BİLİM-TEKNOLOJİ-YENİLİK EKOSİSTEMİ DERGİSİ

JOURNAL OF SCIENCE-TECHNOLOGY-INNOVATION ECOSYSTEM

E-ISSN : 2757-6140 Cilt | Volume : 5 Sayı | Issue : 1 Yıl | Year : 2024

JOURNAL OF SCIENCE-TECHNOLOGY-INNOVATION ECOSYSTEM

BİLİM-TEKNOLOJİ-YENİLİK EKOSİSTEMİ DERGİSİ

JSTIE 2024, 5(1)

Bilim-Teknoloji-Yenilik Ekosistemi Dergisi (BİTYED) yılda İki kez (Haziran ve Aralık) yayınlanan uluslararası veri indeksleri tarafından taranan hakemli bir dergidir. Gönderilen makaleler ilk olarak editörler ve yazı kurulunca bilimsel anlatım ve yazım kuralları yönünden incelenir. Daha sonra uygun bulunan makaleler alanında bilimsel çalışmaları ile tanınmış iki ayrı hakeme gönderilir. Hakemlerin kararları doğrultusunda makale yayımlanıp yayımlanmaz kararı alınır.

Bilim-Teknoloji-Yenilik Ekosistemi Dergisi'nde yayınlanan makalelerde fikirler yalnızca yazar(lar)ına aittir. Dergi sahibini, yayıncıyı ve editörleri bağlamaz. Bu sayıda yer alan tüm çalışmalar başvuru anında ve yayın öncesi olmak üzere iki kez **iThenticate** uygulaması aracılığıyla benzerlik taramasından geçirilmiştir.

OPEN ACCESS

Journal of Science-Technology-Innovation Ecosystem (JSTIE) offers free, immediate, and unrestricted access to peer reviewed research and scholarly work. Users are allowed to read, download, copy, distributed, print, search, or link to the full texts of the articles, or use them for any other lawful purpose, without asking prior permission from the publisher or the author.

Bilim-Teknoloji-Yenilik Ekosistemi Dergisi (BİTYED)
Çanakkale Onsekiz Mart Üniversitesi, Bilim ve Teknoloji Uygulama ve Araştırma Merkezi (ÇOBİLTUM)
Terzioğlu Kampüsü, 17100 – Çanakkale – TÜRKİYE
Telefon: +90 (286) 218 00 18 Dahili: 24006, Fax: +90(286) 218 19 48
Web: http://bityed.dergi.comu.edu.tr / E-mail: bityek@comu.edu.tr

ISSN: 2757-6140 (Online)

JSTIE 2024, 5(1)

The Journal of Science-Technology-Innovation Ecosystem is indexed by the following data indices.
Bilim-Teknoloji-Yenilik Ekosistemi Dergisi aşağıdaki veri indeksleri tarafından taranmaktadır.

Journal of Science-Technology-Innovation Ecosystem

(Bilim-Teknoloji-Yenilik Ekosistemi Dergisi)

OPEN ACCESS

JSTIE: MID1732024 | 2024, 5(1): 23-35 | e-ISSN: 2757-6140

Effects of Siegafresh® and Different Essential Oils on Quality Parameters in Storage of Hayward Kiwi Fruits

Muhammed Emre Erdurmuş , Fatih Cem Kuzucu[1] ,

Horticulture Department, Faculty of Agriculture, Çanakkale Onsekiz Mart University, Çanakkale, Türkiye

Article History

Received: 17/04/2024

Accepted: 05/06/2024

Published: 11/06/2024

Research Article

Abstract: This study was carried out to determine the changes in some quality characteristics of the fruits after 120 days of storage of SiegaFresh® Finish and different essential oil saturated MAP applications on the export-oriented 'Hayward' kiwi variety. For this purpose, fruits harvested during the period considered to be the optimal harvest maturity for the 'Hayward' kiwi variety (Fruit flesh hardness: 6.0-6.5 kg/cm², water-soluble dry matter ratio: 9.5-10%), 1) Low density polyethylene (LDPE) bags, 2) Thyme oil (*Thymus vulgaris* L.) at a dose of 0.5%, 3) Bitter almond oil (*Prunus amygdalus* var. *amara*) at a dose of 0.5%, 4) Thyme (0.5%) + bitter almond oil (0.5%), 5) was stored in MAP bags saturated with SiegaFresh®Finish. Kiwi fruits were stored in cold storage at 0±1°C temperature and 90-95% relative humidity conditions for 120 days. Quality changes were determined in samples taken at 30-day intervals during storage. Compared to the control application during storage, MAP applications generally showed significant differences in terms of important ripeness parameters such as weight loss, fruit flesh hardness (MES), amount of soluble solids content (SSC), titratable acidity (TEA), pH value, Vitamin C content and fruit flesh color. It has been determined that the 'Hayward' variety can be stored successfully for up to 120 days with SiegaFresh®Finish and essential oil impregnated MAP applications.

Keywords: Kiwi, Siegafresh, thyme oil, bitter almond oil, quality, post-harvest

Hayward Kivi Meyvelerinin Depolanmasında Siegafresh® ve Farklı Uçucu Yağların Kalite Parametreleri Üzerine Etkileri

Makale Geçmişi

Geliş: 17/04/2024

Kabul: 05/06/2024

Yayınlama: 11/06/2024

Araştırma Makalesi

Öz: Bu çalışma ihracata yönelik 'Hayward' kivi çeşidinde SiegaFresh® Finish ve farklı uçucu yağ emdirilmiş MAP uygulamalarının 120 günlük depolama sonunda meyvelerdeki bazı kalite özelliklerindeki değişimlerin belirlenmesi amacıyla gerçekleştirilmiştir. Bu amaç doğrultusunda, 'Hayward' kivi çeşidi için optimal hasat olgunluğu olarak kabul edilen (Meyve eti sertliği: 6,0-6,5 kg/cm², suda çözünür kuru madde oranı: %9.5-10) dönemde hasat edilen meyveler, 1) Düşük yoğunlukta polietilen (LDPE) torbalar, 2) %0.5 dozunda kekik yağı (*Thymus vulgaris* L.), 3) %0.5 dozunda acı badem yağı (*Prunus amygdalus* var. *amara*), 4) Kekik (%0.5) + acı badem yağı (%0.5), 5) SiegaFresh®Finish emdirilmiş MAP torbalara konarak depolanmıştır. Kivi meyveleri soğuk hava deposunda 0±1°C sıcaklık ve %90-95 oransal nem koşullarında 120 gün boyunca muhafaza edilmiştir. Depolama süresince 30 gün aralıklarla alınan örneklerde kalite değişimleri belirlenmiştir.

[1]Correspondence (Sorumlu yazar): fatihcem@comu.edu.tr

Citation (Alıntı): Erdurmuş, M. E., Kuzucu, F. C. 2024. Effects of Siegafresh and different essential oils on quality parameters in storage of Hayward kiwi fruits. Journal of Science-Technology-Innovation Ecosystem, 5(1): 23-35.

Depolama boyunca kontrol uygulamasına göre ağırlık kaybı, meyve eti sertliği (MES), suda çözünebilir kuru madde (SÇKM) miktarı, titre edilebilir asitlik (TEA), pH değeri, C vitamini miktarları ve meyve et rengi gibi önemli olgunluk parametreleri bakımından genel anlamda MAP uygulamalarının tümünden iyi sonuçlar alınmıştır. SiegaFresh®Finish ve uçucu yağ emdirilmiş MAP uygulamaları ile 'Hayward' çeşidinin 120 güne kadar başarılı bir şekilde depolanabileceği tespit edilmiştir.

