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Research Article

Hozat Apricot Kernel: Pomological and Physicochemical Properties with Comparation of Apricot Kernel Varieties Harvested in Turkey

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Abstract

Apricot is a fruit demanded and consumed in a variety of ways by consumers. Apricot fruit has a kernel inside of it. Due to limited knowledge of bioactive compounds, apricot kernels were predicted as a food waste in the past, and they had no economic value. Awareness as to nutrition and bioactive compounds increased recently, the idea has emerged that apricot kernel is as healthy as its fruit, therefore science research has focused on examining bioactive properties of fruit kernels.

In this study, sweet and bitter apricot kernel varieties harvested in 2022 were used. The sweet apricot kernel varieties used in this study were Hasanbey (Malatya), Savak (Igdir), Alyanak (Isparta) and Hozat sweet; the bitter apricot kernel varieties were Hozat bitter and Zerdali (Malatya). Pomological and physicochemical properties of Hozat apricot kernels, compared with other apricot kernels harvested in Turkiye, were performed. As pomological properties, weight of seed, weight of kernel and seed-to-kernel weight ratio were investigated. Moisture content, ash content, acidity (pH), protein content, oil content and total phenolic content of apricot kernels were also determined. The effect of the variety variable on pomological and physicochemical properties of the apricot kernel were evaluated using the SPSS 29 program.

Overall, it was found that the variety variable had a significant effect on pomological and physicochemical properties of apricot kernels. It means each apricot kernel variety has its unique pomological and physicochemical properties.

Keywords: Tunceli, Apricot, Kernel, Statistics, Hozat.

Hozat Kayısı Çekirdeği: Pomolojik ve Fizikokimyasal Özelliklerinin Turkiye'de Yetiştirilen Kayısı Çekirdek Çeşitleriyle Karşılaştırılması

Öz

Kayısı yaygın olarak tüketilen ve talep edilen bir meyve ürünüdür. Kayısı çekirdeği meyvenin içinde bulunmaktadır. Geçmişte kayısı çekirdeği hiçbir ekonomik değeri olmayan, gıda atık maddesi olarak görülen bir ürün olmsına karşın gıda maddelerinin içinde bulunan bioaktve içerikle alakalı bilgi birikimi arttıkça gıda atık maddelerinde bulunun bu maddeler önem kazanmaya başlamıştır. Bu da kayısı çekirdeğinde bulunan besin içeriğin araştırılaması gerekliliğini doğurmuştur.

Bu çalışmada 2022 yılında yetiştirilen acı ve tatlı kayısı çekirdekleri kullanılmıştır. Kullanılan tatlı kayısı çekirdek çeşitleri Hasanbey, Savak, Alyanak ve Hozat tatlı olup acı kayısı çeşidi olarak Zerdali ve Hozat acı kullanılmıştır. Pomolojik analiz olarak çekirdek ağırlığı, kabuklu çekirdek ağırlığı ve iç çekirdeğin toplam çekirdeğe oranı olarak gerçekleştirilmiştir. Fizikokimyasal özellik olarak nem, kül, asit (pH), protein, yağ ve toplam fenolik içerik analizleri yapılmıştır. Çeşidin bu özelliklere olan etkisini belirlemede SPSS 29 uygulaması kullanılmıştır.

Genel olarak, kayısı çekirdek çeşidinin çekirdeğin pomolojik ve fizikokimyasal özelliklerini öenmli düzeyde etkilediği belirlenmiştir. Bu da her bir kayısı çekirdek çeşidinin kendine özgü özelliklere sahip olduğunu göstermektedir.

Anahtar Kelimeler: Tunceli, Kayısı, Çekirdek, İstatistik, Hozat

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1. Introduction

The apricot, *Prunus armeniaca* L.is a member of the Rosaceae. It is an edible plant and native to parts of Asia due to that it could be grown in climates where winters are cold and summer are warm. The global apricot production continuously rises as the demand for plant sources has been increasing. Apricot is consumed on daily basis in Middle Eastern countries, with Turkey being the world's largest producer of the fruit. Malatya province is the largest producer of the fruit in Turkiye every year **[67].** Apricot varieties harvested in Malatya and by-products of the fruit were well studied to understand its properties. Because some of apricot varieties are commercially grown in only one region of country; vast majority of the varieties are not known outside of the region. Although Hozat apricot is widely cultivated every year, there is no study investigating properties of Hozat apricot and its kernel in literature.

