33$^{ab}$ | 40.0$^{cdef}$ | 40.5$^{fg}$ | 32.5$^{ab}$ | 93.5$^{ab}$ | 11.5$^{ab}$ | 403$^{f}$ | 5.3$^{abcde}$ |
| Mean | 0.58 | 12.47 | 37.6 | 47.0 | 29.8 | 94.4 | 10.3 | 487 | 5.24 |
| LSD | 0.052 | 0.57 | 5.0 | 6.6 | 2.46 | 8.9 | 0.73 | 67.5 | 0.46 |
| p value | <.001 | <.001 | <0.01 | <.001 | <0.001 | >0.05 | <.001 | 0.0003 | <0.01 |

In a column, means with the same letter are not different from each other (p<0.05). Z.S.: Zeleny sedimentation, M.Z.S.: Modified Zeleny sedimentation, F.N: falling number

The larger the particle size of the flour, the higher is the syrup absorbing ratio of baklava. Maintaining crisp baklava production by proper sieve arrangements in mill diagram is among important criteria in baklava production. Particle size distribution is important, as it gives information about final product crispness and mill diagram (Anonymous, 2010c)

*L**(lightness), *-a**(greenness) and *+b**(yellowness) values of the baklava flour samples were 94.04, -5.14 and 14.66 respectively (Table 2). Flour samples differed from each other (p<0.001) in terms of color parameters with sample M11 having the highest L* value. However, M3, M5, M11, M12, P1, P5 and P6 did not differ (p>0.05) from each other. M1 had the highest *b** value and was statistically different from other samples. P7 and P8, following M1, was not different (p>0.05) from each other. When differences among the samples were investigated, flour samples supplied from Gaziantep had higher *b** values. Moreover, yellowness of the samples changed in a wide range. So, it will not be wrong to say that the main criteria in expressing flour color is *b** value. Similarly, Yasunaga and Uemura (1962) stated that *L** and *b** values must be measured to express flour color. Because, *a** value is not an important parameter especially for the flours obtained from white wheat (Oliver et al., 1992).

Moisture contents of the baklava flours were determined and results were calculated according to 14% moisture content or on dry basis as stated in the methods. Average ash content of the samples was 0.58% and LSD was 0.052 (Table 3). Flour samples differed from each other (p<0.001) in terms of ash content. It was observed that ash content generally changed between 0.54 – 0.58% and flour samples obtained from Gaziantep had higher ash content as a result of high ash content in durum wheat. Koten et al. (2008) reported ash content of baklava flours between 0.41 - 0.64%. Protein content of the flours obtained from Gaziantep was under the average value. LSD was 0.57 and flour samples differed from each other (p<0.01) in terms of protein content. Average protein content was 12.47% which was higher than 7% that was the lower limit indicated in the Turkish Food Codex, Wheat Flour Statement (Anonymous, 2013).

**Table 4.** Farinograph test results of baklava flour samples

| Sample | Water abs.(%) | D.T (min.) | Stability (min.) | D.S (B.U.) | M.T.I (B.U.) |
|---|---|---|---|---|---|
| M1 | 65.5[a] | 2.0[b] | 4.4[hi] | 95.8[a] | 64.9[ab] |
| M2 | 59.5[cdefg] | 3.5[ab] | 10.2[abcdefg] | 58.0[bcde] | 25.0[de] |
| M3 | 60.4[cdefg] | 2.4[b] | 9.3[cdefgh] | 59.3[bcd] | 23.3[de] |
| M4 | 59.4[cdefg] | 1.9[b] | 3.3[i] | 65.5[abcd] | 43.7[bcd] |
| M5 | 60.1[cdefg] | 4.7[ab] | 10.6[abc] | 43.0[cdef] | 10.9[de] |
| M6 | 60.8[cd] | 2.3[b] | 9.9[bcdefgh] | 54.5[bcde] | 22.9[de] |
| M7 | 58.5[fg] | 5.9[a] | 9.6[bcdefgh] | 73.5[abc] | 45.2[abcd] |
| M8 | 59.1[defg] | 2.6[b] | 12.1[abcde] | 45.5[cdef] | 19.2[de] |
| M9 | 59.6[cdefg] | 2.3[b] | 11.2[abcdef] | 52.5[bcde] | 34.4[cde] |
| M10 | 58.4[g] | 2.0[b] | 9.1[cdefgh] | 62.8[abcd] | 38.6[bcd] |
| M11 | 60.5[cdef] | 2.0[b] | 8.1[defghi] | 69.0[abcd] | 32.8[cde] |
| M12 | 60.7[cde] | 2.3[b] | 16.0[a] | 22.5[ef] | 10.6[e] |
| P1 | 63.2[b] | 2.4[b] | 9.2[cdefgh] | 55.5[bcde] | 19.4[de] |
| P2 | 61.2[cd] | 2.4[b] | 7.5[efghi] | 57.0[bcde] | 29.0[cde] |
| P3 | 61.0[cd] | 2.5[b] | 12.8[abcde] | 38.0[cdef] | 30.0[cde] |
| P4 | 60.4[cdefg] | 2.5[b] | 12.9[abcde] | 36.5[def] | 28.0[de] |
| P5 | 59.9[cdefg] | 2.3[b] | 10.6[abcdefg] | 43.5[cdef] | 28.5[cde] |
| P6 | 60.0[cdefg] | 2.1[b] | 15.2[ab] | 15.0[f] | 11.0[e] |
| P7 | 59.4[cdefg] | 2.3[b] | 5.3[ghi] | 88.0[ab] | 71.0[a] |
| P8 | 61.4[bc] | 2.7[b] | 5.2[ghi] | 63.0[abcd] | 55.2[abc] |
| P9 | 58.7[efg] | 2.5[b] | 5.8[fghi] | 72.0[abcd] | 65.0[ab] |
| P10 | 61.2[cd] | 2.4[b] | 13.2[abcd] | 36.5[def] | 22.8[de] |
| Mean | 60.4 | 2.6 | 9.6 | 54.9 | 33.8 |
| LSD | 2.1 | 3.0 | 5.8 | 36.1 | 20.3 |
| p value | <0.001 | >0.05 | 0.004 | 0.021 | 0.002 |