Anahtar Kelimeler: Kivi, Siegafresh, kekik yağı, acıbadem yağı, kalite, hasat sonrası

Introduction

Kiwi fruit belongs to the order Ericales, family Actinidiaceae and genus *Actinidia*. Kiwi, scientifically known as *Actinidia deliciosa,* is thought to be of Chinese origin. Kiwi is a kind of fruit that can adapt to both subtropical and temperate climates. Kiwi is widely grown throughout the world. Kiwi is a climacteric fruit that ripens quickly after harvesting. Harvest maturity is one of the factors that significantly affects the quality and shelf life of kiwi fruit. Because determining the ideal harvest maturity is crucial to fruit size and consumer acceptability for kiwi fruit. The flesh firmness, sugar, aroma and acid contents of harvested kiwis are directly related to the ripeness of the fruit and such features are important for the durability and quality of kiwi fruit. The atmospheres surrounding the products use a system in which gas levels are constantly monitored and adjusted to maintain optimal concentrations in controlled atmosphere (CA) cold storage facilities used to store the products. However, it is thought to be more suitable for products that can be stored for long periods since this system requires intensive capital and is expensive for businesses (Zagory and Kader, 1988).

On the other hand, modified atmosphere packaging (MAP) contributes to the preservation of post-harvest product quality by changing the atmosphere surrounding the products in cold storage. In this system, gas concentrations are controlled to a lesser degree. Typically, the interaction of the physiology of products and the physical environment is kept within wider limits by determining the initial atmospheric conditions. Besides, advances in the production of polymeric films have increased interest in creating and maintaining modified atmospheres within film packages (Kader, 1988).

Packaging is an important step in terms of preserving fresh fruits and vegetables. While modified atmosphere packages help preserve the quality of the products, they ensure the preservation of high relative humidity and turgidity of fruits and vegetables by preventing water vapor permeability of the package. Packaging can be enriched with substances such as fungicides or ethylene adsorbents to control fungal and bacterial diseases (Zagory et al., 1988).

In recent years, the usage of plant-origin organic products arose from the quest to avoid chemicals or pesticides. Along with this, the usage of plant-origin essential oils is among the research topics because of their environment-friendly aspects. The usage of these organic essential oils in dipping, spraying and washing methods in post-harvesting of fruit, while methods such as application in gaseous form at high pressure or impregnation with polyethylene packaging materials have also been developed. Nevertheless, the above-mentioned methods are more suitable for fruit such as kiwi due to their shell structure, because of the potential of essential oils to transfer their scent to fruit and the toxic effects of using them in very high doses (Snowdon, 1990; Ziedan and Farrag, 2008; Antunes et al., 2010).

A significant portion of post-harvest losses are caused by fungal diseases. In the world, it is known that post-harvest losses vary between 10-50% due to fungi (Tripathi et al., 2008). Post-harvest rot disease depends on the type of crop, harvesting and maturity stages, and storage and transportation conditions. Pathogens can be transmitted to the product in the field and/or after harvesting, however, infection formation becomes more evident during storage. That is why, post-harvest rot disease control should be begun in the field. Thus, physical damage and deformations on the product should be prevented during harvest and post-harvest applications (Sivakumar et al., 2014).

The most prominent pathogens infect the kiwi fruit during storage are: *Botrytis cinerea*, *Alternaria alternata*, *Penicillium* sp. and *Phoma destructiva* (Arslan, 1998). But the biggest economic losses are caused by Botrytis cinerea, and this pathogen causes serious economic losses in more than 200 crops in the world (Feliziani et al., 2014a). Different methods, such as cooling, are used to control the post-harvest infections. The application of chemical pesticides is one of these methods. Nevertheless, interest in non-chemical methods has increased because of the increase in consumer awareness, and the risks to the environment and human health. That is why, alternative methods such as temperature applications (Bal, 2009), ozone applications (Feliziani et al., 2014b; Barboni et al., 2010), and essential oil applications (Daferera et al., 2003; Servili et al., 2017) are used. These methods can help in the control of post-harvest infections and also reduce the economic losses in kiwi fruit.

Essential oils can be absorbed into MAP bags to provide an antimicrobial effect during food storage. Particularly, the usage of natural essential oils can have a positive impact on consumers. Therefore, impregnating natural essential oils into MAP bags and using them for storage is recently seen as a new technology in Türkiye. Moreover, the transfer of essential oils impregnated into polyethylene bags to the product, and the prevention of their potential toxic effects will be investigated in future studies.

In this study, the combination of SiegaFresh®Finish and essential oil impregnated MAP applications and the storage shelf-life properties of fruit were examined together with the change in the quality characteristics of kiwi fruit in addition to the use of MAP in post-harvest storage. And, it will minimize the quality loss by extending the storage period of fresh kiwi fruit. Furthermore, this study aimed to contribute to the sector by determining successful applications in storage and marketing.

Materials and Methods

Materials

The main material of this study was the 'Hayward' variety of the kiwi fruit (*Actinidia deliciousa* L. cv.), which was obtained from the Saraylım Agriculture situated in Çorum Province of Türkiye. Kiwi fruits were harvested during the commercial harvesting period (Fruit flesh firmness: 6.0-6.5 kg/cm² and soluble solids comtent: 9.5-10%) and placed under pre-cooling conditions. Then, after the completion of the 24-hour pre-cooling period, they were subjected to the applications subject to the experiment. The kiwi parcel, from which plant material was obtained for the research, was planted in 2015 and the kiwi vines are 8 years old. The trial material, which was determined to be in the same group in terms of color and size within the harvested fruit group, as a result of visual classification, was created as a homogeneous group and 380 fruits were selected as trial material.

The packaging materials to be used for the preservation of the test material during the cold storage process and the best preservation of fruit quality characteristics during the 120-day storage period are planned to be produced by treating with different volatile oils (0.5% thyme oil, 0.5% bitter almond oil) and the disinfectant substance used under the trade name SiegaFresh® (by impregnating the mentioned active substance into the MAP) to be used as packaging materials during the storage process. Additionally, before the commencement of the cold storage trial process, disinfection was carried out using a disinfectant marketed under the trade name SiegaFresh® Start. The impregnation of volatile oils and SiegaFresh® Finish into the bags was carried out by Aypek Packaging Ltd., and for this purpose, a high-speed mixer homogenization process was conducted for 2 hours in a water-based solution containing volatile oils or SiegaFresh® Finish at a concentration of 0.5% to impregnate them into the MAP. Additionally, to determine the effectiveness of these bags, a separate group was created as a control (MAP Control) using LDPE bags to which no volatile oils or SiegaFresh® Finish were applied.

Methods

The trial, which was planned for 120 days with 3 replications, 5 fruits in each replication, was designed according to the randomized plot design, and a total of 360 kiwi fruits were used. The packaging materials and their properties used in the research are listed below according to their application codes. The control group fruits were unpackaged and the MAP control group fruits were placed in MAPs without impregnation of volatile oils or SiegaFresh® Finish, in MAP 1 and MAP 2 applications, thyme oil (*Thymus vulgaris* L.) and bitter almond oil (*Prunus amygdalus* var. a*mara*) were used as volatile oils, in MAP 3 application, an equal mixture of these two volatile oils was used, and in MAP 4 application, SiegaFresh® Finish was used.