Apricots are well known for their characteristic yellowish-orange flesh color, taste and woody stone containing the kernel. Apricots contain various bioactive compounds, vitamins (A, C and E) and minerals **[7].** Therefore, consuming the fruit has a positive effect on human health. Even though the fruit is certainly the most important and value-added part of the plant, the kernel, one of the by-products, has growing interest as awareness of healthy diet increases [29].

Apricot kernel is an organic product that was occasionally considered an unwanted part of the fruit in the past and was evaluated as an industrial waste. To protect climate and nature, various studies were performed to use the kernel in industry [10]**.** Moreover, the waste valorisation of kernels from apricot could achieve greater economic benefits and reduce waste disposal problems as it can be converted into value-added products. The studies found that the kernel can be utilized for thermal energy source [60]**,** medicine [44]**,** cosmetic products [41]**,** pharmaceutical products [20] and fabrication of antimicrobial film [70]**.** The kernel is also considered a promising ingredient in food industry due to its distinctive properties.

The first objective of this study gets a comprehensive information on Hozat apricot kernel varieties with identifying pomological and physicochemical properties. The investigated pomological characteristics were seed weight, kernel weight and seed-to-kernel weight. For physicochemical properties, the analyses identifying moisture content, ash content, acidity (pH), oil content, protein content and total phenolic content of the kernel were performed. The second objective is comparation of properties of Hozat apricot kernel varieties with some other apricot kernels harvested in Turkiye. The used apricot varieties were Isparta Alyanak (sweet), Igdir Salak (sweet), Malatya Hasanbey (sweet) and Malatya Zerdali (bitter).

2. Material and Method

2.1. Sample Preparation Process

Samples were obtained from local market in Isparta, Malatya, Igdir and Tunceli in 2022. In order for the samples to fully represent apricot kernel mass, each apricot kernel was collected from at least 4 sellers. After the samples were taken, all of them were brought to Munzur University Food Engineering laboratory and they kept in dark at 20^0C until the analysis start off.

Each apricot kernel variety was separately mixed and 10 of them were randomly selected to determine the pomological characteristics of apricot kernel varieties. For physicochemical analyses, the outer shell of the apricot was broken, and inner kernel part was taken away. For each apricot variety, at least 250 g of each apricot kernel was weighed then the weighed kernels were pulverized and mixed. Mixed apricot kernel powder was used in the analyses.

2.2. Method

2.2.1. *Determination of pomological characteristics*

Pomological characterization was performed on 10 apricot kernels randomly selected from the mass. The weight of kernel with its shell (seed weight, g), the weight of inner kernel (kernel weight, g) and seed-to-kernel weight ratio (%) were investigated [66].

2.2.2. *Moisture content*

10 g sample was dried in an oven at 105^0C until it reached constant weight, then cooled in a desiccator [11].

2.2.3. *Ash content*

Determination of ash content was performed using the AOAC[1] method [3]. 3 g of sample was weighed into the crucibles, after waiting for 1 hour in the oven, the burning process was carried out at 600^0C in the muffle furnace until the inside of the crucible turned white. The crucibles were cooled in desiccator, then weighed.

2.2.4. *Acidity (pH)*

The method used in the study of Kalkan et. al. (2012) adapted for this study [36]. 5 g sample was mixed with 50 mL distilled water for 2 hours using a magnetic stirrer, then the mixture was filtered, and 20 mL was taken from the filtrate. Acidity was determined in a calibrated digital pH meter.

2.2.5. *Oil content*

The oil content in Tunceli apricot kernel varieties were determined by using the Soxhlet method which is explained in the study of Dogan and Basaoglu (1985) [17]. 10 g of powdered apricot kernel was weighed into Soxhlet cartridge. N-hexane was used for the extraction process. The extraction process was decided to be 5 hours [6].

