KSÜ Tarım ve Doğa Derg 29 (2), 503-519, 2026
KSU J. Agric Nat 29 (2), 503-519, 2026
DOI:10.18016/ksutarimdoga.vi.1770938

Milk Kefir and Water Kefir Production Using Loquat at Different Extent of Maturity

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ABSTRACT
Loquat (*Eriobotrya japonica* L.) is a subtropical fruit with a short shelf life after harvest. Transforming loquat into high-quality and long shelf-life products is essential to increase the consumption of the fruit. In this study, milk kefir and water kefir samples were produced with unripe green (G), semi-ripe yellow (Y), and ripe orange (O) loquat. The quality of samples was evaluated in terms of pH, Brix, color, total phenolic content (TPC), total flavonoid content (TFC), and antioxidant capacity (AOC) during the storage at 4±1 °C for 28 days. The sensorial quality of samples was determined by consumer acceptance and ranking tests. During the shelf-life, in milk kefir samples, pH decreased, and Brix increased. In water kefir samples, pH decreased, and brix remained constant by lyophilized culture (Method 1), pH increased, and brix decreased by kefir grain (Method 2). The water kefir produced with grain was closer to the color of the fresh fruit. The highest TPC, TFC, and AOC were observed in the water kefir produced with ripe orange loquat using Method 2 (OWK2). Based on the sensory evaluation, the most preferred milk kefir was produced from unripe green loquat (GMK), and water kefir was produced from semi-ripe yellow loquat using Method 1 (YWK1) with 33.75% and 18.4%, respectively. These results indicated the potential usage of loquat in high-quality milk kefir and water kefir production with extended shelf-life.

Food Science

Research Article

Article History
Received : 23.08.2025
Accepted : 03.10.2025

Keywords
Loquat
Kefir
Phenolics
Sensory evaluation
Shelf-life

Farklı Olgunluktaki Yenidünya Kullanılarak Süt Kefiri ve Su Kefiri Üretimi

ÖZET
Yenidünya (*Eriobotrya japonica* L.) hasat sonrası raf ömrü kısa olan subtropikal bir meyvedir. Meyvenin tüketimini artırmak için yüksek kaliteli ve uzun raf ömürlü ürünlere dönüştürülmesi önemlidir. Bu çalışmada, kabuklu olgunlaşmamış yeşil (G), yarı olgun sarı (Y) ve olgun turuncu (O) yenidünya kullanılarak su kefiri ve süt kefiri üretilmiştir. Örneklerin kalite özellikleri pH, briks, renk, toplam fenolik madde (TPC), toplam flavonoid içerik (TFC) ve antioksidan kapasite (AOC) açısından 4±1°C'de 28 gün depolama süresinde değerlendirilmiştir. Örneklerin duyusal özellikleri tüketici beğeni ve tercih testleri ile belirlenmiştir. Depolama süresinde, süt kefiri örneklerinde pH azaldı ve briks arttı. Su kefiri örneklerinde ise liyofilize kültür (Yöntem 1) ile pH azaldı ve briks değişmedi, dane (Yöntem 2) ile pH arttı ve briks azaldı. Dane (Yöntem 2) ile üretilen su kefiri renginin taze meyvenin rengine daha yakın olduğu belirlendi. En yüksek TPC, TFC ve AOC değerleri Yöntem 2 kullanılan olgun turuncu yenidünya ile üretilen su kefiri (OWK2) olduğu gözlemlendi. Duyusal analize göre en çok tercih edilen süt kefiri ve su kefiri sırasıyla %33,75 ile olgunlaşmamış yeşil yenidünyadan üretilen örnek (GMK) ve %18,4 ile yarı-olgun sarı yenidünyadan üretilen Yöntem 1'in uygulandığı örnektir (YWK1). Bu sonuçlar, yenidünya meyvesinin uzun raf ömrü ile yüksek kaliteli süt kefiri ve su kefiri üretiminde potansiyel kullanımını göstermektedir.

Gıda Bilimi

Araştırma Makalesi

Makale Tarihçesi
Geliş Tarihi : 23.08.2025
Kabul Tarihi : 03.10.2025

Anahtar Kelimeler
Yenidünya
Kefir
Fenolikler
Duyusal değerlendirme
Raf ömrü

Atıf İçin : Oner, M. E., & Karamanoglu, S., (2026). Farklı Olgunluktaki Yenidünya Kullanılarak Süt Kefiri ve Su Kefiri Üretimi. *KSÜ Tarım ve Doğa Derg 29* (2), 503-519. DOI: 10.18016/ksutarimdoga.vi.1770938.
To Cite: Oner, M. E., & Karamanoglu, S., (2026). Milk Kefir and Water Kefir Production Using Loquat at Different Extent of Maturity. *KSU J. Agric Nat 29* (2), 503-519. DOI: 10.18016/ksutarimdoga.vi.1770938.

INTRODUCTION

Loquat (*Eriobotrya japonica* L.) is a subtropical fruit with high nutritional value, consisting of vitamins A and B, minerals such as phosphorus, potassium, and calcium. It reduces the risk of diabetes, cancer, and cardiovascular diseases, strengthens the immune system, and regulates blood pressure (Liu et al., 2025). It is cultivated in Antalya and Mersin provinces in the Mediterranean region of Türkiye. The Ayva Gobek variety is grown in the Alanya district of Antalya, has received a geographical indication as "Alanya Loquat" (TürkPatent, 2018). Mostly, loquat is consumed fresh, and it is a perishable fruit with a short storage time after harvesting (Polat, 2024). Therefore, it is important to transform fresh loquat into high-quality and long shelf-life value-added products to increase the consumption of the fruit. Researchers have attempted to use loquat in the production of juice, nectar, jam, pulp, and leather and showed the potential usage of this fruit in different product types (Ozkan et al., 2024). In the study, they found total phenolic content (TPC) and total flavonoid content (TFC) of loquat products ranged from 61.2±5.4 to 855.7±36.0 mg GAE 100 g^{-1} and 37.2±1.6 to 979.5±65.3 mg CE 100 g^{-1}, respectively. They reported that the highest chlorogenic acid, *p*-coumaric acid, and epicatechin contents were obtained in loquat leather as 201.20±9.99 mg 100 g^{-1}, 47.50±2.21 mg 100 g^{-1}, and 46.87±0.28 mg 100 g^{-1}, respectively. In another study, Oner et al. (2024) investigated the effect of ultrasound pretreatment on the drying process of loquat cubes by using freeze and tray drying methods. This study indicated freeze drying method was a good option to produce low moisture content, high dehydration capacity, and enhanced phenolic content and antioxidant capacity in the final product.

Functional foods have a positive impact on health and reduce disease risks in addition to basic nutritional needs. Among the functional fermented foods, kefir, produced in two main forms, milk kefir and water kefir, offers positive effects on digestive health, immune system, and microbiota (Ganatsios et al., 2021). Both milk kefir and water kefir contain live microorganisms that support the digestive system. These microorganisms play a role in balancing the intestinal flora, strengthening the immune system, and suppressing pathogenic microorganisms Azizi et al., 2021). Traditional milk kefir is produced by adding kefir grains to pasteurized milk and then fermented at room temperature (20-25 °C) for 18-24 h. In industrial scale, milk kefir is produced using 1-3% commercial starter culture instead of kefir grains. In water kefir production, 5-10% grains are mixed with sugar and/or substrate with water and fermented at room temperature (20-25°C) for 24-48 h. Final products, both milk kefir and water kefir, were stored under refrigeration conditions (4±1 °C) up to 4 weeks (Guzel-Seydim et al., 2021; Gökırmaklı et al., 2025; Soutelino et al., 2025).

The addition of fruits to kefir drinks creates alternative value-added products. This fruit addition affects the pH, brix, color values, and bioactive contents of the kefir product, and changes are observed during the shelf life. Besides the usage of different milk types (Irkın & Songun, 2022), there have been several studies regarding the milk kefir production by using grapefruit, orange, and tangerine juice (Binici et al., 2023), plum (Kök-Taş et al., 2013), strawberry, banana, and apricot puree (Harmankaya et al., 2019). On the other side, researchers investigated the use of fruits in water kefir production, such as apple, orange, dragon fruit, and kiwi juices (Dikmetas et al., 2025), plum (Gökırmaklı et al., 2025), and aronia pomace and aronia juice (Esatbeyoglu et al., 2023). Mostly, these studies indicated that the addition of fruits in milk kefir and water kefir production enhanced the phenolics and improved the sensorial properties; thereby, acceptance of the kefir as a beverage. However, this may vary based on the fruit variety, maturity, and usage amount in the product (Turgut & Diler, 2023).

