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The production of ready to drink terebinth coffee and the changes occurring during storage

İçime hazir menengiç kahvesi üretimi ve depolama sirasinda meydana gelen değişimler

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ABSTRACT

The purpose of this study was to bring a new product to the food industry and investigate a different application area for ready-to-drink terebinth (*Pistacia terebinthus*) coffee made with water and milk. Accordingly, formulation was determined based on preliminary trials conducted with terebinth coffees. Coffees prepared according to this formulation were processed and preserved using two different methods. In the first method, the products were filled into amber-colored glass bottles using hot filling technique and sterilized, while in the other method, potassium sorbate was added to the products and preserved in amber-colored glass bottles. Samples were stored at room temperature (24°C) and in the refrigerator (+4°C) for 180 days. Dry matter, ash, pH, free fatty acids, fatty acid compositions, color characteristics, antioxidant activity, total phenolic content, and phenolic fractions were investigated in the prepared ready-to-drink menengic coffees. As a result of the analyses, while the fat content remained constant in the coffee samples, an increase in free fatty acids and a decrease in pH were detected. Although there was a slight decrease in antioxidant capacities and phenolic content during the storage period, it was determined that this decrease was not significant. Luteolin, ellagic acid, gallic acid, fumaric acid, and vanillic acid were predominantly found in menengic coffees in terms of phenolic compounds. In milk coffees, it was observed that flocculation occurred due to heat treatment.

Key Words: Pistacia terebinthus, coffee, antioxidant, phenolic, fatty acid

ÖZ

Bu çalışmada, su ve süt ile hazırlanan içime hazır menengiç (*Pistacia terebinthus*) kahvesinin gıda endüstrisinde farklı bir kullanım alanının ortaya çıkarılması ve yeni bir ürünün gıda endüstrisine kazandırılması amaçlanmıştır. Bu amaçla, menengiç kahvesi için yapılan ön denemeler sonucunda bir formülasyon belirlenmiştir. Belirlenen formülasyon doğrultusunda hazırlanan kahveler, iki farklı yöntemle işlenerek saklanmıştır. İlk yöntemde, sıcak dolum tekniği kullanılarak ürünler amber renkli cam şişelere doldurulmuş ve sterilize edilmiştir. Diğer yöntemde ise, ürünlere potasyum sorbat eklenerek amber renkli cam şişelerde muhafaza edilmiştir. Örnekler, cam şişelerde oda sıcaklığında (24℃) ve buzdolabında (+4℃) 180 gün süreyle depolanmıştır. Hazırlanan içime hazır menengiç kahvelerinde kuru madde, kül, pH, serbest yağ asitleri, yağ asitleri kompozisyonları, renk özellikleri, antioksidan aktivite, toplam fenolik madde, fenolik madde fraksiyonları araştırılmıştır. Yapılan analizler sonucunda kahve örneklerindeki yağ miktarı sabit kalırken serbest yağ asitlerinde artış, pH da ise düşüş tespit edilmiştir. Depolama süresi boyunca antioksidan kapasitelerinde ve fenolik madde miktarlarında az da olsa bir azalma olduğu fakat bunun yüksek değerlerde olmadığı belirlenmiştir. Fenolik maddeler açısından menengiç kahvelerinde ağırlıklı olarak luteolin, ellagik asit, gallik asit, fumarik asit ve vanilik asit bulunmuştur. Sütlü kahvelerde ise ısıl işlem etkisiyle floklaşmalar meydana geldiği tespit edilmiştir.

Anahtar Kelimeler: Menengiç, kahve, antioksidan, fenolik, yağ aside

Introduction

Pistacia terebinthus is a medicinal aromatic plant belonging to the *Anacardiaceae* family, known for containing a high number of bioactive compounds (Özcan, 2004). It has a strong aroma and is rich in oil, protein, and dietary fibers. Pistacia species are also rich in antioxidants and phenolic compounds and possess antimicrobial properties. Additionally, due to its lack of caffeine content and richness in unsaturated fatty acids, menengiç is highly beneficial for health. Terebinth coffee is abundant in vitamins (B and E vitamins) and minerals (sodium, potassium, phosphorus, iron, magnesium, zinc, copper) (Eytemiş, 2016). The fruits of the *Pistacia terebinthus* tree, known as menengiç, are consumed as snacks, either roasted or mashed. Menengiç fruits, harvested from wild trees growing naturally in the mountainous and rural areas of the Mediterranean, Southeastern Anatolia, and Central Anatolia regions, are left to dry under the sun for a few days after being washed. The dried fruits are then roasted in a wide pan until they turn dark brown. After roasting, menengiç coffee is made by grinding them into a paste-like consistency. Menengiç seeds have a high oil content (38-45%), which presents a significant alternative for oil production in the food industry. The oil in the seeds contains a substantial amount of oleic acid (51.6%), palmitic acid (20.9%), and linoleic acid (19.6%). These fatty acids can be included in the groups of oils consumed for their health benefits. The versatile properties of menengiç—such as high protein content, oil, flavor, and aroma—enhance its potential applications in the food industry. Furthermore, the growing demand for natural products increases the consumption of menengiç due to its functional properties (Sidar, 2011). Papageorgiou et al. (1999) identified α-pinene, β-pinene, sabinene, and terpinen-4-ol as the primary constituents in the volatile oil of *P. terebinthus var. chia* (*P. lentiscus var. latifolius*) resin. Küsmenoğlu et al. (1995) determined that α-pinene, terpinolene, and limonene were the main components in the fresh peel essential oil of *Pistacia vera* fruit. According to Özcan et al. (2009), limonene and β-pinene were the primary constituents in the volatile oil of ripe terebinth fruit; however, there were also notable quantities of α-phellandrene, terpinolene, and α-pinene. Geçgel & Arıcı (2008) reported that the significant saturated fatty acids in terebinth were palmitic and stearic acids, while the important unsaturated fatty acids included oleic and linoleic acids. They found that the oleic acid content was notably high (49.26%-52.67%) among the fatty acids. Additionally, the linolenic acid content was found to be below 1% in all samples, and the total trans fatty acid content varied between 0.16% and 0.89%. Somporn et al. (2011) investigated the effects of roasting temperature on several properties of coffee beans, including color values, volatile oils, antioxidant activity, and phenolic compounds. It was determined that as the roasting temperature increased, the color values (L and b) of the coffee beans also increased. Antioxidant activity was found to be higher in lightly roasted coffee beans. Additionally, it was determined that as roasting temperatures increased, the levels of gallic acid, p-coumaric acid, cinnamic acid, and chlorogenic acid in the coffee beans increased.

