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REVIEW ARTICLE

# Application of modified atmosphere packaging on stone fruits: A review

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ABSTRACT

Stone fruits, such as plum, peach, apricot, nectarine, and cherry, possess considerable economic significance on a global scale. In spite of their importance, these fruits encounter challenges due to their heightened susceptibility to decay and a constrained market lifespan. They undergo a surge in ethylene production and rapid ripening, which results in various postharvest complications such as excessive weight loss, decay, over ripeness, and physiological disorders like internal breakdown and chilling injury symptoms. Modified Atmosphere Packaging (MAP) emerges as a valuable technique to address these challenges. By generating a low-oxygen environment, MAP effectively prolongs the shelf life of fresh produce by decelerating respiration and inhibiting the growth of pathogens. When implemented in conjunction with low temperatures, MAP holds the potential to influence fruit metabolism, diminish ethylene production, minimize respiration, reduce weight losses, and preserve essential vitamins and organic acids. This review delves into recent advancements in the utilization of Modified Atmosphere Packaging for stone fruits. It provides insights into the impact of MAP on postharvest quality parameters and shelf life for these fruits. Additionally, the review identifies gaps in the existing literature and outlines potential directions for future research in this field.

**Keywords:** Stone fruit, sweet cherry, map, postharvest technology, cold storage

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## INTRODUCTION

The phrase 'stone fruit' denotes the fruits deriving from the Prunus species, encompassing peaches, nectarines, plums, cherries, and apricots. These particular fruits are classified as drupes owing to their constitution, which exhibits a delicate external epicarp, an edible pulpy mesocarp, and a robust, lignified endocarp (also known as a stone) located at the fruit's center and encompassing the seed (Riva et al., 2020).

Due to their exceptional nutritional composition and delightful taste, there exists a substantial global demand for stone fruit. Prominent stone fruit exporters include South Africa and Chile in the southern hemisphere, as well as Spain and Turkey in the

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northern hemisphere (HORTGRO, 2018). Despite this high demand, these fruits encounter a limited duration for postharvest storage, characterized by a rapid deterioration in quality that impacts color, texture, total soluble solids, and total acidity. The transition from optimal ripeness to over ripeness occurs swiftly, influenced by variables such as temperature and handling practices. Stone fruits are susceptible to swift dehydration and withering, with the potential occurrence of stem browning in cherries, as moisture vapor moves from the fruit to the surrounding environment. Furthermore, they are prone to decay caused by fruit-rotting organisms, with factors such as inoculum levels, surface wounds from handling, fungicide treatment, and temperature exerting an influence on the probability of decay (Mitchell & Crisosto, 1995). In recent times, the stone fruit industry has heavily relied upon postharvest technologies in order to optimize the economic yield of their harvests (Riva et al., 2020). These technologies, which encompass chemical treatments, controlled atmosphere, and modified atmosphere, have demonstrated efficacy in prolonging the shelf life. However, there has been a noticeable surge in the demand for "fresh" and "natural" products, devoid of the incorporation of "hazardous" chemicals, over the course of the past decade.

Modified Atmosphere Packaging (MAP) is a storage technique that has proven to be highly effective in preserving a wide range of food items, thereby significantly extending their shelf life while simultaneously ensuring the retention of their "freshness" or fresh-like qualities. Currently, MAP has become an indispensable component of the food industry, particularly within the realm of fresh produce, and has established itself as the fastest-growing method of preservation, widely utilized for safeguarding various fresh and dry foods (Kundana et al., 2022; Emblem, 2013). The adaptability, simplicity, and cost-effectiveness of modified atmosphere technology render it suitable for a diverse assortment of fruits and vegetables (Silva et al., 2010). The employment of Modified Atmosphere Packaging (MAP) has demonstrated its efficacy in minimizing the deterioration of quality in various fruits, such as cherries (Kurubaș et al., 2018; ÖZTÜRK et al., 2019; Zi & Dong, 2022), plums (Avcı et al., 2022; Bi et al., 2022; Díaz-Mula et al., 2011; Sottile et al., 2013), peaches (Mendes et al., 2018; Acevedo et al., 2021; Santana et al., 2011), apricots (Dorostkar et al., 2022; Moradinezhad & Jahani, 2019; Soleimani & Mozaffari, 2020), and nectarines (Özkaya et al., 2016; Malakou & Nanos, 2005). A notable advantage of MAP resides in its elimination of artificial chemicals, guaranteeing the absence of harmful residues and causing minimal harm to the environment, particularly when employing recyclable plastic films. Recent advancements in the innovation and production of polymeric films, which display a wide array of gas diffusion properties, have heightened interest in the implementation of MAP for fresh produce (Mangaraj et al., 2009).