Value-added product from loquat has potential in enhancing the economic value of the fruit since postharvest physiological activity of loquat leads to rapid senescence and increased susceptibility of spoilage at ambient temperatures (Zhang et al., 2023). Even though the instability of functional components in processed product is a significant challenge, there have been studies about processing loquat into different final products (Qiao et al., 2024). These findings confirm the need for improvements in the loquat processing industry. Limited studies addressed loquat usage in milk kefir and water kefir production. The objective of this study is to produce milk kefir and water kefir using loquat harvested at different ripening stages (green, yellow, and orange color) in order to evaluate their effect on phenolics and antioxidants of kefir products. While milk kefir with loquat was produced with lyophilized culture, water kefir was produced with loquat using two different methods: lyophilized culture (Method 1) and grains (Method 2). Therefore, the effect of methods on the quality of water kefir was evaluated. The quality characteristics of the produced samples were determined by measuring pH, Brix, color, total phenolic (TPC) and flavonoid content (TFC), and antioxidant capacity (AOC). Changes in quality characteristics were observed during storage under refrigerated conditions at 4±1 °C for 14 and 28 days. Furthermore, milk kefir and water kefir samples were evaluated by sensory analysis.

MATERIAL and METHOD

Material

The Ayva Gobek variety of loquat (*Eriobotrya japonica* L.) in green (G), yellow (Y), and orange (O) colors according to the maturity stages was obtained from a local producer in Alanya/Antalya, TR. Lyophilized culture purchased from Sevdanem (Isparta, TR) was used in milk kefir production. Lyophilized culture obtained from Sevdanem (Isparta, TR) and kefir grains (5g/100ml) purchased from Etik-Farma (Sivas, TR) and activated in 10% sugar solution at 25 °C for 72 h were used for water kefir production.

Milk Kefir and Water Kefir Production

The loquat was washed and the seeds of the fruit were removed. Then, it was blended by using a laboratory-type blender (Waring Commercial Blender, Torrington, CT, USA). In milk kefir production, 50 mL of blended loquat and 0.25 g of lyophilized milk kefir culture were added to 450 mL of UHT milk (Dost, Balıkesir, TR) with 0.1% fat and fermented in an incubator (Memmert, Buchenbach, DE) at 25 °C for 72 h. Two methods were applied in water kefir production; in the first method (WK1), lyophilized water kefir culture and in the second method (WK2) activated kefir grain solution (inoculum) was used. In method 1 (WK1), 100 mL of 5% sugar solution, 25 mL of blended loquat, and 0.05 g of lyophilized water kefir culture were used and fermented in an incubator (Memmert, Buchenbach, DE) at 25 °C for 72 h. In method 2 (WK2), 100 mL of inoculum obtained from active water kefir grain and 25 mL of blended loquat were fermented in an incubator (Memmert, Buchenbach, DE) at 25 °C for 48 h. After fermentation, milk kefir and water kefir samples were stored in a freezer at -20±1 °C until further analysis. Descriptions of milk kefir and water kefir samples produced using loquat and loquat fruit at different maturity stages are shown in Table 1.

Table 1. Description of the loquat fruit and milk kefir and water kefir produced using the loquat
Çizelge 1. Yenidünya meyvesi ve yenidünya meyvesi kullanılarak üretilen süt ve su kefiri örneklerinin tanımları

Sample	Description
G	Unripe green color loquat
Y	Semi-ripe yellow color loquat
O	Ripe orange color loquat
NPO	Ripe orange color loquat with no peel
GMK	Milk kefir produced with lyophilized culture using unripe green color loquat
YMK	Milk kefir produced with lyophilized culture using semi-ripe yellow color loquat
OMK	Milk kefir produced with lyophilized culture using ripe orange color loquat
NPOMK	Milk kefir produced with lyophilized culture using ripe orange color loquat with no peel
GWK1	Water kefir produced with lyophilized culture using unripe green color loquat (Method 1)
YWK1	Water kefir produced with lyophilized culture using semi-ripe yellow color loquat (Method 1)
OWK1	Water kefir produced with lyophilized culture using ripe orange color loquat (Method 1)
NPOWK1	Water kefir produced with lyophilized culture using ripe orange color loquat with no peel (Method 1)
GWK2	Water kefir produced with water kefir grains using unripe green color loquat (Method 2)
YWK2	Water kefir produced with water kefir grains using semi-ripe yellow color loquat (Method 2)
OWK2	Water kefir produced with water kefir grains using ripe orange color loquat (Method 2)
NPOWK2	Water kefir produced with water kefir grains using ripe orange color loquat with no peel (Method 2)

TSS and pH Measurement

Total soluble solids (TSS) and pH of the samples were measured at 20±1 °C using a digital refractometer (Atago PAL-1, Tokyo, JP) and pH meter (Milwaukee Mi 151, ROU), respectively.

Color Analysis

Color analysis was performed using Konica Minolta (Konica Minolta CR-400, Tokyo, JP). The color values of the samples were determined as L* (darkness to lightness) changing between 0 to 100, a* (red to green), b* (yellow to blue) chromatic components ranging from +60 to -60, C* (least to full saturation) changing between 0 to 60, and Hue angle (h^o) ranging from 0 to 360, in which 0 or 360 red, 90 yellow, 180 green and 270 blue. Total color difference (ΔE*) was measured by using reference as a white standard calibration plate. During the measurements, 20 mL sample was placed in disposable petri dishes, and color values were randomly measured from 3 different points at room temperature (~20 °C).

Spectrophotometric Analysis

A UV-VIS spectrophotometer (Shimadzu UV-1280, Duisburg, DE) was used for spectrophotometric analysis, and each measurement was performed in three replicates with three repeats.

Samples (2.0 g) were homogenized with 5 mL of 75% aqueous methanol and then sonicated for 15 min and centrifuged (2700 rpm at 4 °C) for 10 min, and the supernatants were collected. This extraction procedure was repeated twice, and three supernatants were pooled. These extracts were stored at -20 °C until analysis (Capanoglu et al., 2008).

Total phenolic content (TPC) was determined using Folin-Ciocalteu reagent according to the method of (Singleton & Rossi, 1965). Measurements were performed at 765 nm, and TPC results were reported in gallic acid equivalent (mg GAE 100 mL^{-1}) of the sample.

Total flavonoid content (TFC) was evaluated according to the method of (Dewanto et al., 2002). Samples were analyzed at 510 nm, and TFC results were reported in rutin equivalent (mg RE 100 mL^{-1}) of the sample.

Antioxidant capacity (AOC) was determined by 1,1-diphenyl-2-picrylhydrazyl (DPPH) (Molyneux, 2004). Samples were measured at a wavelength of 517 nm, and the results were reported in mg trolox equivalent (mg TE 100 mL^{-1}).

Shelf-life Study

Milk kefir and water kefir samples with loquat fruit were placed in sterile centrifuge tubes and stored in the refrigerator at 4±1 °C. TSS, pH, color, TPC, TFC, and AOC of the samples were evaluated after 14 and 28 days of storage.

Sensory Analysis

In the sensory analysis of the consumer acceptance test, the samples were evaluated according to the sensory attributes of color, taste, aroma, odor, acidity, sweetness, turbidity, and overall liking by 16 semi-trained panelists using a nine-point hedonic rating scale (1: I did not like it at all to 9: I liked it a lot). Panelists were exposed to training with high-quality samples at the beginning of the evaluation. Four milk kefir and eight water kefir samples were served to panelists in transparent glasses separately (Meilgaard et al., 2015). The samples were randomly coded and served with water. In addition, a consumer ranking test was applied to determine the most favorable sample from milk kefir and water kefir samples.

Statistical Analysis

Statistical analysis was performed using JMP statistical software (JMP version 13.0; Cary, NC, USA). One-way analysis of variance (ANOVA) followed by Tukey's multiple comparison test at 95% confidence intervals was used to determine significant differences between samples. All analyses were repeated in twice and three replications (n=6) spectrophotometric analyses were repeated in triplicate and three replications (n=9). The results were expressed as mean ± standard deviation.

RESULTS and DISCUSSION

TSS and pH

The TSS and pH values of loquat increased during the ripening stages, as in most of the fruits (Shah et al., 2023). The TSS and pH values of loquat harvested at different extent of maturity are shown in Table 2. The TSS and pH value of loquat samples ranged from 6.00±0.14 to 12.65±0.35 and from 2.71±0.02 to 4.43±0.01, respectively. Due to lower pH values, the unripe green (G) and semi-ripe yellow (Y) loquat were more acidic than the ripe orange loquat fruits with (O) and without (NPO) peel ($p < .05$). Similarly, due to the low sugar content in unripe fruit, the TSS value was found as 6.00±0.14 for G and 8.05±0.07 for Y samples, while it was determined as 12.65±0.35 for O and 12.00±0.14 for NPO samples ($p < .05$).

Table 2. pH and TSS values of loquat fruit harvested at different extent of maturity
Çizelge 2. Farklı olgunlukta hasat edilen yenidünya meyvesinin pH ve TSS değerleri

Sample	pH	TSS (°Bx)
G	2.74±0.01c	6.00±0.14d
Y	2.71±0.02c	8.05±0.07c
O	4.43±0.01a	12.65±0.35a
NPO	4.11±0.01b	12.00±0.14b

[a-d] Data in the same column followed by the same letter are not significantly different ($p > .05$).