Pelvan & Demirtaş (2018) examined the oil content, antioxidant activity, and total phenolic content of oils from *Pistacia terebinthus L.* and *Pistacia vera* cultivated in Turkey. The phenolic content of the samples ranged from 3.03 to 4.52 mg GAE/100 g, the oil content from 50.33% to 54.00%, and the antioxidant activity from 371.23 to 736.48 µmol TE/100 g. Hayoğlu et al. (2010) used both roasted and unroasted terebinth in their investigation of the potential application of terebinth in confectionery production. The ash, moisture, and sugar contents of confections made from roasted and unroasted terebinth were found to be 1.83% and 1.23%, 2.67% and 3.78%, and 70% and 60%, respectively. Sensory assessments by panelists revealed that, in terms of flavor and aroma, the roasted terebinth confection was superior. In the study conducted by Amanpour et al. (2015, 2019), a total of 51 volatile components were identified in roasted terebinth, with terpenes

being the most abundant among them. The characteristics of the oil extracted from terebinth seeds were studied by Kaya and Özer (2015). The amounts of fatty acids in the samples were determined to be as follows: oleic acid 45.8%, palmitic acid 24.27%, linoleic acid 23.93%, palmitoleic acid 3.78%, stearic acid 1.7%, and linolenic acid 0.47%. In a study conducted by Köten and Ünsal (2022), it was determined that the protein, ash, fat, phenolic compound, and antioxidant content of the noodles produced by adding roasted terebinth—both in its raw form and roasted at different temperatures before being turned into flour—to wheat flour increased. In this study, some of the ready-to-drink terebinth coffees, prepared with water and milk and formulated through preliminary trials, were sterilized by filling them into amber-colored glass bottles using the hot filling technique, while others were preserved in amber-colored glass bottles with the addition of potassium sorbate. Changes in the products stored at room temperature (24°C) and in the refrigerator (+4°C) for 180 days were examined.

Material and Method

Material

The terebinth coffee used in this study was obtained from the local market in Şanlıurfa. Drinkable quality water was used in the production of the coffee. The milk and/or milk powder, along with sugar, were purchased ready-made from the market.

Method

Terebinth coffee production

The terebinth coffees were prepared according to the traditional method. For this purpose, 30 g of coffee was mixed with 100 ml of water and milk, and this mixture was cooked. The cooked samples were separated from the sediment under suitable conditions. A portion of the prepared product was filled into 200 ml amber-colored glass bottles using the hot filling technique and sterilized at 105-110 °C for 5-10 minutes, while another portion was filled into amber-colored glass bottles after adding potassium sorbate at a ratio of 1:1000. The ready-to-drink products were stored at both refrigerator and room temperatures and subjected to physical, chemical, and sensory analyses at regular intervals. The terebinth coffees were stored in amber-colored glass bottles at room temperature (25±2˚C) and at +4°C for 6 months. Necessary analyses were conducted monthly starting from the beginning of production.

Experimental design

The analyzed samples are coded as follows and will be referred to by their codes throughout the text:

SS4: Coffee prepared with water, sterilized, and stored at 4 ^{0}C

SS24: Coffee prepared with water, sterilized, and stored at 24 ^{0}C

SK4: Coffee prepared with water, preservative added, and stored at 4 ^{0}C

SK24: Coffee prepared with water, preservative added, and stored at 24 ^{0}C

STS4: Coffee prepared with milk, sterilized, and stored at 4 ^{0}C

STS24: Coffee prepared with milk, sterilized, and stored at 24 ^{0}C

STK4: Coffee prepared with milk, preservative added, and stored at 4 ^{0}C

STK24: Coffee prepared with milk, preservative added, and stored at 24 ^{0}C

Analyses made on terebinth coffee

pH, total dry matter (%), moisture (%), ash (%), Protein (%), Cellulose (%), color (L*, a*, b* values) (AOAC, 2005; Cemeroğlu, 2007), fatty acid (Jennings & Akoh, 1999), free fatty acid, Essential Oil (Pirbalouti & Aghaee, 2011) , Antioxidant (Çam et al., 2009), Total Phenolic Substance (Medina-Remon et al., 2009), analyzes were made in the produced terebinth coffees. Trials were made in three replications and two parallels, and the SPSS package program was used in the evaluation ($P \leq 0.05$). The differences between the means in the groups were determined by Duncan test (Curran et al., 1996).

Results and Discussions

Some parameters of terebinth seed

Average values obtained from various analyses performed on terebinth seeds are presented in Table 1. The essential oil composition of terebinth seeds is provided in Table 2.