In a column, means with the same letter are not different from each other (p<0.05) *abs.:* absorption, D.T.: development time, D.S.: degree of softening, M.T.I.: mixing tolerance index, B.U.: Brabender Unit

Zeleny sedimentation values and modified Zeleny sedimentation values of the flour samples were given in Table 3. M1, P7, P8 and P9 were not different (p>0.05) from each other and the lowest Zeleny and modified Zeleny sedimentation values were determined in these samples. This is because; these samples containing a high ratio of durum wheat which was mentioned formerly, tend to sediment faster than the other flour samples. When Zeleny sedimentation value was concerned, flour samples were accordant with flour mills' specifications in which it was stated that Zeleny sedimentation value must be higher than 35-36 mL with an average of 38 mL and modified Zeleny sedimentation value must be 10 mL higher than Zeleny sedimentation value in baklava flours (Anonymous, 2010b). A decrease in modified sedimentation value was not observed in flour samples which indicated that sunn pest damaged wheat was not used in baklava production. Koten et al. (2008) reported that Zeleny sedimentation value ranged between 28 – 54 mL in baklava flour samples.

Average gluten content and the gluten index of the baklava flour samples were 29.8% and 94.9% respectively. Flour samples differed from each other (p<0.01) in terms of gluten content while they did not differ in terms of gluten index (p>0.05). The highest protein containing sample M8 had the highest gluten content, while the lowest protein containing sample M10 had the lowest gluten content, as expected. Results of the study were accordant with Akyildiz (2010) who reported that flours used in baklava production contained 28-30% gluten. On the other hand, as gluten contents of M4 and M10 were considerably under the average gluten content, it was concluded that dough obtained from these flours would be difficult to handle due to low gluten content. Koten et al. (2008) reported gluten and gluten index values between 27.5 – 34.0% and 68.0 – 97.0% respectively.

Flour samples differed from each other in terms of dry gluten content (p<0.001) and falling number (p<0.01) and the LSD values were 0.73 and 67.5 respectively. M10 had the lowest dry gluten content; P7 had the highest falling number and were different (p<0.001) from other samples. On the other hand, M1, M5, M6, M7, M8, M9, M11, M12, P1, P2, P3, P4, P5, P8 and P9 did not differ (p>0.05) in terms of falling number. Koten et al. (2008) reported dry gluten of baklava flour samples between 9.4 – 11.0%.

Average starch damage and LSD values were 5.24% and 0.46 respectively. Flour samples differed from each other (p<0.01) in terms of starch damage having the highest starch damage in M1. However, M1, P1, P5, P6 did not differ from each other (p>0.05). Starch damage is an important quality parameter for the evaluation of hard and soft wheats (Lin and Czuchajowska, 1996). Elgun and Ertugay (2002) stated that starch damage increased during milling of hard wheat. Ozkaya and Ozkaya (1994) reported that starch damage in flour changed between 5.5 - 9.5% depending on wheat characteristics and milling conditions.

