Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi
Journal of Agricultural Faculty of Gaziosmanpasa University
https://dergipark.org.tr/tr/pub/gopzfd

Araştırma Makalesi/*Research Article*

JAFAG
ISSN: 1300-2910
E-ISSN: 2147-8848
(2024)41(1) 8-16
doi:10.55507/gopzfd.1397096

Comparison of Cold Storage Abilities of 'Ayvaniye' and 'Granny Smith' Apple Cultivars

Fatmanur ÇEZİK[1] Osman Nuri ÖCALAN[1] Emircan DİNÇER[1]
Ala Asi Mohammed AL-SALIHI[1] Muhammed Rahmetullah ÇİĞDEM[1]
Mehmet Emin İŞBİLİR[1] Ebubekir PAŞAZADE[2]
Burhan ÖZTÜRK[3] Onur SARAÇOĞLU[1]

[1]Tokat Gaziosmanpaşa University, Faculty of Agriculture, Department of Horticulture, Tokat
[2] Central Black Sea Transition Zone, Agricultural Research Institute, Tokat
[3] Ordu University, Faculty of Agriculture, Department of Horticulture, Ordu

***Corresponding author's email: osmannuri.ocalan@gop.edu.tr**

Alındığı tarih (Received): 28.11.2023 Kabul tarihi (Accepted): 16.02.2024

Abstract: The aim of this study is to compare the 'Granny Smith' apple cultivar, which is well-known to withstand storage, and the 'Ayvaniye' apple, a local cultivar, in terms of some quality characteristics, and to determine their suitability for storage. The apples included in the experiment were stored at 1±0.5 °C and 90±5% relative humidity for 6 months. Measurements and analyses were done once a month from the beginning to the end of storage. The parameters examined in the trial are: Weight loss, fruit flesh firmness, pH, titratable acidity (TA), soluble solids content (SSC), total phenolic substance content (TPC), total antioxidant activity (TAA) and fruit outer colour (L*, a*, b*). As a result; weight loss, pH, TAA, L* and a* parameters were found higher in 'Ayvaniye' cultivar. In terms of TA, SSC, TPC and b* parameters, 'Granny Smith' cultivar was better. Additionally, the flesh firmness of 'Granny Smith' cultivar was higher at the beginning of storage. When all parameters were evaluated, 'Ayvaniye' cultivar is suitable for cold storage for 6 months, but weight loss may be a problem for storage longer than 6 months.

Keywords: Antioxidant, Firmness, *Malus communis* L., Phytochemical, Total phenolic

'Ayvaniye' ve 'Granny Smith' Elma Çeşitlerinin Soğukta Depolama Kabiliyetlerinin Karşılaştırılması

Öz: Bu çalışmanın amacı, depolamaya dayanımı iyi bilinen 'Granny Smith' elma çeşidiyle, yerel bir çeşit olan 'Ayvaniye' elmasının bazı kalite özellikleri bakımından karşılaştırılması yapılarak depolamaya uygunluğunun belirlenmesidir. Denemeye alınan elmalar 1±0.5 °C ve %90±5 nispi nemde 6 ay boyunca muhafaza edilmiştir. Depolamanın başlangıcından sonuna kadar ayda bir olmak kaydıyla ölçüm ve analizler yapılmıştır. Denemede incelenen parametreler şunlardır: Ağırlık kaybı, meyve eti sertliği, pH, titre edilebilir asitlik (TEA), suda çözünür kuru madde (SÇKM), toplam fenolik madde içeriği (TPC), toplam antioksidan aktivite (TAA) ve meyve dış rengi (L*, a*, b*). Çalışma sonucunda, 'Ayvaniye' çeşidinde ağırlık kaybı, SÇKM, TAA, L* ve a* parametreleri daha yüksek bulunmuştur. pH, TEA, TPC ve b* parametreleri açısından ise 'Granny Smith' çeşidi daha iyidir. Ek olarak depolama başlangıcında 'Granny Smith' elmalarının meyve eti sertliği daha yüksek olmuştur. Tüm parametreler değerlendirildiğinde 'Ayvaniye' çeşidinin 6 ay boyunca soğuk depolamaya uygun olduğu tespit edilmiştir ancak 6 aydan uzun depolamalar için ağırlık kaybı problem olabilir.

Anahtar Kelimeler: Antioksidan, Sıkılık, *Malus communis* L., Toplam fenolik

1. Introduction

Apple (*Malus communis* L.); it is a temperate climate fruit species belonging to the *Malus* genus of the *Rosales* order, *Rosaceae* family, *Pomoideae* subfamily. Today, cultivated apple has spread to almost all temperate climate regions of the northern and southern hemispheres. In Türkiye, it is almost grown in every region. However, Northern Anatolia, grown wild species is most suitable region. The transition areas between Northern Anatolia, the Black Sea coastal region, and the Central Anatolia and Eastern Anatolia plateaus constitute the apple culture areas. In the Aegean region, it is grown successfully in areas above 500 m altitude (Güleryüz, 1975; Özkan, 1998; Yanar and Ecevit, 2009).

According to 2021 data of FAO stats, Asia (65.8%) has the highest apple production in the world (Figure 1).

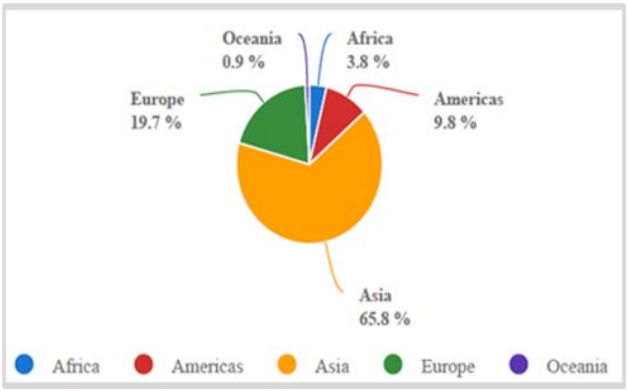


Figure 1. Percentage distribution of apple production among continents in 2021. (FAO)
Şekil 1. *2021 yılında Kıtalar arasında elma üretiminin yüzdesel dağılımı (FAO)*