Table 1. Some analysis values of Terebinth seed (%)

Component		Terebinth seed
Moisture		26.74±0.03
Ash		2.40±0.01
Protein		9.49±0.02
Fat		46.05±0.03
Cellulose		24.56±0.2
Color	L*	30.29±0.01
	a*	-1.55±0.03
	b*	3.98±0.02

Protein, ash, cellulose, antioxidant activity and fat amounts were calculated as % dry matter.

Table 2. The essential oil composition of Terebinth seed (%)

Essential oil components	Terebinth seed
Alpha pinene	31.03±0.02
Limonene	14.45±0.01
Cis-β-osimen	16.04±0.01
Trans-β-osimen	5.74±0.02
Beta Mirisen	6.21±0.03
Alpha Terpinolene	5.33±0.01
Carvacrol	5.25±0.02
Beta Pinene	3.19±0.02
Trans Karyofillen	2.40±0.02
Sabinen	1.76±0.03
Kampen	1.79±0.02
Alpha Thujen	1.27±0.03
Bornilasetat	1.08±0.01
Para Simen	1.10±0.01
4.8-Dimetil-1,3,7-Nonatrien	0.80±0.02
Alfa Terpinen	0.74±0.02
Delta 3 Karen	0.77±0.03
Unrecognized essential oil	1.05±0.02
Elemol	-
Caryophyllene oxide	-
9,12-oktadekadienoik asit, methyl ester	-

Terebinth coffee chemical values

The dry matter values of terebinth coffees are presented in Table 3, ash values in Table 4, pH values in Table 5, and free fatty acid values in Table 6. No change was observed in the total dry matter content of samples prepared with water or milk during storage, and the statistically significant differences were attributed to the very low degree of freedom for error. In the samples prepared with milk and stored at +4°C, no difference was observed in terms of statistical and general total dry matter values until the 120th day. After the 120th day, analyses were terminated due to flocculation in the milk samples. The dry matter values of samples prepared with milk were found to be higher than those of samples prepared with water (Table 3).

No change was observed in the total dry matter content of samples prepared with water or milk during storage, and the statistically significant differences were attributed to the very low degree of freedom for error. In the samples prepared with milk and stored at +4°C, no difference was observed in terms of statistical and general total

dry matter values until the 120th day. After the 120th day, analyses were terminated due to flocculation in the milk samples. The dry matter values of samples prepared with milk were found to be higher than those of samples prepared with water (Table 3).

While no time-dependent change was observed in the ash values of coffees prepared with milk, a decrease in ash values was noted after 6 months in samples prepared with water. Additionally, ash contents were found to be higher in samples prepared with milk (Table 4).

As shown in Table 5, there was a slight, regular decrease in pH values in terebinth coffees prepared with water during the storage period. In the study conducted by Fedai (2018), decreases in pH values over time were also observed. In samples prepared with milk, a decrease in pH was noted over time, albeit irregularly. It is thought that these irregularities are due to flocculation in the structure of the products.

It is believed that there was a significant increase in the free fatty acid values of all samples during the storage period, and this increase may be attributed to chemical reactions occurring in the structure of the samples over time and under varying storage conditions. In the study by Karahan (2017), it was determined that free fatty acid values increased with time (Table 6).

Table 3. Terebinth coffee dry matter values (%)

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4
0	43.91±1.09^{aB}	43.91±1.09^{aB}	43.91±1.09^{aB}	43.91±1.09^{aB}	57.07±1,14^{aA}	57.07±1,14^{aA}	57.07±1,14^{aA}	57.07±1,14^{aA}
30	43.86±0.02^{abB}	40.83±0.02^{dC}	43.89±0.05^{aB}	43.94±0.02^{aB}	57.18±0.97^{aA}	56.97±1.32^{aA}	57.22±0.32^{aA}	56.99±1.12^{aA}
60	43.76±0.02^{bB}	43.74±0.00^{bB}	43.81±0.02^{abB}	43.88±0.02^{abB}	56.67±1.01^{aA}	56.93±2.01^{aA}	56.97±0.93^{aA}	56.98±1.43^{aA}
90	43.62±0.07^{cB}	43.63±0.02^{cB}	43.75±0.02^{bB}	43.86±0.04^{abB}	56.28±0.66^{aA}	56.36±0.63^{aA}	56.68±0.86^{aA}	56.55±0.52^{aA}
120	43.65±0.02^{cB}	43.62±0.04^{cB}	43.71±0.04^{bcB}	43.85±0.04^{abB}	56.88±1.71^{aA}	56.86±3.01^{aA}	56.78±1.43^{aA}	56.95±1.01^{aA}
150	43.57±0.03^{cA}	43.61±0.02^{cA}	43.68±0.02^{bcA}	43.81±0.05^{abA}	-	-	-	-
180	43.51±0.05^{dA}	43.56±0.04^{cA}	43.55±0.04^{cA}	43.78±0.02^{bA}	-	-	-	-

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05).