- **Control:** Storage without packaging material (without MAP)
- **MAP Control:** Storage in modified atmosphere packaging

• **MAP 1:** Storage in MAPs treated with thyme oil (0.5% thyme oil)

• **MAP 2:** Storage in MAPs treated with bitter almond oil (0.5% bitter almond oil)

• **MAP 3:** Storage in MAPs treated with a mixture of bitter almond and thyme oil (0.5% bitter almond oil + thyme oil)

• **MAP 4:** Storage in MAPs treated with SiegaFresh® Finish

Within the scope of the research, the experimental material prepared as MAP applications and control groups was stored in cold storage rooms at the Canakkale Onsekiz Mart University, Faculty of Agriculture, Department of Horticulture. The fruits were stored for 120 days, and during storage, the room temperature was maintained at 0±1°C, with relative humidity between 90-95%. Before the storage process, the cold storage room was disinfected using SiegaFresh® Start.

Examined Quality Parameters

Observations, analyses and measurements were done in a laboratory situated at Çanakkale Onsekiz Mart University, Faculty of Agriculture Department of Horticulture during 0, 30, 60, 90 and 120 days of storage aimed to determine the variation in kiwi fruit quality at their initial stage.

Weight Loss (WL %)

A number of 10 kiwi fruit were selected for each application while establishing the experiment, and at the end of each storage period, weight loss was measured using a precision balance to the sensitive scale of 0.01g. Weight loss regarding to the initial weight of the separated kiwi fruit was calculated as % at the end of the storage period.

Soluble Solid Contents (SSC %)

Some fruit juice was taken from the fruit in each replication to measure the amount of soluble solid contents of kiwi fruit, and analyzed using a hand refractometer and it was determined as %.

Fruit Flesh Firmness (FFF Kgf)

The skins of each fruit were peeled thinly from both sides, and a hand penetrometer was used to measure fruit flesh firmness. Measurements were carried out using an 8mm tip, and the obtained results were expressed in kg/cm2.

h° Values at Flesh Color

Minolta Colorimeter (CR 300) was used to determine the variations in kiwi flesh color during storage. L* and b* values of the kiwi fruit were measured at the equatorial level with the help of this device. Additionally, a* and b* values were taken into account while calculating the Hue angle (ho) of the fruit (McGuire, 1992).

Fungal Rot Ratios (%)

During the experiment, fruit removed from the storage for analysis purposes at the end of the storage periods were examined, and the fungal growths (Alternaria, Botrytis, Penicillium) were detected just by observation. During the process of determination of fungal rot disease, the fungal development rate was calculated as % by taking into account the number of kiwi fruit.

pH Values

The pH values of these solutions were measured according to the neutralization principle using the electrometric measurement method.

Vitamin C Content (mg 100g^{-1})

The amount of 2,6-Dichlorophenolindophenol was measured by using the spectrophotometric method and Shimadzu.UV-VIS -1800.spectrophotometer proposed by Pearson (1970). The samples were added to 25 g of fruit puree and 175 ml of 0.4% oxalic acid and then filtered them on Whatmann No: 2 filter paper for 10 minutes. In response to the mixture of Oxalic Acid/Distilled Water: 1/10 solution and Oxalic Acid/2,6-Dichlorophenolindophenol: 1/10 solution were read at 520 nm transmittance and the L1 value was determined.; The L2 value for the samples was determined by measuring the Filtrate/Distilled Water: 1/10 solution and Filtrate/2,6-Dichlorophenolindophenol: 1/10 solution at 520 nm transmittance value in response to the filtrate solution with samples taken from each filtrate for each sample.

Statistical analyses

The experiment was carried out with three replications according to the randomized complete block design.

5 kiwi fruits were used in each replication. The SAS 9.1 computer package program was used and the analysis of variance was performed for the statistical analysis of data, and differences between the means of the data were compared with the LSD (P<0.05) test.

Results and Discussion

Fruit Flesh Firmness (FFF kgf)

Variations in FFF values of 'Hayward' kiwi variety according to different periods and storage applications during storage is presented in Figure 1. According to the findings of this study, some decreases were observed in FFF values during the storage period of kiwi fruit. Statistically significant differences were found in the variation of FFF values during the storage period (p≤0.05).

A rapid loss of firmness was observed in the control group fruit after the 90th day when the differences in FFF values between storage applications were examined, while it has been determined that the losses are more limited in terms of the MAP applications. The lowest FFF value (2.13 kgf) was determined in the fruit of the control group. Values of 2.43 kgf in MAP Control application, 2.60 kgf in MAP 1 application, 2.90 kgf in MAP 2 application, while 3.16 kgf were observed in MAP 3 application. Furthermore, it was determined that the application that best preserved FFF loss was MAP 4 application with a value of 3.67 kgf. These results show that all treatments, except the control group, are effective only in preserving FFF. Additionally, in this study, it has been determined that these decreases in FFF values as the storage period increases were lower than in control fruit in all MAP applications, and the results were compatible with most kiwi storage studies (Koyuncu et al., 2005; Kaynaş, 2017; Alkın et al., 2022).

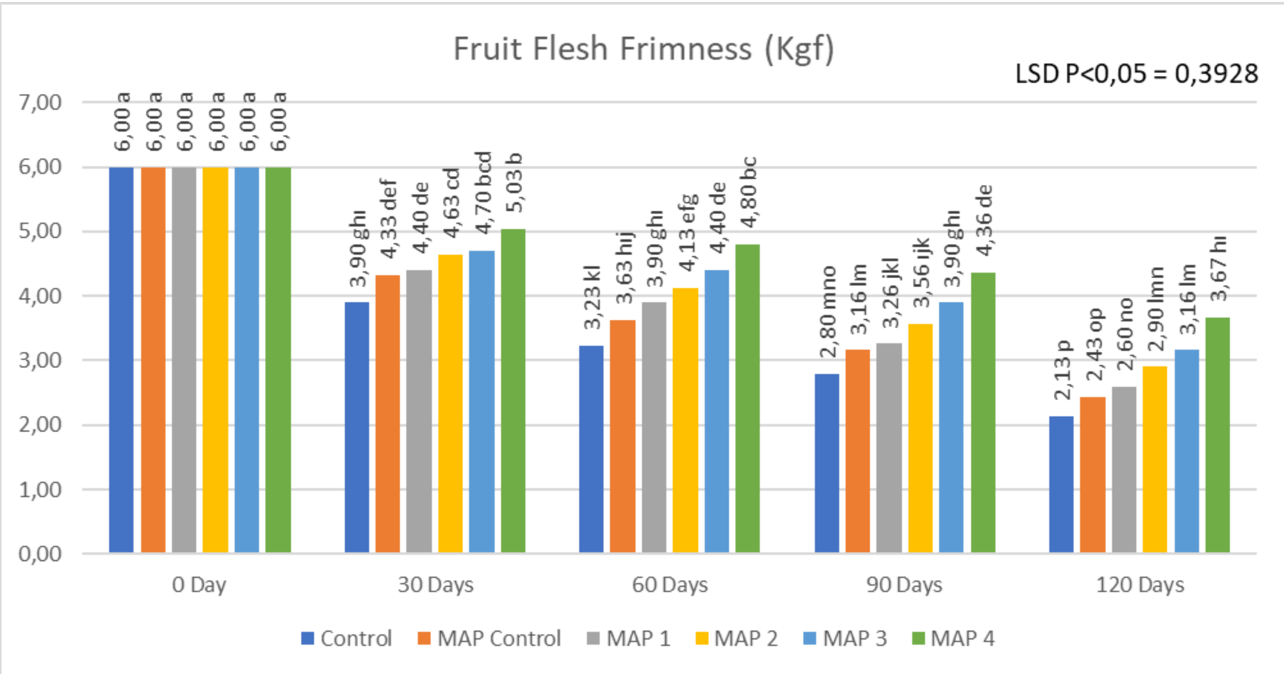

Figure 1. Effects of storage applications on fruit flesh firmness in Hayward kiwi variety (kgf).

