Akademik Ziraat Dergisi 10(1): 11-18 (2021)
ISSN: 2147-6403 e-ISSN: 2618-5881 DOI: http://dx.doi.org/10.29278/azd.749983

Research
(Araştırma)

Determination of color properties of organic and conventional hazelnut flour

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Alınış tarihi: 9 Haziran 2020, Kabul tarihi: 5 Aralık 2020
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Abstract

Objective: In this study, it was aimed to determine the differences in color characteristics of hazelnut flours obtained from organic and conventional hazelnuts, which play an important role in consumer preferences.

Materials and Methods: Six commercially important hazelnut cultivars (Çakıldak, Foşa, Mincane, Palaz, Sivri, Tombul) were selected. The samples were collected from Western (Düzce), Middle (Samsun, Ordu) and Eastern Black Sea (Trabzon) regions. The hazelnuts which were separated from their husks and dried in the sun were unshelled by hand and turned into flour. *L* (brightness), *a* (redness) and *b* (yellowness) values of the samples were determined on the HunterLab Color Flex EZ color measurement device, and then the *chroma value* (*C*), *hue angle* (*h°*), *total color difference* (*ΔE*) values were calculated. Statistical tests were performed using SAS-JAMP v10.0 software. One-way ANOVA was used to determine significant differences between levels, and LSD test was used for comparisons of multiple means.

Results: According to the study results, *L* values of organic nuts were higher than conventioanals ($P<0.05$) and no difference was found between *a, b, chroma* and *hue* values ($P>0.05$). Cultivars was found to be effective on *L* and *a* ($P<0.05$), Tombul was found to be brighter than other cultivars, Çakıldak has the highest *a* value. It has been determined that the total color difference (*ΔE*) between the production methods is perceptible

Conclusion: According to these results, organic hazelnut flours are thought will have a positive effect on consumer preferences since they have a brighter appearance.

Key words: Color, organic food, organic hazelnut, sensory evaluation

Organik ve konvansiyonel fındık unlarının renk özelliklerinin belirlenmesi

Öz

Amaç: Bu çalışmada organik ve konvansiyonel fındıklardan elde edilen fındık unlarının, tüketici tercihinde önemli rolü olan renk özellikleri açısından farklarının tespiti amaçlanmıştır.

Materyal ve Yöntem: Ticari olarak öneme sahip 6 farklı çeşit (Çakıldak, Foşa, Mincane, Palaz, Sivri, Tombul) seçilmiştir. Örnekler Batı (Düzce), Orta (Samsun, Ordu) ve Doğu Karadeniz (Trabzon) bölgelerinden toplanmıştır. Zuruflarından ayrılıp güneşte kurutulan fındıklar elle dış kabuklarından ayrılmış ve un haline getirilmiştir. Örneklerin *L* (parlaklık), *a* (kırmızılık) ve *b* (sarılık), değerleri HunterLab Color Flex EZ renk ölçüm cihazında tespit edilmiş, ardından *kroma değeri* (*C*), *hue açısı (h°)*, *toplam renk farkı (ΔE)* değerleri hesaplanmıştır. İstatistiksel testler, SAS-JAMP v10.0 yazılımı kullanılarak gerçekleştirilmiştir. Seviyeler arasındaki anlamlı farkların belirlenmesi için tek yönlü ANOVA, çoklu ortalamaların karşılaştırmaları için LSD testi kullanılmıştır.

Araştırma Bulguları: Çalışma sonuçlarına göre organik fındıkların *L* değerleri konvansiyonellerden daha yüksek çıkarken ($P<0.05$) *a, b, chroma ve hue* değerlerinde farklılık tespit edilmemiştir. Çeşit faktörünün *L* ve *a* değerleri üzerinde etkili olduğu görülürken (P<0.05), Tombul diğer çeşitlerden daha parlak bulunmuş, en yüksek a değerine Çakıldak'ın sahip olduğu tespit edilmiştir. Üretim yöntemleri arasındaki toplam renk farkının (*ΔE*) algılanabilir düzeyde olduğu tespit edilmiştir.

Sonuç: Bu sonuçlara göre daha parlak bir görünüme sahip olduğu için organik fındık unlarının tüketici tercihleri üzerinde olumlu bir etki yaratacağı düşünülmektedir.

