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Araştırma Makalesi / Research Article

Effects of Temperature on Process Efficiency and Oil Color in Hazelnut Oil Extraction with Screw Machine

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Abstract

This study was carried out in order to determine the color values of the oils obtained by the oil extraction machine at different temperatures, and the press and energy efficiency of the device. For this purpose, the oils were extracted from Giresun Quality (GQ) and Levant Quality (LQ) hazelnuts by pressing at 5 different temperatures (i.e. cold pressed, 50 °C, 100 °C, 150 °C and 200 °C). The color values of the obtained oils were measured with the HunterLab Color Flex EZ colorimeter device. According to the results, while the oil amount increased with an increase in temperature up to 100 °C in GQ, the extracting time decreased. For LQ, on the other hand, while the extracting time increased with the increase in temperature, the amount of oil obtained decreased. In terms of energy efficiency, the most suitable pressing temperature was determined as 100 ºC for GQ and room temperature (20 ⁰C) for LQ. Also, a significant decrease was observed in L* (brightness), b* (yellowness) and color intensity (C*) values with increasing temperature, and a serious color difference (ΔE) emerged in relation to this decrease. In addition, no significant change was observed in a* (redness) and H° (color tone) values (p>0.05). When the change of the efficiency of Giresun quality and Levant quality hazelnuts with temperature in the oil extraction process by the helix method was examined, different results were obtained. While the efficiency increased with higher temperature in Giresun quality hazelnuts, the efficiency increasement with temperature in Levant quality was not observed.

Keywords: Color, Energy, Giresun Quality, Levant Quality, Process efficiency,

Vidalı Sistem ile Fındık Yağı Ekstraksiyonunda Sıcaklığın Proses Verimi ve Yağ Rengi Üzerine Etkisi

Öz

Bu çalışma, yağ çıkarma makinası ile farklı sıcaklıklarda elde edilen yağların renk değerlerinin belirlenmesi ve cihazın enerji verimliliğinin sıcaklıkla değişimini belirlemek amacıyla yapılmıştır. Bu amaçla Giresun Kalite (GK) ve Levant Kalite (LK) fındıklar 5 farklı sıcaklıkta (soğuk sıkım, 50 °C, 100 °C, 150 °C ve 200 °C) preslenerek yağlar elde edilmiştir. Elde edilen yağların renk değerleri HunterLab Color Flex EZ kolorimetre cihazı ile ölçülmüştür. Analiz sonuçlarına göre, GK'da 100 °C'ye kadar sıcaklık artışı ile yağ miktarı artarken, ekstraksiyon süresi azalmıştır. LK için ise sıcaklık artışı ile ekstraksiyon süresi artarken elde edilen yağ miktarı azalmıştır. Enerji verimliliği açısından en uygun presleme sıcaklığı GK için 100 ºC, LK için oda sıcaklığı (20 ºC) olarak belirlenmiştir. Öte yandan artan sıcaklıkla birlikte L* (parlaklık), b* (sarılık) ve renk yoğunluğu (C*) değerlerinde önemli bir azalma gözlenmiş ve bu azalmaya bağlı olarak ciddi bir renk farkı (ΔE) ortaya çıkmıştır. Ayrıca a* (kızarıklık) ve Hº (renk tonu) değerlerinde de önemli bir değişiklik gözlenmemiştir. Helezon yöntemiyle yağ çıkarma prosesinde Giresun kalite ve Levant kalite fındığın veriminin sıcaklıkla değişimi incelendiğinde farklı sonuçlar elde edilmiştir. Giresun kalite fındıkta artan sıcaklıkla verim artarken, Levant kalitede sıcaklıkla artan verim gözlemlenmemiştir.

Anahtar Kelimeler: Renk, Enerji, Giresun Kalite, Levant Kalite, Proses verimliliği,

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1. Introduction

Hazelnut, which has been the most important agricultural export product of Turkiye for many years, is a hard-shelled fruit in the Fagales team, Betulaceae family. The homeland of Anatolian hazelnuts is the natural spread of the most important wild and cultivated varieties (Karaosmanoğlu and Üstün, 2019). Turkiye, which is the most important producer country with an annual production of approximately 650 thousand tons (in shell), also conducts 60.8% of the world hazelnut exports with an export amount of 157 thousand tons (TOB, 2020). The annual revenue of 2.5 billion dollars from exports brings hazelnuts to the 19th rank among all export products of our country (TİM, 2022).