Several reviews have been conducted on the general use of Modified Atmosphere Packaging (MAP) for fresh produce (Kundana et al., 2022; Qu et al., 2022; Fang & Wakisaka, 2021; Oliveira et al., 2021; Caleb et al., 2013; Mangaraj et al., 2009). However, to the best of our knowledge, there is currently no review that specifically examines the application of modified atmosphere packaging for stone fruit, despite their well-known susceptibility to spoilage. The objective of this review is to thoroughly investigate the existing knowledge regarding the postharvest application of MAP in order to maintain the quality and prolong the storage life of stone fruit. Additionally, this review aims to elucidate the mechanism of action and the recommended storage conditions of MAP in relation to stone fruits. Moreover, potential future advancements for MAP in the preservation of stone fruit will be outlined in this review.

## MODIFIED ATMOSPHERE PACKAGING: AN OVERVIEW

Modified Atmosphere Packaging (MAP) for commodities involves the utilization of polymeric film packages to enclose actively respiring produce, thus enabling the manipulation of oxygen (O2) and carbon dioxide (CO2) levels within the package atmosphere. The main objective of this method is to enhance the shelf life of the produce (Mangaraj et al., 2009). The roots of modified atmosphere storage can be traced back to approximately 10,000 years ago, during the Neolithic period in the Middle East. During this time, underground pits were initially utilized for grain storage (Kays, 1997). Some of these pits were unintentionally sealed, resulting in the inadvertent creation of a modified atmosphere due to the respiratory activity of the grains, which consumed oxygen and produced carbon dioxide (CO2). The introduction of fired clay pots played a crucial role by providing containers with gas exchange barriers, thus facilitating the storage of raisins in a modified atmosphere (Ben-Yehoshua et al., 2005).

The fundamental principle that underlies Modified Atmosphere Packaging (MAP), as illustrated in Figure 1, revolves around the substitution of the air inside the package with a fixed mixture of gases. Once introduced, there is no subsequent control over the composition of the gases, and it will inevitably undergo changes (Tajeddin et al., 2018). It is crucial to differentiate MAP from Controlled Atmosphere Packaging (CAP), in which the composition of the atmosphere is actively maintained and controlled throughout the entire period of storage (Tajeddin et al., 2018). The primary objective of MAP design is to establish conditions that optimize the duration of time that agricultural commodities can be stored. MAP aims to achieve a state of equilibrium in the concentration of oxygen (O2) and carbon dioxide (CO2) inside the package, aligning with recommended levels to maximize the storage life of the commodity (Kargwa et al., 2020). The literature provides recommended modified atmosphere conditions for the storage of stone fruits (peach, nectarine, plum, apricot, and cherry) (Table 1). Passive MAP relies on natural processes such as the respiration of the produce and the permeability of the film, while active MAP involves the displacement of the air inside the package with a predetermined mixture of gases. This creates an atmosphere that changes over time during storage, based on the rate of produce respiration, storage conditions, and film permeability (Ghidelli & Pérez-Gago, 2018).