Anahtar kelimeler: Duyusal değerlendirme, organik fındık, organik gıda, renk

Introduction

Organic food is defined as the product of a farming system which avoids the use of artificial elements such as man-made chemical fertilisers, veterinary drugs, pesticides, growth regulators, antibiotics, and genetically modified organisms. (Araujo et al., 2014). Consumer evaluation studies have shown that consumers want to buy organic foods because they think it is healthier, tastier and safer even though they are more expensive (Yadav and Pathak, 2016; Rana and Paul, 2017; Chekima et al., 2017; Hansen et al., 2018; Asif et al., 2018). In parallel with the increasing demand for organic food, organic food production has also increased in recent years (Islam et al. 2012; Krejcova et al., 2016). Today, some 80 million euros of organic food is produced by 2.7 million producers on 57.8 million ha of land (FiBL and IFOAM, 2018). As in organic foods, organic hazelnut production is in an increasing trend. With an increase close to 100%, organic hazelnut production in Turkey in the last 10 years, reaching nearly 17,500 tons in 2018 and this amount accounted for 3.5% of total hazelnut production (TOB, 2018).

Hazelnut (*Corylus avellana* L.) is the second most common nut in the world after almonds in the *Betulaceae* family (Ciemniewska-Zytkiewicz et al., 2015; Karaosmanoğlu and Üstün, 2019). The most important producing region is Turkey's Black Sea coast (40°-41° Latitudes and longitudes 37°-42°); this region realizes 79% of world hazelnut production and 70% of its exports; Turkey to Italy, Spain, Portugal, France, Azerbaijan and the US are followed (Karaosmanoğlu and Üstün. 2017; Turan, 2018). Although there are a total of 20 different varieties of hazelnut production in Turkey 7 of them (Tombul, Foşa, Mincane, Palaz, Karafındık, Sivri and Çakıldak) has commercial importance (Pelvan et al., 2012; Balık et al., 2016).

Hazelnut is very popular nut due to its unique taste and texture. Moreover, it contains many compounds that are important for human nutrition and health such as fat and monounsaturated fatty acids (mainly oleic acid), protein, carbohydrates, vitamins (mainly α-tocopherol), minerals, dietary fibers, phytosterols (mainly β-sterol) and antioxidant phenolics (Gunes et al., 2010; Ghirardello et al., 2016).

One of the most important hazelnut products is hazelnut flour. Hazelnut flour is a product obtained by grinding the natural or roasted hazelnuts in accordance with the technique. Hazelnut flour is used in the food industry for the production of pastry, bakery products, ice cream and dairy products, confectionery and chocolate products, and can also be added to breakfast cereals, bread, yogurt, soup, salad and main dishes (Karaosmanoğlu and Üstün, 2019).

For consumers, color is one of the most important quality parameters in dried foods (Özdemir and Devres, 2000; Özdemir et al., 2001). Supplying the market with the best product available is always critical (Kaya et al., 2011; Turan and Karaosmanoğlu, 2019). Therefore, knowing the color values of foods is important in terms of affecting consumer preferences. Conventional hazelnut and hazelnut flours have been studied in many studies (Özdemir et al., 2001; Özdemir et al., 2003; Şimşek 2007; Ercoşkun, 2009; Evren, 2011; Donno et al., 2013). however, no studies on organic hazelnuts have been found in the literature. In this study, it is aimed to eliminate this deficiency in the literature and to determine the effect of production method and cultivar factor on flour color. For his purpose, the color characteristics of the hazelnut flours obtained from 6 different hazelnut cultivars commercially grown with organic and conventional methods were investigated.

Materials and Methods

Sample collection

The hazelnuts produced in Trabzon, Ordu, Samsun and Düzce according to certified organic and conventional agricultural systems were purchased. Hazelnut samples were selected from commercially important cultivars in each region. The locations of organic and conventional hazelnut samples harvested shown in figure 1 Foşa, Sivri and Mincane varieties from Trabzon province; Tombul, Palaz and Çakıldak cultivars from Ordu and Samsun provinces; and Foşa, Sivri and Tombul cultivars from Düzce province. Each hazelnut varıety from each province was represented with three kg from three different producers. Thus, for each province a total of 18 samples, 9 of which organic and 9 conventional, and totally 72 different samples of which 36 organic and 36 conventional were collected. The collected samples were stored of 20-25 C° in packages made of kraft paper until they were analyzed. Before the analysis, hazelnuts were broken with nutcracker, the shells were separated by hand and turned into flour in the blender.

The harvest started when half of the hazelnuts on the branch were falled. The collected hazelnuts were brought to the blend the same day and laid on the concrete ground in 20-25 cm thickness. The hazelnuts were separated from their husks using a husker machine. Finally, it was dried on the concrete floor in the sun for 4 days.