In addition to its economic importance, hazelnut is an important food for human nutrition with its macro and micro nutrients. The ratio of oil, which is the main component in the chemical composition of hazelnut, varies between 46.04% and 72.50% according to the varieties (Ferrao et al., 2021). Hazelnut oil has a unique profile with its high tocopherol (mainly α-tocopherol), monounsaturated fatty acids (oleic acid), polyunsaturated fatty acids, and phytosterols (β-sitosterol) (Karaosmanoğlu, 2022a). Due to its advantageous composition of hazelnut oil, it has been reported to obtain features as preventing cardiovascular diseases, being anticancer, and including immune system supporting properties (Ferrao et al., 2021). For this reason, in order to reduce the risk of cardiovascular diseases, the Food and Drug Administration (FDA) stated that it would be beneficial to consume 42.5 g of nuts, including hazelnuts, daily (Krol et al., 2021).

Color in foodstuffs is one of the most important quality parameters for consumers and it directly affects consumer preference (Guine et al., 2001; Karaosmanoğlu, 2022b). Changes in the chemical structure of foods as a result of heat treatments such as roasting, heating, boiling and during storage are accompanied by variations in their colors. For this reason, many researchers have examined the color change of hazelnut oil under different extraction, refining and storage conditions (Shi et al., 2021). For example, Karabulut et al. (2005) reported that the L* (brightness) value of crude oil increased compared to refined oil, while the values of a* (redness) and b* (yellowness) decreased.

Extraction in the hazelnut oil industry consists of physical (press) and chemical extraction processes. It is known that the temperature factor in hydraulic pressing, which is widely used in oil extraction, greatly affects the pressing time. On the other hand, temperature and preheating time significantly affect oil yield. It has been revealed that the two-factor interaction between pressure and pressing time significantly affects the oil yield, while the other interaction factors do not have a significant effect on the oil yield (Santoso et al., 2013).

Press-based physical extraction systems used today consume a lot of energy, take up a lot of space and can be installed at high costs. For these reasons, especially small and medium-sized oil production facilities cannot become widespread. For the solution of this problem, the design of a high-efficiency, low-energy and space-saving crude oil production machine is of great importance. In this study, the effect of temperature increase on energy and process efficiency and color values of oil in different hazelnut species in the process of obtaining oil from hazelnut by screwing method was investigated.

2. Material and Method

The samples used in the study were selected from Giresun Quality (first quality) Tombul and Levant Quality Çakıldak hazelnuts. The samples were hand-picked from the ground in mid-August from the gardens of three villages, Akköy, Altınca and Seyitköy, in the Batlama valley of Giresun Province. After harvest, the samples were removed from their green husks and sun-dried in the concrete threshing floor at ambient conditions. Dried hazelnuts were kept in plastic packaging at -18°C until the day of analysis. The hard shells were manually broken and separated before extracting the oil from the samples by pressing. In order to determine the efficiency of the press system, the total oil amount of the samples was determined by chemical extraction method.

2.1. Experimental Setup

A spiral made of stainless steel was produced to do the work. The outer bucket, in which the helix operates, is surrounded by an electrical heater and continuous temperature control has been made. The rotation of the spiral and the product feed rate were kept constant throughout the study. The schematic picture of the machine used in the study, which is our own manufacture, is shown in Figure 1.Natural hazelnut kernels were weighed on precision balance in the form of samples of 100 grams each. The samples of 100 grams were filled into the feeding chamber at the beginning of the study. After the spiral sleeve is heated up to the temperature at which the operation will be performed, the screw motor is activated and the extracting process is started. When the hazelnuts were finished in the chamber and the oil flow process was completed in the oil pouring part, the chronometer was stopped and the pressing time was calculated. Extraction process was carried out from natural hazelnut kernels at ambient temperature (cold pressed), 50, 100, 150 and 200°C. In the study, the ambient temperature was measured as 25.6 and 25.8 ^{0}C.

Before the analysis, nut sizes, weights and shell thicknesses of the samples were measured according to the methods mentioned in Karaosmanoğlu (2022c) (Table 1).