2.2.6. *Protein content*

Protein content was determined by Kjeldahl method [4]. 1 g of powdered apricot kernel was weighed, and 25 mL sulfuric acid and catalyst tablet were added to it. The burning process was continued until green colour was formed. After the tubes cooled, the distillation process was started. Titration was performed using 0.1 N HCI, crude protein content of apricot kernel varieties was determined according to the following formula.

$$\% \text{ Protein Content} = \frac{[(V_1 - V_0)\text{x N x F x } 14 \text{ x } 10^{-3}]\text{x } 100}{M}$$

V_1 = Volume of spent HCI acid solution (mL)

V_0 = Volume of HCI acid solution spent in the witness experiment (mL)

N = Concentration of adjusted hydrochloric acid solution (0.1)

M = Weight of sample taken (gr)

F = Nitrogen to protein conversion factor (6.25)

2.2.7. *Total phenolic content (TPC)*

The total phenolic content (TPC) was determined using Folin- Ciocalteu reagent (FRC) according to Slinkard and Singleton (1977) [58]. For the analyze, 1 mL sample, which was diluted at a suitable rate with solvent, was mixed with 5 mL of FRC solution (0.2 N), then the mix was vortexed and was kept at dark for 5 minutes. Then, 8 mL of sodium carbonate solution (%7.5) was added and incubated in the dark area at room temperature for 2 hours. Thereafter, the absorbance values of the samples were measured at a wavelength of 765 nm by UV-Vis spectroscopy (Shimadzu UV-1800). The result was expressed as mg Gallic acid equivalent (GAE)/ 100 g dry weight. The standard curve of gallic acid was conducted with different concentrations range (10, 50, 100 and 200 mg/L) and with good linearity (r^2>0.99). For each sample, the Folin-Ciocalteu assay was performed in triplicate.

2.2.8. *Statistical analysis*

All the analyses of apricot kernel varieties were done in three parallels according to a randomized block design [6]. SPSS 29 program was used to evaluate results of each analysis. Kolmogorov- Smirnov test was utilized to determine whether results for each analysis show homogeneous distribution. It was found that each analysis data set showed a homogeneous distribution, hence parametric statistical methods were decided to be used for the evaluation. In variance analysis, one-way ANOVA and Duncan multiple comparison test (0.05%) were used for significance levels. Pearson test was used for correlation statistics.

3. Results and Discussion

Evaluation of pomological characteristics of apricot kernel varieties was demonstrated at table 4.1. It was found that seed weight was 1.44- 4.76g, kernel weight was 0.38- 1.13g and seed-to-kernel weight ratio was between 16.36- 31.56%. In previous studies investigating the pomological properties of apricot kernel, it was stated that seed weight ranged from 1 to 5 g [7, 14, 18, 21, 31, 33, 38, 47, 48, 50, 52], kernel weight changed between 0.29 g and 0.65 g [8, 25, 52, 65] and seed-to-kernel weight ratio was in between 18.8- 38.0% [8, 25, 45, 51, 52, 62]. The seed-to-kernel weight ratio, kernel weight and seed weight of apricot kernel varieties changed significantly dependent on variety of apricot kernel, p<0.001.

Table 4.1. Pomological characteristics of apricot kernel varieties.

	Seed Weight (g)	Kernel Weight (g)	Seed-to-Kernel Weight Ratio (%)
Isparta Alyanak	4.76 ± 0.82d	1.13 ± 0.32b	23.42 ± 3.26b
Iğdır Salak	2.32 ± 0.26c	0.38 ± 0.08a	16.36 ± 2.12a
Hasanbey	2.27 ± 0.20c	0.53 ± 0.03a	23.58 ± 1.36b
Hozat Sweet	1.72 ± 0.19a, b	0.53 ± 0.05a	31.09 ± 3.18c
Hozat Bitter	1.44 ± 0.12a	0.45 ± 0.04a	31.56 ± 4.61c
Zerdali	2.11 ± 0.25b, c	0.48 ± 0.05a	22.83 ± 2.53b

Even though weight of seed and kernel were significantly higher in Isparta apricot kernel than any other varieties used in this study. the seed-to-kernel weight ratio was the highest in Hozat varieties with no significant difference between them. No statistical difference for kernel weight was found between sweet and bitter apricot kernels, p=0.072. However, seed weight of sweet and bitter apricot kernels showed statistically difference, p<0.05. This finding was also demonstrated in the study of Rampackova et. al. (2021) [51], which evaluated 32 different apricot kernel varieties. In addition, Igdir statistically had the lowest seed-to-kernel weight ratio with 16.36%. It is compatibility with the result of Ozyoruk and Guleryuz (1992) [48], which observed that Igdir apricot kernel had 2.4 g seed weight with 11- 18.2% seed-to-kernel ratio.

