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Impact of Quince Seed Mucilage on Quality Traits and Bioactive Components of 'Hayward' Kiwifruit Cultivar During Cold Storage

Ayva Çekirdeği Müsilajının Soğuk Depolama Sırasında 'Hayward' Kivi Çeşinin Kalite Özellikleri ve Biyoaktif Bileşenleri Üzerine Etkisi

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IMPACT OF QUINCE SEED MUCILAGE ON QUALITY TRAITS AND BIOACTIVE COMPONENTS OF 'HAYWARD' KIWIFRUIT CULTIVAR DURING COLD STORAGE

ABSTRACT

The main objective of this study was to evaluate the effects of quince seed mucilage (QSM) treatment on kiwifruit (*Actinidia deliciosa* cv. 'Hayward') quality characteristics and bioactive compounds during cold storage. In the study, fruit were stored at 0±0.5°C and 90±5% relative humidity (RH) for 120 day. At day 60th, QSM-treated fruits showed lower weight loss compared to controls. The respiration rate of QSM-treated fruits was lower than that of the control during the first 30 days, but higher in the subsequent measurement periods. QSM treatment significantly improved fruit firmness in the last two periods, with firmness about 50% higher at 90 days and 70% higher at 120th days compared to controls. However, QSM treatment did not significantly affect fruit skin and flesh color. The soluble solids content of QSM-treated kiwifruit was higher than the control at 90th and 120th days, but it was lower until day 60th. Vitamin C levels in QSM-treated fruits were higher at 60th and 120th days but lower at 30th and 90th days. Titratable acidity was lower in QSM-treated fruits at day 30th. Total phenolics and FRAP antioxidant activity were lower in QSM-treated fruits during the first two measurement periods but higher in the last two. DPPH tests indicated higher antioxidant activity in QSM-treated fruits throughout storage, and total flavonoid content was generally higher except at 90th days. As a result, QSM could be used as an effective tool to maintain fruit firmness and bioactive compounds of kiwifruit.

Keywords: Antioxidant, Edible Coating, Total Flavonoids, Total Phenolics, Vitamin C.

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AYVA ÇEKİRDEĞİ MÜSİLAJININ SOĞUK DEPOLAMA SIRASINDA 'HAYWARD' KİVİ ÇEŞİNİN KALİTE ÖZELLİKLERİ VE BİYOAKTİF BİLEŞENLERİ ÜZERİNE ETKİSİ

ÖZ

Bu çalışmanın temel amacı, ayva tohumu müsilajı (QSM) uygulamasının soğuk depolama sırasında kivinin (*Actinidia deliciosa* cv. 'Hayward') kalite özellikleri ve biyoaktif bileşenleri üzerindeki etkilerini değerlendirmektir. Çalışmada, meyveler 0±0.5 °C sıcaklık ve %90±5 bağıl nem koşullarında 120 gün depolanmıştır. 60. gün itibarıyla, QSM ile uygulanan meyveler kontrol grubuna göre daha düşük ağırlık kaybı göstermiştir. QSM uygulanan meyvelerin solunum hızı ilk 30 gün boyunca kontrol grubundan düşük, ancak sonraki ölçüm dönemlerinde daha yüksek bulunmuştur. QSM uygulaması, meyve sertliğini son iki ölçüm döneminde önemli ölçüde artırmış; 90. gün ve 120. günlerde sertlik sırasıyla %50 ve %70 oranında kontrol grubundan daha yüksek olmuştur. Ancak, QSM uygulamasının