During the ripening process, the main variations in fruit flesh firmness are associated with the breakdown of cellular components such as cellulose and pectin. Enzymatic activities, especially enzymes such as pectin methyl esterase and polygalacturonase, can cause the bonds in pectin networks to weaken and reduce fruit flesh firmness. However, during the ripening process, expansion and growth in the cells may cause the fruit flesh tissue to soften and firmness to decrease. Essential oils often have antimicrobial and antioxidant properties. These properties may reduce microbial activity in fruit flesh and may slow down oxidation processes. This situation may also help the fruit flesh maintain its freshness and firmness for a longer period. The reasons why essential oil applications give better results in preserved kiwi fruit may also be supported by these explanations. The air permeability of MAP bags may affect the moisture balance and gas exchange in the fruit flesh. Correct air permeability levels may keep the ripening process of fruit flesh under control, and it was also determined as a result of the experiment that it helps maintain the firmness of fruit. SiegaFresh, used in the experiment, is a substance sensitive to ethylene positively affected the firmness of the fruit flesh in kiwi. SiegaFresh is an ethylene absorbent substance used to control the exposure of fruit to ethylene during the ripening process. It is also known that ethylene is a gas that plays a role in the ripening process of many fruits and vegetables. In the experiment, it was thought that this was the most important point in the positive effect of SiegaFresh application on FFF. The fruit flesh softens and ripens when kiwi fruits are exposed to ethylene during the ripening process. Exposure of kiwi fruit to ethylene can be controlled by using SiegaFresh. As a result, it is understood that the firmness of the fruit flesh can be preserved for a longer time. The protective effect of SiegaFresh against ethylene helps the fruit flesh to remain at the desired firmness level (Shaymaa et al., 2016; Şen et al., 2022).

Weight Loss (WL-%)

Variations in weight loss during storage were determined in the 'Hayward' kiwi variety to which MAP applications were applied. The findings are presented in Figure 2. According to the results of this study, it has been determined that the MAP applications are of great importance to the kiwi fruit in terms of maintaining weight loss as compared to the fruit of the control group ($p \leq 0.05$).

Considering the weight losses detected during storage, weight loss values increased from the beginning to the 120th day as the storage period increased in all applications (Figure 2). The percentage weight loss detected in the Control group was recorded as 1.2% on the 30th day, 3.7% on the 60th day, 5.5% on the 90th day and 8.1% on the 120th day. While, it was determined that the highest weight loss occurred in the control group. In the MAP Control application, weight loss was determined as 0.8% on the 30th day, 1.2% on the 60th day, 1.6% on the 90th day and 2.3% on the 120th day. Our findings compared the increase in weight loss in the control group with the increases in MAP C application, showing that the increases in MAP C application were at lower levels. In the same way, on the 120th day, a weight loss of 2.3% was observed in MAP 1 application, 2.2% in MAP 2 application, 2.1% in MAP 3 application, and 2% in MAP 4 application. Consequently, it has been observed that weight loss percentages between 2.3% and 2% observed for 120 days of storage period in MAP applications of 'Hayward' kiwi variety resulted well. Particularly, the lowest weight loss increases on the 90th day was determined in kiwi fruit to which MAP 4 was applied.

Lower weight loss in the fruit and delayed ripening after the shelf-life period were detected in the kiwi storage study conducted by Korkmaz, (2020).

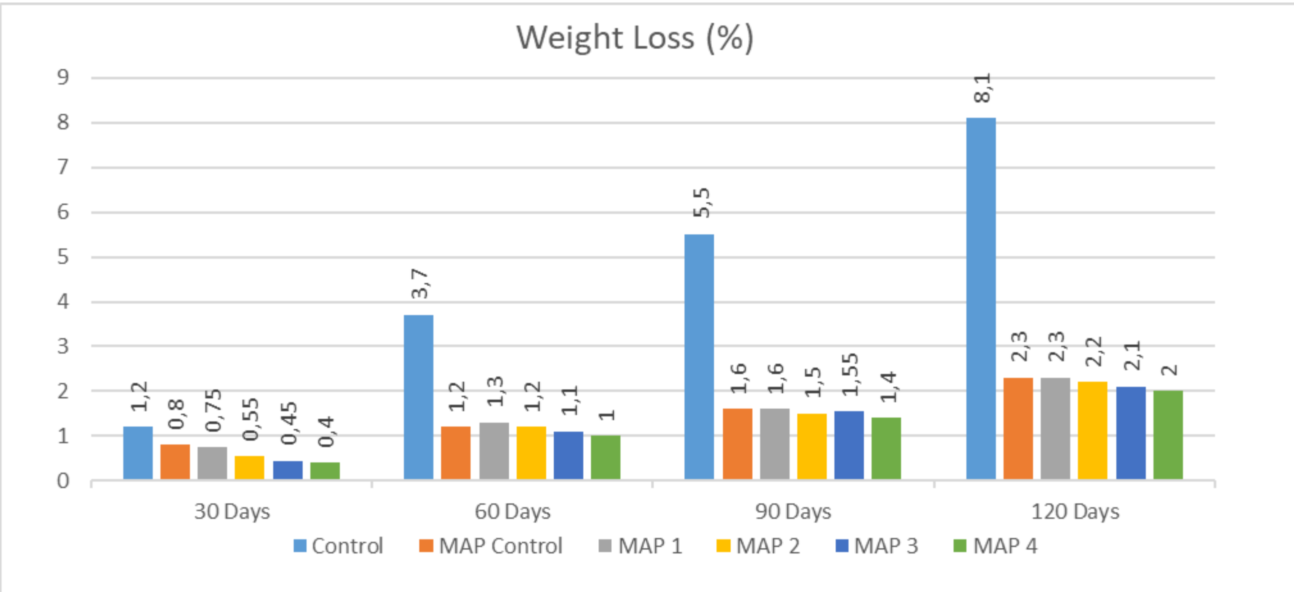

Figure 2. Effects of storage applications on total weight loss in fruit of Hayward kiwi variety (%)

Essential oils may have antioxidant properties and slow down oxidation processes in fruit. This may reduce weight loss by keeping fruit fresher longer. Essential oils may reduce the evaporation of fruit juice and thus, it may reduce weight loss by preserving the moisture of the fruit. Some essential oils can regulate the metabolism of fruit cells. In this way, it can keep cells alive longer. This can reduce the fruit weight loss. MAP bags can extend the shelf life of fruit by controlling components such as oxygen, carbon dioxide and humidity of the atmosphere in which the fruit are located, and it can maintain its quality and may affect fruit weight. Because MAP bags regulate the metabolic activities of fruit by controlling the respiration rate and gas exchange of fruit, ensuring that the fruit stay fresh for longer and reduce fruit weight loss.

SiegaFresh applications slow down the ripening process of fruit by controlling the atmosphere in which the kiwi fruit are located and optimizing the oxygen and carbon dioxide levels, and it keeps metabolic activities under control by regulating the respiratory rate in kiwi fruit. In this way, it has been determined that the weight loss of kiwi fruit was reduced (Thanassoulopoulos and Yanna, 1995; Serrano et al., 2005; Nikos et al., 2011).