Possible correlations among the weight of seed, the weight of kernel and seed-to-kernel weight ratio were examined. It was found that there wasn't any correlation between apricot seed weight and seed-to-kernel weight ratio (r= -0.297), and between apricot kernel weight and seed-to-kernel weight ratio (r= 0.110). However, for walnut kernels harvested in Suceava, Romania [43], and in Ovacık, Hozat and Nazimiye, Tunceli [5], a strong positive correlation between kernel weight and seed-to-kernel weight ratio was demonstrated. This can be interpreted that correlation between the weight of seed or kernel and seed-to-kernel weight ratio could be related to type of fruit. Moreover, it was found that there was a strong corelation between apricot seed weight and apricot kernel weight (r= 0.906).

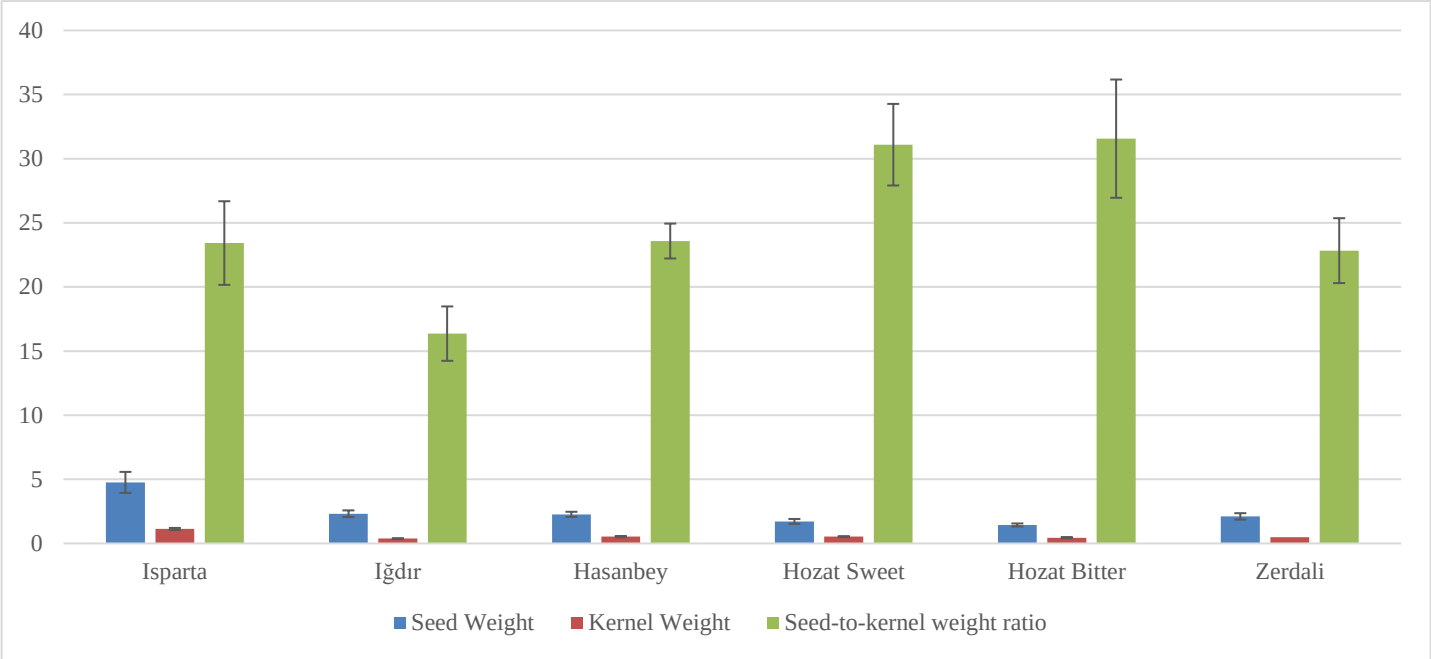

Figure 1. Pomological characteristics of apricot kernel varieties.