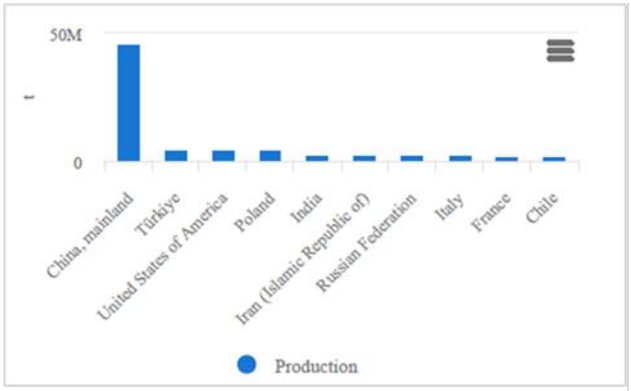


Figure 2. The top 10 countries with the most apple production in 2021. (FAO)
Şekil 2. *2021 yılında en fazla elma üretimi yapan ilk 10 ülke (FAO)*

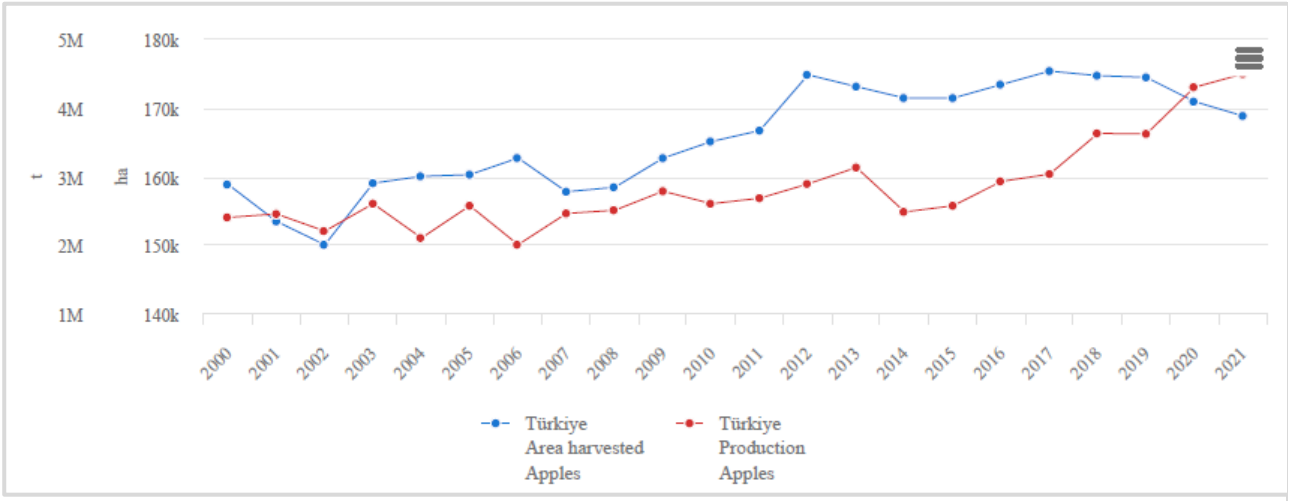


Figure 3. Apple production by years in Türkiye (FAO
Şekil 3. *2021 yılında Türkiye'de yıllara göre elma üretimi (FAO)*

In 2021, total apple production was 93 144 358.17 tons in the world (FAO). According to the countries, China ranked first with a production of 45 983 400 tonnes. Turkey followed with 4 493 264 tonnes. The USA ranked third with a production of 4 467 206 tonnes (FAO; Figure 2). Türkiye has shown a steady increase in apple production in recent years (FAO; Figure 3).

Apple generally loses its quality after harvest. In stored products, the loss of quality is very slow. Storage is the process of keeping the product in conditions that preserve its quality for later marketing (Karaman at al., 2009). The most appropriate way to preserve the products with the least loss of quality and quantity is cold storage (Kaynaş at al., 2009). Apples can be stored under appropriate storage conditions for 4-10 months, depending on the cultivar (Saraçoğlu at al., 2011). There is not enough information regarding cold storage of local apple cultivars in rural areas. Determining the post-harvest storage capabilities and fruit quality characteristics of local cultivars will provide both a more profitable income for the people in that region producing them and benefit for future breeding studies.

'Ayvaniye' was evaluated as the local apple cultivar in this study. It is cultivated in Gürün district of Sivas province. This local cultivar has been grown for many years. There is no orchard consisting only of this cultivar in the district, and producers grow it for domestic consumption. In addition, the 'Ayvaniye' cultivar is marketed in small quantities to neighbouring provinces and districts outside the Gürün district and to Istanbul. 'Ayvaniye' cultivar apples ripen late and harvest time is mid-October. It has the ability to be preserved for a long time under ordinary storage conditions after harvest. Some pomological and chemical properties of the fruit are as follows: Fruit weight is 135.22, fruit width is 66.58 mm, fruit length is 71.24 mm, fruit skin colour is

slightly yellowish red, soluble solids content is 12.7%, pH is 3.30 and titratable acidity value is 9.68 g/L (Paşazade, 2015).

Another cultivar used in the study is 'Granny Smith'. The cultivar, originated from Australia, is widely grown in Türkiye. It produces abundant crops every year. It produces fruit early and ripens late. It is harvested after mid-October. The fruits are medium sized, sometimes large and high quality. Its skin colour is bright green. Red stain occurs in high areas. It can be stored up to 9 months (Gerçekçioğlu at al., 2018).

In apples, late cultivars are more resistant than early varieties. Therefore, fruits of resistant varieties are used for long-term storage (Karaçalı, 2018). The aim of this study is to investigate the suitability of the late 'Ayvaniye' apple cultivar for storage, included in the genetic resources of Türkiye, in comparison with the 'Granny Smith' apple cultivar, known for its storage resistance.