**Table 5.** Extensograph test results of baklava flour samples

| Code | 45'A (cm$^2$) | 45'Rmax (B.U) | 45' E (mm) | 90'A (cm$^2$) | 90'Rmax (B.U) | 90' E (mm) | 135'A (cm$^2$) | 135'Rmax (B.U) | 135' E (mm) |
|---|---|---|---|---|---|---|---|---|---|
| M1 | 81.8$^{fg}$ | 439.5$^{gh}$ | 140.3$^{i}$ | 91.8$^{fgh}$ | 610.0$^{cde}$ | 122.5$^{h}$ | 103.5$^{fg}$ | 676.5$^{efgh}$ | 121.5$^{ef}$ |
| M2 | 124.8$^{abcd}$ | 610.0$^{abc}$ | 163.0$^{efg}$ | 153.0$^{abcd}$ | 754.0$^{abcd}$ | 165.0$^{bcd}$ | 146.5$^{abcd}$ | 794.8$^{abcdef}$ | 158.3$^{ab}$ |
| M3 | 117.2$^{bcde}$ | 502.3$^{cdefgh}$ | 179.0$^{cd}$ | 123.8$^{def}$ | 604.2$^{cde}$ | 165.5$^{bcd}$ | 135.5$^{abcde}$ | 684.7$^{defg}$ | 159.7$^{ab}$ |
| M4 | 136.5$^{ab}$ | 637.0$^{ab}$ | 173.5$^{de}$ | 138.5$^{bcde}$ | 717.5$^{abcd}$ | 148.0$^{defg}$ | 115.0$^{ef}$ | 873.5$^{abc}$ | 118.0$^{f}$ |
| M5 | 139.5$^{ab}$ | 636.0$^{ab}$ | 173.3$^{de}$ | 166.0$^{ab}$ | 841.0$^{ab}$ | 164.5$^{bcd}$ | 161.2$^{a}$ | 866.3$^{abcd}$ | 152.5$^{abc}$ |
| M6 | 101.5$^{ef}$ | 460.5$^{fgh}$ | 171.8$^{def}$ | 116.8$^{defg}$ | 591.0$^{de}$ | 157.3$^{cde}$ | 108.5$^{efg}$ | 584.5$^{gh}$ | 146.5$^{bcd}$ |
| M7 | 123.8$^{abcde}$ | 586.0$^{abcd}$ | 170.6$^{def}$ | 127.2$^{cdef}$ | 732.2$^{abcd}$ | 142.2$^{efgh}$ | 117.3$^{def}$ | 719.5$^{bcdefg}$ | 134.2$^{cdef}$ |
| M8 | 139.4$^{ab}$ | 575.4$^{abcde}$ | 197.9$^{a}$ | 152.3$^{abcd}$ | 735.4$^{abcd}$ | 173.5$^{bc}$ | 129.4$^{bcdef}$ | 753.1$^{bcdefg}$ | 149.6$^{abcd}$ |
| M9 | 136.2$^{ab}$ | 615.6$^{ab}$ | 175.3$^{cde}$ | 153.5$^{abcd}$ | 868.8$^{ab}$ | 151.4$^{def}$ | 150.0$^{abc}$ | 878.7$^{abc}$ | 146.1$^{bcd}$ |
| M10 | 110.1$^{cde}$ | 581.4$^{abcd}$ | 154.0$^{ghi}$ | 122.3$^{def}$ | 758.8$^{abcd}$ | 134.9$^{fgh}$ | 106.9$^{efg}$ | 785.3$^{abcdef}$ | 117.7$^{f}$ |
| M11 | 102.8$^{def}$ | 472.3$^{efgh}$ | 170.3$^{def}$ | 113.5$^{efg}$ | 585.3$^{de}$ | 156.8$^{cde}$ | 102.5$^{fg}$ | 621.8$^{fgh}$ | 139.8$^{bcdef}$ |
| M12 | 142.9$^{a}$ | 650.0$^{a}$ | 173.3$^{de}$ | 170.2$^{ab}$ | 926.8$^{a}$ | 155.7$^{cdef}$ | 164.4$^{a}$ | 961.0$^{a}$ | 144.5$^{bcde}$ |
| P1 | 103.0$^{def}$ | 502.0$^{defgh}$ | 165.5$^{defg}$ | 125.5$^{def}$ | 708.5$^{bcd}$ | 146.5$^{defg}$ | 120.5$^{cdef}$ | 702.0$^{cdefg}$ | 140.5$^{bcdef}$ |
| P2 | 124.3$^{abcde}$ | 530.3$^{bcdefg}$ | 180.0$^{bcd}$ | 147.8$^{abcde}$ | 705.5$^{bcd}$ | 164.5$^{bcd}$ | 147.5$^{abc}$ | 889.5$^{ab}$ | 170.5$^{a}$ |
| P3 | 123.5$^{abcde}$ | 566.5$^{abcdef}$ | 171.0$^{def}$ | 137.3$^{bcde}$ | 699.5$^{bcd}$ | 159.0$^{cde}$ | 136.8$^{abcde}$ | 738.0$^{bcdefg}$ | 152.5$^{abc}$ |
| P4 | 138.8$^{ab}$ | 577.5$^{abcde}$ | 190.3$^{abc}$ | 167.3$^{ab}$ | 741.0$^{abcd}$ | 181.3$^{ab}$ | 156.8$^{ab}$ | 751.0$^{bcdefg}$ | 170.8$^{a}$ |
| P5 | 127.5$^{abc}$ | 599.3$^{abcd}$ | 168.8$^{defg}$ | 164.0$^{abc}$ | 849.3$^{ab}$ | 159.8$^{bcde}$ | 159.0$^{ab}$ | 889.3$^{ab}$ | 149.5$^{abcd}$ |
| P6 | 123.5$^{abcde}$ | 573.7$^{abcde}$ | 169.4$^{defg}$ | 152.0$^{abcd}$ | 789.5$^{abc}$ | 156.0$^{cdef}$ | 154.8$^{ab}$ | 855.6$^{abcde}$ | 150.8$^{abcd}$ |
| P7 | 62.0$^{g}$ | 285.5$^{i}$ | 156.5$^{fgh}$ | 66.5$^{h}$ | 326.5$^{f}$ | 150.0$^{defg}$ | 70.0$^{h}$ | 363.5$^{ij}$ | 141.5$^{bcdef}$ |
| P8 | 76.8$^{g}$ | 409.0$^{h}$ | 141.8$^{hi}$ | 79.8$^{h}$ | 473.5$^{ef}$ | 128.8$^{gh}$ | 81.8$^{gh}$ | 496.3$^{hi}$ | 127.3$^{def}$ |
| P9 | 59.3$^{g}$ | 266.0$^{i}$ | 160.0$^{efg}$ | 58.3$^{h}$ | 292.3$^{f}$ | 144.5$^{defg}$ | 56.8$^{h}$ | 294.0$^{j}$ | 140.8$^{bcdef}$ |
| P10 | 134.0$^{ab}$ | 530.5$^{bcdefg}$ | 195.5$^{ab}$ | 179.0$^{a}$ | 737.0$^{abcd}$ | 200.0$^{a}$ | 163.5$^{a}$ | 848.5$^{abcde}$ | 160.0$^{ab}$ |
| Mean | 114.9 | 527.6 | 170.0 | 132.1 | 684.0 | 155.8 | 126.7 | 728.5 | 145.1 |
| LSD | 22.9 | 108.0 | 16.0 | 37.1 | 197.4 | 21.8 | 30.0 | 182.9 | 24.0 |
| p value | <.001 | <.001 | <.001 | <.001 | <.001 | <0.001 | <.001 | <.001 | 0.0036 |