Table 1. Nut and kernel dimensions, weights and shell thicknesses of hazelnut samples

Cultivar	Nut lenght (mm)	Nut width (mm)	Nut depth (mm)	Kernel lenght (mm)	Kernel width (mm)	Kernel depth (mm)	Nut weight (g)	Kernel weight (g)	Shell thickness (mm)
Çakıldak	19.06	15.36	16.46	14.01	11.12	12.37	1.57	0.87	0.91
Tombul	18.56	15.02	16.58	14.32	11.79	12.73	1.70	1.03	0.95

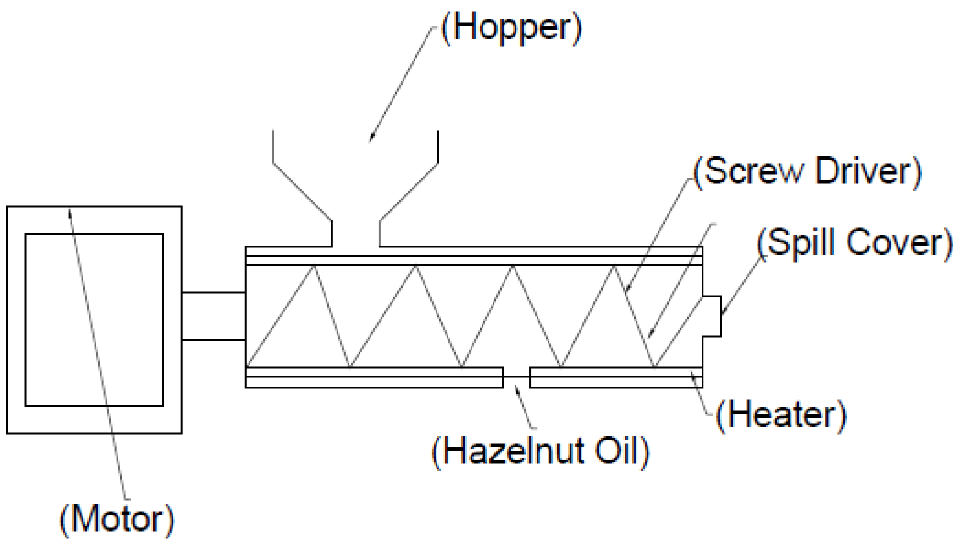

Figure 1. Hazelnut oil extracting machine

2.2. Process Efficiency

GQ and LQ samples were weighed with precision balance and 100 gr samples were prepared. The samples were pressed at temperatures of 25-50-100-150-200 ºC, respectively. The time elapsed during pressing was calculated by keeping a chronometer. The filtrate obtained at the end of the extraction process was filtered and the amount of oil was found by weighing it with a precision balance.

2.3. Color analysis

L, a and b values of hazelnut oils were determined by HunterLab Color Flex EZ colorimeter device. Before the analysis, the device was calibrated as X:79.05, Y:84.02, Z:89.03. 50 mL of oil was poured into the optical cylinder and L, a and b values were read by reading from different points (Karaosmanoğlu and Üstün, 2021). In addition, the color scale was created by entering the obtained color values into the Lab color system in Adobe photoshop-CS6 program (Karaosmanoğlu, 2022c).

According to Munsell color system, chroma (C*), which is a measure of color intensity or saturation and describes chromaticity ranging from 0 (fully unsaturated) to 100 (pure color), and hue (H°) value, which reflects the hue of the color and expressed in degrees on a 360° scale (Patras, 2019), were determined by the formulas below. Finally, by calculating the ΔE values of the samples, it was tried to reveal the color difference of the samples exposed to heat from cold pressing.

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

$$h° = \arctan\,(b/a) \quad (2)$$

$$\Delta E = \sqrt{(L\ cold\ press - L\ process)^2 + (a\ cold\ press - a\ process)^2 + (b\ cold\ press - b\ process)^2} \quad (3)$$

2.4. Statistical Analysis

Statistical analysis was performed by using JMP version 16 (Buckinghamshire, England) statistical software and was carried out in three repetitions. One-way ANOVA followed by Tukey post-hoc test was used to compare the means of study groups, and results were expressed as mean ± standard deviation (n=3).