2. Materials and Methods

2.1. Plant material

The study was planned according to one way ANOVA with three replications. For both varieties, 12 trees were determined, four trees in each replicate. In the experiment, 'Granny Smith' and 'Ayvaniye' apples were harvested from Gürün district of Sivas province on October 23, 2022. Starch content was taken into consideration when determining the harvest date. Harvesting was done when one third of the starch content in the apple had been converted into sugar. 'Granny Smith' apples were harvested from 6-year-old trees grafted onto MM106 rootstock. 'Ayvaniye' apples were harvested from 14-year-old trees grafted onto seedling rootstocks. Injured and rotten apples were separated, and care was taken to ensure that they were homogeneous in size and weight. The apples included in the experiment were placed in plastic crates. Then, they were stored for 6 months at 1±0.5 °C and 90±5% relative humidity (Altuntaş et al., 2009; Saraçoğlu et al., 2011).

2.2. Measurements and analysis

2.2.1. Weight loss

At the beginning of cold storage, the initial weights of the fruits were determined with a digital scale (Radwag, Poland) with an accuracy of 0.01 g. Final weights were then determined on the 30th, 60th, 90th, 120th, 150th and 180th days of storage. The data were calculated as a percentage according to the Equation 1.

$$\text{Weight loss } (WL) = \frac{\text{WL(first)} - \text{WL(end)}}{\text{WL(first)}} x100 \quad (1)$$

2.2.2. Fruit flesh firmness

Flesh firmness was measured in kg with a hand penetrometer (model FT-327; McCormick Fruit Tech, Yakima, WA) by removing a thin skin from the fruit surface and then converted to Newton (N) (Ozturk et al., 2013).

2.2.3. pH, Titratable acidity (TA) and Soluble solids content (SSC)

After evaluating the fruit firmness, the fruits were blended in a blender and placed in 50 ml falcon tubes. For pH measurement, 5 g of fruit samples were weighed and 95 ml of pure water was added. Then, pH value was determined. Immediately afterwards, 0.1 N sodium hydroxide was added to the samples for titratable acidity determination and titrated to pH 8.1. Titratable acidity was calculated according to malic acid types with the following equations:

$$A = \frac{\text{S.N.F.E}}{\text{C}} \times 100 \quad (2)$$

A: Percentage of acidity (%),
S: Amount of sodium hydroxide used (ml),
N: Normality of sodium hydroxide used,
F: Factor of sodium hydroxide used,
E: equivalent value of the corresponding acid (0.067 for malic acid),
C: Amount of sample taken (ml).

The water-soluble solid content of the juice samples obtained after centrifugation was measured with a digital refractometer (Atago PAL-1, Japan (Brix= 0-53%)) and expressed as percentage.

2.2.4. Total phenolic substance compounds (TPC) and Total antioxidant activity (TAA)

Total phenolics content was measured according to the procedure described by Singleton and Rossi (1965). Briefly, fruit pulp was extracted with a buffer containing acetone, water and acetic acid (70:29.5:0.5 v/v) for 24 h at dark. Samples were replicated three times. Extracts were combined with Folin-Ciocalteu's phenol reagent and water, and incubated at room for 8 min followed by the addition of 7% sodium carbonate. After 2 h, the absorbance at 750 nm was measured in an automated UV–vis spectrophotometer (Model T60U, PG Instruments). Gallic acid was used as the standard. The results were expressed as micrograms (µg) gallic acid equivalent (GAE) g^{-1} fresh weight (fw). Total

antioxidant capacity analysis was performed by Ozgen et al. (2006) was done according to the procedure described. Fruit juices were taken from the samples and replicated three times. The absorbance values of the samples were read at 593 nm. Results are expressed as µmol Trolox equivalent (TE) g^{-1} fresh weight (fw).

2.2.5. Fruit colour (L*,a*,b*)

The colour parameters L*, a*, and b* were measured from the outer skin of the fruit (for all three cheeks) with a colorimeter (Minolta, model CR–400, Tokyo, Japan). L* represents values from black (0) to white (100), a* from green(-) to red(+), and b* from blue(-) to yellow(+).

2.2.6. Statistical analysis

The experiment was designed according to way ANOVA. All statistical analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA), checking the significance ($p<0.05$) of differences between means according to the Duncan multiple comparison test.

3. Results and Discussion

Harvested fruits continue their vital activities by using the energy released by their respiration in other metabolic events. This metabolic activity is closely related to the storage conditions of fruits. Under appropriate storage conditions, it is possible to minimize the rate of metabolic events in the fruit by slowing down respiration. The most suitable storage for apples is provided under conditions of -1 to 0 °C temperature and 85-95% relative humidity (+4 °C for European cultivars) (Karaman et al., 2009). By keeping the ambient humidity high, water loss in fruits is limited and damages such as quality decrease, wilting, decrease in crispness and weight loss are delayed (Karaçalı, 2018).

3.1. Weight loss (%) and fruit flesh firmness (kg/cm^3)

The weight losses in 'Ayvaniye' and 'Granny Smith' apples are shown in Figure 4A. Accordingly, it was determined that the weight losses in the 'Ayvaniye' cultivar were higher during storage. At the end of the 6th month, weight loss was determined as 3.25% in 'Ayvaniye' apples and 2.69% in 'Granny Smith' apples. In a similar study in the literature, it was determined that the weight loss in 'Braeburn' apples (control group) stored in cold temperatures for 6 months was over 3% (Öztürk et al., 2014). Another success of the 'Granny Smith' apple is Erbaş and Koyuncu (2020), who reported that the weight loss in the control group apples at the end of 6 months of cold storage was 4.42%. In another study, the weight losses in the 6th month of 'Granny Smith' and 'Amasya' apples stored in cold storage for 10 months were reported as 4.55% and 5.75%, respectively (Saraçoğlu, 2007). When compared to our findings, it seems that the data in the literature is higher. These differences may be due to the 'Granny Smith' apple cultivar being grown on different rootstocks and in different ecological regions.