meyve kabuğu ve et rengi üzerinde anlamlı bir etkisi olmamıştır. QSM uygulanan kivilerin suda çözünür kuru madde içeriği 90 ve 120. günlerde kontrol grubundan daha yüksek, ancak 60. güne kadar kontrolden daha düşük bulunmuştur. QSM uygulanan meyvelerin C vitamini seviyeleri 60. ve 120. günlerde kontrol grubundan yüksek, 30. ve 90. günlerde ise daha düşüktür. Titre edilebilir asit miktarı, 30. gün QSM uygulanan meyvelerde daha düşüktür. Toplam fenolikler ve FRAP antioksidan aktivitesi, QSM uygulanan meyvelerde ilk iki ölçüm döneminde daha düşük, son iki dönemde ise daha yüksek bulunmuştur. DPPH testleri, depolama süresince QSM uygulanan meyvelerde daha yüksek antioksidan aktivite olduğunu göstermiş ve toplam flavonoid içeriği genellikle daha yüksek bulunmuştur, ancak 90. günde bu durum geçerli olmamıştır. Sonuç olarak, QSM, kivi meyvelerinin sertliğini ve biyoaktif bileşenlerini korumada etkili bir araç olarak kullanılabilir.

Anahtar Kelimeler: Antioksidan, C Vitamini, Toplam Fenol, Toplam Flavonoid, Yenilebilir Kaplama.

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1. INTRODUCTION

In recent years, factors such as increasing population, decreasing agricultural areas and production quantities, access to safe food and the search for healthy nutrition make the storage process of fruits and vegetables and the safety of this process important (Wang, 2012; Neme et al., 2021; Güner et al., 2022; Peksen et al., 2023). Furthermore, continuous innovations and developments in the food industry have made it imperative to investigate new strategies for the storage of fresh fruits and vegetables (Lin and Zhao, 2007; Campos et al., 2011). The focus of these strategies is on maintaining product quality and providing healthy products to consumers in line with consumer demands. In this context, coating materials derived from edible natural resources have significant potential.

Although edible film materials may seem like a new technology at first, they actually have a history dating back to the 12th century (Hardenburg, 1967). Edible coatings are natural or nature-identical materials, generally less than 0.3 mm thick (Embuscado and Huber, 2009), that can be used in addition to or in place of natural protective wax coatings to prevent the movement of moisture, oxygen and soluble substances on foods (Smith et al., 1987; Avena-Bustillos et al, 1997; McHugh and Senesi, 2000). Edible coatings provide protection during storage of fruits and vegetables by forming a barrier on their surface, which preserves product quality (Rojas-Graü et al., 2008; Porat and Fallik, 2008; Falguera et al., 2011; Tezotto-Uliana et al., 2014; Ates et al., 2022).

Seeds offer a good potential for use in the food industry because they can be used as waste material, are accessible and safe for health. One of these uses is as a natural edible coating material. Quince seed mucilage (QSM), one of the na-

tural edible coating materials, is a natural polysaccharide material and is known for its gel forming properties (Jouki et al., 2013; Yousuf and Maktedar, 2023). The major water-soluble polysaccharides found in QSM were reported to be partially O-acetylated (4-O-methyl-D-glucurono)-D-xylan with a high proportion of glycuronic acid residues (Lindberg et al., 1990). QSM is also characterized by its hydrophilic properties and superior barrier, mechanical and antioxidant performances (Jouki et al., 2014a; Jouki et al., 2014b). Due to these properties, it reduces water loss in fruits during storage and prolongs storage life by maintaining fruit flesh firmness (Shahbazi et al., 2021). Indeed, it has been reported that postharvest natural edible coatings preserved fruit quality and reduced weight losses in many fruit species such as pear (Dave et al., 2017), apple (Thakur et al., 2019), and sweet cherry (Hu and Feng, 2022).

Kiwifruit is an important part of people's daily diet due to its rich bioactive content (Karakaya et al., 2019). Kiwifruit, which shows climacteric characteristics, is consumed with pleasure by consumers during the eating stage. It can be kept in cold storage for about 4-6 months (Ozturk et al., 2019). However, due to ethylene sensitivity, ripening continues during storage and softening of the fruit flesh may occur (Boquete et al., 2014; Korkmaz et al., 2023). Therefore, in addition to favorable conditions, some additional measures should be taken to delay aging. Generally, post-harvest preservative measures include packaging (Ozturk et al., 2024), modified atmosphere packaging (Karakaya et al., 2019), natural or natural-identical coatings (Hassani et al., 2012; Huang et al., 2017; Vivek and Subbarao, 2018). As the storage periods of products are extended with postharvest practices, significant advantages are provided in the chain from the orchard to the consumer, which can make significant contributions to both the household economy and the country economy.