3. Findings and Discussion

3.1. Oil Extraction Durations

The variations in extraction durations in relevance with temperature change for packs 100 g of GQ was presented in figure 2 while the same was presented for LQ in figure 3. In both sample groups, it was observed that the oil was extracted in a shorter time at room temperature than after being heated. After processing GQ at 50ºC extraction temperature, the time taken for extraction decreases with the increasing temperature. LQ, on the other hand, has an extraction time that increases at the same rate with temperature. It can be said that the increase in the oil extraction duration with temperature is related to the decrease in the compression effect of the screw driver as a result of the oil thinning with temperature.

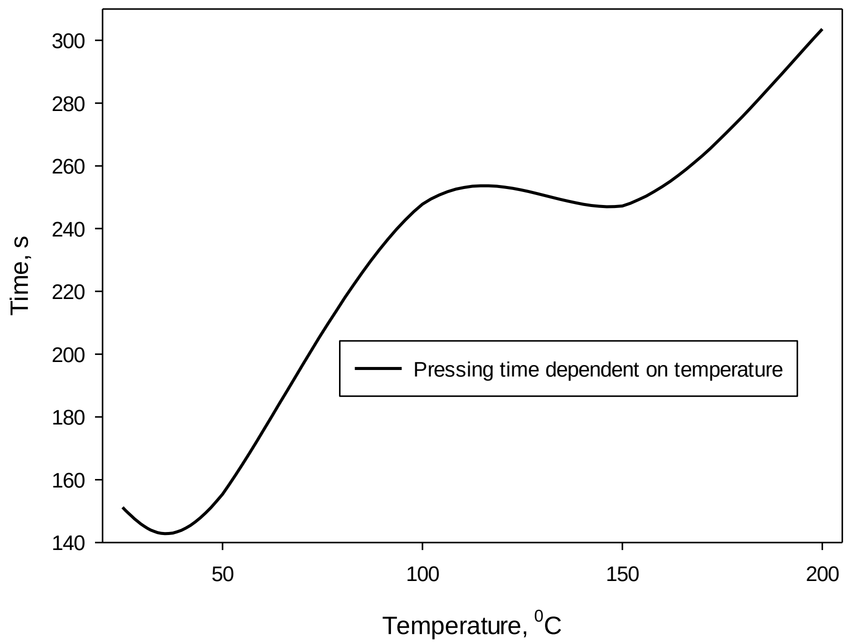

Figure 2. Variation of the extraction time depending on the temperature of Giresun Quality hazelnuts

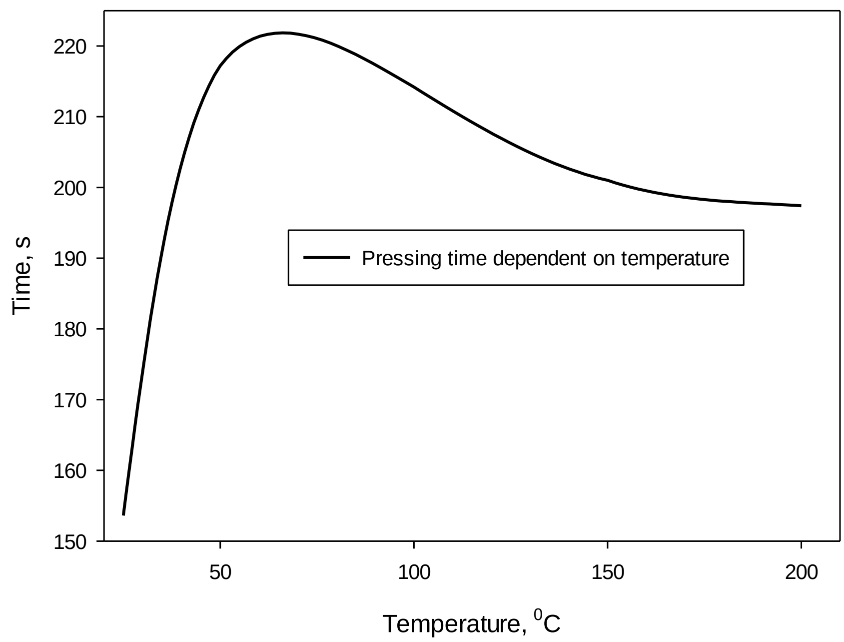

Figure 3. Variation of the extraction time depending on the temperature of Levant Quality hazelnuts