The TSS and pH changes as a result of the metabolic activities of microorganisms during the fermentation. The TSS decreases due to the consumption of sugar as an energy source by microorganisms, and the pH, which affects the product quality (taste, flavor, aroma, etc.), decreases due to the organic acids produced by microorganisms. In milk kefir production, lactose sugar in milk turns into lactic acid with the development of lactic acid bacteria during fermentation, and thereby, the pH value decreases (Binici et al., 2023). For this reason, as shown in Table 3 (a), the pH of all samples during the milk kefir fermentation period of 72 h decreased significantly ($p < .05$). Meanwhile, a significant decrease was observed in TSS of all milk kefir samples during fermentation, indicating sugar was used as a carbon source (Gamba et al., 2019). The TSS and pH values of water kefir samples obtained from loquat harvested at different extent of maturity by applying 2 different production methods are shown in Table 3 (b). Fermentation time, environment, and temperature, and grain microbiota, have an effect on the pH value of the product (Soutelino et al., 2025). The pH values of the water kefir samples produced by first method (GWK1, YWK1, OWK1, NPOWK1) and second method (GWK2, YWK2, OWK2, NPOWK2) decreased significantly after 72 h and 48 h or fermentation process, respectively ($p < .05$). Similar results were obtained in TSS values of water kefir samples, which were also decreased significantly after fermentation ($p < .05$). This is because sugar content of water kefir prepared from fruit juices decreases due to conversion of sugar into ethanol and CO_2 during fermentation. These observations are consistent with the findings that water kefir samples produced by using mandarin and persimmon fruits (Güzel-Seydim et al., 2023).

Table 3. Changes in the pH and TSS values of milk kefir (a) and water kefir (b) with loquat during the fermentation period

Çizelge 3. Yenidünya meyvesi ile üretilen süt kefiri (a) ve su kefirinin (b) fermantasyon sürecinde pH ve TSS değişimi

(a)	pH		TSS (°Bx)	
Sample	0 h	72 h	0 h	72 h
GMK	5.91±0.02A	5.71±0.02B	9.30±0.01A	6.80±0.14B
YMK	6.61±0.01A	6.40±0.01B	9.50±0.14A	6.00±0.14B
OMK	7.94±0.01A	7.69±0.01B	10.20±0.01A	7.10±0.14B
NPOMK	8.24±0.00A	7.90±0.01B	10.35±0.07A	7.15±0.07B

[A-B] Data in the same row followed by the same letter are not significantly different ($p > .05$).

(b)	pH			TSS (°Bx)		
Sample	0 h	48 h	72 h	0 h	48 h	72 h
GWK1	4.32±0.01A	-	4.18±0.01B	3.80±0.14A	-	1.35±0.07B
YWK1	4.12±0.02A	-	4.04±0.01B	4.70±0.14A	-	2.75±0.21B
OWK1	5.16±0.01A	-	4.72±0.01B	5.45±0.01A	-	3.85±0.07B
NPOWK1	5.13±0.01A	-	4.58±0.01B	5.15±0.01A	-	3.65±0.07B
GWK2	4.45±0.01A	4.23±0.01B	-	7.25±0.07A	5.35±0.07B	-
YWK2	4.32±0.01A	4.16±0.01B	-	8.80±0.14A	6.90±0.14B	-
OWK2	5.21±0.01A	4.88±0.01B	-	9.85±0.07A	5.25±0.07B	-
NPOWK2	4.91±0.01A	4.75±0.01B	-	10.50±0.14A	6.40±0.14B	-

The TSS and pH values of milk kefir obtained from loquat harvested at different extent of maturity during 28 days of storage at 4±1 °C are shown in Table 4 (a). In all milk kefir samples, pH value decreased significantly after 14 days of storage ($p < .05$), and further decrease was observed in most samples after 28 days of storage; therefore, acidity of samples increased during the refrigerated storage conditions. This decrease in pH value might be due to the breakdown of lactose by bacteria and creating an acidic environment, and thereby, milk kefir becomes acidic (Guzel-Seydim et al., 2021). When the TSS value was evaluated, an increasing trend was observed in OMK and NPOMK from milk kefir samples produced from fruit with high sugar content at 0, 14, 28 days storage time ($p < .05$). There was no difference in TSS values in milk kefir produced using unripe green loquat for 14 and 28 days of storage at 4±1 °C ($p > .05$). The pH and TSS values of water kefir obtained from loquat harvested at different extent of maturity by applying 2 different methods during 28 days of storage under refrigerator conditions (4±1 °C) was shown in Table 4 (b). After 28 days of storage, a significant decrease in pH values was determined in water kefir samples produced with lyophilized culture (method 1) ($p < .05$). However, in water kefir samples obtained by using kefir grains (method 2), pH values decreased at the end of 14 days but increased at the end of 28 days ($p < .05$). These results are consistent with the finding that water kefir samples fermented by using lyophilized culture and addition of pomegranate and/or orange juice during the 4 weeks of shelf-life (Kazakos et al., 2016). There was no difference observed in the TSS values of GWK1, OWK1 and NPOWK1 water kefir samples obtained by the first method during 28 days of storage at 4±1 °C ($p > .05$), and a decrease in YWK1 was determined only in water kefir

produced using semi-ripe yellow loquat fruit ($p < .05$). However, the TSS value of water kefir samples obtained using the second method decreased during the 28-day shelf-life period ($p < .05$). This revealed that the usage of lyophilized culture or grain in production affected the TSS and pH of the water kefir since grains had better acidification ability compared to lyophilized culture, which resulted in higher amounts of microorganisms and thereby changes in the final product (Szkolnicka et al., 2024). For example, when the first water kefir production method was applied using unripe green loquat, there was no difference between the TSS values at the end of the shelf-life period of 0, 14, and 28 days. When the second method was applied to the same conditions, the TSS value in the GWK2 sample decreased to 5.35±0.07, 3.65±0.07, and 3.35±0.07 at the end of 0, 14, 28 days, respectively ($p < .05$). The degree of ripeness in fruits is essential as one of the determining factors in sugar content. At the same time, the continuation of microbial activity during storage causes a decrease in sugar content (Gökırmaklı et al., 2025).

Table 4. Changes in the pH and TSS values of milk kefir (a) and water kefir (b) with loquat during the shelf-life
Çizelge 4. Yenidünya meyvesi ile üretilen süt kefiri (a) ve su kefirinin (b) raf ömrü süresinde pH ve TSS değişimi

(a)		pH			TSS (°Bx)	
Sample	0 day	14 days	28 days	0 day	14 days	28 days
GMK	5.71±0.02dA	4.90±0.01cB	4.72±0.01cC	6.80±0.14aA	5.60±0.14cB	5.90±0.14dB
YMK	6.40±0.01cA	5.04±0.01bB	5.02±0.01aB	6.00±0.14bB	6.05±0.07bB	6.45±0.07cA
OMK	7.69±0.01bA	5.12±0.01aB	4.96±0.01bC	7.10±0.14aC	7.45±0.07aB	7.95±0.07bA
NPOMK	7.90±0.01aA	5.13±0.01aB	4.93±0.01bC	7.15±0.07aC	7.75±0.21aB	8.65±0.07aA
(b)		pH			TSS (°Bx)	
Sample	0 day	14 days	28 days	0 day	14 days	28 days
GWK1	4.18±0.01fA	4.14±0.00eB	3.94±0.01eC	1.35±0.07fA	1.35±0.07fA	1.15±0.07gA
YWK1	4.04±0.01gA	4.02±0.01gA	3.88±0.01fB	2.75±0.21eA	2.30±0.14eAB	2.05±0.07fB
OWK1	4.72±0.01cA	3.94±0.01hB	3.81±0.01gC	3.85±0.07dA	4.05±0.07bcA	4.15±0.21bA
NPOWK1	4.58±0.01dA	4.43±0.01cB	4.34±0.01dC	3.65±0.07dA	3.80±0.01cdA	3.75±0.07cdA
GWK2	4.23±0.01eB	4.18±0.01dB	4.64±0.01cA	5.35±0.07cA	3.65±0.07dB	3.35±0.07eC
YWK2	4.16±0.00fB	4.11±0.01fC	4.62±0.01cA	6.90±0.14aA	3.55±0.07dB	3.45±0.07deB
OWK2	4.88±0.00aB	4.67±0.01aC	5.08±0.01aA	5.25±0.07cA	4.10±0.14bB	3.85±0.07cB
NPOWK2	4.75±0.01bB	4.49±0.02bC	4.86±0.01bA	6.40±0.14bA	5.15±0.21aB	4.75±0.07aB

[a-g, A-C] Data in the same column followed by the same lower-case letters and in the same row followed by the same upper-case letters are not significantly different ($p > .05$).