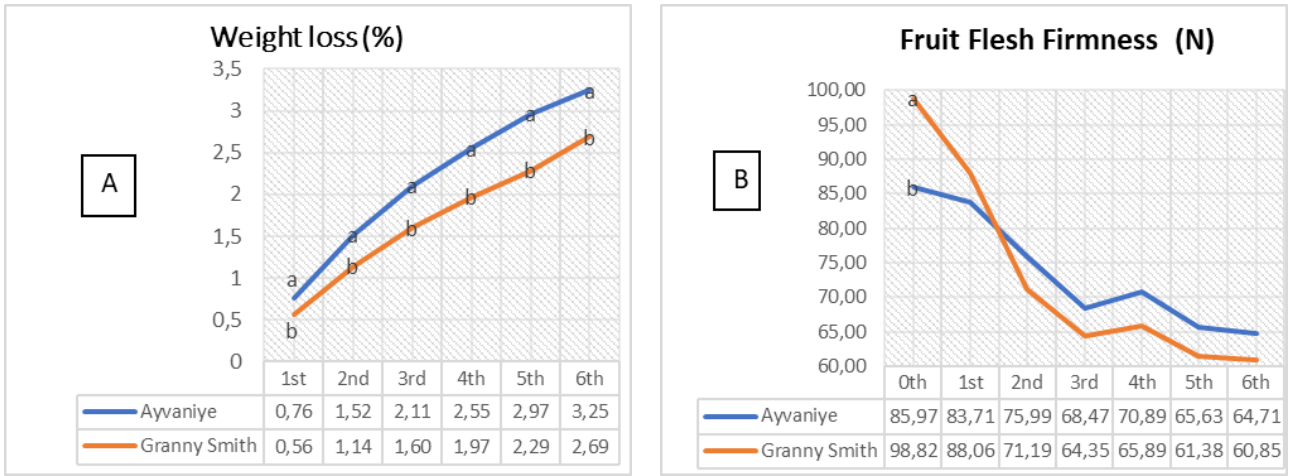


Figure 4. Weight (A) and firmness (B) losses in 'Ayvaniye' and 'Granny Smith' apples during storage **(Significant differences observed between cultivars each month are indicated with different letters)**.
Şekil 4. *'Ayvaniye' ve 'Granny Smith' elmalarında depolama boyunca meydana gelen ağırlık (A) ve sertlik (B) kayıpları* ***(Çeşitler arasında her ay gözlenen önemli farklılıklar farklı harflerle belirtilmiştir)***.

At the beginning of storage (0th month), it was determined that 'Granny Smith' cultivar apples had harder fruit flesh compared to 'Ayvaniye' cultivar (Figure 4B). However, there was a significant decrease

in the 'Granny Smith' cultivar and at the end of the first month, the fruit flesh firmness reached the same level as the fruits of the other cultivar. In the following periods, the firmness of the fruit flesh of both cultivars were decreased to a similar level. When it came to the last period of storage, there was no significant difference between the cultivars. In a study conducted in previous years, the reactions of 'Granny Smith' apple and 'Yomra' apple, which is also a local cultivar, to cold storage were compared. As a result of the measurements made at 0, 3 and 4th months, it was reported that the 'Granny Smith' cultivar had harder structured fruits compared to the local cultivar (Saraçoğlu et al., 2011). These results contain similar and different findings when compared to this study. The difference can be explained by the fact that the local cultivar we used harder fruit flesh. In another study, examining the pomological properties of local apple cultivars grown in Çatak and Tatvan regions, it was reported that the fruit flesh firmness of apples was varied between 60.82-38.26 N (Özrenk et al., 2010). The local apple cultivar (Ayvaniye) we used in this study has a value above these values (85.97 N).

3.2. pH, titratable acidity (TA) and soluble solids content (SSC)

It was determined that TA and SSC values were found higher in 'Granny Smith' cultivar apples while pH values were found higher in 'Ayvaniye' cultivar. pH values were increased during storage in both cultivars (Figure 5A). On the other hand, TA values were decreased throughout storage (Figure 5B).