3.2 Variation of Oil Yield with Temperature

Figure 4, for GQ, and figure 5, for LQ summarize the variation of the amount of oil extracted from hazelnuts considering the change in temperature. While the process efficiency increases with temperature up to 100°C in GQ, it decreases after 100°C. Interestingly, it was observed that the amount of oil released in LQ decreased with temperature. It can be said that as a result of the decrease in viscosity with the increase of oil temperature in LQ, the oil passes to the pulp side with the screw driver movement.

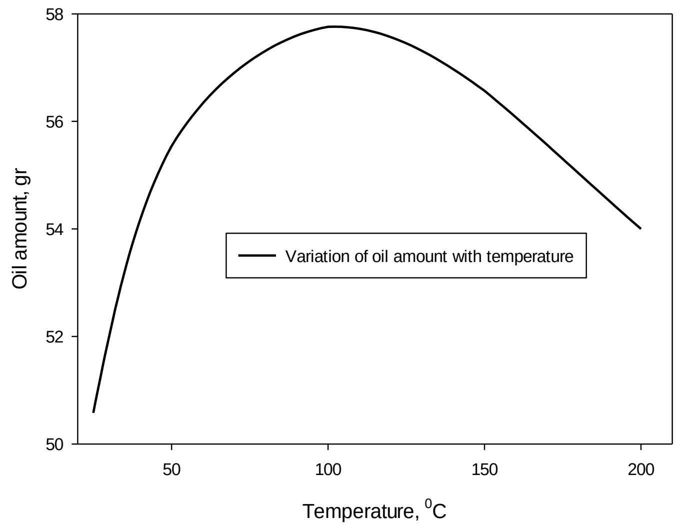

Figure 4. Change of oil content of Giresun quality hazelnuts depending on temperature

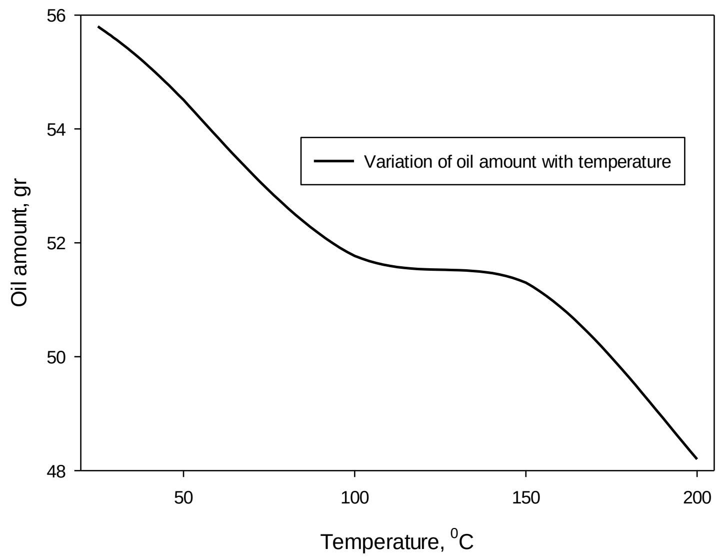

Figure 5. Change of oil content of Levant quality hazelnuts depending on temperature

In general, it was observed that Giresun and Levant quality samples exhibited different behavior with different pressing temperatures, oil yields and extraction times. It is interesting that there is a great difference in the extraction times and the extraction efficiency after 50 °C. It is known that there are differences between the physical properties and chemical compositions of Giresun and Levant quality hazelnuts, and the variety factor affects these parameters (Karaosmanoğlu, 2022a; Karaosmanoğlu and Üstün 2019; Çetin et al., 2020). It can be thought that the difference in extraction yield and time may be due to the differences in the chemical compositions of the oils of the samples, the differences in their physical properties or other factors.