Color

The quality of fermented products is also associated with their sensory characteristics perceived by the consumer, and color forms the first impression of a product, which plays a decisive role in consumer preferences. The color values of green (G), yellow (Y), and orange (O) loquat harvested at different extent of maturity are given in Table 5. According to the color values of the loquat, the NPO sample had the lightest color with the highest L* value of 40.49, while the green loquat fruit (G), which was unripe, had the darkest color with 35.51 ($p < .05$). There was no significant difference between the yellow semi-ripe fruit (Y) and the orange fruit without skin (NPO) ($p > .05$). The O and NPO samples showed a significant increase in redness (a*) compared to the other G and Y samples due to the ripeness of the fruits ($p < .05$). The highest b* value was detected in the yellow loquat (Y) harvested during the semi-ripening period, as it had the yellowest color compared to the other samples ($p < .05$). The yellow loquat (Y) with the highest C* value had the most vivid color ($p < .05$) compared to the other samples, while the ripe orange (O) showed no difference ($p > .05$). Total color difference (ΔE*) was highest in the unripe green loquat (G) ($p < .05$), but no significant difference was detected between Y, O and NPO fruits ($p > .05$). Results indicating that the ripeness level of the fruit was essential in color quality. These findings confirm the study by Çoklar & Akbulut (2016), who reported the increase in maturity level of hawthorn fruit resulted in darker and reddish color; therefore, more vivid and yellow color was determined in ripe hawthorn fruit compared to unripe ones.

Table 5. Color values of the loquat fruit harvested at different extent of maturity
Çizelge 5. Farklı olgunlukta hasat edilen yenidünya meyvesinin renk değerleri

Sample	L*	a*	b*	C*	h°	ΔE*
G	35.51±1.37c	1.58±0.22c	5.38±0.34b	5.61±1.30b	73.09±4.21a	58.16±1.35a
Y	39.09±1.37ab	3.57±0.11b	8.11±0.98a	8.86±0.94a	66.12±2.04b	54.80±1.30b
O	37.21±0.40bc	4.45±0.27a	5.64±0.66b	7.19±0.06ab	51.58±1.78c	56.64±0.38ab
NPO	40.49±0.59a	4.54±0.48a	4.14±0.25b	5.95±0.25b	50.00±0.69c	54.45±0.46b

[a-c] Data in the same column followed by the same letter are not significantly different ($p > .05$).

The changes in color values of milk kefir produced from G, Y, O, and NPO fruits during 28 days of storage at 4±1 °C are given in Table 6. On day 0, the darkest color was obtained in OMK, while the lightest color was determined in (NPOMK) ($p < .05$). This might be due to the intensity of the color pigment in the peel. Since the OMK sample had the most vivid color (C*: 26.86) and the most yellowish color (b*: 27.38) compared to the others. In addition, the total color difference (ΔE*) was highest in the OMK sample ($p < .05$), while no significant difference was observed between YMK and NPOMK samples ($p > .05$). The color of milk kefir can be affected by factors such as production method and time, the fruit used and its ratio, and the rate of oxidation of polyphenolic enzymes during the preparation of the fruit (Soutelino et al., 2025). During the 28 days of storage period, the L* value of the milk kefir samples decreased ($p < .05$), thus darkening in color was observed. Besides, the redness increased in all samples ($p < .05$), the yellowness (b*) did not change in GMK and NPOMK samples ($p > .05$), while it decreased in YMK and OMK samples ($p < .05$). No change was observed in chroma value (C*), and thereby, color intensity of GMK, OMK and NPOMK samples ($p > .05$). At the end of 28 days storage, the hue angle (h°) of the GMK sample approached from green to yellow color, but there was a decrease in yellowness of YMK, OMK and NPOMK samples ($p < .05$). Total color difference (ΔE*) increased after 28 days of storage in GMK, OMK and NPOMK samples ($p < .05$).

Table 6. Changes in the color values of milk kefir with loquat during the shelf-life
Çizelge 6. Yenidünya meyvesi ile üretilen süt kefirinin raf ömrü süresinde renk değerleri

	L*			a*		
Sample	0 day	14 days	28 days	0 day	14 days	28 days
GMK	75.07±0.60aA	75.84±0.35aA	70.93±1.53abB	-1.56±0.5bB	-1.86±0.19cB	0.92±0.02cA
YMK	73.38±0.82bA	72.64±0.21bAB	71.88±0.52aB	-0.71±0.97bB	0.28±0.23bAB	0.62±0.11cA
OMK	69.77±1.12cA	69.67±0.36dA	67.35±0.07cB	2.88±0.65aB	2.11±0.10aB	4.07±0.26aA
NPOMK	75.47±0.62aA	71.11±0.99cB	69.78±0.29bB	-1.38±0.43bC	0.45±0.34bB	1.44±0.21bA
	b*			C*		
Sample	0 day	14 days	28 days	0 day	14 days	28 days
GMK	14.03±0.87cA	11.87±0.23dB	13.82±0.45dA	14.32±0.59cA	12.01±0.23dB	14.37±0.18dA
YMK	22.59±0.95bA	19.18±0.50cB	18.06±0.17cB	22.48±0.79bA	19.21±0.51bB	18.07±0.18cC
OMK	27.38±0.94aA	26.35±0.57aAB	25.61±0.63aB	26.86±1.36aA	26.80±0.39aA	25.93±0.62aA
NPOMK	22.70±0.85bAB	22.49±0.14bB	23.52±0.16bA	22.74±0.82bA	18.44±0.33cB	23.55±0.16bA
	h°			ΔE*		
Sample	0 day	14 days	28 days	0 day	14 days	28 days
GMK	97.61±0.57aA	98.24±0.41aA	94.21±0.54aB	21.41±0.97cB	19.24±0.34dC	25.61±1.36cA
YMK	91.26±1.08cA	90.85±0.68bA	88.02±0.34bB	25.47±0.70bA	25.65±0.45cA	25.68±0.53cA
OMK	83.19±0.51dB	85.36±0.29bA	80.96±0.64cC	32.61±0.44aB	32.67±0.46aB	34.04±0.37aA
NPOMK	92.91±0.20bA	90.75±0.58bB	88.79±0.66bC	25.96±0.62bC	28.81±0.21bB	30.58±0.26bA

[a-d, A-C] Data in the same column followed by the same lower-case letters and in the same row followed by the same upper-case letters are not significantly different ($p > .05$).

The changes in color values of the water kefir obtained by applying 2 different methods from the loquat harvested at different extent of maturity during 28 days of storage at 4±1 °C are shown in Table 7. In day 0, the lightest color was detected in the orange loquat water kefir without peel obtained by Method 2, which is NPOWK2 sample with 77.09 L* value, while the darkest color was detected in GWK2 and YWK2 samples with the lowest L* values of 66.57 and 66.32 ($p < .05$). When GWK and OWK samples were compared based on the method applications, more yellowish color was obtained with the second method ($p < .05$), indicating closer to the fruit color was obtained in water kefir produced with water kefir grains. Similarly, the OWK2 sample had the most vivid color with the highest C* value ($p < .05$). Therefore, the production method and duration of water kefir production, the fruit used and its ratio, and the rate of oxidation of polyphenolic enzymes during the preparation of the fruit affect the color quality of the final product. For example, researchers found that dark color after usage of apple and dragon fruit in water kefir, while light color was observed when kiwi and orange juice were used (Dikmetas et al., 2025), which might be due to polyphenol oxidase enzyme activity. In another study, more vivid and bright color was determined in water kefir prepared with aronia pulp and aronia juice due high level of anthocyanin content of aronia (Esatbeyoglu et al., 2023). Moreover, the addition of date made water kefir redder, while tangerine water kefir had a more yellow

color (Güzel-Seydim et al., 2023), which indicated that fruit color and its concentration were more effective in the color of water kefir products.

Table 7. Changes in the color values of water kefir with loquat during the shelf-life
Çizelge 7. Yenidünya meyvesi ile üretilen su kefirinin raf ömrü süresinde renk değerleri