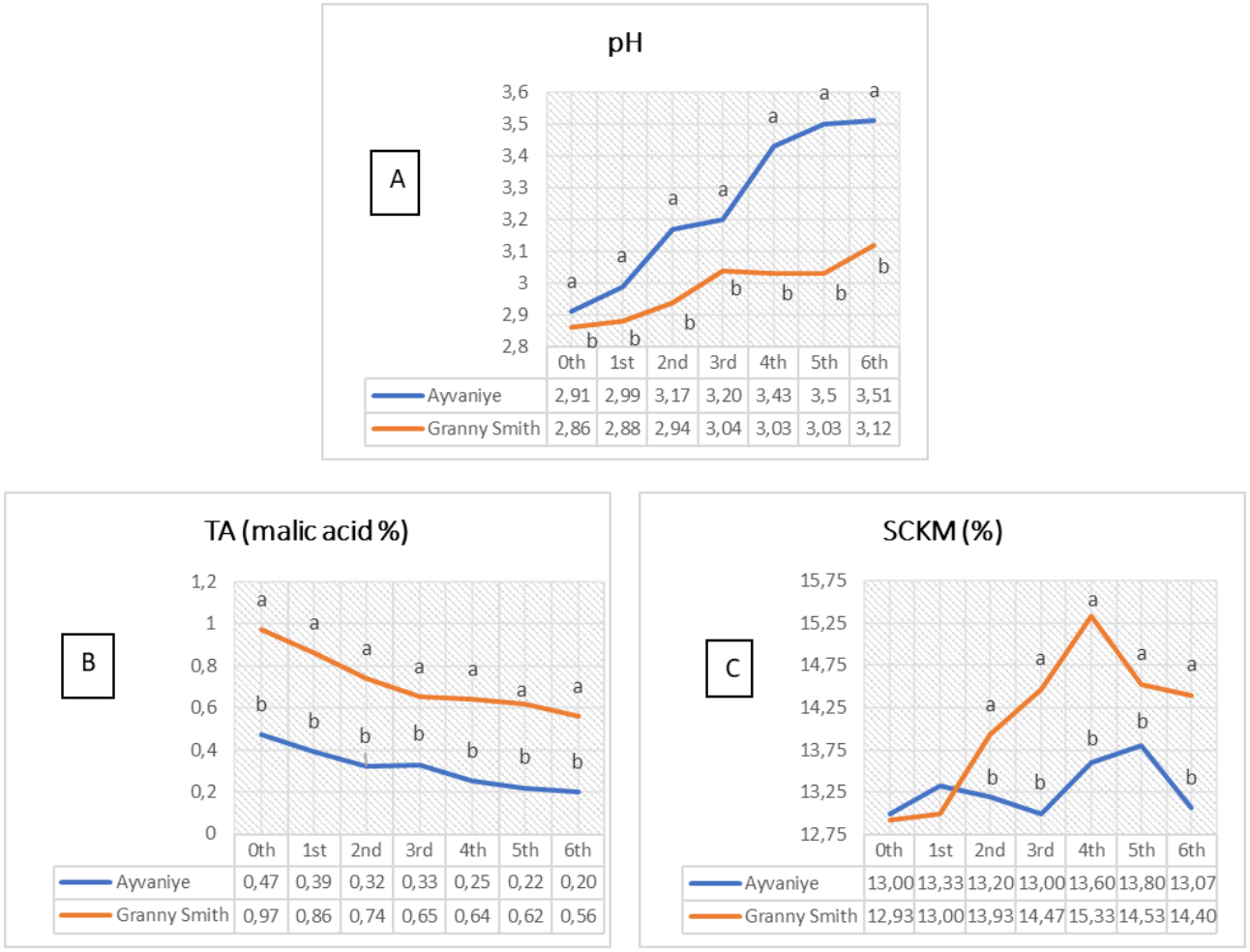


Figure 5. Changes in pH (A), TA (B) and SSC (C) values of 'Ayvaniye' and 'Granny Smith' apples during storage **(Significant differences observed between cultivars each month are indicated with different letters)**.
Şekil 5. *'Ayvaniye' ve 'Granny Smith' elmalarının depolama boyunca pH (A), TA (B) ve SÇKM (C) değerlerinin değişimi* ***(Çeşitler arasında her ay gözlenen önemli farklılıklar farklı harflerle belirtilmiştir)***.

SSC amounts were varied: In 'Ayvaniye' apples, it was increased until the 5th month and then decreased, and in 'Granny Smith' apples, it was increased until the 4th month and then decreased (Figure 5C). It is known that organic acids are consumed during the respiration process of fruits during the ripening process, causing TA

to decrease and SSC and pH values to increase (Hosseinifarahi et al., 2020). Organic acid contents of some products such as apples, pears and tomatoes; It continues to decrease after harvest because they take part in the neutralization of cations in respiration, sometimes in sugar synthesis, and crystallize in the form of salt in the cell (Türk et al., 2017). On the other hand, an increase in pH values occurs with the breakdown of organic acids carrying H+ ions (Polat et al., 2020). The reason for the increase in SSC was attributed to Khan et al. (2008) stated that it was caused by the loss of juice and the increase in solubility of cell wall components. It has been reported in different studies that in fruits belonging to species showing climacteric features, there is an increasing in the SSC value until the climacteric maximum point, and after this point, a decreasing in this feature is observed due to the effect of aging (Güner et al., 2022; Kurubaş & Erkan, 2018; Selçuk & Erkan, 2015). In this study, 'Ayvaniye' apples reached their climacteric maximum at the end of the 5th month, and 'Granny Smith' apples reached their climacteric maximum at the end of the 4th month. After this point, SSC amounts began to decline. In parallel with findings of this study, Güner et al. (2022) in the 'Fuji' apple and Öztürk et al. (2013) in the local apple cultivar 'Ak Sakı', reached similar results in terms of pH, TA and SSC.

3.3. Total phenolic substance compounds (TPC) and Total antioxidant activity (TAA)

TPC values are given in Figure 6A. Accordingly, significant differences were found between the two cultivars. By the end of the 5th month, the TPC content of 'Granny Smith' apples was found to be higher than 'Ayvaniye' apples. When it came to the last month of storage, higher TPC was detected in 'Ayvaniye' apples. In addition, it was determined that the TPC values of both cultivars reached their lowest values at the end of the 3rd month and started to increase after this point. TAA values are given in Figure 6B. Here, significant differences emerged in other storage periods except the 3, 5 and 6th months. Contrary to TPC, TAA values were found to be higher in 'Ayvaniye' apples at 0, 1, 2 and 4th months. In general, while there was a decrease in 'Ayvaniye' apples in terms of TAA, there was an increase in 'Granny Smith' apples. There was no significant difference between the two cultivars in the last two periods of storage.

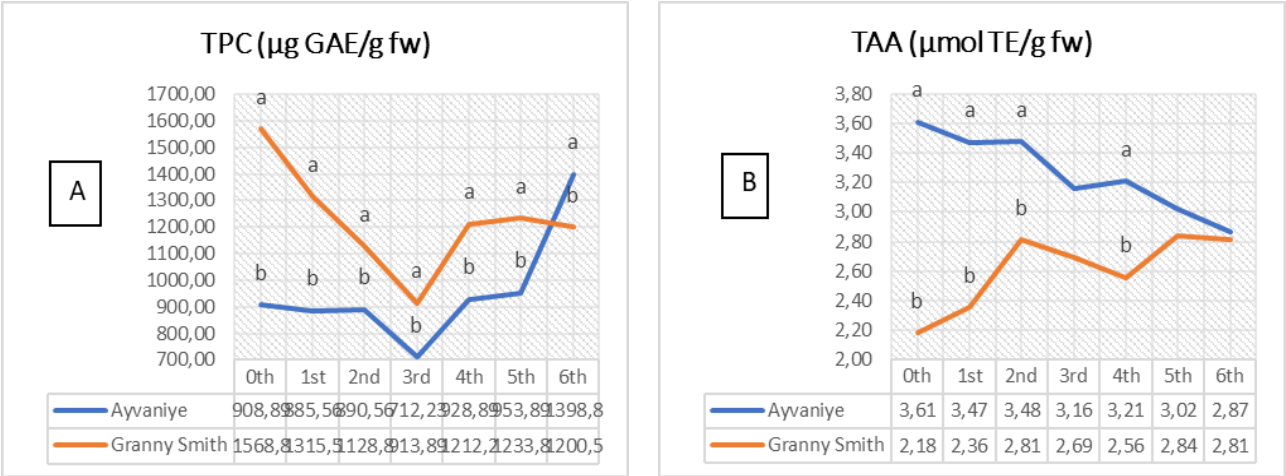


Figure 6. Total phenolic substance (TPC) (A) and total antioxidant activity (TAA) (B) values of 'Ayvaniye' and 'Granny Smith' apples throughout storage

*Significant differences observed between cultivars each month are indicated with different letters.