Physicochemical properties of apricot kernel varieties were demonstrated at table 4.2. The analyses were performed to determine moisture content, ash content, acidity (pH), oil content and protein content of various apricot kernel varieties. It was found that physicochemical properties of apricot kernel varieties used in this study significantly changed according to the variety, $p<0.001$.

Moisture ratios of apricot kernel varieties used in this study were determined in the range of 2.92- 28.37% with Isparta apricot kernel statistically having the highest moisture content. Previous studies demonstrated that moisture content of apricot kernel varieties was in the range of 2 - 5% [32, 35, 55, 63]. However, Bayer and Melton (1990) [8] and Shariatifar et. al. (2017) [56] found that the apricot kernel harvested in New Zeland has 27.4-38.8% moisture content. Moisture contents of apricot kernels used in this study are in according with literature. Moreover, it was found that the moisture content of apricot kernel changed significantly regarding apricot kernel variety, but moisture contents of Hozat sweet and bitter apricot kernel had no significant difference.

Table 4.2. Physicochemical properties of various apricot kernel varieties.

	Moisture Content	Ash Content	Acidity (pH)	Oil Content	Protein Content
Isparta	28.37 ± 1.76b	1.85 ± 0.21a	6.69 ± 0.01b	45.94 ± 1.38a	18.90 ± 0.26a
Iğdır	3.76 ± 0.48a	3.42 ± 0.17d	6.63 ± 0.05b	45.83 ± 1.30a	26.01 ± 0.13d
Hasanbey	4.20 ± 0.16a	2.42 ± 0.24b, c	6.49 ± 0.04a	43.20 ± 0.80a	24.47 ± 0.31b
Hozat Sweet	2.92 ± 0.07a	2.15 ± 0.12a, b	6.69 ± 0.04b	67.08 ± 3.98b	24.77±0.21b, c
Hozat Bitter	3.43 ± 0.15a	1.88 ± 0.15a	6.62 ± 0.04b	63.37 ± 6.39b	24.90 ± 0.10c
Zerdali	3.90 ± 0.07a	2.62 ± 0.22c	6.54 ± 0.03a	40.77 ± 2.01a	26.48 ± 0.07e
Significance	<0.001	<0.001	<0.001	<0.001	<0.001

Ash ratios of apricot kernel varieties were found in the range of 1.85- 3.42%. In previous studies, ash content in apricot kernel varieties was reported to be in the range of 1.7- 2.9% [2, 8, 10, 15, 23, 45, 50, 55, 57, 63]. Therefore, it could be stated that the result of this study is compatible with the previous studies in the literature. The ash content in apricot kernels statistically differ according to the variety. This finding is parallel to the result of Seker et. al., 2010 [55]. The reason for ash ratio difference in apricot kernels could be due to season in which apricot kernels were harvested [1]. In addition, kernel genotype and growing conditions of the plant could also have an effect on the ash content of the kernels [29, 63]. Igdir apricot kernel had the highest ash content, followed by Zerdali apricot kernel. There is no significant difference on ash contents of Hozat apricot kernels.

The acidity of apricot kernel varieties was found in pH range of 6.49- 6.69, Malatya bitter and sweet apricot kernel (Zerdali and Hasanbey) had statistically lower ph value than other apricot kernels used in this study. No statistical difference was found in ph value between sweet and bitter apricot kernels, p=0.13.

There was a significant difference on oil contents of apricot kernels used in this study. Hozat apricot kernel varieties had significantly higher oil content than other apricot kernels, with no significant difference between them. Previous studies stated that apricot kernel varieties have oil content in range of 40- 55% [8, 15, 23, 45, 55, 64]. However, the oil content of apricot kernels harvested in Ladakha region was found to be 66.7% [37]. In this study, oil ratios of Hozat apricot kernels were found to be 63.37-67.08% and even though oil ratios of apricot kernel varieties used in this study, except Hozat varieties, are in accordance with the