	L*			a*		
Sample	0 day	14 days	28 days	0 day	14 days	28 days
GWK1	69.49±0.28eA	47.53±0.70gC	67.55±0.82eB	1.00±0.05aC	4.51±0.26aA	1.66±0.07bB
YWK1	69.95±0.31eA	67.73±0.51cB	67.76±0.79eB	0.81±0.14abB	0.66±0.24efB	2.88±0.16aA
OWK1	73.25±0.65cA	70.17±0.63bB	72.79±0.97bA	0.09±0.15cB	0.10±0.02gB	1.73±0.15bA
NPOWK1	75.79±0.97bA	74.25±1.15aA	70.99±0.86cB	0.17±0.05cB	0.53±0.08fB	2.55±0.44aA
GWK2	66.57±0.53fB	59.62±0.54eC	72.45±0.53bA	0.71±0.02abC	2.10±0.22cA	1.48±0.42bB
YWK2	66.32±0.71fB	63.23±0.66dC	69.43±0.62dA	0.69±0.35bB	0.97±0.10eB	2.46±0.42aA
OWK2	71.65±0.42dB	56.86±0.90fC	83.56±0.88aA	0.29±0.24cB	3.26±0.46bA	0.15±0.07cB
NPOWK2	77.09±0.62aB	60.77±0.43eC	84.67±0.71aA	0.34±0.04cB	1.55±0.19dA	0.26±0.07cB

	b*			C*		
Sample	0 day	14 days	28 days	0 day	14 days	28 days
GWK1	11.46±0.35eC	21.86±0.08cA	17.51±0.66dB	11.50±0.34eC	21.79±0.77cA	17.36±0.59eB
YWK1	13.35±0.71dB	14.25±0.36gB	24.35±0.76bA	13.04±0.16dC	14.74±0.37fB	23.61±0.55cA
OWK1	14.69±0.34cB	15.73±0.48fB	28.25±0.90aA	14.92±0.66bC	16.40±0.20eB	28.22±0.85aA
NPOWK1	9.92±0.47fB	6.92±0.10hC	27.20±0.66aA	9.66±0.56fB	6.83±0.19gC	27.02±0.38bA
GWK2	15.58±0.41bB	16.42±0.29eB	21.10±0.62cA	15.61±0.40bC	16.88±0.57deB	21.18±0.65dA
YWK2	14.04±0.44cdC	17.77±0.37dB	21.65±0.45cA	14.02±0.53cC	17.46±0.73dB	21.91±0.33dA
OWK2	16.66±0.42aB	28.08±0.37aA	15.53±0.97eB	17.10±0.70aB	28.28±0.51aA	16.06±0.47fB
NPOWK2	9.23±0.09fC	22.58±0.43bA	13.03±0.41fB	9.44±0.52fC	22.88±0.99bA	13.02±0.42gB

	h°			ΔE*		
Sample	0 day	14 days	28 days	0 day	14 days	28 days
GWK1	85.00±0.41eA	78.69±1.00fB	83.6±0.64eA	25.18±0.19cC	27.47±0.35dB	29.59±1.16cA
YWK1	86.56±0.44dB	88.00±0.78cA	84.04±0.83deC	25.30±0.47cC	28.23±0.74dB	31.67±0.37abA
OWK1	89.98±0.49cA	90.55±0.30bA	85.63±0.40cB	22.25±0.86dC	25.86±0.83eB	32.25±0.83aA
NPOWK1	91.00±0.83bB	93.78±0.36aA	84.77±0.35cdC	19.43±0.57eB	19.53±0.71fB	32.66±0.88aA
GWK2	87.10±0.45dA	83.00±0.46eC	85.53±0.83cB	27.65±0.41aB	36.37±0.64bA	26.84±0.58dB
YWK2	87.31±0.55dA	86.82±0.24dA	84.00±0.66deB	26.32±0.47bC	32.78±0.95cA	30.21±0.96bcB
OWK2	90.23±0.77bcA	82.98±0.82eB	90.08±0.72bA	25.09±0.88cB	44.03±0.67aA	15.32±1.21eC
NPOWK2	92.31±0.32aA	86.90±0.93cdB	91.22±0.36aA	19.08±0.44eB	36.88±0.80bA	12.95±0.34fC

[a-h, A-C] Data in the same column followed by the same lower-case letters and in the same row followed by the same upper-case letters are not significantly different ($p > .05$).

In shelf-life study, at the end of 14 days a decrease in L* value ($p < .05$), and thus, darkening was observed in all water kefir samples except NPOWK1; however, at the end of the 28-day storage period, all water kefir samples except OWK1 had lighter color and thereby color loss was observed. Reddish color (a*) remained constant or increased in water kefir samples after 14 and 28 days of storage. A significant increase in the b* values expressing the yellowish color was observed during the storage period ($p < .05$). It is thought this may be due to the continued extraction of color pigments from loquat fruit during storage. When chroma (C*) was evaluated, a significant increase ($p < .05$) was determined in all water kefir samples during the 28 days of storage at 4±1°C, thus increasing the color intensity. When two production methods were compared, the water kefir samples (OWK1 and NPOWK1) produced by first method showed more yellowish and intense color compared to same samples produced by second method ($p < .05$). Hue angle (h°) values showed that OWK2 and NPOWK2 samples produced using the second method retained their yellow color characteristics for 28 days of storage ($p > .05$). Total color difference (ΔE*) generally increased in all water kefir samples during storage.

TPC, TFC, and AOC

Phenolic compounds have positive effects on health as well as color, taste, odor, and bitterness in foods. They are mostly found in fruits and vary according to fruit type, climatic conditions, ripeness, and growing season. Flavonoids derived from plants are also the most common group of naturally occurring phenolic substances (Costa

et al., 2022). The TPC, TFC, and AOC values of loquat fruit harvested at different extent of maturity are shown in Figure 1. The highest TPC, TFC and AOC value was obtained in unripe green loquat (G) compared to loquat fruits of Y, O and NPO ($p < .05$). The decrease in total phenolics content and antioxidant capacity with an increase in ripeness of the fruit might be due to continuous decrease in phenolics during loquat fruit development as in peach, grape and olive (Garrido et al., 2016; López-Huertas & Palma, 2020; Zhang et al., 2022; Li et al., 2023). Whereas other researchers reported an increase in phenolic compounds during the ripening period of blueberries and mandarins (Aires et al., 2017; Costanzo et al., 2022). Phenolics are strongly affected by many factors, including cultivar, species, ripeness, harvest time, climatic conditions, storage time, and environment. Additionally, there was no significant difference observed in orange loquat with peel (O) and no peel (NPO) fruits based on TPC, TFC, and AOC values.

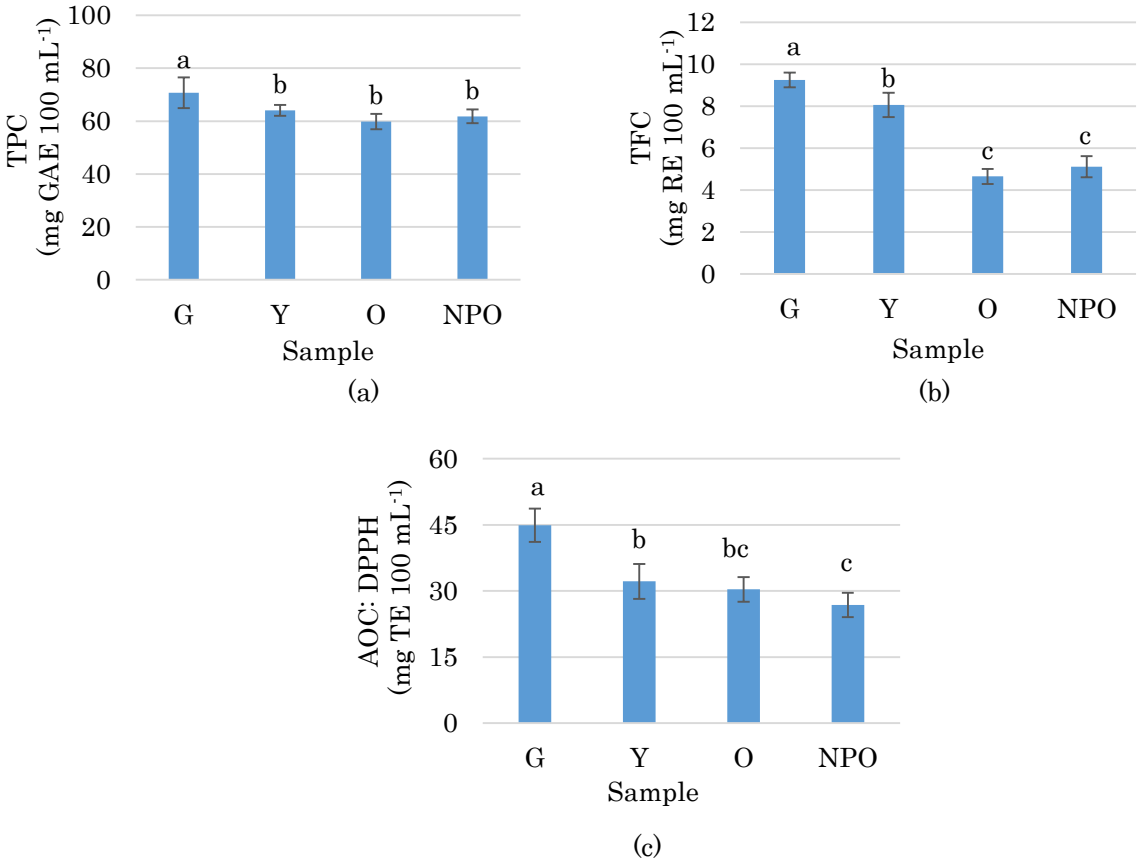

Figure 1. TPC (a), TFC (b) and AOC (c) values of loquat fruit harvested at different extent of maturity. Same letters in the graph are not significantly different ($p > .05$).

Şekil 1. Farklı olgunlukta hasat edilen yenidünya meyvesinin TPC (a), TFC (b) ve AOC (c) değerleri. Grafikteki benzer harfler farklılık göstermemektedir ($p > .05$).