The hypothesis of this study was that QSM used as an edible coating material can minimize quality losses and extend the storage life of kiwifruit during cold storage. The aim of this study was to determine the effects of QSM, a plant-based edible biofilm, on the postharvest storage performance of kiwifruit.

2. MATERIALS AND METHODS

2.1. Plant Materials

The plant material used in this study was the 'Hayward' cultivar (*Actinidia deliciosa*), which is widely grown in Türkiye. Fruits with similar size and skin surface color were hand-harvested when they reached a soluble solids content (SSC) of 6.5%. Following harvest, the fruits were transported to the laboratory using a refrigerated vehicle maintained at 10±1.0°C with 80±5.0% RH, within a 30 min. The fruit brought to the laboratory, any fruit exhibiting deformities or signs of disease or pest were discarded.

2.1.1. Methods

For each analysis period, 45 fruit were used (15 fruit per rep). In total, 225 fruit were utilized throughout the cold storage. A natural edible coating was prepared for the treatment. The coating material was obtained by mixing 100 g of quince seeds in 100 mL of distilled water using a magnetic stirrer for 24 h. Subsequently, it was left at room temperature for 48 h. During this period, the resulting gel-like coating material was separated from the seeds and diluted with 5 L of distilled water. The fruit, except for the control, were immersed in this solution for approximately 2 min. The control fruits were immersed in distilled water for the same duration. After treatment, the fruit were placed on paper towels to allow the surface water to remove. The fruits were then placed in trays, with 15 fruit per trays, and stored in a cold storage. The fruit stored in the cold storage were maintained at 0±0.5°C and 90±5% RH for 120 d, with evaluations conducted at 30-day intervals (days 30, 60, 90, and 120).

2.2.1. Weight Loss, Respiration Rate and Firmness

Weight loss was measured using a digital scale (±0.01 g) (Radwag PS 4500/C/1, Poland) for the fruit designated for each analysis period (3 rep). Weight loss was determined as the difference between the initial and final weights. The measurement values were expressed as a percentage (%). Respiration rate was determined by placing 5 randomly selected fruits from each replicate (total of 15 fruit) into a 2 L gas-tight measurement chamber. A gas sensor (Vernier, Oregon, USA) was then placed inside the chamber. Measurements were conducted over a 1 h period while the fruit was in the chamber. The CO_2 produced during this time was measured, and the average value was calculated. Results were expressed as nmol CO_2 kg^{-1} s^{-1}. A penetrometer (FT-327, McCormick Fruit Tech., WA, USA) with an 11.1 mm tip was used to determine fruit firmness. A piece of peel was removed from the surface of the fruit (in 10 fruit) to be measured. Then, the tip of the device was inserted into the fleshy part of the fruit placed on a stable surface with the peeled surface upwards. At the end of the process, the value on the screen was recorded. This recorded value was presented as Newton (N) (Ozturk et al., 2019).

2.2.2. Fruit Color (Skin and Flesh Color)

Color characteristics (L*, a* and b*) were measured by placing opposite surfaces of the fruit (in 10 fruit) directly in contact with the fruit using a colorimeter (Minolta, model CR-400, Japan). Color evaluations were presented according to the CIE (Commission Internationale de l'Eclairage) (McGuire, 1992).