Soluble Solid Content (SSC %)

One of the most important parameters of harvest maturity, progression of maturity in storage and shelf life of the fruit are the SSC in fruit varieties that exhibit a climacteric structure such as kiwi. Variation of SSC amounts in 'Hayward' kiwi variety in terms of stages and storage applications throughout the storage period are presented in Figure 3. Findings show that the SSC generally increase as the storage duration increases in kiwi varieties. The effect of storage periods and post-harvest applications on the amount of SSC in kiwi fruit was found to be statistically significant ($p \leq 0.05$).

Generally, an increase in the SSC was observed in the 'Hayward' kiwi variety during fruit storage period. The SSC in the fruit of control group, which was 9.50% at the beginning, but increased to 17.20% in the 120th day of the storage. According to our findings, the values were 16.26%, 16.53%, 15.93%, 14.53%, and 14.00% in MAP Control, MAP 1, MAP 2, MAP 3, and MAP 4 applications, respectively, when the effect of different post-harvest applications was examined on the SSC. It was observed that all MAP applications showed lower SSC values as compared to the control group, and had similar values among themselves.

It is a normal process that as ripening progresses, then the starch in fruit structure breaks down and turns into simple sugars, and such situation leads to an increase in the amount of SSC. In this study, it was noted that the MAP applications suppressed the ripening of fruit. That is why, less change was observed in SSC (Kaynaş, 2017; Shaymaa et al, 2016).

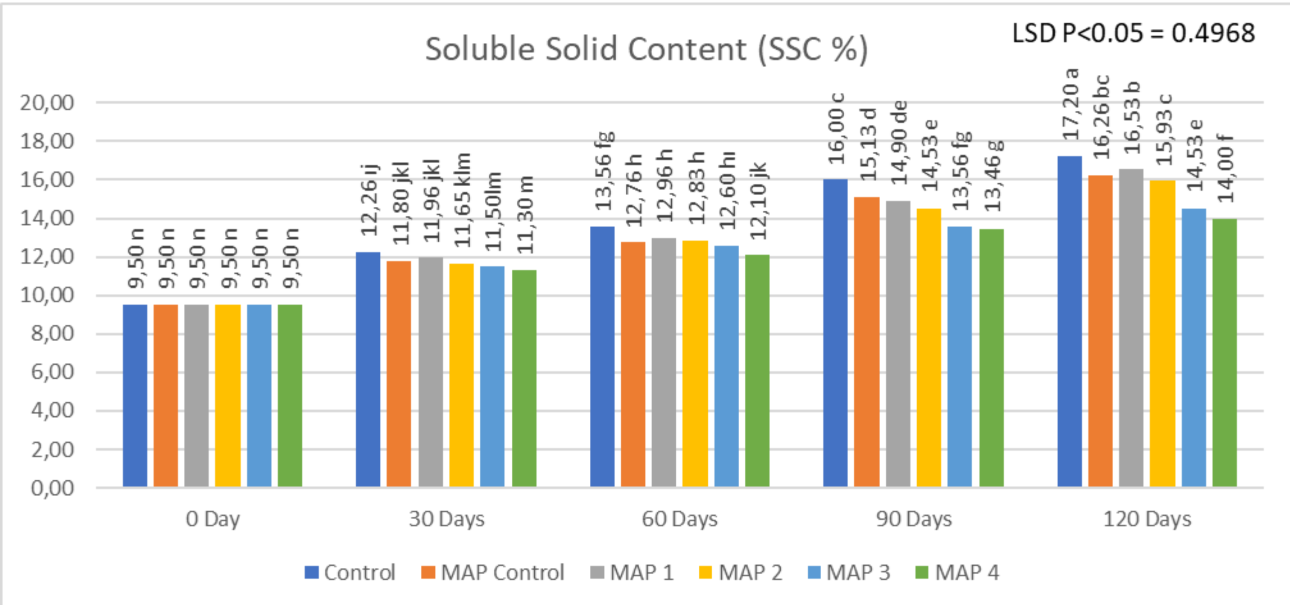

Figure 3. Effects of storage applications on the amounts of SSC in Hayward kiwi variety (%)

The rate of respiration of kiwi may change during storage. High respiration rate can cause loss of SSC of the fruit. Metabolic processes can also affect the amount of SSC. Intake and loss of water in kiwi during storage is an important factor. As water intake decreases, the amount of SSC may increase. Enzymatic activities in kiwi may vary during storage. These activities can affect the amount of SSC. The cellular structure of kiwi may vary during storage. These changes may affect the amount of SSC. Storage conditions such as humidity, temperature, and gas concentration can also affect the amount of SSC. It is important to provide storage conditions such as humidity, temperature, and gas concentration throughout the storage period in order to preserve best the SSC content of kiwi during storage. SiegaFresh" can often help reduce water loss and/or increase the water retention capacity of kiwi fruit. This can help maintain the amount of SSC. (Shaymaa et.al., 2016).

h° Value at Flesh Color

The Hue angle (ho) values of the flesh color determined during the storage period in the ‘Hayward’ kiwi variety, stored in the cold under MAP conditions after applying different post-harvest applications, are given in Figure 4. According to the results, shown in Figure 4., it has been observed that the values of Hue angle (ho) of kiwi fruit decreased from the beginning during its 120-day storage period.

It has been determined that the effects of different storage periods on ho values of the ‘Hayward’ kiwi variety were found statistically significant ($p \leq 0.05$). In the fruit, stored in the control group, ho value which was 113.73o at the beginning of the storage period, decreased to 99.50o at the end of the 120 days. Because, a continuous decrease in ho values was observed throughout the duration of 120-day storage period.

It was observed that the highest ho values were recorded in MAP 4 and MAP 3 applications as 103.16o and 102.50o, respectively when the effects of different post-harvest applications on ho values in “Hayward” kiwi variety are examined. These applications were followed by MAP 2 with a value of 100.96o, MAP 1 with a value of 100.10o, and MAP Control (C) with a value of 99.96o. These applications belong to the same statistical class. The effects of different post-harvest applications on ho values of the ‘Hayward’ kiwi variety were found to be statistically significant (Figure 4.).

According to the results of this study, it was concluded that the MAP applications on ‘Hayward’ kiwi variety preserved the flesh color (ho value) better than that of the control group. In a study examining the quality characteristics of ‘Sungold’ kiwi fruit variety after storage, it was observed that the flesh color (ho value) decreased with increasing storage time (Sakaldaş ve Gündoğdu, 2020).