Phenolic substances, which are microbiologically and nutritionally important, play an essential role in human health. Milk kefir is an important source of phenolic substances due to compounds in milk, and also significant increase occurs when combined with fruit and thereby its phenolics (Sabokbar & Khodaiyan, 2016). The TPC values of milk kefir obtained from loquat harvested at different extent of maturity during 28 days of storage at 4±1 °C are shown in Table 8 (a). On day 0, the TPC values of GMK, YMK, OMK, and NPOMK were 29.02±0.53, 20.54±0.28, 17.83±0.29, and 28.77±0.43 mg GAE 100 mL^{-1}, respectively. The highest TPC obtained in milk kefir sample produced from unripe green loquat (GMK); however, it was not significantly different from with milk kefir produced from no peel ripe orange loquat (NPOMK) ($p > .05$). In general, it was observed that the TPC increased in all milk kefir samples at the end of 28 days storage ($p < .05$). This is might be due to the continuation of the metabolic activities of microorganisms in kefir (Tzavaras et al., 2022). When milk kefir made of goat milk and kefir grains was investigated, a significant increase in TPC was observed after 14 days of storage; however, a decrease was determined after 21 days of storage (Yilmaz-Ersan et al., 2016). Besides the fermentation method and storage period, milk type and fruit addition were effective on phenolic compounds during the storage period (Soutelino et

al., 2025). In the current study usage of fruit increased the phenolics in milk kefir up to 28 days of refrigerated storage.

The changes in TPC values of the water kefir obtained by applying two different methods from the loquat harvested at different extent of maturity during 28 days of storage at 4±1 °C are shown in Table 8 (b). On day 0, the TPC values of water kefir samples fermented using lyophilized culture (Method 1) and kefir grains (Method 2) ranged from 14.87±4.69 to 20.91±2.29 mg GAE 100 mL^{-1} and from 13.57±0.97 to 25.48±0.91 mg GAE 100 mL^{-1}, respectively. It was observed that the water kefir (OWK2) produced by the second method had the highest TPC value ($p < .05$). In addition, the lowest TPC was obtained in GWK produced by either method 1 or 2 ($p < .05$), indicating the sugar content of the fruit is effective on TPC enhancement. These findings confirm other research results, such as the highest TPC in water kefir produced by using dates with high sugar content when compared to kefir produced with tangerine (Güzel-Seydim et al., 2023). During the 28 days of storage, there was no significant change observed in the GWK1 ($p > .05$), but a decrease was detected when the second method was applied in kefir production ($p < .05$). When compared to the day 0 samples, the TPC of YWK1 did not change ($p > .05$), while an increase was observed in the OWK1 sample ($p < .05$). Compared to the first method, a significant decrease was found in the water kefir samples produced by the second method at the end of 28 days ($p < .05$). These results indicating in water kefir production, the method applied, the type and ripeness of the fruit and storage time affected the TPC (Tu et al., 2019; Ozcelik et al., 2021).

Table 8. Changes in the TPC of milk kefir (a) and water kefir (b) with loquat during the shelf-life
Çizelge 8. Yenidünya meyvesi ile üretilen süt kefiri (a) ve su kefirinin (b) raf ömrü süresinde TPC değişimi

(a)	TPC (mg GAE 100 mL^{-1})		
Sample	0 day	14 days	28 days
GMK	29.02±0.53aC	34.75±0.21aB	38.46±0.31bA
YMK	20.54±0.28bC	23.24±0.34cB	25.57±0.15dA
OMK	17.83±0.29cB	34.61±0.19aA	34.99±0.72cA
NPOMK	28.77±0.43aC	33.99±0.39bB	40.00±0.91aA
(b)	TPC (mg GAE 100 mL^{-1})		
Sample	0 day	14 days	28 days
GWK1	14.87±4.69dA	12.03±0.64hA	13.58±0.09gA
YWK1	20.71±0.64bcAB	20.62±0.12dB	21.11±0.19bA
OWK1	18.25±1.03cC	36.16±0.20bA	25.05±0.13aB
NPOWK1	20.91±2.29bB	41.52±0.22aA	18.57±0.07dC
GWK2	13.57±0.97dA	13.80±0.69gA	12.12±0.14hB
YWK2	18.50±1.66bcA	16.62±0.55fB	17.32±0.12eAB
OWK2	25.48±0.91aA	23.16±0.31cB	20.40±0.09cC
NPOWK2	19.18±2.21bcA	17.64±0.14eA	14.44±0.10fB

[a-h, A-C] Data in the same column followed by the same lower-case letters and in the same row followed by the same upper-case letters are not significantly different ($p > .05$).

The TFC of milk kefir obtained from loquat harvested at different extent of maturity during 28 days of storage at 4±1 °C is shown in Table 9 (a). On day 0, TFC of milk kefir samples was determined as 28.15±0.84, 15.19±0.52, 13.50±0.56, 13.45±0.60 mg RE 100 mL^{-1} for GMK, YMK, OMK, and NPOMK samples, respectively. Similar to the TPC, the highest TFC was determined in milk kefir (GMK) produced from unripe green loquat ($p < .05$). As the fruit kept ripening, the TFC decreased in milk kefir samples regardless with peel or no peel ($p < .05$). When day 0 and day 28 samples were compared, significant increase was illustrated in TFC ($p < .05$). Similar results to TPC values were observed in TFC of milk kefir samples. When OMK and NPOMK were compared, a significant increase in TFC of NPOMK was found at the end of 28 days, which might be due to the greater extraction of phenolics and flavonoids from the fruit without peel and thereby a larger surface area as the time prolongs (Tzavaras et al., 2022).

The changes in TFC of water kefir obtained by applying two different methods from loquat harvested at different extent of maturity during 28 days of storage at 4±1 °C are shown in Table 9 (b). On day 0, the TFC of water kefir samples in the order of GWK, YWK, OWK, NPOWK produced using methods 1 and 2 were 3.76±0.34, 9.47±0.34, 8.77±0.34, 7.58±0.25 mg RE 100 mL^{-1} and 6.45±0.71, 10.00±0.50, 10.77±0.28, 6.130.37 mg RE 100 mL^{-1}, respectively. When these two water kefir production methods were compared, the TFC was higher in YWK2 and OWK2 samples produced by using method 2. Besides the method applied, the degree of fruit ripeness, and thereby, the sugar content, affects the TFC in the final product (Liu et al., 2025). During the shelf-life, the TFC of the water kefir samples obtained by applying the first and second methods were varied from 3.76±0.34 to 9.47±0.34 mg RE

100 mL^{-1} and from 6.45±0.71 to 10.77±0.28 mg RE 100 mL^{-1} in day 0, from 5.05±0.41 to 9.88±0.85 mg RE 100 mL^{-1} and from 7.22±0.27to 14.93±0.42 mg RE 100 mL^{-1} in day 14, from 5.99±0.41 to 10.17±0.34 mg RE 100 mL^{-1} and from 5.50±0.38 to 13.48±0.32 mg RE 100 mL^{-1} in day 28, respectively as shown in Table 9 (b). While an increase in TFC was observed in OWK1 and NPOWK1 samples ($p < .05$) at the end of 28 days of storage, when the same samples were produced by using the second method a decrease was observed in TWK2 ($p < .05$) and no significant difference was determined in NPOWK2 ($p > .05$). This is indicating the difference between producing methods also affected TFC during storage time. This might be due to higher microbial activity in water kefir produced with kefir grains than lyophilized yeast. Similarly, other researchers had reported an increase in TFC from 13.71 to 17.16 mg L^{-1} in water kefir obtained from soy whey using water kefir grains at different storage times (Tu et al., 2019).

Table 9. Changes in the TFC of milk kefir (a) and water kefir (b) with loquat during the shelf-life
Çizelge 9. Yenidünya meyvesi ile üretilen süt kefiri (a) ve su kefirinin (b) raf ömrü süresinde TFC değişimi

(a) Sample	TFC (mg RE 100 mL^{-1}) 0 day	14 days	28 days
GMK	28.15±0.84aC	30.18±1.24aB	37.82±0.27aA
YMK	15.19±0.52bB	12.34±0.78cC	20.27±0.36bA
OMK	13.50±0.56cB	13.21±0.29bcB	17.78±0.33dA
NPOMK	13.45±0.60cB	13.74±0.27bB	18.87±0.37cA
(b) Sample	**TFC (mg RE 100 mL^{-1}) 0 day**	**14 days**	**28 days**
GWK1	3.76±0.34gC	5.05±0.41gB	5.99±0.41gA
YWK1	9.47±0.34cAB	9.88±0.85cA	8.96±0.40dB
OWK1	8.77±0.34dB	8.67±0.70dB	10.17±0.34bA
NPOWK1	7.58±0.25eB	7.08±0.36fC	8.02±0.31eA
GWK2	6.45±0.71fB	7.99±0.27eA	5.50±0.38hC
YWK2	10.00±0.50bC	14.93±0.42aA	13.48±0.32aB
OWK2	10.77±0.28aB	14.35±0.21aA	9.54±0.40cC
NPOWK2	6.13±0.37fB	7.22±0.27fA	6.59±0.51fB

*Data in the same column followed by the same lower-case letters and in the same row followed by the same upper-case letters are not significantly different ($p > .05$).