3.3. Color values of hazelnut oils obtained by pressing at different temperatures and durations

Color is the most important quality parameter that affects consumers' food purchasing preferences (Karaosmanoğlu, 2022b). For this reason, color values need to be expressed mathematically in order to be able to be accurately and repeatedly measured and explained both in the processing of products and in the development of new products (Çelik and Çakmakçı, 2020). For this reason, HunterLab system, in which the color of the objects is measured spectrophotometrically to find the L (brightness), a (redness-greenness) and b (yellow-blueness) values and the Munsell, where color intensity (chroma-C) and hue (hue-h) are determined, have found wide use in food technology.

The L, a, b, C and h values of Giresun and Levant quality hazelnuts, obtained by pressing method at different temperatures, are presented in table 2. While the L value in GQ hazelnut oil was measured as 32.22 in cold pressed, it showed a continuous decrease with the increase in temperature and decreased to 25.05 in 200°C application ($P<0.05$). Similarly, in LQ hazelnut oils, the highest L value was detected in cold pressed (32.11), while it decreased to 150°C but then increased. No difference was observed between GQ and LQ samples except 150°C ($P>0.05$). Similar to our results, Kesen et al. (2016) reported the L value of raw hazelnut oil as 29.13. However, Shi et al. (2021) found a higher value (75.97). Factors such as pre- and post-harvest applications, storage conditions and variety can affect the color values of oils (Özyurt et al., 2020). The difference with the literature may be due to the listed factors.

Table 2. Color values of hazelnut oils pressed at different temperatures

parameters	process condition		process condition	
L	GQ-cold press	32,22$^{\pm 0,12}$ Aa	LQ-cold press	32,11$^{\pm 0,09}$ Aa
	GQ-50 °C	31,25$^{\pm 0,13}$ Ba	LQ-50 °C	30,70$^{\pm 0,27}$ Ba
	GQ-100 °C	29,64$^{\pm 0,05}$ Ca	LQ-100 °C	28,73$^{\pm 0,12}$ Ca
	GQ-150 °C	26,04$^{\pm 0,32}$ Da	LQ-150 °C	23,24$^{\pm 0,10}$ Eb
	GQ-200 °C	25,05$^{\pm 0,16}$ Ea	LQ-200 °C	24,91$^{\pm 0,29}$ Da
a	GQ-cold press	0,51$^{\pm 0,03}$ Aa	LQ-cold press	-0,19$^{\pm 0,07}$ CDb
	GQ-50 °C	-0,07$^{\pm 0,01}$ Ba	LQ-50 °C	-0,17$^{\pm 0,10}$ CDa
	GQ-100 °C	-0,45$^{\pm 0,04}$ Cb	LQ-100 °C	0,25$^{\pm 0,09}$ ABa
	GQ-150 °C	0,55$^{\pm 0,04}$ Aa	LQ-150 °C	0,13$^{\pm 0,03}$ Bb
	GQ-200 °C	-0,39$^{\pm 0,05}$ Ca	LQ-200 °C	-0,37$^{\pm 0,05}$ Da
b	GQ-cold press	10,71$^{\pm 0,09}$ Aa	LQ-cold press	10,52$^{\pm 0,03}$ Aa
	GQ-50 °C	8,98$^{\pm 0,02}$ Bb	LQ-50 °C	9,37$^{\pm 0,03}$ Ba
	GQ-100 °C	8,23$^{\pm 0,05}$ Ca	LQ-100 °C	8,42$^{\pm 0,08}$ Ca
	GQ-150 °C	6,32$^{\pm 0,09}$ Da	LQ-150 °C	4,48$^{\pm 0,07}$ Db
	GQ-200 °C	5,28$^{\pm 0,12}$ Ea	LQ-200 °C	4,83$^{\pm 0,02}$ Eb
C	GQ-cold press	10,72$^{\pm 0,09}$ Aa	LQ-cold press	10,52$^{\pm 0,03}$ Aa
	GQ-50 °C	8,98$^{\pm 0,02}$ Bb	LQ-50 °C	9,37$^{\pm 0,03}$ Ba
	GQ-100 °C	8,24$^{\pm 0,05}$ Ca	LQ-100 °C	8,42$^{\pm 0,09}$ Ca
	GQ-150 °C	6,34$^{\pm 0,09}$ Da	LQ-150 °C	4,48$^{\pm 0,07}$ Eb
	GQ-200 °C	5,30$^{\pm 0,12}$ Ea	LQ-200 °C	4,84$^{\pm 0,02}$ Db
h	GQ-cold press	87,27$^{\pm 0,16}$ BCa	LQ-cold press	91,03$^{\pm 0,37}$ ABa
	GQ-50 °C	90,43$^{\pm 0,09}$ ABa	LQ-50 °C	91,04$^{\pm 0,65}$ ABa
	GQ-100 °C	93,16$^{\pm 0,24}$ Aa	LQ-100 °C	86,32$^{\pm 2,55}$ Cb
	GQ-150 °C	85,04$^{\pm 0,34}$ Ca	LQ-150 °C	88,38$^{\pm 0,42}$ BCa
	GQ-200 °C	94,16$^{\pm 0,44}$ Aa	LQ-200 °C	94,30$^{\pm 0,55}$ Aa