In all orchards, tiller were cut twice a year, older branches are diluted by cutting, damaged and diseased branches were pruned. Pruning residues were collected and removed from the garden. Weed cleaning was done with a weed engine two weeks before the harvest in the gardens. Organic nut samples were obtained from certified organic orchards, in which liquid foliar fertilizer, micro nutrients (boron, zinc, iron) and solid fertilizers (compost, chicken and animal manure) were applied for fertilizing, and spinosate, *Bacillus thuringiensis*, powder and liquid sulfur were applied for controlling pests, and conventional samples were obtained from the orchards in the same region in which chemical pesticides and fertilizers were used. Except fertilization and pest control, there was no difference in cultural practices such as pruning, harvesting and storage in organic and conventional gardens.

Figure 1. The locations of organic and conventional hazelnut samples harvested.

Color measurement

According to the International Commission on Illumination (Commission Internationale de l'Eclairage CIE), color is defined by L, a, b system. According to the three-dimensional color spacing system, the L value refers to the brightness of the objects; low number (0-50) indicates dark and a high number (51-100) indicates light; a scale refers to red vs. green where a positive number indicates red and a negative number indicates green; and b scale refers to yellow vs. blue where a positive number indicates yellow and a negative number indicates blue (Ercoşkun, 2009). L (brightness), a (redness) and b (yellowness) values of hazelnut flour were determined by HunterLab Color Flex EZ color measuring device. Prior to measurement, the device was calibrated to be X: 79.05, Y: 84.02, Z: 89.03. Approximately 100 g hazelnut flour was put into the optical cylinder and then measured at different points and L, a and b values were determined. (Mexis and Kontominas, 2009). According to the Munsell color system, the chroma value (C), hue *angle* ($h°$), total color difference (ΔE) (Kalkan et al., 2016) were calculated with the following equations.

(1) $C = \sqrt{(a)^2 + (b)^2}$

(2) $h° = \arctan(b/a)$

(3) $\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$, ($\Delta L = L_{Conv} - L_{Org}$, $\Delta a = a_{Conv} - a_{Org}$, $\Delta b = b_{Conv} - b_{Org}$)

Statistical analysis

The experiments were performed in triplicates in a completely randomized block design. Descriptive statistics were obtained using the SPSS v22.0 software. Statistical tests were performed using the SAS-JAMP v10.0 software, and one-way ANOVA was conducted significat differences among level, followed by the least significance (LSD) different test was used for the multiple comparisons of means. Results were considered to be significantly different at P <0.05.

Results and Discussıon

Color is the characteristic of human visual perception composed of spectral distribution of light. One of the most important features that play a role in the choice of a food by the consumer is color. In addition, many deterioration reactions in foods are also characterized by color changes (Altuğ Onoğur and Elmacı, 2011).

L (brightness) values of hazelnuts grown by organic and conventional methods are given in Table 1. It was observed that the cultivation method affected the L value and the organic nuts (66.38) were brighter than the conventionals (65.36) (P <0.05). While the cultivar factor was found to be effective on L values, the most brighter cultivar was determined to be Tombul with 67.29, and the most darker cultivar was determined to be Çakıldak with 65.09 (P <0.05). Similar to our results, Özdemir et al. (2003) found that the L values of hazelnut flour were 67.61 in Çakıldak, 70.87 in Foşa, 68.35 in Palaz and 65.82 in Tombul. Ercoşkun (2009) reported as 60.93 and Akçin and Bostan (2019) reported as 66.89. Brightness is a visual feature that positively affects the purchasing preferences of consumers, because the color observed on the surface of the food affects the image of freshness and gives the allure (Altuğ Onoğur and Elmacı, 2011). For this reason, organic hazelnuts are expected to positively affect consumer's buying preferences.

Table 1. *L* values of organic and conventional hazelnut flour

	L		
Cultivars	Organic	Conventioanal	Cultivar means
Çakıldak	66.55±0.59	63.64±0.59	65.09±0.42 B
Foşa	66.03±0.59	65.59±0.59	65.81±0.42 B
Mincane	66.55±0.84	65.20±0.84	65.88±0.59 B
Palaz	66.38±0.59	65.39±0.59	65.88±0.42 B
Sivri	65.34±0.59	65.18±0.59	65.26±0.42 B
Tombul	67.43±0.48	67.14±0.48	67.29±0.34 A
Agricultural method mean	66.38±0.26 a	65.36±0.26 b	

Values are expressed as mean ± standart error. Tombul n=9; Çakıldak, Foşa, Sivri, Palaz n=6; Mincane n=3. Values in the column with different capital letters are significantly different (P<0.05). Values in the same row with lower-case letters are significantly different (P<0.05).