2.2.3. Soluble Solids Content (SSC), Titratable Acidity (TA), and Vitamin C

For measurements of soluble solids content (SSC), titratable acidity, and vitamin C, 5 fruit from each replicate were used. The selected fruit were pureed using a blender. The puree was then passed through a strainer to separate the liquid from the solid parts. A small amount of the homogenized liquid was dripped onto the lens of a digital refractometer (PAL-1, McCormick Fruit Tech., Yakima, Wash., USA) for reading. The resulting SSC value was expressed as a percentage (%) (Karakaya et al., 2020). To determine titratable acidity, 10 mL of the obtained liquid was combined with 10 mL of distilled water and stirred until homogeneous. After dilution, 0.1 mol L^{-1} sodium hydroxide was added until the pH reached 8.2. The values were expressed as malic acid equivalents (%) (Öztürk and Ağlar, 2019). For vitamin C, an ascorbic acid test kit (Catalog no: 116981, Merck) was immersed in the prepared liquid for 2 seconds. The kit was then taken out and left for up to 8 s to oxidize and remove excess contamination. The kit was placed in the inner chamber of the Reflectoquant plus-10 (Merck RQflex plus-10) for reading and after waiting for 5 s, the value on the digital display was recorded. The recorded value was expressed as mg 100 g^{-1} (Ozturk et al., 2019).

2.2.4. Total Phenolics, Total Flavonoids, and Antioxidant Activity

For the determine the bioactive contents, the fruit juices pureed in each analysis period were stored in falcone tubes at -20°C until the day of analysis. On the day of analysis, the samples were thawed at room temperature (21°C) and measurements for total phenolics, total flavonoids, and antioxidant activities (DPPH and FRAP) were performed using a spectrophotometer. Total phenolics were measured according to the method established by Beyhan et al. (2010). The values were expressed as g gallic acid equivalents (GAE) kg^{-1} of fresh weight (fw). Total flavonoids were measured following the method described by Chang et al. (2002). The total flavonoids were expressed as g quercetin equivalents (QE) kg^{-1} fw. The DPPH assay was conducted based on the method of Blois (1958), while the FRAP assay was performed according to the method of Benzie and Strain (1996). The antioxidant activity readings (DPPH and FRAP) were presented as mmol Trolox equivalents (TE) kg^{-1} fw.

2.2.5. Statistical Analysis

Normality of the data was evaluated using the Kolmogorov-Smirnov test, while the Levene test was employed to check for homogeneity of variances. For datasets that satisfied these criteria, variance analysis was performed alongside the computation of descriptive statistics. The significance of differences between treatment groups was assessed using two-sample *t*-tests, with a significance threshold set at $p < 0.05$. All statistical procedures were conducted using Minitab® 17 software (Minitab Inc., State College, PA, USA).

3. RESULTS AND DISCUSSION

3.1. Weight Loss, Respiration Rate and Firmness

In the study, no significant effect of edible coating treated to postharvest kiwifruit fruits on weight loss was observed overall. Only on day 60th, fruit treated with QSM exhibited a lower weight loss compared to control. However, there were significant differences in respiration rates. Specifically, at days 60th, 90th, and 120th, the edible coating treatment resulted in statistically lower respiration rates than the control. Conversely, on day 30th, a higher respiration rate was observed in the coated fruit. Regarding firmness values, no significant effect of the QSM treatment on fruit firmness was detected up to day 60th of storage. However, at days 90th and 120th, the coating treatment was significantly more effective in maintaining firmness compared to the control (Table 1).

Table 1. Effects of quince seed mucilage on weight loss, respiration rate and firmness of kiwifruit during cold storage

Treatments	Weight loss (%)			
	30	60	90	120
Control	0.17 a	0.30 a	0.83 a	1.76 a
QSM	0.17 a	0.23 b	0.86 a	1.77 a
Treatments	**Respiration rate (nmol CO_2 kg^{-1} s^{-1})**			
	Harvest	30	60	90	120
Control	0.79 a	0.74 b	4.99 a	14.74 a	17.32 a
QSM	0.79 a	1.58 a	3.74 b	4.53 b	5.01 b
Treatments	**Firmness (N)**				
	Harvest	30	60	90	120
Control	55.62 a	45.62 a	36.5 a	19.42 b	10.39 b
QSM	55.62 a	41.98 a	36.8 a	31.40 a	17.36 a

*Means in columns with the same letter do not differ according to *t*-tests at P<0.05.