In a column, means with the same letter are not different from each other ($p<0.05$), A: energy, $R_{max}$: maximum resistance to extension, E: extensibility

Farinograph test results of the flours were presented in Table 4. Average water absorption was 60.4%, LSD value was 2.1. Flour samples differed ($p<0.01$) from each other in terms of water absorption. M1, having the highest starch damage, had the highest water absorption and was different ($p<0.001$) from other samples. It was observed that water absorption and development time changed between 59-61% and 2-3 minutes respectively, while stability of the samples changed in a wide range. It is known that additives are included in special purpose flours in order to increase extensibility, energy and resistance. It is supposed that the variation in the stability is related with inclusion of additives in flour samples. Thus, Pomeranz (1988) and Elgun and Ertugay (2002) reported that reducing agents used in the dough formulation degraded gluten proteins by transforming disulfide groups into sulfhydryl groups and accelerated dough maturing by breaking intermolecular bonds in gluten molecule. Dough can be kneaded with a small energy input when the reducing agents are included (Hoseney, 1994).

Extensograph test results of the baklava flour samples were given in Table 5. Dough energy and resistance to extension increased, extensibility decreased during the test. Flour samples differed from each other in terms of extensograph parameters at the end of 135 minutes (energy; $p<0.001$, resistance to extension; $p<0.001$, extensibility; $p<0.01$). Extensograph parameters can give an opinion about baklava rolling characteristics. Rolling the baklava dough easy is an important quality characteristic in baklava production. Baklava dough must be durable to rolling but must not shrink back after rolling. Baklava flours with high extensibility and moderate resistance to extension are needed to meet these quality characteristics.

As a result, it was found that quality characteristics of flour samples obtained from flour factories and baklava producers changed regionally. Especially, flours obtained from Gaziantep had different physical, physicochemical and rheological properties depending on high durum wheat content. On the other hand, there was not an apparent difference between samples obtained from millers and baklava producers.

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