literature, the oil content of Hozat sweet apricot kernel draws attention in terms of the highest oil content found in apricot kernel varieties until now. This difference can be interpreted as genotype difference of Hozat sweet apricot kernel variety [28, 53]. Moreover, different studies found different oil content for the same apricot kernel variety [26, 55]. This may be caused by many factors. These factors could be difference of soil structure in which apricot varieties were grown, different maintenance conditions or even different climate conditions [19, 39, 68]. Hozat bitter apricot kernel was found to have higher protein content than Hozat sweet apricot kernel, with no significant difference between them. However, protein content between Malatya sweet apricot kernel (Hasanbey) and Malatya bitter apricot kernel (Zerdali) statistically showed difference in favour for Malatya bitter apricot kernel. Protein ratio in apricot kernel varieties was stated to be found between 14.1- 27.7% by previous studies [8, 9, 15, 23, 34, 45, 50, 51]. Contrary to these, Kappor et. al. (1987) [37] found 45.3% protein content in apricot kernel harvested in Ladakha region. In this study, protein content found to range from 18.90% to 26.48% is consistent with most of the studies' result in the literature. Moreover, protein content in apricot kernels statistically changed according to the variety, with Zerdali statistically having the highest protein content. The lowest protein content among apricot kernels used in this study was found in Isparta Alyanak apricot kernel. This result is the proof that the genotype feature in apricot kernels influences protein content [30]. Moreover; soil structure, climate conditions and apricot fruit's care throughout cultivation were stated to have an effect on protein content of fruit's kernel [19, 39, 68].

Different solvent varieties were used to decide which solvent type is better to extract phenolic content in Hozat apricot kernels. It was found that methanol showed significantly better extraction efficiency to extract phenolic content in apricot kernel than other solvents. It is compatibility with the study of Yigit et. al. (2009) [67] and Teffane et. al. (2022) [61], which demonstrated that methanol is much better to extract phenolic content in apricot kernels. Thus, it was decided to use methanol as a solvent to determine total phenolic content of apricot kernel varieties used in this study.

Total phenolic contents of various apricot kernels could be seen at table 4.4. Total phenolic contents of apricot kernels used in this study ranged from 64.04 to 89.46 mg GAE/100g dry weight. There was a significant difference between bitter apricot kernels (Malatya Zerdali and Hozat Bitter) and sweet apricot kernels (Malatya Hasanbey, Hozat Sweet and Igdir), having statistically higher phenolic content than the bitter kernels. The same result was also found by other studies [40, 42, 67, 71]. However, Rampackova et. al. (2021) [51] used 32 cultivars of different apricot kernel, and found that even though average of the sweet kernels had higher phenolic content than average of the bitter kernels, some bitter kernels had higher phenolic content than some sweet kernels. It could be due to the specific plant genotype and interactions of cultivation conditions [42, 54].

Previous studies have found that total phenolic contents of apricot kernel varieties could change according to extraction method and solvent [16, 24, 69]. In addition, various studies have demonstrated that total phenolic contents of apricot kernel varieties could show difference regarding with type of the kernel [12, 27, 42, 51]. In this study, there was a significant difference depending on type of apricot kernel, $p<0.001$, with Hozat sweet kernel having significantly higher total phenolic content than other apricot kernels. The reason for why total phenolic content changes according to type of kernel was explained by other studies, which stated that genetic variety, growing conditions, geographical location and soil composition could affect total phenolic content in the kernel of fruits [13, 22, 27, 59].

Table 4.3. Total phenolic content of Hozat apricot kernel varieties according to the solvent.

Apricot Kernel Type	Solvent	Total Phenolic Content (mg GAE/ 100g dry weight)
Hozat Bitter	Water	19.96 ± 2.49a
	Ethanol	15.66 ± 4.33a
	Methanol	64.99 ± 2.18b
Hozat Sweet	Water	14.17 ± 1.92b
	Ethanol	11.98 ± 2.35a
	Methanol	89.46 ± 4.99c

Table 4.4. Total phenolic content (TPC) of apricot kernel varieties (mg GAE/ 100 g dw).