Table 4. Terebinth coffee ash values (%)

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4
0	0.64±0.00^{aB}	0.64±0.00^{aB}	0.64±0.00^{aB}	0.64±0.00^{aB}	0.90±0.00^{aA}	0.90±0.00^{aA}	0.90±0.00^{aA}	0.90±0.00^{aA}
30	0.62±0.01^{bB}	0.63±0.00^{bB}	0.62±0.01^{bB}	0.63±0.02^{aB}	0.91±0.00^{aA}	0.91±0.00^{aA}	0.91±0.02^{aA}	0.90±0.07^{aA}
60	0.62±0.01^{bB}	0.62±0.00^{bB}	0.62±0.02^{bB}	0.62±0.02^{bB}	0.90±0.01^{aA}	0.90±0.01^{aA}	0.90±0.00^{aA}	0.90±0.06^{aA}
90	0.61±0.02^{bcB}	0.61±0.02^{bcB}	0.61±0.01^{bcB}	0.62±0.00^{bB}	0.90±0.02^{aA}	0.91±0.01^{aA}	0.90±0.04^{aA}	0.91±0.03^{aA}
120	0.60±0.01^{cB}	0.61±0.02^{bcB}	0.60±0.01^{cB}	0.62±0.01^{bB}	0.90±0.01^{aA}	0.90±0.02^{aA}	0.91±0.03^{aA}	0.90±0.04^{aA}
150	0.60±0.00^{cA}	0.61±0.00^{bcA}	0.60±0.01^{cA}	0.62±0.00^{bA}	-	-	-	-
180	0.60±0.02^{cA}	0.61±0.03^{bcA}	0.60±0.00^{cA}	0.62±0.01^{bA}	-	-	-	-

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05).

Table 5. Terebinth coffee pH values

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4
0	5.82±0.01^{aA}	5.82±0.01^{aA}	5.82±0.01^{aA}	5.82±0.01^{aA}	5.86±0.03^{aA}	5.86±0.03^{cA}	5.86±0.03^{aA}	5.86±0.03^{cA}
30	5.72±0.00^{bB}	5.80±0.00^{aB}	5.64±0.02^{bBC}	5.80±0.01^{aB}	5.48±0.00^{bC}	6.41±0.00^{aA}	5,72±0.02^{aB}	6.31±0.00^{abA}
60	5.58±0.01^{cB}	5.62±0.03^{bB}	5.53±0.04^{cBC}	5.66±0.02^{bB}	5.51±0.03^{bBC}	6.47±0.01^{aA}	5.22±0.00^{bC}	6.36±0.00^{abA}
90	5.43±0.02^{dB}	5.58±0.01^{bB}	5.42±0.00^{cB}	5.53±0.03^{cB}	4.96±0.02^{cC}	4.96±0.02^{dC}	4.71±0.01^{cD}	6.06±0.00^{bcA}
120	5.36±0.04^{dB}	5.37±0.04^{cB}	5.23±0.04^{dB}	5.38±0.02^{dB}	4.67±0.00^{dC}	4.75±0.01^{eC}	4.58±0.02^{cC}	5.94±0.02^{cA}
150	4.71±0.00^{eD}	5.19±0.01^{dC}	5.12±0.02^{dC}	5.37±0.02^{dB}	5.48±0.00^{bB}	6.53±0.00^{aA}	5.31±0.00^{bB}	6.49±0.00^{aA}
180	4.43±0.02^{D}	5.13±0.04^{dBC}	5.00±0.04^{eBC}	5.22±0.02^{eBC}	5.83±0.07^{aAB}	6.08±0.00^{bA}	5.02±0.02^{bBC}	6.02±0.00^{bcA}

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05).

Table 6. Terebinth coffee free fatty acids values (%)

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4

0	1.92±0.02^{cA}	1.92±0.02^{dA}	1.92±0.02^{eA}	1.92±0.02^{dA}	1.64±0.02^{eB}	1.64±0.02^{dB}	1.64±0.02^{dB}	1.64±0.02^{dB}
30	2.42±0.02^{bA}	2.30±0.00^{cdA}	1.92±0.01^{eB}	2.49±0.00^{cdA}	2.31±0.00^{dA}	1.73±0.04^{dC}	2.03±0.02^{cA}	1.62±0.03^{dC}
60	2.53±0.00^{bB}	2.38±0.02^{cdB}	3.14±0.01^{dA}	2.61±0.04^{cB}	2.42±0.02^{dB}	2.35±0.01^{cB}	2.93±0.04^{bAB}	1.82±0.03^{cC}
90	2.75±0.00^{aB}	2.54±0.02^{cC}	3.31±0.02^{cA}	2.54±0.03^{cC}	2.77±0.03^{cdB}	2.36±0.01^{cC}	2.90±0.00^{bB}	1.95±0.02^{cD}
120	2.81±0.02^{aBC}	2.71±0.01^{cC}	3.42±0.03^{bA}	2.91±0.02^{bB}	2.85±0.03^{cB}	2.52±0.03^{cCD}	2,93±0.02^{bB}	2.24±0.01^{bD}
150	2.84±0.01^{aC}	2.98±0.01^{bC}	3.46±0.01^{bA}	3.60±0.02^{aA}	3,18±0.02^{bB}	3,13±0.02^{bB}	2.95±0.03^{bC}	2.36±0.03^{bD}
180	2.86±0.02^{aD}	3.16±0.00^{aCD}	3.87±0.01^{aB}	3.65±0.00^{aC}	3.44±0.02^{aC}	5.52±0.03^{aA}	3.09±0.07^{aCD}	3.63±0.03^{aC}

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05).

Terebinth coffee color values

The average L*, a*, and b* values of menengiç coffees are presented in Tables 7, 8, and 9.

The L values in the samples range between 30 and 40, giving the samples a brownish color due to the characteristics of terebinth coffee. Naturally, this is also reflected in the L value. Additionally, while samples prepared with milk exhibited higher L* values at the beginning of storage, they reached almost the same level as samples prepared with water by the end of 6 months of storage (Table 7). It was determined that a value was above 5 in the menengiç coffee samples prepared with both water and milk. An increase in the values recorded on the 30th day was observed in the samples compared to the 0th day, which was attributed to the interaction between menengiç and water and milk. No significant change was observed in the following days (Table 8).