In the same parameter, different capital letters (A-E) in the same column and different lowercase letters (a-b) in the same row indicate the statistical difference between the means (P<0.05). GQ: Giresun quality, LQ: Levant quality

Although the a values of the samples in both quality groups decreased with increasing temperature, it was observed that this change was not regular. The highest *a* value in GQ was found at cold pressed (0.51) and the lowest at 100 °C (-0.45). In LQ, on the contrary, the highest value was determined at 100 °C and the lowest value at 200 °C. However, it can be said that temperature applications are not very effective since *a* values vary in the narrow range between 0.5 and -0.5. Although statistical differences were observed between GQ and LQ samples, there was no consistent variation. Karabulut et al. (2005) reported the *a* values of hazelnut oils in the range of 2.01, Yılmaz and Öğütçü (2014) -2.06 to -2.90, which is consistent with our results.

While the highest yellowness (b) values in both GQ and LQ were detected in cold pressed (10.71-10.52, respectively), a continuous decrease was observed with increasing temperature and the lowest values were at 200°C (5.28- 4.83, respectively). With increasing temperature application, the decrease in b value exceeded 50%. In oil refining, it is known that the deodorization stage, which involves high temperature application, lightens the oil color (Karabulut et al., 2005; Özyurt et al., 2020). Kesen et al. (2016) reported a significant decrease in the b value of refined hazelnut oil compared to raw hazelnut oil. Accordingly, it can be said that the decrease in b value is related to the application of increasing temperature. Although there is no difference between GQ and LQ in cold pressed, the b value of GQ at the highest temperature was higher than LQ. Ozyurt et al. (2020) determined the yellowness value of hazelnut skin oils to be 14.17, while Erdoğan (2020) determined it to be in the range of 17.55-15.23. The color intensity (C) of the samples showed great parallelism with the b value and decreased continuously with increasing temperature application, except for one application (LQ-150°C). There was generally no significant relationship between the h values of hazelnut oils and the applied temperature.

There was a continuous increase in GQ in the ΔE values calculated to determine the color change caused by the applied temperature compared to cold pressing, that is, the color changed regularly with increasing temperature. This change is clearly understood from Figure 6. The change in LQ was similar to GQ except for the last application. The actual color difference can be understood in the color scale created, although it is not very clear (Table 3). According to our results, while no significant difference was observed between GQ and LQ, a significant color difference (ΔE) was observed due to the decrease in L and b values with increasing temperature.