Type of Apricot Kernel	Total Phenolic Content
Malatya Sweet (Hasanbey)	69.91 ± 2.18a
Malatya Bitter (Zerdali)	64.04 ± 1.09a
Hozat Sweet	89.46 ± 4.99b
Hozat Bitter	64.99 ± 2.18a
Isparta Sweet (Alyanak)	68.31± 1.09a
Igdir Sweet (Salak)	69.03 ± 1.09a

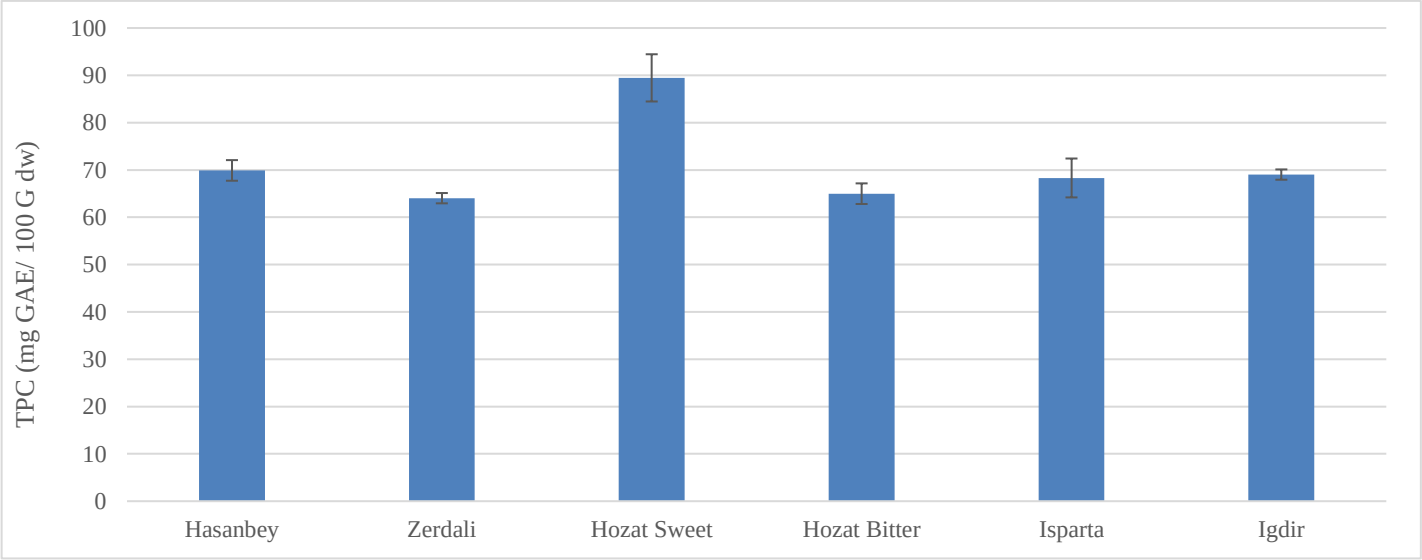

Figure 3. Total phenolic content of apricot kernel varieties.

4. Conclusions and Recommendations

All in all, Hozat apricot kernel varieties harvested in 2022 were analysed in this research, pomological characteristics of these apricot varieties were found as seed weight 1.44-1.72g, kernel weight 0.45-0.53g and seed-to-kernel weight ratio 31.09-31.56%. Pomological characteristics of other apricot kernel varieties used in this study were also determined as seed weight 2.11-4.76g, kernel weight 0.38-1.13g and seed-to-kernel weight 16.36-23.58%. It was found that even though seed weights of Hozat apricot kernel varieties were significantly lower than other apricot kernel varieties, seed-to-kernel weight ratios of Hozat apricot kernel varieties were significantly the highest.

Physicochemical properties of apricot kernels used in this study showed statistically difference according to type of kernel. The physicochemical properties of Hozat apricot kernel varieties were found as 2.92-3.43 % in moisture content, 1.88-2.15 % in ash content, 6.62-6.69 pH in acidity, 63.37-67.08 % in oil content and 24.77-24.90 % in protein content. It is noticeable that oil contents of Hozat apricot kernels were found to be the highest oil content found in apricot kernel up till now. The physicochemical properties of other apricot kernel varieties used in this study were also determined as 3.76-28.37% in moisture content, 1.85-3.42 % in ash content, 6.49-6.69 pH in acidity, 40.77-45.94 % in oil content and 18.90-26.48 % in protein content. Moreover, TPC of apricot kernels showed statistically difference according to type of kernel, with Hozat sweet having the highest TPC. TPC of Hozat apricot varieties showed statistically difference. It is a need to express that sweet apricot kernels had higher TPC than bitter apricot kernels.

5. Acknowledge

The author declares that this document does not require an ethics committee approval or any special permission. Our study does not cause any harm to the environment.

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