Although the coating treatment forms a barrier on the fruit surface that inhibits respiration, it is hypothesized that it does not influence weight loss because internal degradation processes, such as the breakdown of nutrients like pectin and starch into simpler sugars and other substances, continue. Consistent with our findings, Shahbazi et al. (2021) reported that both pure okra mucilage and QSM treatments were similarly effective as the control in preventing weight loss during storage. However, Kozlu and Elmacı (2020) reported that in mandarins coated with QSM, the coating was effective in reducing weight loss during storage and in maintaining firmness from the 4th day of storage onward. Similarly, Yousuf and

Maktedar (2022) found that QSM had a significant effect on delaying weight loss in stored walnuts, and Yousuf and Maktedar (2024) identified a significant impact of QSM on delaying weight and firmness losses in stored apples. Ozturk et al. (2022) also found that *Aloe vera* treatments slowed the respiration rate of medlar fruit during storage and significantly retarted weight and firmness losses compared to the control. Islam et al. (2022) observed that *Aloe vera* treatment resulted in weight loss in jujube fruit similar to that of the control (with the exception of day 7th), and that respiration rate and firmness (with the exception of day 28th) were lower in edible coatings compared to the control. Similarly, Aglar et al. (2017) reported that edible coatings were similarly effective as the control in preventing weight and firmness loss in sweet cherry by day 21st. However, Hashemi et al. (2017) reported that a coating material derived from basil seeds was effective in delaying weight loss in apricots. Noshad et al. (2019) indicated that, when treatment mucilages from *Plantago major*, *P. psyllium*, and *Descurainia sophia* to store sliced apples, the firmness values were generally similar to the control (with the exception of *Plantago psyllium* mucilage).

3.2. Fruit Color (Skin and Flesh Color)

In terms of color values, the study observed a decrease in nearly all parameters as storage duration progressed. Additionally, it was found that the edible coating treatment had no significant effect on the skin color change of kiwifruit. However, for flesh color change, the b* values (on days 30th, 60th, and 90th) were significantly higher in fruit treated with the edible coating. Only on day 120th did the fruits with edible coating show a significantly lower L* value compared to the control (Table 2).

Color change in fruit is associated with the degradation of chlorophyll (Knee, 1972), and color change in stored products is generally undesirable. In this context, although the coating treatments in this study did not have a significant effect on color values, they resulted in less color change compared to the control. Similarly, Noshad et al. (2020) reported that QSM has a significant effect in reducing color changes in foods. Kozlu and Elmacı (2020) found that, in their study, the L* values of control mandarins gradually increased, while there was no significant change in the L* values of mandarins coated with QSM. In contrast, Yousuf and Maktedar (2022) emphasized that QSM affected the color changes in stored walnuts, with the highest L* values measured in coated samples on day 35th of storage. Shahbazi et al. (2021) reported that strawberries coated with a combination of okra mucilage and QSM had numerically higher L* values compared to the control, with no negative impact on the strawberries' original color. Sabir et al. (2023) found that the L* values of 'Alphonse Lavallée' and 'Red Globe' grape cultivars treated with *Aloe vera* at different concentrations were generally higher than those of the control during storage. However,

Islam et al. (2022) stated that the effect of *Aloe vera* on color changes in stored jujube fruit was significant only in the last two measurement periods, with the measured values being lower than those of the control.

Table 2. Effects of quince seed mucilage on L*, a* and b* of skin and flesh color of kiwifruit during cold storage