The AOC of milk kefir obtained from loquat harvested at different extent of maturity during 28 days of storage at 4±1 °C is shown in Table 10 (a). By using the DPPH method, AOC of GMK, YMK, OMK, and NPOMK were determined as 8.58±0.56, 7.68±0.46, 2.19±0.50, and 5.48±1.00 mg TE 100 mL^{-1}, respectively, on day 0. With the unripe green loquat, GMK had the highest AOC throughout the samples ($p < .05$). It is important to highlight that the usage of unripe fruit increased acidity, which enhanced the antioxidants. Our result was consistent with the findings in a study in which higher AOC was found in milk kefir obtained with a lower pH grapefruit juice rather than orange or mandarin using grapefruit juice (Binici et al., 2023). In the shelf-life study, the AOC of GMK, YMK, OMK, and NPOMK samples were determined as 8.58±0.56, 7.68±0.46, 2.19±0.50, and 5.48±1.00 mg TE 100 mL^{-1} in day 0, 9.24±0.21, 7.74±0.65, 5.90±0.96, and 4.49±0.65 mg TE 100 mL^{-1} in day 14, 14.02±0.14, 3.24±0.24, 0.74±0.13, and 0.70±0.03 mg TE 100 mL^{-1} in day 28, respectively. GMK had the highest AOC when compared to other samples during the storage period ($p < .05$). At the end of 28 days of storage, no significant difference was observed between OMK and NPOMK ($p > .05$). In YMK and OMK samples, the amount of AOC remained the same or decreased after 14 days of storage. The fruit type and its antioxidant capacity used in milk kefir production might be effective during the storage period. For instance, water kefir produced using different concentrations of black mulberry, strawberry, pomegranate, and black carrot showed an increase in the amount of AOC during 12 weeks of storage under refrigerated conditions, and the sample with the highest antioxidant activity was found in water kefir with 25% black carrot addition (Alagöz Kabakcı et al., 2022).

The changes in AOC of water kefir obtained by applying two different methods from loquat harvested at different extent of maturity during 28 days of storage at 4±1 °C are shown in Table 10 (b). In day 0, the highest AOC was found in YWK1 and NPOWK1 samples obtained by the first method and OWK2 sample produced by the second method ($p < .05$). Although AOC of unripe loquat (G) was high, the lowest AOC was obtained in GMK ($p < .05$). Since kefir is an acidic product, the pH value is a determining factor on the properties and quality of the product; however, the low pH significantly reduced antioxidant capacity of milk kefir (Darvishzadeh et al., 2021). In shelf-life study, a decreasing trend was determined at the end of 14 days and 28 days storage for both methods ($p < .05$). Some microorganisms in kefir grains synthesize bioactive compounds with antioxidant effect during the

fermentation process and contribute to the increase in the total antioxidant activity level, but the prolongation of time negatively affects the viability of microorganisms and thus the concentration of antioxidants (Tu et al., 2019).

Table 10. Changes in the AOC of milk kefir (a) and water kefir (b) with loquat during the shelf-life
Çizelge 10. Yenidünya meyvesi ile üretilen süt kefiri (a) ve su kefirinin (b) raf ömrü süresinde AOC değişimi

(a)	AOC (DPPH) (mg TE 100 mL^{-1})		
Sample	0 day	14 days	28 days
GMK	8.58±0.56aC	9.24±0.21aB	14.02±0.14aA
YMK	7.68±0.46bA	7.74±0.65bA	3.24±0.24bB
OMK	2.19±0.50dB	5.90±0.96cA	0.74±0.13cC
NPOMK	5.48±1.00cA	4.49±0.65dB	0.70±0.03cC
(b)	AOC (DPPH) (mg TE 100 mL^{-1})		
Sample	0 day	14 days	28 days
GWK1	5.25±0.21cA	4.10±0.07dB	1.04±0.59dC
YWK1	8.31±0.55aA	5.47±0.05aB	1.66±0.11bcC
OWK1	6.36±0.68bA	5.21±0.04bB	1.16±0.19dC
NPOWK1	7.73±0.43aA	4.67±0.08cB	0.41±0.15eC
GWK2	3.12±2.18dA	0.79±0.08hB	2.35±0.11aA
YWK2	6.36±0.82bA	3.12±0.18eB	1.78±0.09bcC
OWK2	7.49±0.47aA	2.68±0.09fB	1.87±0.16bC
NPOWK2	3.80±0.65dA	1.06±0.09gB	1.53±0.06cC

[a-h, A-C] Data in the same column followed by the same lower-case letters and in the same row followed by the same upper-case letters are not significantly different ($p > .05$).

Sensory Evaluation

The consumer acceptance and consumer ranking test values of milk kefir obtained with loquat fruit harvested at different extent of maturity are shown in Figures 2 and 3, respectively. The milk kefir sample GMK, which was produced using unripe green color loquat with the lowest pH value, had the highest value in terms of acidity compared to the other samples ($p < .05$). This sample was evaluated as the highest in terms of sweetness, although the brix value was lower than the other samples. Similarly, other researchers found that milk kefir obtained by adding plum and molasses was the most liked sample in terms of taste since the addition of plum decreased the pH value (Kök-Taş et al., 2013). However, in another study, it was determined that banana kefir with a high pH value was more liked by the consumer among the milk kefir samples obtained by adding strawberry, apricot, and banana (Harmankaya et al., 2019). Apart from acidity, other parameters also affect the overall liking result. In the current study, among the milk kefir samples, the GMK sample, which had a darker yellowish color, was rated the highest ($p < .05$). The panelists rated the GMK sample as cloudier compared to other samples, this sample was rated the highest in terms of overall liking ($p < .05$). The most preferred milk kefir sample was the GMK sample with 33.75%, while the OMK sample was the least preferred milk kefir sample with 18.13%. The results of the consumer ranking test were found to be consistent with the overall taste evaluation.

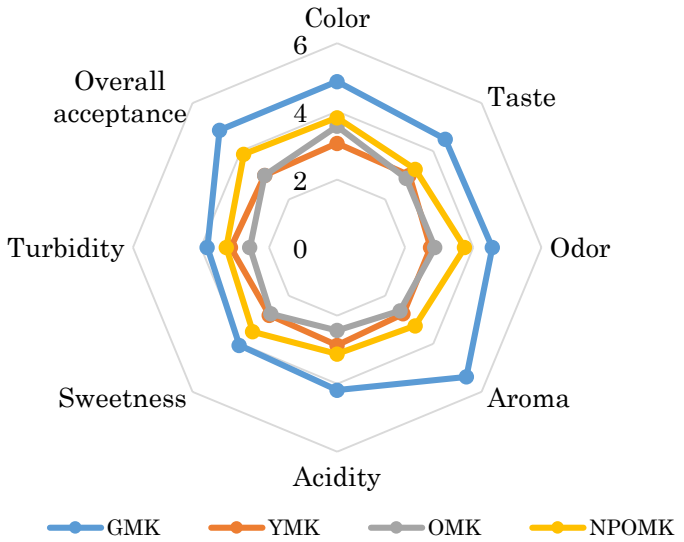

Figure 2. Consumer acceptance test for sensory evaluation of milk kefir with loquat
Şekil 2. Yenidünya meyvesi ile üretilen süt kefiri örnekleri için tüketici beğeni testi

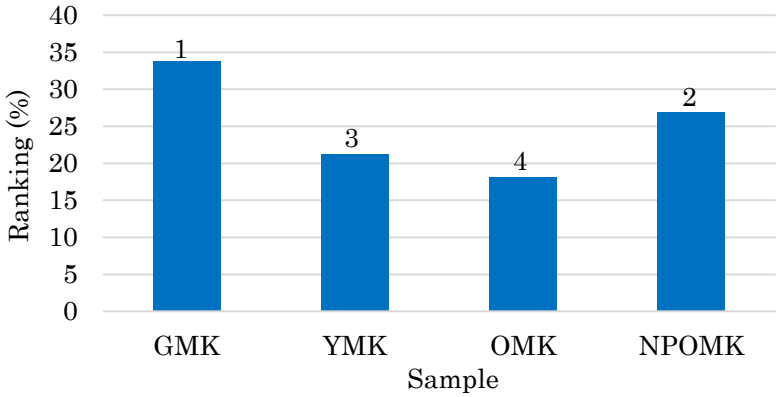

Figure 3. Consumer ranking test for sensory evaluation of milk kefir with loquat
Şekil 3. Yenidünya meyvesi ile üretilen süt kefiri örnekleri için tüketici tercih testi

Figure 4 shows the consumer acceptance of 8 different water kefir samples obtained with loquat fruit harvested at different extent of maturity using two different water kefir production methods. It is noteworthy that the sensorial acceptance of water kefir is subject to change depending on process conditions, substrate properties, storage time, and temperature (Ozcelik et al., 2021). In fruit water kefir, samples with high acidity are generally preferred by consumers. Bueno et al. (2021) found that the highest score in terms of color, smell, appearance, and taste in water kefir was obtained by adding acidic dragon fruit and apple. Other researchers indicated that the usage of red plum, cornelian cherry, pomegranate, rosehip, and hawthorn in water kefir production resulted in positive sensory evaluation of general acceptance with the slightly acidic and alcohol content (Ozcelik et al., 2021). In the measurements, the pH values of GWK1 and YWK1 were lower than OWK1 and NPOWK1. Similar results were obtained in the pH and Brix values of these same samples, regardless of the water kefir production method.