While samples prepared with water initially exhibited significantly lower values than those prepared with milk, by the 30th and 60th days of storage, all samples reached the highest values in their respective series. Although a general decrease in b values was observed from the 60th to the 150th day of storage, an increase was noted again on the 150th day. On the 180th day of storage, a significant decrease was observed in all samples, reaching the lowest values since the beginning of storage (Table 9).

Table 7. Terebinth coffee L* values

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4
0	33.17±0.07^{bcB}	33.17±0.07^{bB}	33.17±0.07^{abB}	33.17±0.07^{bcB}	38.55±0.02^{aA}	38.55±0.02^{aA}	38.55±0.02^{aA}	38.55±0.02^{aA}
30	32.91±0.02^{cC}	31.02±0.03^{cD}	34.45±0.02^{abB}	31.59±0.02^{dD}	35.38±0.02^{bAB}	33.43±0.12^{cBC}	36.43±0.07^{bcA}	32.49±0.03^{cC}
60	32.75±0.02^{cBC}	30.47±0.02^{cD}	32.83±0.02^{bBC}	30.35±0.01^{eD}	33.61±0.02^{cB}	32.44±0.07^{dBC}	36.33±0.04^{bcA}	32.00±0.00^{cC}
90	35.83±0.01^{aAB}	35.99±0.03^{aAB}	35.85±0.04^{aAB}	36.65±0.03^{aA}	35.83±0.04^{bAB}	34.32±0.02^{bB}	37.11±0.01^{bA}	34.44±0.04^{bB}
120	32.12±0.03^{cE}	30.17±0.03^{cF}	30.94±1.38^{cF}	33.19± 0.02^{bcD}	35.75±0.02^{bB}	31.10±0.02^{eF}	36.91±0.03^{bcA}	34.31±0.02^{bC}
150	32.09±0.01^{cA}	30.15±0.02^{cB}	31.70±1.69^{bcB}	32.63±0.04^{cdA}	32.52±0.02^{dA}	31.04±0.03^{eB}	32.13±0.02^{eA}	31.86±0.07^{dB}
180	34.23±0.01^{bAB}	33.30±0.00^{bB}	33.56±0.04^{abB}	34.07±0.00^{bAB}	35.17±0.02^{dA}	33.42±0.02^{cB}	33.43±0.04^{dB}	34.44±0.00^{bAB}

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05).

Table 8. Terebinth coffee a* values

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4
0	5,23±0.02^{cB}	5,23±0.02^{cB}	5,23±0.02^{cB}	5,23±0.02^{cB}	6.13±0.02^{bA}	6.13±0.02^{bA}	6.13±0.02^{cA}	6.13±0.02^{bA}
30	7.61±0.01^{aB}	7.23±0.02^{aBC}	7.79±0.01^{aB}	7.04±0.04^{aC}	8.10±0.02^{aA}	7.44±0.00^{aB}	8.07±0.00^{aA}	7.65±0.02^{aB}
60	7.75±0.02^{aA}	7.54±0.01^{aA}	7.84±0.02^{aA}	7.82±0.09^{aA}	7.85±0.01^{aA}	6.05±0.03^{bB}	7.55±0.01^{bA}	7.52±0.03^{aA}
90	6.68±0.09^{bA}	6.76±0.03^{bA}	6.96±0.04^{bA}	6.92±0.02^{bA}	6.52±0.03^{bA}	5.95±0.00^{bB}	6.72±0.02^{cA}	6.67±0.02^{bA}
120	6.52±0.03^{bA}	6.43±0.01^{bA}	6.37±0.03^{bA}	6.37±0.03^{bA}	6.47±0.00^{bA}	5.86±0.02^{bB}	6.50±0.00^{cA}	6.61±0.01^{bA}
150	7.34±0.01^{aA}	5.59±0.00^{cC}	6.22±0.02^{bB}	6.22±0.02^{bB}	6.38±0.00^{bB}	6.14±0.04^{bB}	7.25±0.02^{bA}	6.53±0.03^{bB}
180	6.63±0.04^{bA}	5.66±0.02^{cB}	6.14±0.00^{bA}	6.24±0.02^{bA}	6.44±0.02^{bA}	6.25±0.02^{bA}	6.53±0.01^{cA}	6.61±0.02^{bA}

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05).

Table 9. Terebinth coffee b* values

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4
0	6.76±0.08^{dB}	6.76±0.08^{eB}	6.76±0.08^{fB}	6.76±0.08^{eB}	10,91±0.01^{dA}	10,91±0.01^{bcA}	10,91±0.01^{eA}	10,91±0.01^{cdA}
30	14.22±0.03^{aB}	13.1±0.01^{aC}	14.91±0.01^{aB}	12.19±0.02^{aD}	16.59±0.07^{aA}	14.00±0.05^{aB}	16.06±0.00^{aA}	13.19±0.00^{aC}
60	13.01±0.02^{bB}	12.47±0.00^{bBC}	13.76±0.02^{bB}	11.89±0.04^{aC}	15.15±0.00^{bA}	11.50±0.02^{bC}	15.02±0.03^{bA}	12.33±0.04^{bBC}
90	10.34±0.04^{cB}	10.07±0.04^{cB}	10.19±0.08^{dB}	10.14±0.09^{bB}	12.33±0.04^{cA}	10.11±0.01^{cB}	12.21±0.01^{dA}	10.16±0.02^{cdB}
120	10.09±0.01^{cC}	10.04±0.02^{cC}	11.27±0.00^{cB}	9.32±0.00^{cD}	12.20±0.02^{cA}	9.47±0.04^{dD}	12.11±0.01^{dA}	10.00±0.00^{cdC}
150	13.34±0.07^{bB}	12.11±0.01^{bC}	11.56±0.00^{cD}	10.95±0.01^{bE}	13.45±0.02^{cB}	11.15±0.04^{bD}	14.61±0.01^{cA}	11.25±0.02^{cD}
180	9.69±0.02^{cA}	9.13±0.04^{cA}	8.21±0.02^{eB}	8.76±0.02^{dB}	9.63±0.04^{eA}	9.86±0.02^{cdA}	9.92±0.02^{fA}	9.88±0.20^{dA}