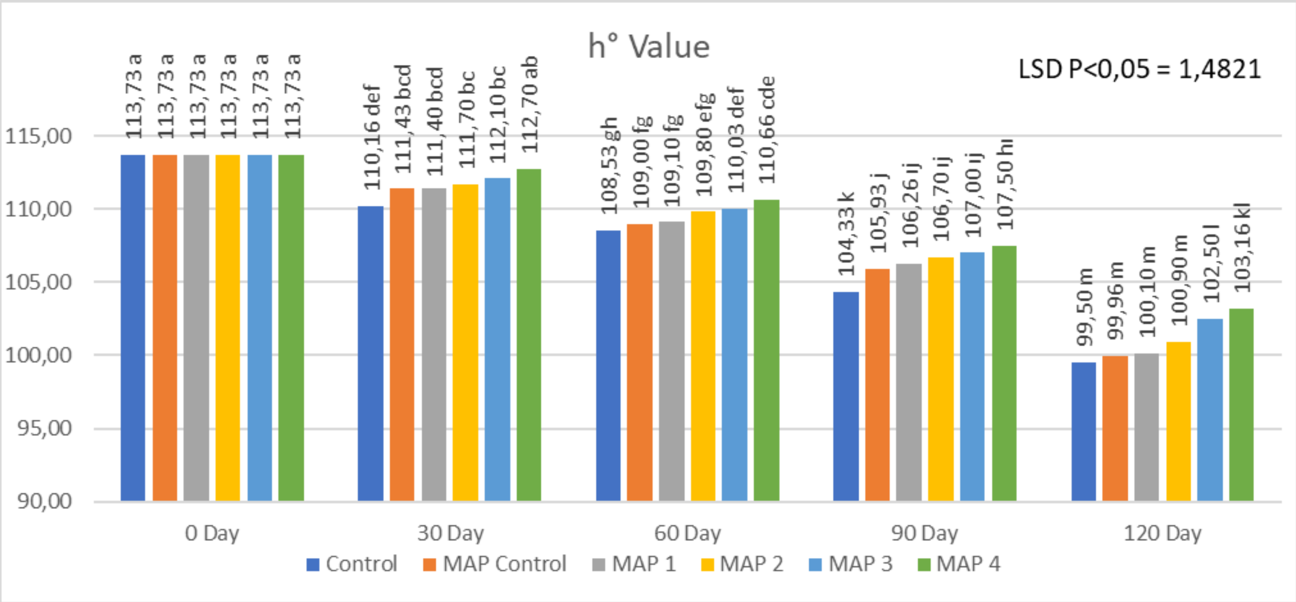

Figure 4. Effects of storage applications on ho value of fruit in Hayward kiwi variety (%)

Variations in the flesh color of kiwi fruit during storage are generally related to the ripening process and storage conditions. The flesh color of kiwi fruit can generally change from green to yellow, then orange and finally orange-brown tones during the ripening process. These color variations are usually associated with the maturation of carotenoid pigments naturally found within the fruit additionally oxidation may also be effective in variations in the color of the kiwi fruit flesh.

pH Values

The pH values, determined in cold-stored 'Hayward' kiwi varieties during the storage period are presented in Figure 5. During the examination of the variations in pH levels of fruit of the 'Hayward' kiwi variety stored under different MAP conditions, it was determined that a regular increase was observed throughout the storage period. These variations were found to be statistically significant ($p \leq 0.05$). The pH value of fruit in the control group, which was 3.41 at the beginning of the storage period, but it increased to 4.62 at the end of the storage period (Figure 5).

It was seen that the highest pH value has been recorded as 3.75 in the MAP 4 application when the effect of different post-harvest applications on pH values was examined. According to the other applications, it was determined that the MAP 3 application was noted as 3.79, MAP 2 application was recorded as 4.10, MAP 1 application was observed as 4.33, and MAP Control (C) application was reported as 4.20. Moreover, it has been determined that these applications belong to different statistical classes (Figure 5.).

According to the results of a previous study, it has been observed that in many fruit the amount of acid decreases towards maturity, while the amount of pH increases (Galeta and Himelrick, 1990).

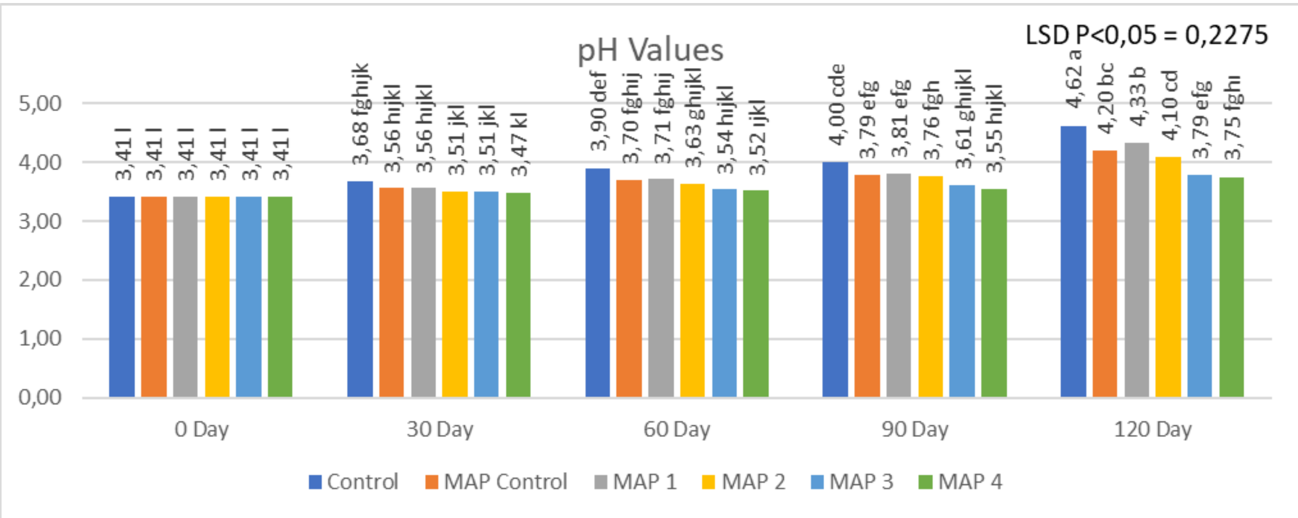

Figure 5. Effects of different storage applications on pH values in Hayward kiwi variety

The pH values of kiwi during storage may vary depending on various factors. Oxidative reactions may occur as a result of kiwi when come in contact with oxygen during storage. As a result of these reactions, acidity may increase while pH value decrease.

Acidity may increase and pH value decrease as a result of the fermentation of naturally occurring sugars during the storage period of kiwi fruit.

The level of acidity may increase or decrease as a result of the activity of microorganisms during the storage of kiwi, this situation may also affect the pH values. Temperature, humidity and light like abiotic factors, at which the kiwi is stored, may also affect the pH values. Particularly, high levels of temperature and humidity may help to increase the activity of microorganisms and may also vary the pH values (Şen et al., 2022).

Vitamin C Content (mg 100 g-1)

The amounts of vitamin C detected during the storage period in "Hayward" kiwi variety with different post-harvest applications are shown in Figure 6.

Some continuous decreases were observed throughout the storage period when the variations in the amounts of vitamin C in fruit stored under different MAP conditions after harvest in the fruit of 'Hayward' kiwi variety were examined. These decreases were found to be statistically significant ($p \leq 0.05$). Kiwi fruit, in the control group, started with a Vitamin C content of 154.63 $mg.100g^{-1}$ at the beginning of storage, however, this amount was decreased to 81.26 $mg.100g^{-1}$ at the end of the storage period.

When the effects of different applications on the amounts of vitamin C were examined, the highest value was determined in MAP 4 application with 100.36 mg $100g^{-1}$ followed by MAP 3 and MAP 2 applications with Vitamin C content as 90.23 mg $100g^{-1}$ and 88.70 mg $100g^{-1}$, respectively, and the above-mentioned MAP applications belonged to the same statistical class. In case of other applications, it was observed that the MAP 1 application was recorded as 87.66 mg 100 g^{-1}, while MAP Control (C) application was noted as 83.33 mg 100 g^{-1}, and it has also been observed that the MAP applications belong to the same statistical class (Figure 6).