Şekil 6. *'Ayvaniye' ve 'Granny Smith' elmalarının depolama boyunca toplam fenolik madde (TPC) (A) ve toplam antioksidan aktivite (TAA) (B) değerleri*

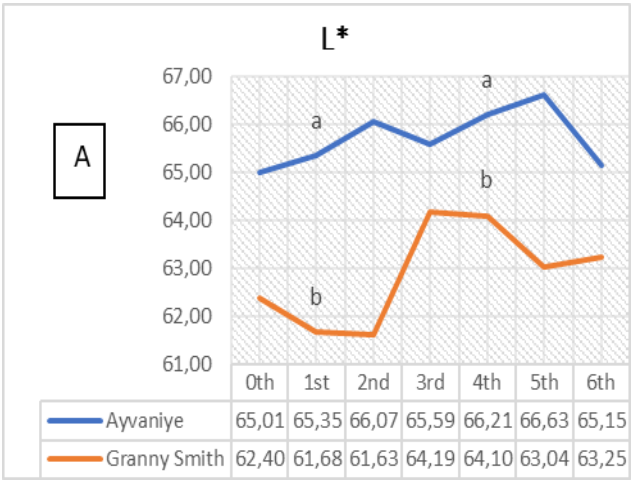
**Çeşitler arasında her ay gözlenen önemli farklılıklar farklı harflerle belirtilmiştir.*

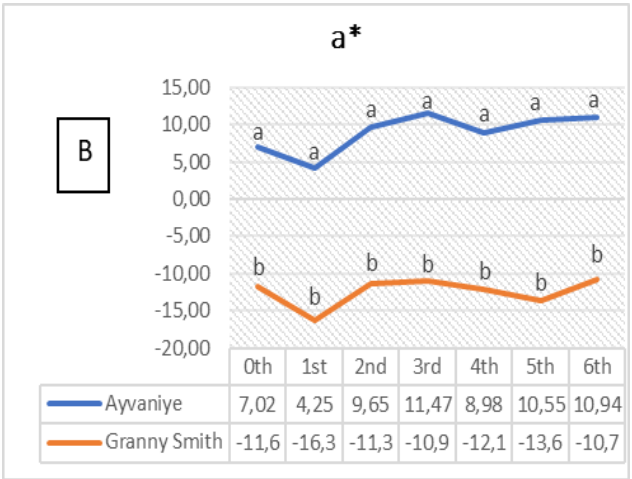
It is important to keep the phytochemical content of fruits at higher levels throughout storage. Some phenolic substances can protect cell components against oxidative damage because they have antioxidant activity (Sayyari et al., 2022). According to Ali et al. (2019), the main cause of the decrease in TPC may be oxidation. As a result of this study, it was determined that while the phenolic substance content decreased in some periods, the antioxidant activity increased in that period (especially in the early periods of the 'Granny Smith' cultivar). Again, while the phenolic substance content increased in some periods, it was determined that the antioxidant activity decreased in that period (especially in the last periods of the 'Ayvaniye' cultivar). Contrary

to this study, some studies have reported a positive relationship between total phenolic substances and total antioxidant activity (Amiri et al., 2021; Haider et al., 2020; Sogvar et al., 2016). However, this positive relationship may not occur in different fruits and stress conditions. This may be due to the presence of substances such as anthocyanin, flavonoid and ascorbic acid, which have antioxidant properties, in addition to phenolic substances (Hassanpour, 2015; Heldt & Piechulla, 2015). Additionally, the increase in the activities of antioxidant enzymes (Ascorbate peroxidase (APX), glutathione reductase (GR) catalase (CAT) and superoxide dismutase (SOD)) under different stress conditions may have affected the positive relationship between total phenol and antioxidant activity (Yasar & Uzal, 2023; Yasar et al., 2008). In addition, changes in the total phenol content of fruits after harvest; may vary depending on cultivar, maturity stage at harvest, growing season and storage time (Özgan & Sabır, 2018). As a matter of fact, Güner et al. (2022) reported that there was a decrease in the total phenolic substance and antioxidant activities of 'Fuji' apples throughout storage.

3.4. Fruit colour (L*,a*,b*)

In terms of L* values, significant differences were found between the two cultivars only in the 1st and 4th months of storage (Figure 7A). It was determined that the L* values of 'Ayvaniye' apples were higher in these months. Therefore, it was determined that 'Ayvaniye' apples had a lighter and brighter appearance compared to 'Granny Smith' apples. a* values are given in Figure 7B. Accordingly, significant differences were found between the two cultivars. During storage, it was determined that the skin colour of 'Ayvaniye' apples was red and its tones, while the skin colour of 'Granny Smith' apples was green and its tones. In addition, a more intense yellow colour and shades were detected in the skin colour of 'Granny Smith' apples compared to 'Ayvaniye' apples (Figure 7B).





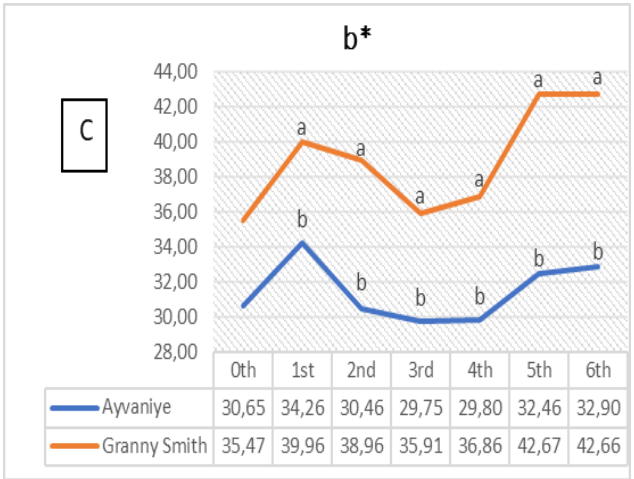


Figure 7. Changes in L* (A), a* (B) and b* (C) values of 'Ayvaniye' and 'Granny Smith' apples throughout storage
*Significant differences observed between cultivars each month are indicated with different letters.
Şekil 7. *'Ayvaniye' ve 'Granny Smith' elmalarının depolama boyunca L* (A), a* (B) ve b* (C) değerlerinin değişimi*
**Çeşitler arasında her ay gözlenen önemli farklılıklar farklı harflerle belirtilmiştir.*