Treatments		Skin Color				
		Harvest	30	60	90	120
Control	L*	48.05 a	46.94 a	45.18 a	39.87 a	40.57 a
QSM		48.05 a	46.78 a	44.58 a	39.89 a	40.29 a
Control	a*	4.41 a	4.90 a	4.28 a	3.46 a	3.78 a
QSM		4.41 a	4.03 a	4.29 a	3.36 a	3.68 a
Control	b*	28.90 a	29.20 a	29.52 a	17.05 a	16.87 a
QSM		28.90 a	29.37 a	29.65 a	17.07 a	16.90 a
Treatments		**Flesh Color**				
		Harvest	30	60	90	120
Control	L*	61.09 a	55.79 a	58.83 a	48.36 a	50.04 a
QSM		61.09 a	55.83 a	57.14 a	49.77 a	47.63 b
Control	a*	15.01 a	14.85 a	13.99 a	11.27 a	10.45 a
QSM		15.01 a	15.29 a	13.29 a	10.73 a	9.83 a
Control	b*	33.26 a	31.54 b	30.44 b	19.25 a	17.23 b
QSM		33.26 a	33.12 a	31.95 a	19.07 a	18.04 a

*Means in columns with the same letter do not differ according to *t*-tests at P<0.05.

3.3. Soluble Solids Content (SSC), Titratable Acidity (TA), and Vitamin C

When examining the biochemical characteristics of the study, significant differences in SSC (%), emerged from day 60th of storage. On day 60th, the coating treatment resulted in a lower SSC, whereas on days 90th and 120th, the control showed a lower SSC. The vitamin C content (mg 100 g^{-1}) decreased over the storage period for both control and coating treatments. Additionally, the vitamin C values decreased more significantly in control throughout storage. In this context, the coating treatment was more effective in preserving vitamin C content compared to the control, with this effect being particularly significant on days 60th and 120th. No significant differences in TA (% malic acid), were found between treatments, except on day 30th (Table 3). The determination of harvest time and the end of the storage period are primarily based on SSC and TA (Faizy et al., 2021). Shahbazi et al. (2021) reported that strawberries stored with a coating of okra mucilage and QSM had lower TA compared to the control. Noshad et al. (2019) found that

when treating mucilages from *Plantago major*, *P. psyllium*, and *Descurainia sophia* to stored sliced apples, the TA and SSC were lower compared to the control. However, ascorbic acid content was higher, particularly in apples treated with *Plantago psyllium* mucilage. Tamjidi et al. (2023) reported that, in strawberries stored with coatings containing *Lallemantia iberica* seed mucilage and cinnamon essential oil, the coating treatments had an effect on TA, but did not have a significant impact on SSC. Regarding other edible coating treatments, Islam et al. (2022) demonstrated that *Aloe vera* treatments were effective in preserving the SSC, TA and vitamin C content of stored jujube fruit. Aglar et al. (2017) reported that the edible coating material (Parka™), maintained a lower SSC level in cherries compared to the control and had no significant effect on TA and vitamin C content. Hashemi et al. (2017) found that the SSC content of cut apricots of the edible coating obtained from basil seed was lower than the control until the 6th day of storage, but higher than the control on the last measurement day.

Table 3. Effects of quince seed mucilage on soluble solids content (SSC), vitamin C and titratable acidity of kiwifruit during cold storage

Treatments		Biochemical characteristics				
		Harvest	30	60	90	120
Control	SSC (%)	6.50 a	12.70 a	13.35 a	11.10 b	12.05 b
QSM		6.50 a	12.60 a	13.10 b	12.95 a	13.70 a
Control	Vitamin C (mg 100 g^{-1})	31.5 a	24.1 a	20.3 b	21.4 a	10.2 b
QSM		31.5 a	22.0 b	21.5 a	18.9 b	11.1 a
Control	Acidity (% malic acid)	0.89 a	0.37 a	0.27 a	0.14 a	0.16 a
QSM		0.89 a	0.29 b	0.26 a	0.12 a	0.17 a

*Means in columns with the same letter do not differ according to *t*-tests at P<0.05.