The decrease in the amount of vitamin C could be considered as an indicator of the use of ascorbic acid in metabolism during the progressive ripening process of the fruit (Kök, 2006). Similarly, it is stated in another study that the amount of vitamin C in kiwi fruit decreases during the ripening period (Namdar, 2005).

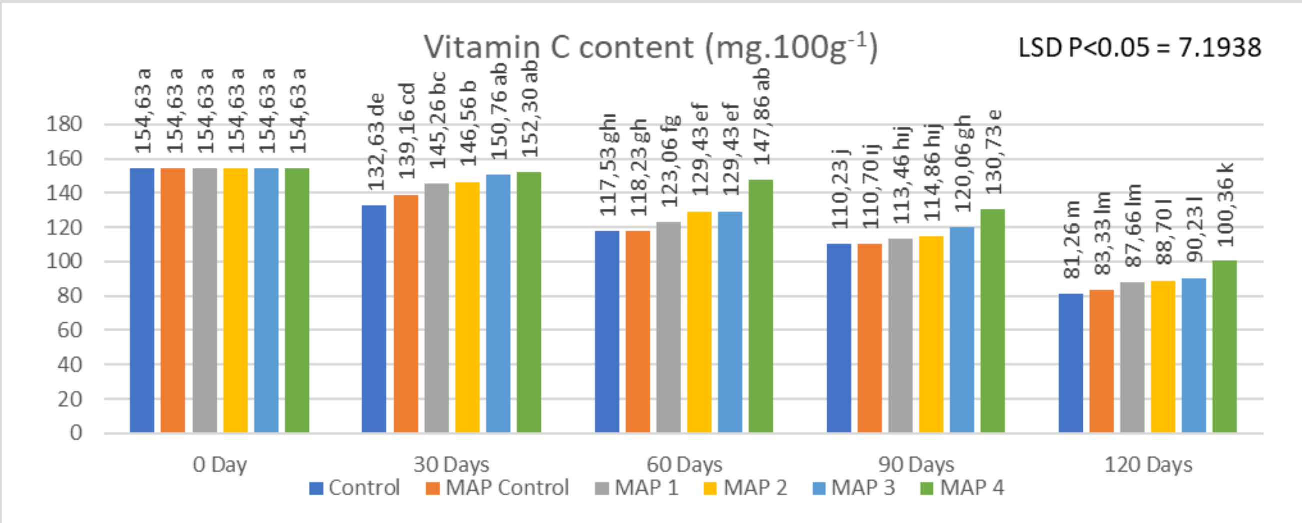

Figure 6. Effects of different storage applications on vitamin C content in Hayward kiwi variety

Fungal Rot Ratios (%)

Fungal rot, which occurs in fruit warehouses during storage, is one of the crucial problems that could cause commercial losses and shortening of the shelf life of fruit. Therefore, it is important to minimize fruit losses by controlling the fungal rot during storage applications.

In a study, conducted on 'Hayward' kiwi variety, the fruit loss rates resulting from fungal rot diseases determined through observation during 120 days of storage are presented in Figure 9. In the control group, fruit showing fungal rot disease, were observed in each storage period. Fruit decaying rates increased particularly, after the 60th day, while the decaying rates showed the highest value on the 90th day.

It has been observed that the less decaying was found in the MAP Control (C) application as compared to the control group. In the MAP 4 application, no rotten kiwi fruit was found in the first 60 days of storage, however, 0.5% decaying was observed on the 90th day and 1% on the 120th day. In case of the MAP 3 application, no fruit decaying was observed during the first 30 days, but the fruit decaying rates of 1% on the 60th day, 1.5% on the 90th day while 1% on the 120th day were observed. Lower fruit decaying rates were determined in MAP Control (C), MAP 1 and MAP 2 applications as compared to the control group.

According to the results of this study, it was concluded that SiegaFresh Finish and essential oil-containing MAP applications to "Hayward" kiwi varieties were effective in reducing fruit losses caused by the fungal rot disease that occurred during the fruit storage (Shaymaa et al., 2016; Thanassopoulos and Laidou,1997; Gutiérrez-Pozo et al., 2023; Combrinck et al. 2011).

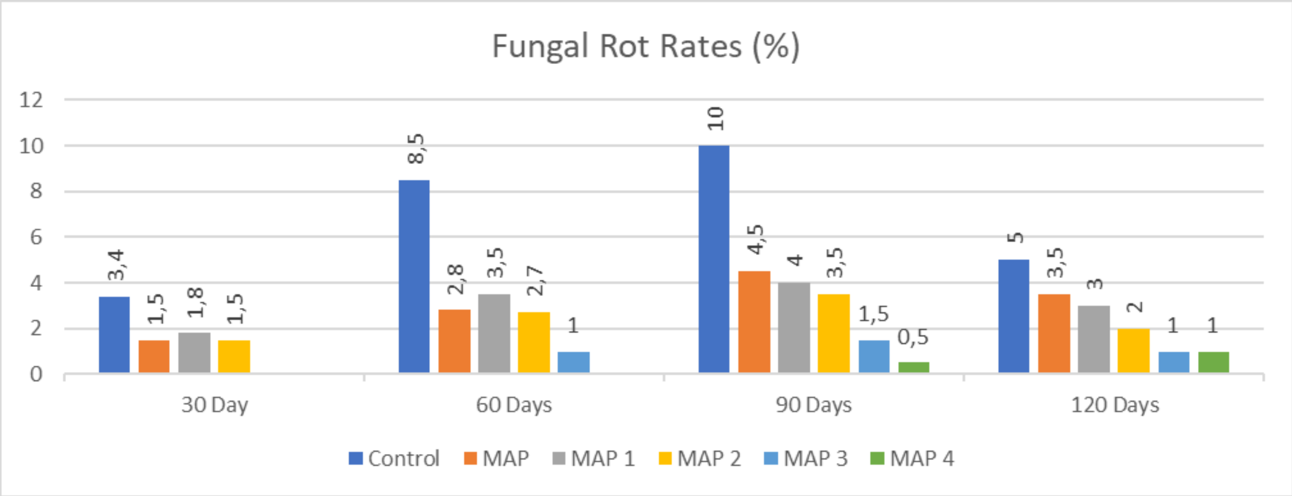

Figure 7. Rates of fungal rot disease in "Hayward" kiwi varieties after storage periods

Conclusion

According to the results of this study, quality losses occurred as the storage period increased in all applications, however, it has been observed that these quality losses are better preserved with the MAP applications. Furthermore, it was determined that the MAP applications, applied in 'Hayward' kiwi variety, had a significant effect especially on weight loss and FFF parameters. Significant differences were observed between MAP applications containing essential oil and MAP C applications aimed to examine their effects. For this reason, it has been observed that all MAP applications provided positive results in terms of quality criteria. Minimizing fruit loss is one of the primary objectives in storage. The important obtained results are that the SiegaFresh Finish application causes almost no fruit loss, and that applications containing essential oils, minimize the fruit loss. Among the essential oils, the mixture of bitter almond+thyme oils provided satisfactory results. Afterwards, the order could be made as bitter almond oil, and finally, the thyme oil.

In conclusion, the 'Hayward' kiwi variety could be stored successfully for up to 120 days with MAP applications. Additionally, SiegaFresh Finish application reduces the post-harvest losses, and it is also concluded that this application can be used effectively to maintain the quality of kiwi fruit. On the other hand, the transfer of the intense aromatic scents of bitter almond and common thyme oils to the kiwi fruit has changed the natural flavor profile of the fruit. Moreover, it was also concluded that these essential oils affect the quality of commercial products by creating a combination of undesirable taste and odor.