4. Conclusion

In this study, the storage suitability of the 'Ayvaniye' apple cultivar was compared with the 'Granny Smith' apple cultivar in terms of some quality parameters. As a result of 6 months of cold storage, 'Ayvaniye' cultivar apples; weight loss, pH, TAA, L* and a* values were found to be higher compared to the 'Granny Smith' cultivar. In 'Granny Smith' cultivar apples, TA, SSC, TPC (excluding the last storage period) and b* values were higher. In addition, it was not determined that the flesh of 'Granny Smith' apples was harder at the beginning of storage, and that there was no significant difference between the two cultivars in later periods. As a result, it was determined that the 'Ayvaniye' cultivar is suitable for cold storage, but weight loss may be a problem for storage longer than 6 months.

Acknowledgement

We would also like to thank Mr. Sadettin Gamsız, who opened his garden to provide us with the apples tested in the article.

References

Ali, S., Khan, A. S., Nawaz, A., Anjum, M. A., Naz, S., Ejaz, S., & Hussain, S. (2019). Aloe vera gel coating delays postharvest browning and maintains quality of harvested litchi fruit. *Postharvest Biology and Technology*, *157*, 110960. https://doi.org/10.1016/j.postharvbio.2019.110960

Altuntaş, E., Cemal, Kaya., Yıldız, M., & Tekelioğlu, O. (2009). Amasya ve Granny Smith elma çeşitlerinin raf ömrü sürecince fiziko-mekanik özelliklerinin belirlenmesi. Tarım Bilimleri Araştırma Dergisi, (2), 7-13.

Amiri, S., Nicknam, Z., Radi, M., Sayadi, M., Bagheri, F., Karimi Khorrami, N., & Abedi, E. (2021). Postharvest quality of orange fruit as influenced by salicylic acid, acetic acid, and carboxymethyl cellulose coating. *Journal of Food Measurement and Characterization*, *15*(5), 3912-3930. https://doi.org/10.1007/s11694-021-00966-y

Erbaş, D., & Koyuncu, M. A. (2020). Granny Smith elma çeşidinin depolama performansı üzerine farklı 1-MCP dozlarının etkisi. *Journal of the Institute of Science and Technology*, *10*(4), 2301-2314. https://doi.org/10.21597/jist.773411

FAO. https://www.fao.org/faostat/en/#data/QCL/visualize (Erişim Tarihi: 15.10.2023)

Gerçekçioğlu, R., Soylu, A., & Bilgener, Ş., (Editörler). (2018). Genel Meyvecilik (Meyve Yetiştiriciliğinin Esasları). *NOBEL AKADEMİK YAYINCILIK EĞİTİM DANIŞMANLIK TİC. LTD. ŞTİ. Yayın No.: 351.* Geliştirilmiş 5. Basım, VIII+360 s.

Güleryüz, M., 1975. Özel Meyvecilik Ders Notları. *Atatürk Üniversitesi Ziraat Fakültesi Yayınları.* 128.

Güner, E., Evrenosoğlu, Y., & Mertoğlu, K. (2022). Derim Sonrası Farklı Dozlarda Kekik ve Lavanta Yağının Fuji Elma Çeşidinin Kalite Korunumu Üzerine Etkileri. *Ziraat Fakültesi Dergisi*, *17*(2), 64-69. https://doi.org/10.54975/isubuzfd.1081961

Haider, S. A., Ahmad, S., Khan, A. S., Anjum, M. A., Nasir, M., & Naz, S. (2020). Effects of salicylic acid on postharvest fruit quality of "Kinnow" mandarin under cold storage. *Scientia Horticulturae*, *259*, 108843. https://doi.org/10.1016/j.scienta.2019.108843

Hassanpour, H. (2015). Effect of Aloe vera gel coating on antioxidant capacity, antioxidant enzyme activities and decay in raspberry fruit. *LWT-Food Science and Technology*, *60*(1), 495-501. https://doi.org/10.1016/j.lwt.2014.07.049

Heldt, H. W., & Piechulla, B. (2015). Plant biochemistry. Academic Press. 4'üncü Basımdan Çeviri. Çeviri Editörleri: Prof. Dr. Faik Ahmet Ayaz & Prof. Dr. Atalay Sökmen). 608 s.

Hosseinifarahi, M., Jamshidi, E., Amiri, S., Kamyab, F., & Radi, M. (2020). Quality, phenolic content, antioxidant activity, and the degradation kinetic of some quality parameters in strawberry fruit coated with salicylic acid and Aloe vera gel. *Journal of Food Processing and Preservation*, *44*(9), e14647. https://doi.org/10.1111/jfpp.14647

Karaçalı, İ. (2018). Tarımsal Ürünlerin Muhafazası. *Ege Üniversitesi Yayınları Ziraat Fakültesi Yayın No: 555.* 3. Baskı, 139 s.

Karaman, S., Okuroğlu, M., Kızıloğlu, F.M., Memiş, S., & Cemek, B. (2009). Karaman ili iklim koşullarına uygun elma depolama yapılarının planlanması. *Tarım Bilimleri Araştırma Dergisi*, (1), 145-154.

Kaynaş, K., Şeker, M., Gündoğdu, M.A., Sakaldaş, M., Akçal, A., & İzmir, A. (2009). Çanakkale'de Elma Yetiştiriciliğinin Sorunları ve Çözüm Önerileri. *Tarım Bilimleri Araştırma Dergisi*, (1), 35-39.