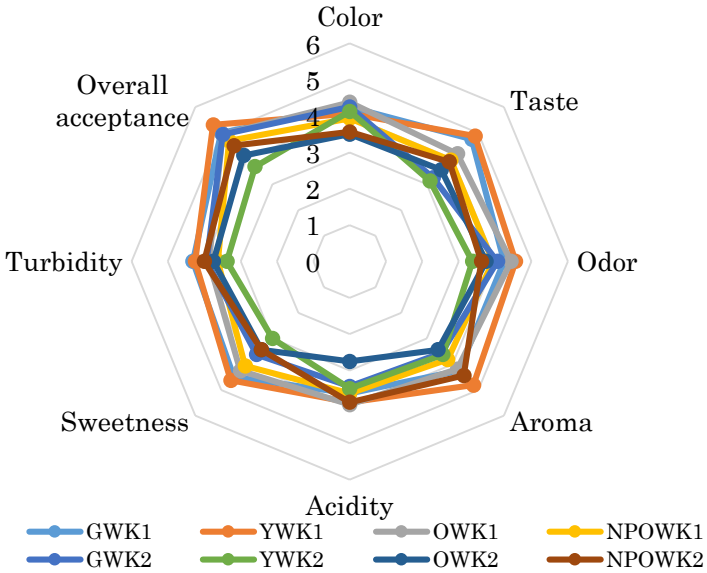

Figure 4. Consumer acceptance test for sensory evaluation of water kefir with loquat
Şekil 4. Yenidünya meyvesi ile üretilen su kefiri örnekleri için tüketici tercih testi

Although GWK1 and YWK1 samples were determined as acidic, no significant difference was observed between the other samples produced with the first method ($p > .05$). Similar results were observed in water kefir samples produced by the second method. Despite the lower Brix values of GWK1 and YWK1 samples compared to the other samples, the panelists evaluated these samples as sweet and gave with high overall acceptance. Mostly sweet taste was preferred in water kefir made with fruit, and findings in the aronia water kefir study by (Esatbeyoglu et al., 2023) confirmed these results. When comparing the color values of water kefir samples, the GWK1 and YWK1 samples with a darker yellowish color were more preferred. However, the YWK2 sample produced by method 2 was the lowest in terms of sensory parameters. In terms of overall acceptance, the YWK1 water kefir sample was evaluated as the highest when compared to the other samples. However, among the water kefir produced using

semi-ripe yellow loquat fruit, the sample produced with method 1 (YWK1) was the most accepted, while the sample produced with method 2 (YWK2) received the lowest score in terms of overall acceptance ($p < .05$).

Consumer ranking test was applied to eight different water kefir samples obtained with loquat fruits harvested at different extent of maturity using two different production methods, as shown in Figure 5. The result was in line with the overall acceptance data, and the most preferred water kefir by the panelists (18.4%) was YWK1 obtained with semi-ripe yellow loquat produced by method 1, while YWK2 was the least preferred water kefir produced by method 2 under the same conditions (8.59%). NPOWK2, the water kefir produced from ripe orange-color loquat with no peel using method 2, was the least preferred sample with 8.59%. In general, water kefir samples produced by method 2 were less preferred.

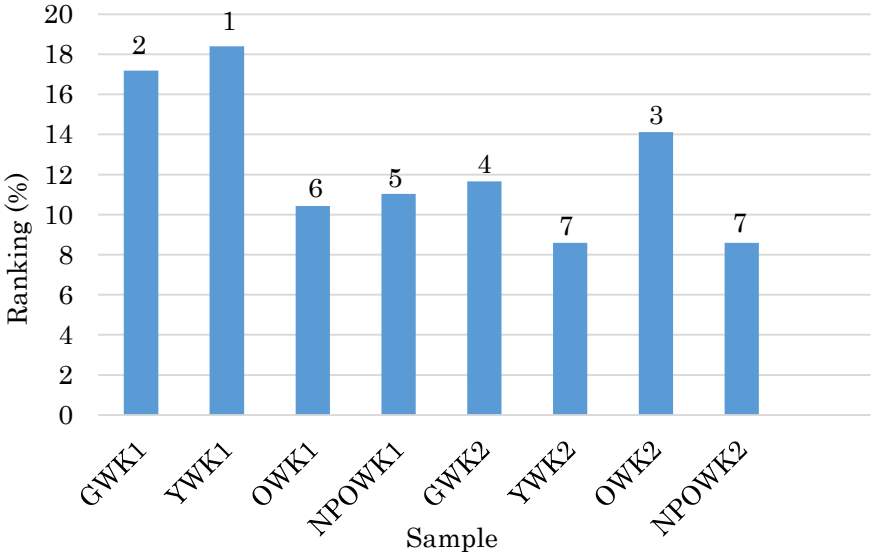

Figure 5. Consumer ranking test for sensory evaluation of water kefir with loquat
Şekil 5. Yenidünya meyvesi ile üretilen su kefiri örnekleri için tüketici tercih testi

CONCLUSION

The highest pH and Brix value was determined in the O sample (ripe loquat with orange color). During the 28-day storage period at 4±1°C, the pH values decreased in water kefir produced using method 1 (lyophilized water kefir culture), while the Brix value remained unchanged. In water kefir produced using method 2, the pH value increased, and the Brix value decreased during the storage period. Additionally, the pH value decreased, and the Brix value increased during the storage period of milk kefir samples; thereby, acidity and sugar content increased in the samples. The yellow color loquat (Y) harvested during the semi-ripe stage was found to have the most vibrant (highest C* value) and yellowish (b* value) color. When comparing GWK1 and OWK1 samples produced using method 1 with GWK2 and OWK2 samples produced using method 2, products produced using Method 2 were closer to the original color of the loquat fruit. During the 28-day storage period at 4±1°C, vivid and yellowish color was observed in milk kefir samples produced using both method 1 and method 2. When the OMK was compared with milk kefir samples, a more vivid, yellowish, and darker color was obtained. During the 28-day storage process at 4±1°C, darkening and redness were observed in the milk kefir samples.

The TPC, TFC, and AOC values of loquat harvested at different maturity were determined to be in the range of 59.85±2.91–70.71±5.84 mg GAE 100 mL^{-1}, 9.25±0.35–4.66±0.36 mg RE 100 mL^{-1}, and 44.92±3.76–26.85±2.75 mg TE 100 mL^{-1}, respectively. The highest TPC, TFC, and AOC were determined in unripe green loquat (G). The highest TPC, TFC, and AOC values in water kefir samples were determined in the OWK2 sample produced using method 2, and no difference was observed in the AOC content of the YWK1 and NPOWK1 samples compared to the OWK2 sample. The highest TPC and TFC in milk kefir samples were detected in unripe green milk kefir (GMK). At the end of the 28-day storage period, when water kefir produced using method 2 was compared with that produced using method 1, a significant decrease in TPC values was observed in the water kefir sample produced using method 2, while an increase in TPC was determined in the milk kefir samples due to milk being an important source of phenolic compounds. A decrease in AOC values was detected in water kefir samples at the end of the 28-day shelf life, and a similar result was observed in milk kefir samples.

Among the eight types of water kefir samples produced using two different methods, the most preferred sample was YWK1 with 18.4%, followed by GWK1 (17.18%), OWK2 (14.11%), and GWK2 (11.16%). According to the

consumer preference test, the ranking of the four types of milk kefir samples was as follows: GMK (33.75%), NPOMK (26.88%), YMK (21.25%), and OMK (18.13%). The samples with the highest acidity, darkest yellow color, and highest sweetness value were preferred in sensory evaluation. Results indicated that loquat at different extent of maturity has potential for usage in both milk kefir and water kefir production with high nutritional and sensorial quality.

Acknowledgement

This article has been produced from Sema Karamanoglu's MSc. Thesis, named "Quality Characteristics of Water and Milk Kefir Produced with Loquat Fruit at Different Extent of Maturity".

Ethics Statement

The sensory analyses conducted in this study were undertaken under the ethical approval granted by the Alanya Alaaddin Keykubat University Science and Engineering Sciences Scientific Research and Publication Ethics Committee (Document Number: 05.06.2025-250957, Meeting Date: 04.06.2025, Meeting Number: 03, Decision Number: 04). Informed consent was obtained from all participants involved in the study. Participation was voluntary, and participants were informed about the objectives, procedures, potential risks, and benefits of the study before consenting.

Contribution Rate Statement Summary of Researchers

The authors declare that they have contributed equally to the article.

Conflict of Interest

The authors declare no conflicts of interest.

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