*SSC: soluble solids concentration (%), TA: titratable acidity (% malic acid), Vit C: Vitamin C (mg 100 g^{-1})

3.4. Total Phenolics (TPC), Total Flavonoids (TFC), and Antioxidant Activity

When examining bioactive compounds, significant differences were observed among treatments throughout the storage period. The TPC was higher in control on days 30th and 60th of storage, whereas it was higher in the coating treatment on days 90th and 120th. The coating treatment was found to be effective in preserving the TFC, with the differences observed during storage being statistically significant. Similarly, the coating treatment resulted in significantly higher DPPH values compared to the control throughout storage. However, the effect of the coating on FRAP values was significant only on days 90th and 120th. Overall, the edible coating treatment had a significant impact on the preservation of bioactive compounds. This effect was consistent for TFC and DPPH throughout the storage period, while it was significant for TPC and FRAP in the later stages of storage (Table 4).

Table 4. Effects of quince seed mucilage on total phenolics, total flavonoids and antioxidant activity (in DPPH and FRAP assays) of kiwifruit during cold storage

Treatments		Bioactive Compounds				
		Harvest	30	60	90	120
Control	**TPC**	13.55 a	12.08 a	8.82 a	9.58 b	9.53 b
QSM		13.55 a	8.21 b	8.03 b	10.87 a	13.75 a
Control	**TFC**	8.64 a	5.94 b	2.93 b	4.89 a	3.05 b
QSM		8.64 a	7.90 a	3.53 a	4.84 a	4.31 a
Control	**DPPH**	18.91 a	13.14 b	11.88 b	9.00 b	8.83 b
QSM		18.91 a	18.19 a	18.09 a	18.20 a	9.91 a
Control	**FRAP**	32.16 a	31.96 a	27.44 a	26.37 b	22.14 b
QSM		32.16 a	23.26 b	26.57 b	30.40 a	35.89 a

*Means in columns with the same letter do not differ according to *t*-tests at P<0.05.

*TPC: Total phenolics (g GAE kg^{-1} fw). TFC: Total flavonoids (g QE kg^{-1} fw). DPPH and FRAP (mmol TE kg^{-1} fw)

Overall, in this study, the QSM coating was found to be effective in preserving bioactive compounds ($P \leq 0.05$). A similar study by Yousuf and Maktedar (2024) also demonstrated that QSM-based coating materials were more effective than the control in maintaining bioactive contents. Additionally, Yousuf and Maktedar (2022) highlighted that QSM-coated internal walnuts had higher bioactive content compared to the control on days 7^{th} and 35^{th}. Kozlu and Elmacı (2020) observed that while both QSM and control treatments showed a gradual reduction in total phenol content in segmented mandarin fruit during storage, the decrease was less pronounced with QSM treatment. Again the researcher, in the antioxidant (DPPH) test, control values decreased progressively, whereas the coating treatment exhibited fluctuating increases and decreases, indicating that coating treatments were more effective in preserving antioxidant content. Hashemi et al. (2017) reported that different concentrations of basil gum treated to fresh-cut apricots resulted in lower total phenolics and DPPH contents in low-concentration coatings compared to the control until the 6^{th} day of storage, but higher contents on the final measurement day (8^{th} day). Islam et al. (2022), treating *Aloe vera*, found that TPC (except on days 14^{th} and 28^{th}), DPPH, and FRAP (except on day 14^{th}) contents in stored jujube fruits were higher compared to the control, although TFC content was similar to that of the control. Conversely, Ozturk et al. (2022) found that *Aloe vera*+MAP treatment had a significant impact on TPC, TFC, DPPH, and FRAP activity in medlar fruit during storage. Aglar et al. (2017) reported that the biofilm, an edible coating material, had similar TPC levels compared to the control (except on day 14^{th}), but a significantly different FRAP content (except on day 14).

4. CONCLUSIONS

As an edible coating, the treatment of QSM has been found to reduce respiration rates and preserve firmness during storage. Additionally, it has been shown to have significant effects on total phenolics, total flavonoids, and antioxidant activity throughout the storage period. Generally, QSM was determined to be effective in the storage of kiwifruit. In this context, QSM, as an edible coating material, is thought to offer environmentally and economically sustainable alternatives to storage materials with health-unfriendly contents or traditional storage methods.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics

This study does not require ethics committee approval.

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