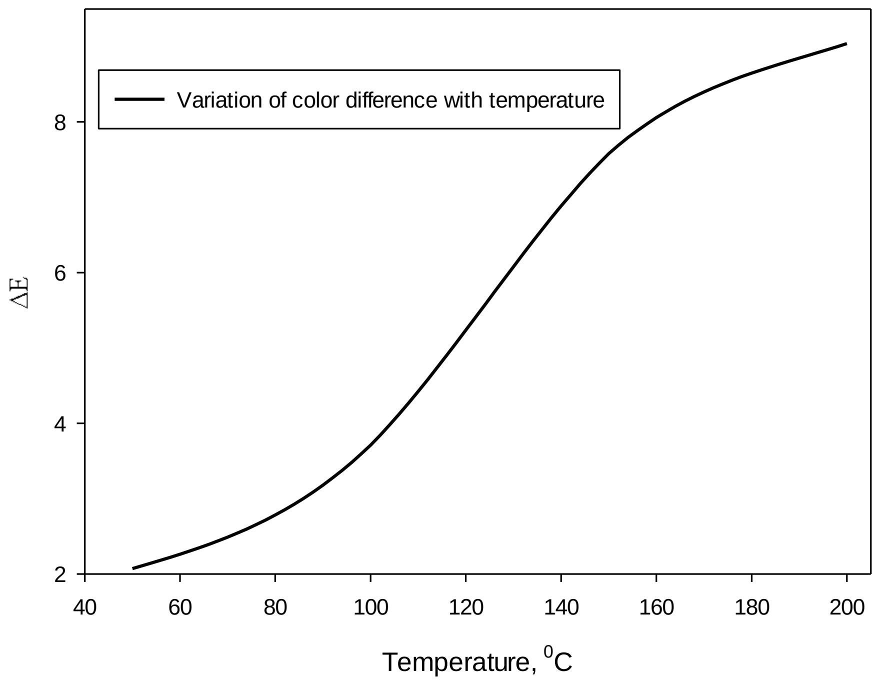

Figure 6. Change of color difference of Giresun quality hazelnut with temperature

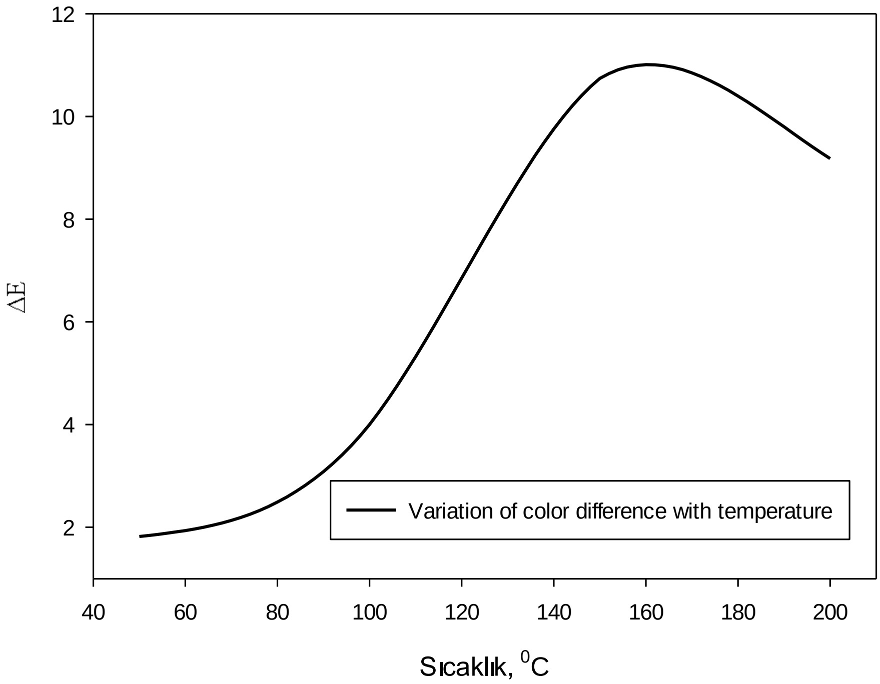

Figure 7. Change of color difference of Levant quality hazelnut with temperature

Table 3. Color scale of hazelnut oils pressed at different temperatures. (GQ: Giresun Quality, LQ: Levant Quality)

GK-cold press					LQ- cold press
GQ-50°C					LQ-50°C
GQ-100°C					LQ-100°C
GQ-150°C					LQ-150°C
GQ-200°C					LQ-200°C

4. Conclusions

In this study, the color values, press performance and energy efficiency of the oils obtained from the oil extraction machine, which performs oil extraction by pressing at different temperatures, were investigated. According to the results of the study, it was observed that the application temperatures had an effect on both the press efficiency and the color properties of the oil obtained. In terms of oil yield and energy consumption, 100^{o}C temperature is the most appropriate value for Giresun Quality; however, for Levant Quality, this value was room temperature. On the other hand, with the increase of the applied temperature for extraction, there was a significant decrease in the L, b and C values, while no consistent change was observed in the a and h values. Depending on the L and b values, there was a color difference (ΔE) between all temperature application.

Authors' Contributions

All authors contributed equally to the study.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The author declares that this study complies with Research and Publication Ethics.

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