Additional Information and Declarations

Authors' Contributions: Both authors have contributed equally to the article. All authors read and approved the final manuscript.

Conflict of Interests: The authors of the article declare that they do not have any conflict of interest.

References

Alkın, G., Şeker, M., Kaynaş, K. 2022. Geçci ve İhracata Yönelik Şeftali Çeşitlerinde Uçucu Yağ Emdirilmiş MAP Uygulamalarının Depolama Kalitesine Etkisi. Yüksek Lisans Tezi, Çanakkale Onsekiz Mart Üniversitesi, Lisansüstü Eğitim Enstitüsü, Çanakkale.

Antunes, M. D., Cavaco, A. M. 2010. The use of essential oils for postharvest decay control: A review. Flavour and Fragrance Journal, 25(5): 291-312.

Arslan, U. 1998. Doğu Karadeniz Bölgesinde Kivi Yetiştiriciliğinin Araştırılması ve Kivi Fidan Üretimi. Yüksek Lisans Tezi. Karadeniz Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Trabzon.

Barboni, T., Cocci, E., Battistelli, A., Mercuri, A. 2010. Postharvest ozone treatment of kiwifruit: Effects on storage quality and phytochemical characteristics. Journal of the Science of Food and Agriculture, 90(4): 622-628.

Combrinck, S., Regnier, T., Kamatou, G. P. 2011. In vitro activity of eighteen essential oils and some major components against common postharvest fungal pathogens of fruit. Industrial Crops and Products, 33(2): 344-349.

Daferera, D. J., Ziogas, B. N., Polissiou, M. G. 2003. GC-MS analysis of essential oils from some Greek aromatic plants and their fungitoxicity on Penicillium digitatum. Journal of Agricultural and Food Chemistry, 51(11): 3176-3182.

Feliziani, E., Romanazzi, G., Smilanick, J. L. 2014a. Postharvest ozone treatments for the control of table grape diseases. Postharvest Biology and Technology, 89: 11-19.

Feliziani, E., Romanazzi, G., Smilanick, J. L., Droby, S., Lichter, A., Gabler, F. M. 2014b. Recent advances in the use of biocontrol agents for postharvest diseases of fresh fruits and vegetables. Postharvest Biology and Technology, 90: 1-7.

Gutiérrez-Pozo, M., Serna-Escolano, V., Giménez-Berenguer, M., Giménez, M. J., Zapata, P. J. 2023. The Preharvest Application of Essential Oils (Carvacrol, Eugenol, and Thymol) Reduces Fungal Decay in Lemons. Agriculture, 13(7): 1437.

Kader, A. A. 1988. Mode of action of oxygen and carbon dioxide on postharvest physiology of' Bartlett pears. In International Symposium on Postharvest Handling of Fruit and Vegetables, 258, 161-168.

Kaynaş, K. 2017. Bahçe Ürünlerinin Biyokimyasal Yapısı. In: Türk, R. ve ark., Bahçe Ürünlerinin Muhafazası ve Pazara Hazırlanması, (1, s..37-60). Somtad Yayınları: Antalya.

Korkmaz, M. 2020. Giresun'un Farklı İlçelerinde Yetiştirilen 'Haywrad'Kivi Çeşidinde Kalite Özelliklerinin Muhafaza Süresince Değişimi. Yüksek Lisans Tezi, Fen Bilimleri Enstitüsü.

Koyuncu, M. A., Islam, A., Küçük, M. 2005. Fat and fatty acid composition of hazelnut kernels in vacuum packages during storage. Grasas y Aceites, 56(4): 263-266.

Kök, E. B. D. 2006. Kivide (Actinidia deliciosa) Farklı Dozda Karpit Uygulamalarının Bazı Meyve Kalite Kriterlerine Etkileri. Tekirdağ Ziraat Fakültesi Dergisi, 3: 213-219. https://dergipark.org.tr/en/pub/jotaf/issue/19057/201556

McGuire, R. G. 1992. Reporting of objective color measurements. HortScience, 27(12): 1254-1255..

Namdar, S. 2005. Samsun Ekoloji Koşullarında Yetiştirelen Hayward Kivi Çeşidinin Soğukta Muhafazasında Farklı Ambalaj Tiplerinin Etkileri. Yüksek Lisans Tezi, Ondokuz Mayıs Üniversitesi, Lisansüstü Enstitüsü, Samsun.

Nikos G, T., Katerina, T., Costas D, E. 2011. Effect of origanum oil and vinegar on the maintenance of postharvest quality of tomato. Food and Nutrition Sciences, 2011.

Pearson, D, 1970. Analyses determination of L-ascorbic acid. International federation of fruit juice producers. No:17.

Sakaldaş, M., Gündoğdu, M. A. 2020. Sungold' Kivi Çeşidinin Kalite Özellikleri Üzerine Modifiye Atmosfer Paketlemenin Etkisi. Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi, 6(2): 186-193.

Serrano, M., Martinez-Romero, D., Castillo, S., Guillén, F., Valero, D. 2005. The use of natural antifungal compounds improves the beneficial effect of MAP in sweet cherry storage. Innovative food science & emerging technologies, 6(1): 115-123.

Servili, M., Esposto, S., Taticchi, A., Urbani, S., Selvaggini, R., Montedoro, G. F., Serravalle, M. 2017. Evaluation of phenolic compounds in virgin olive oil by direct injection in high performance liquid chromatography with fluorometric detection. Journal of Agricultural and Food Chemistry, 55(8): 2589-2595.

Shaymaa M. Raafat, M.I. Abou-Zaid, M.R. Tohamy, H.E. Arisha 2016. Impact of some plant essential oil treatments on controlling cherry tomatoes spoilage, improvement of shelf life and Quality attributes during storage. Zagazig J. Agric. Res., Vol. 43 No. (3).

Sivakumar, D., Bautista-Baños, S., Gómez-López, V. M. 2014. A review on the use of essential oils for postharvest decay control and maintenance of fruit quality during storage. Crop Protection, 64: 27-37.

Snowdon, A. L. 1990. A color atlas of post-harvest diseases and disorders of fruits and vegetables: Volume 1: General Introduction and Fruits. CRC Press.

Şen, F., Akın, M. A., Aktürk, C., Kıyı, H. 2022. Farklı Hasat Sonrası Bazı Uygulamaların Organik Yetiştirilen Nar Meyvelerinin Depolanabilirliğine Etkilerinin Araştırılması. Biyoloji Bilimleri Araştırma Dergisi, 15(1): 19–29. https://bibad.gen.tr/index.php/bibad/article/view/425

Thanassoulopoulos, C. C., Yanna, L. 1995. On the biological control of Botrytis cinerea on Kiwifruit Cv" Hayward" during storage. In III International Symposium on Kiwifruit 444, 757-764 pp.

Tripathi, P., Dubey, N. K., Shukla, A. K. 2008. Use of some essential oils as postharvest botanical fungicides in the management of grey mould of grapes caused by Botrytis cinerea. World Journal of Microbiology and Biotechnology, 24(1): 39-46.

Zagory, D., Kader, A.A. 1988. Modified atmosphere packaging of fruits and vegetables. Critical Reviews in Food Science and Nutrition, 28(1): 1-30.

Ziedan, E.H., Farrag, E.S. 2008. Postharvest application of essential oils for extending the shelf life of fresh fruits. Australian Journal of Basic and Applied Sciences, 2(4): 747-758.