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05)

Antioxidant capacities and phenolic substance amounts of Terebinth coffees

The antioxidant capacities of menengiç coffees are presented in Table 10, while the amounts of phenolic substances are shown in Table 11. The antioxidant capacities of the samples decreased over the storage period. This decrease is attributed to reactions occurring within the product over time and under varying storage conditions. As Cemeroğlu (2007) stated, antioxidant substances break down over time and temperature, leading to a decrease in their antioxidant capacity. Similarly, Zor (2007) found a decrease in antioxidant capacity in mulberry molasses stored at room temperature, depending on the storage duration (Table 10).

While no significant decrease was observed in the total phenolic substance values of the samples during the initial storage periods, it was determined that the total phenolic substance content decreased in parallel with the storage duration, and this decrease was statistically significant. The total phenolic substance amounts were 361.65 (mg gallic acid/g) in the samples prepared with water and 336.77 (mg gallic acid/g) in the samples prepared with milk at the beginning; however, these values decreased to 308.76 (mg gallic acid/g) and 302.79 (mg gallic acid/g) at the end of storage. Similarly, in the study conducted by Fedai (2018) on beverages, it was reported that there was a decrease in the total phenolic content in beverages prepared according to different formulations in parallel with the storage period (Table 11).

Table 10. Antioxidant capacities of terebinth coffees (mg TEAC/g)

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4
0	292.96±3.54^{aA}	292.96±3.54^{aA}	292.96±3.54^{aA}	292.96±3.54^{aA}	294.81±2.26^{aA}	294.81±2.26^{aA}	294.81±2.26^{aA}	294.81±2.26^{aA}
30	283.93±3.55^{bAB}	277.05±0.74^{bB}	287.91±2.19^{aA}	278.75±2.26^{abB}	288.49±3.35^{bA}	285.77±0.51^{bAB}	291.66±4.87^{bcA}	290.49±4.13^{cA}
60	277.52±0.78^{bB}	268.53±0.79^{cC}	283.13±3.62^{abAB}	277.29±4.07^{bB}	283.61±2.82^{cAB}	282.18±2.84^{bAB}	286.37±3.04^{bcA}	285.06±2.47^{cA}
90	265.25±0.55^{cBC}	260.07±0.52^{dcC}	273.77±5.07^{cB}	274.63±3.57^{bB}	279.07±5.31^{bA}	276.3.5±0.51^{cAB}	278.44±3.25^{bAB}	281.73±4.34^{bA}
120	262.71±3.62^{dcC}	252.67±3.49^{deD}	263.37±2.10^{cdC}	272.55±2.18^{bB}	277.88±4.02^{bA}	266.33±1.58^{cC}	276.51±4.22^{bcA}	278.45±3.22^{bA}
150	251.70±2.16^{dcAB}	247.68±2.09^{efB}	251.44±1.10^{deB}	264.76±6.44^{bcA}	-	-	-	-
180	251.76±2.26^{dAB}	241.21±1.42^{fC}	243.77±5.16^{eC}	257.05±3.64^{cA}	-	-	-	-

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05).

Table 11. Phenolic substance amounts terebinth coffees (mg gallik asit/g)

Days	SS24	SS4	SK24	SK4	STK24	STK4	STS24	STS4
0	361.65±2.19^{aA}	361.65±2.92^{aA}	361.65±2.92^{aA}	361.65±2.92^{aA}	336.77±1.93^{aB}	336.77±1.93^{aB}	336.77±1.93^{aB}	336.77±1.93^{aB}
30	363.57±4.85^{aA}	353.01±3.80^{bAB}	363.88±0.82^{aA}	354.69±2.61^{bAB}	335.92±2.02^{aB}	324.15±1.40^{bB}	331.43±3.07^{abB}	328.49±4.58^{bB}
60	353.16±4.21^{abA}	353.01±3.80^{bA}	353.59±3.71^{abA}	343.16±1.50^{cA}	333.67±1.86^{aC}	322.17±2.75^{bCD}	325.33±2.44^{bCD}	321.26±2.36^{cCD}
90	346.33±0.08^{bA}	336.85±0.95^{cAB}	345.26±2.29^{bA}	334.89±3.62^{dAB}	324.93±3.54^{bB}	311.30±1.64^{cC}	317.19±1.51^{cBC}	318.44±3.88^{cdBC}
120	333.08±3.58^{cA}	329.10±2.29^{cdA}	333.59±3.71^{cA}	327.20±2.77^{eA}	315.75±02.28^{cB}	302.79±3.70^{dC}	309.28±3.03^{dBC}	314.31±4.02^{dB}
150	322.15±2.75^{cA}	328.85±1.27^{cdA}	328.18±1.44^{cA}	318.42±2.85^{fA}	-	-	-	-
180	308.76±1.97^{dBC}	319.14±1.42^{dA}	304.46±2.38^{dC}	314.80±1.50^{fAB}	-	-	-	-

The same letters in the same column indicate that the values are statistically insignificant (P>0.05).
The same capital letters in the same row indicate that the values are statistically insignificant (P>0.05).