Kurubaş, M. S. & Erkan, M. (2018). Impacts of 1-methylcyclopropene (1-MCP) on postharvest quality of 'Ankara' pears during long-term storage. *Turkish Journal of Agriculture and Forestry*, *42*(2), 88-96. https://doi.org/10.3906/tar-1706-72

Khan, A. S., Singh, Z., Abbasi, N. A., & Swinny, E. E. (2008). Pre-or post-harvest applications of putrescine and low temperature storage affect fruit ripening and quality of 'Angelino'plum. *Journal of the Science of Food and Agriculture*, *88*(10), 1686-1695. https://doi.org/10.1002/jsfa.3265

Ozgen, M., Reese, R. N., Tulio, A. Z., Scheerens, J. C., & Miller, A. R. (2006). Modified 2, 2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) method to measure antioxidant capacity of selected small fruits and comparison to ferric reducing antioxidant power (FRAP) and 2, 2 '-diphenyl-1-picrylhydrazyl (DPPH) methods. *Journal of Agricultural and Food Chemistry*, *54*(4), 1151-1157. https://doi.org/10.1021/jf051960d

Ozturk, B., Ozkan, Y., Altuntas, E., Yildiz, K., & Saracoglu, O. (2013). Effect of aminoethoxyvinylglycine on biochemical, physicomechanical and colour properties of cv. Braeburn apples. *Semina: Ciencias Agrarias*, *34*(3), 1111-1120.

Özgan, F., & Sabır, F.K. (2018). Albion ve Kabarla çilek çeşitlerinde derim sonrası salisilik ve oksalik asit uygulamalarının soğukta depolama süresince kalite özelliklerine etkileri. *Alatarım*, *17*(2), 89-97.

Özkan, Y., 1998. Ilıman İklim Meyveleri. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Ders Notu.* 371.

Özrenk, K., Gündoğdu, M., Kaya, T., & Kan T. (2011). Çatak ve Tatvan yörelerinde yetiştirilen yerel elma çeşitlerinin pomolojik özellikleri. *Yuzuncu Yıl University Journal of Agricultural Sciences*, *21*(1), 57-63.

Öztürk, B., Keskin, S., Yıldız, K., Kaya, Ö., Kılıç, K., & Uçar, M. (2013). Erzincan koşullarında yetiştirilen 'Ak Sakı'elma çeşidinin depolama performansı üzerine hasat öncesi naftalen asetik asit ve aminoetoksivinilglisin uygulamalarının etkileri. *Journal of Agricultural Faculty of Gaziosmanpaşa University (JAFAG), 2013*(1). https://doi.org/10.13002/jafag185

Öztürk, B., Özkan, Y., Yıldız, K., Öztürk, A., Kılıç, K., Uçar, M., Karakaya, M., & Karakaya, O. (2014, September). The role of pre-harvest aminoethoxyvinylglycine treatments on fruit quality of Braeburn apple during cold storage. In *International Mesopotamia Agriculture Congress* (Vol. 22, p. 25).

Paşazade, E. (2015). Gürün ilçesinde (Sivas) yetiştirilen bazı yerel elma (Malus sp. L.) çeşitlerinin fenolojik ve pomolojik özelliklerinin belirlenmesi. *Gaziosmanpaşa Üniversitesi Fen Bilimleri Enstitüsü Bahçe Bitkileri Ana Bilim Dalı,* 50 s. (Yayımlanmamıştır)

Polat, M., Mertoglu, K., Eskimez, I., & Okatan, V. (2020). Effects of the fruiting period and growing seasons on market quality in goji berry (L.). *Folia Horticulturae*, *32*(2), 229-239. https://doi.org/10.2478/fhort-2020-0021

Saraçoğlu, O. (2007). Modifiye atmosferde elma depolanmasında değişik ambalaj filmlerinin uygunluğunun belirlenmesi. *GOÜ. Fen Bilimleri Enstitüsü, Gıda Mühendisliği ABD. Yüksek Lisans Tezi (Yayınlanmamış)*, Tokat.

Saraçoğlu, O., Kalkışım, Ö., Çekiç, Ç., & Özgen, M. (2011). 'Yomra've 'Granny Smith'Elma Çeşitlerinin Modifiye Atmosfer Koşullarında Muhafaza Edilebilirliğinin Karşılaştırılması. *Gümüşhane Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *1*, 40-46.

Sayyari, M., Esna-Ashari, M., & Tarighi, T.H. (2022). Impacts of salicylic acid, chitosan, and salicyloyl chitosan on quality preservation and microbial load reduction in strawberry fruits during cold storage. *Journal of Food Processing and Preservation*, *46*(7), e16710. https://doi.org/10.1111/jfpp.16710

Selçuk, N. & Erkan, M. (2015). The effects of 1-MCP treatment on fruit quality of medlar fruit (*Mespilus germanica* L. cv. Istanbul) during long term storage in the palliflex storage system. *Postharvest Biology and Technology*, *100*, 81-90. https://doi.org/10.1016/j.postharvbio.2014.09.018

Singleton, V. L., & Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American journal of Enology and Viticulture*, *16*(3), 144-158. DOI: 10.5344/ajev.1965.16.3.144

Sogvar, O. B., Saba, M. K., & Emamifar, A. (2016). Aloe vera and ascorbic acid coatings maintain postharvest quality and reduce microbial load of strawberry fruit. *Postharvest Biology and Technology*, *114*, 29-35. https://doi.org/10.1016/j.postharvbio.2015.11.019

Türk, R., Erkan, M., Güneş, N. T., & Koyuncu, M. A. (2017). Bahçe Ürünlerinin Muhafazası ve Pazara Hazırlanması. *Somtad Yayınları Ders Kitabı*, (1), 542.

Yanar, D., & Ecevit, O. (2009). Elma bahçelerinde faydalı ve zararlı akar türlerinin çeşit tercihi. *Tarım Bilimleri Araştırma Dergisi*, (1), 131-137.

Yasar, F., & Uzal, O. (2023). Oxidative stress and antioxidant enzyme activities in tomato (Solanum lycopersicum) plants grown at two different light intensities. *Gesunde Pflanzen*, *75*(3), 479-485. https://doi.org/10.1007/s10343-022-00716-0

Yasar, F., Ellialtioglu, S., & Yildiz, K. (2008). Effect of salt stress on antioxidant defense systems, lipid peroxidation, and chlorophyll content in green bean. *Russian journal of plant physiology*, *55*, 782-786. https://doi.org/10.1134/S1021443708060071