a (red-greenness) values of hazelnuts grown in organic and conventional methods are given in Table 2. When the table is examined, it is observed that the production method did not affect the *a* values of the samples (P >0.05) but the variety factor was effective (P <0.05). The highest *a* value was found as 4.22 in Çakıldak and the lowest was 3.70 in Mincane. The mean value of all organic hazelnut flour was 4.03 and the conventionals were 4.07. In parallel with our results, the *a* value of hazelnut flour obtained from conventional hazelnuts was found as 4.63 by Evren (2011); as 6.02, 4.39, 5.94 and 6.09, respectively in Çakıldak, Foşa, Palaz and Tombul by Özdemir et al. (2003) and Ercoşkun (2009) found it quite low (2.24).

Table 2. *a* values of organic and conventional hazelnut flour

	a		
Cultivars	Organic	Conventioanal	Cultivar means
Çakıldak	4.14±0.17	4.30±0.17	4.22±0.12 A
Foşa	4.07±0.17	4.09±0.17	4.08±0.12 ABC
Mincane	3.71±0.24	3.70±0.24	3.70±0.17 C
Palaz	4.22±0.17	4.17±0.17	4.19±0.12 AB
Sivri	4.18±0.17	4.23±0.17	4.21±0.12 A
Tombul	3.86±0.14	3.94±0.14	3.90±0.10 BC
Agricultural method mean	4.03±0.07	4.07±0.07	

Values are expressed as mean ± standart error. Tombul n=9; Çakıldak, Foşa, Sivri, Palaz n=6; Mincane n=3. Values in the column with different capital letters are significantly different (P<0.05). Values in the same row with lower-case letters are significantly different (P<0.05).

Table 3. *b* values of organic and conventional hazelnut flour

	b		
Cultivars	Organic	Conventioanal	Cultivar means
Çakıldak	17.30±0.51	17.43±0.51	17.37±0.36
Foşa	18.65±0.51	17.90±0.51	18.28±0.36
Mincane	17.00±0.72	16.39±0.72	16.70±0.51
Palaz	17.73±0.51	17.96±0.51	17.84±0.36
Sivri	16.84±0.51	17.97±0.51	17.40±0.36
Tombul	17.30±0.42	18.46±0.42	17.88±0.30
Agricultural method mean	17.47±0.22	17.68±0.22	

Values are expressed as mean ± standart error. Tombul n=9; Çakıldak, Foşa, Sivri, Palaz n=6; Mincane n=3. Values in the column with different capital letters are significantly different (P<0.05). Values in the same row with lower-case letters are significantly different (P<0.05)

b (yellowness-blueness) values of hazelnuts grown by organic and conventional methods are given in Table 3. According to the results of the analysis, it was determined that the production method and variety factors did not affect the *b* values of hazelnut flour (P >0.05). The mean value of all organic hazelnut flours was 17.47 and the conventional ones were 17.68. Özdemir et al. (2003) stated that the *b* values of hazelnut flour were 24.72 in Çakıldak, 24.25 in Foşa, 24.43 in Palaz and 24.62 in Tombul.

Ercoşkun (2009) reported as 25.86, and Akçin and Bostan (2019) reported as 23.25.

Chroma and *h*° values of hazelnuts grown by organic and conventional methods are given respectively in Table 4 and Table 5. It was determined that the effect of production and variety factor on *C* and *h*° values was statistically insignificant (P>0.05). In addition, our results were found to be compatible with Ercisli et al. (2011) and Çetin et al. (2020).

Table 4. *Chroma* values of organic and conventional hazelnut flour

	(C)		
Cultivars	Organic	Conventioanal	Cultivar means
Çakıldak	17.79±0.65	17.96±1.11	17.88±0.47
Foşa	19.09±0.71	18.37±0.12	18.73±0.50
Mincane	17.40±0.37	16.81±0.73	17.11±0.24
Palaz	18.23±1.47	18.43±0.72	18.33±0.11
Sivri	17.35±0.02	18.46±0.38	17.91±0.36
Tombul	17.72±0.65	18.87±0.83	18.30±0.71
Agricultural method mean	17.93±0.71	18.15±0.51	

Values are expressed as mean ± standart error. Tombul n=9; Çakıldak, Foşa, Sivri, Palaz n=6; Mincane n=3. Values in the column with different capital letters are significantly different (*P*<0.05). Values in the same row with lower-case letters are significantly different (*P*<0.05).