Fatty acid compositions of terebinth coffees

The fatty acid compositions of menengiç coffee are presented in Table 12. As seen in the table, the amounts of palmitic acid in all samples decreased slightly by the end of the 180th day of storage compared to the first day, and this decrease was found to be statistically significant. A similar trend was also observed in the amounts of linoleic acid. It was determined that there was an increase in the oleic acid amounts of the samples compared to the raw material, and the same trend was noted between day 0 and day 180. No significant change was observed in the other fatty acids. It is thought that the aforementioned changes are due to the reactions that occur in the structure of the samples over the storage period. Özcan (2004) reported the fatty acid compositions in menengiç fruits as follows: oleic acid 52.3%, palmitic acid 21.3%, linoleic acid 19.7%, palmitoleic acid 3.4%, stearic acid 2.0%, linolenic acid 0.6%, eicosanoic acid 0.1%, myristic acid 0.1%, and lauric acid 0.1%. Kaya (2012) found the fatty acid compositions in menengiç fruits from the Elazığ region to be: oleic acid 45.4%, palmitic acid 24.66%, linoleic acid 24.16%, saturated fatty acids 26.28%, and unsaturated fatty acids 73.72%. Sidar (2011) found that as the fruits of the terebinth ripen, the amount of linolenic acid decreases while the amount of oleic acid increases. The amounts of fatty acids found in raw terebinth fruit were determined as follows: lauric acid 0.1%, myristic acid 0.1%, palmitic acid 21.1%, palmitoleic acid 3.1%, stearic acid 2.0%, oleic acid 55.7%, linoleic acid 16.8%, linolenic acid 0.7%, eicosanoic acid 0.2%, eicosenoic acid 0.3%, and behenic acid 0.1%.

Table 12. Fatty acid composition of terebinth coffee (%)

Fatty acids	Day	SS24	SS4	SK24	SK4
Myristic acid (C14:0)	0	0.077±0.01	0.077±0.01	0.077±0.01	0.077±0.01
	180	0.129±0.02	0.078±0.02	0.073±0.03	0.075±0.01
Palmitic acid (C16:0)	0	22.121±0.02	22.121±0.02	22.121±0.02	22.121±0.02
	180	21.725±0.01	21.879±0.02	21.87±0.02	21.853±0.03
Palmitoleic acid(C16:1)	0	3.022±0.01	3.022±0.01	3.022±0.01	3.022±0.01
	180	2.903±0.01	2.917±0.02	2.944±0.02	3.021±0.01
Heptadecanoic acid (C17:0)	0	0.129±0.03	0.129±0.03	0.129±0.03	0.129±0.03
	180	0.204±0.01	0.124±0.02	0.120±0.02	0.125±0.01
cis-10-Heptadecanoic acid (C17:1)	0	0.077±0.01	0.077±0.01	0.077±0.01	0.077±0.01
	180	0.073±0.01	0.078±0.02	0.072±0.03	0.078±0.03
Stearic acid (C18:0)	0	2.269±0.02	2.269±0.02	2.269±0.02	2.269±0.02
	180	2.599±0.01	2.350±0.01	2.221±0.01	2.472±0.02
Oleic acid(C18:1n9c)	0	48,223±0.03	48,223±0.03	48,223±0.03	48,223±0.03
	180	47.727±0.02	48.843±0.01	48.78±0.02	48.378±0.02
Linoleic acid(C18:2n6c)	0	23.138±0.02	23.138±0.02	23.138±0.02	23.138±0.02
	180	22.8±0.03	22.821±0.02	22.900±0.02	23.005±0.01
Arachidic acid (C20:0)	0	0.051±0.03	0.051±0.03	0.051±0.03	0.051±0.03
	180	0.279±0.03	0.069±0.02	0.073±0.02	0.047±0.03
Cis-11-eicosatrienoic acid (C20:1)	0	0.101±0.01	0.101±0.01	0.101±0.01	0.101±0.01
	180	0	0	0.100±0.01	0.090±0.01
linolenic acid (C18:3n6)	0	0.794±0.02	0.794±0.02	0.794±0.02	0.794±0.02
	180	0.886±0.03	0.100±0.01	0	0.732±0.03
Erucic acid (C22:1n9)	0	0	-	-	-
	180	0.114±0.01	-	-	-
Nervonic acid (C24:1)	0	0	-	-	-
	180	0.496±0.02		-	-
Undecanoic acid (C11:0)	0	0	-	-	-
	180	0.032±0.02		-	-
Tricosanoic acid (C23:0)	0		0	-	-
	180		0.054±0.01	-	-
Caproic acid (C6:0)	0	-	-	0	-
	180	-	-	0.040±0.01	-
Myristoleic acid (C14:1)	0	-	-	0	-
	180	-	-	0.035±0.02	-
Nervonic acid(C24:1)	0	-	-	0[b]	-
	180	-	-	0.065±0.02	-

Phenolic compound composition of terebinth coffees

The phenolic compound compositions of terebinth coffees are provided in Table 13. In these samples, 25 phenolic compounds were detected, with 18 of them identified. Luteolin, ellagic acid, gallic acid, and fumaric acid were predominantly found among the phenolic compounds in the samples. In a study conducted in Elazığ, Dinç (2012) identified the phenolic compounds in Pistacia terebinthus fruit as follows: resveratrol at 373.5 ppm, vanillic acid at 219.167 ppm, caffeic acid at 154.5 ppm, quercetin at 156.83 ppm, and ferulic acid at 9.667 ppm. The phenolic compounds in Pistacia terebinthus coffee were determined to be: resveratrol at 295.41 ppm, vanillic acid at 179.5 ppm, caffeic acid at 101.5 ppm, quercetin at 129.9 ppm, and ferulic acid at 3.5 ppm.

Durak and Uçak (2015) investigated the antioxidant, antimicrobial, fatty acid, and solvent optimization of melon extract. In this research, 12 different samples were used. The total phenolic compound contents of the samples were determined to be 17.629, 12.564, 16.612, 14.184, 18.559, 13.841, 13.627, 16.222, 12.189, 17.330, 26.118, and 36.392 mg GAE/1000 g extract. The antioxidant activities measured were 15.68%, 9.23%, 16.83%, 12.75%, 14.19%, 12.85%, 16.20%, 18.37%, 8.86%, 23.36%, 46.12%, and 64.43% (% DPPH inhibition). As a result of the study, it was determined that antioxidant activity and phenolic compounds were closely related.

Table 13. The phenolic compound compositions of terebinth coffees (ppb)

Phenolic substance	Day	SS24	SS4	SK24	SK4
Catechin hyrate	0	1977.99±0.02	1977.99±0.02	1977.99±0.02	1977.99±0.02
	180	1232.27±0.03	772.73±0.02	434.45±0.02	585.16±0.01
Acetohyroxamicacid	0	31.26±0.01	31.26±0.01	31.26±0.01	31.26±0.01
	180	64.61±0.02	47.11±0.02	51.77±0.02	31.18±0.01
Vanillic acid	0	1449.00±0.01	1449.00±0.01	1449.00±0.01	1449.00±0.01
	180	2541.93±0.03	2375.22±0.03	2054.72±0.03	2320.53±0.02
Resveratrol	0	0	0	-	-
	180	318.18±0.02	321.26±0.01	-	-
Fumaric acid	0	3901.84±0.02	3901.84±0.02	3901.84±0.02	3901.84±0.02
	180	3481.40±0.02	4769.65±0.01	2520.62±0.01	4088.086±0.01
Gallic acid	0	3901.84±0.02	3901.84±0.02	3901.84±0.02	3901.84±0.02
	180	4599.54±0.03	4476.43±0.03	3757.99±0.01	4117.43±0.01
Caffeic	0	54.513±0.01	54.513±0.01	54.513±0.01	54.513±0.01
	180	105.26±0.02	71.37±0.01	63.43±0.03	0
Phloridzindyhrate	0	500.66±0.03	500.66±0.03	500.66±0.03	500.66±0.03
	180	0	476.05±0.02	0	0
Oleuropein	0	-	-	-	-
	180	-			
Hydoxycinamic	0	-	-	1098.78±0.02	-
	180	-		0	
Ellagic acid	0	11806.11±0.02	11806.110±0.02	11806.110±0.02	11806.110±0.02
	180	2674.70±0.01	3968.88±0.03	0	3431.18±0.01
Myricetin	0	-	-	-	-
	180				
Prtcatechuic	0	-	-	-	-

	180				
Silymarin	0	687.62± 0.02	-	-	-
	180	0			
2-hyroxy1,4nph	0	-	-	-	-
	180				
Butein	0	602.08± 0.02	602.08± 0.02	602.08± 0.02	602.08± 0.02
	180	495.86± 0.03	253.39± 0.02	140.47± 0.01	243.53± 0.03
Naringenin	0	-	-	-	-
	180				
Luteolin	0	30921.58±0.01	30921.58±0.01	30921.58±0.01	30921.58±0.01
	180	15857.05±0.03	17457.20±0.02	2563.06 ±0.03	11483.22±0.02
Kaempferol	0	-	-	-	0
	180				1561.65±0.03
Curmin	0	-	-	-	-
	180				
Thymoquinone	0	-	-	-	-
	180				
Alizarin	0	-	-	-	-
	180				
Hydroxyben	0	79.37± 0.02	79.37± 0.02	79.37± 0.02	79.37± 0.02
	180	83.65± 0.01	105.43± 0.01	50.86± 0.02	92.95± 0.00
Salicylic acid	0	6,60± 0.01	-	-	0
	180	0			11.00± 0.01
Quercetin	0	1558,31±0.02	1558,31±0.02	1558,31±0.02	1558,31±0.02
	180	684,05± 0.03	454,25± 0.03	540,79± 0.03	414,65± 0.01

Conclusion and recommendations

During storage, the pH value of the samples decreased while the free fatty acid values increased. These changes did not have any negative effects on the taste characteristics of the samples.

It was determined that the antioxidant capacity of the menengiç coffees was very high due to the presence of menengiç, and although there was a slight decrease in the antioxidant capacity of the prepared coffees during the storage period, the values remained relatively high. Therefore, menengiç coffees could be a good source of antioxidants. It was determined that oleic, linoleic, and palmitic fatty acids were the dominant fatty acids in menengiç coffees, while alpha-pinene, limonene, and β-ocimene were identified as the most abundant essential oils. In light of the obtained data, it was concluded that menengiç coffee, especially when prepared with water, can be consumed and stored as a ready-to-drink product. This practical option can be easily purchased and used by consumers. Furthermore, such a functional product holds significant potential for both introducing a new offering to the food industry and contributing to health benefits.

Ready-to-drink menengiç coffees will be highly appreciated by consumers. However, due to flocculation in coffees prepared with milk, more detailed studies should be conducted on this subject. Considering the recent increase in demand for functional, healthy, and practical products, the production of ready-to-drink menengiç coffee, which is typically difficult to prepare, will not only introduce a new product to the food industry but also add value to the economy. Increasing research in this area will be beneficial for introducing such functional and traditional products to the food industry and offering new flavors to consumers.

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