Color difference can be defined as the numerical comparison of a sample's color to the standard. It indicates the differences in absolute color coordinates and is referred to as Delta (*Δ*). These formulas calculate the difference between two colors to identify inconsistencies and help people to understand the color more effectively. *ΔE* value of 1 and above indicates that there is a perceptible difference between the samples (Özcan, 2008). In our study results, the *ΔE* value between organic and conventional hazelnuts was found as 1.11 (Figure 2). According to these results, although organic hazelnuts are not very obvious, it can be said that there is a color difference from conventional hazelnuts. In addition, as can be seen in Figure 2, while the most obvious difference is determined in Çakıldak cultivar (2.91), it is not detected in Foşa (0.86).

Table 5. hue angle values of organic and conventional hazelnut flour

	h°		
Cultivars	Organic	Conventioanal	Cultivar means
Çakıldak	76.54±0.48	76.14±0.94	76.34±0.54
Foşa	77.67±0.65	77.14±0.94	77.41±0.27
Mincane	77.66±1.00	77.29±0.96	77.48±0.11
Palaz	76.64±0.99	76.93±0.61	76.79±0.37
Sivri	76.12±0.26	76.61±0.34	76.37±0.05
Tombul	77.42±0.73	77.92±0.95	77.67±0.51
Agricultural method mean	77.00±0.33	77.00±0.61	

Values are expressed as mean ± standart error. Tombul n=9; Çakıldak, Foşa, Sivri, Palaz n=6; Mincane n=3. Values in the column with different capital letters are significantly different (*P*<0.05). Values in the same row with lower-case letters are significantly different (*P*<0.05).

The colors of hazelnuts can be affected by variety and measurement method, as well as fertilizers, maturity, climate and regional conditions (Şimşek, 2007). It is thought that the difference between the varieties is caused by the differences in the composition elements, particle size and formal structures (Şimşek, 2004). The factor affecting the *L* values of organic and conventional hazelnut flours is thought to be caused by the difference in fertilizer since all other conditions are the same.

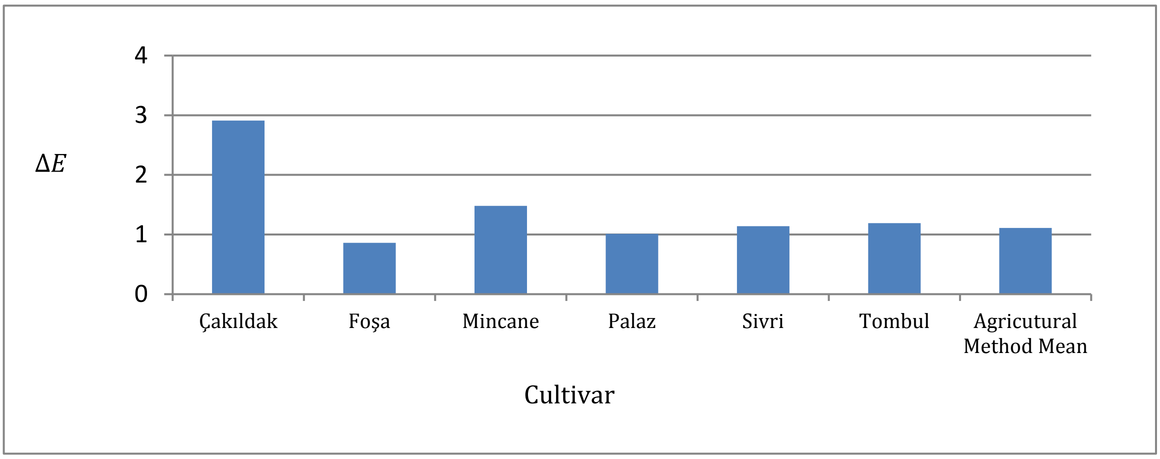

Figure 2. *ΔE* values of hazelnuts grown by organic and conventional methods

Conclusions

This study is the first study to examine the color characteristics of organic hazelnut flour. In addition, the hazelnut flours obtained from conventional hazelnuts collected from the same locations were examined and compared. According to the results of the study, it was observed that the production method affected the *L* value but did not affect the values of *a*, *b, C and h*. L values of organic hazelnuts were found to be higher than conventional ones, so organic hazelnuts were found to be more bright. It has been determined that the cultivar factor affects *L* and *a* values but it has no effect on *b, C and h* value. It was determined that Tombul was more bright than the other cultivars. Among the production methods, ΔE value was determined above the detectable value. According to these results, it is thought that organic hazelnut flours will create a positive perception on the consumer as it has a brighter appearance.

Conflicts of Interest

The authors declare no conflicts of interest.

Authorship contribution statement

HK: Planning the research, investigation, collecting and analyzing samples, writing articles. NŞÜ: Planning the research, review, editing.

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