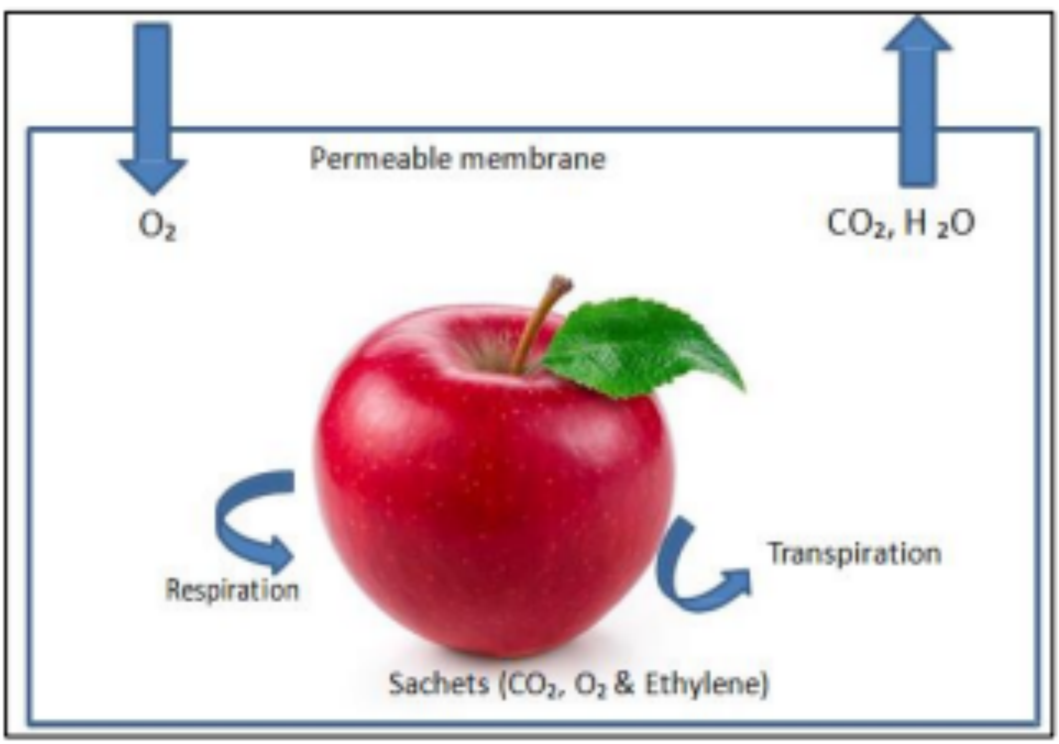



Figure 1: Mechanism of MAP on fruits

**Table 1: Recent Application of Modified Atmosphere for stone fruits storage**

| fruits | Storage condition | Method | cultivar | Inferences | References |
|---|---|---|---|---|---|
| **plum** | 4 °C | MAP+NP+1-MCP | Cuihongli | Fruits exhibited less weight loss, lower respiration rate peaks, and a higher firmness | Bi et al. (2022) |
| | 0 ± 0.5 °C and 90 ± 5% RH | MAP | Black Amber | Respiration rate was lowered, Fruit firmness was maintained, hue angle color was not affected, soluble solid was maintained, Vitamin C was maintained, and Antioxidant activities was maintained after 35 days of storage | Avcı et al. (2022) |
| | 1 ± 0.5 °C and 85 ± 5 % RH. | | Tita | Fruits Exhibited a little decrease in physicochemical characteristics in MAP after more than 40 days | Stan et al. (2021) |
| | 0.5±0.2°C and 92±2% RH | MAP+EV | Laetitia | Efficient in maintaining the fruits flesh firmness, reduced the evolution of the red coloring, and has greater activity of enzymes peroxidase and superoxide dismutase after 30 days. | Nunes et al. (2019) |
| **Apricot** | 0±0.5˚C and 90±5% RH for 20 days | | - | Lowered respiration rate, Delayed softening, maintained Vitamin C, had greater total phenolic and total flavonoids and antioxidant capacity | ASLANTÜRK et al. (2021) |
| | 2°C and 85% RH 28 days | MAP | Shahroudi | significantly reduced weight loss and total soluble solids, and maintained fruit hardness in comparison with other treatments | Dorostkar et al. (2022) |
| | 1 °C | MAP | Jumbo | showed positive effect by recording the lowest fruit weight loss, the highest firmness and lowest chilling injury and fruit decay as compare to control after 10days | Ezzat (2018) |
| | 0.5 ± 0.5 °C and 80 % RH. | MAP+1MCP+KMNO4 | Shahroudi | Weight loss significantly reduced, shelf life was extended 3-fold of unpacked fruits | Apricot 1 |
| | 1±1ºC | MAP+SA+PEG | Canino | effective in reducing fruit quality losses and decay | Nasr (2020) |
| **Peach** | 0ºC | MAP | Douradão | woolliness and internal browning were reduced. polygalacturonase (PG) activity, the levels of phenolic compounds and the antioxidant capacity was enhanced after 30 days | Mendes et al. (2018) |
| | 5ºC | MAP | Tropic Beauty peach | Stable carotenoid and anthocyanin contents, better attributes in the bioactive compounds and Better antioxidant proprieties | Acevedo et al. (2021) |

| | | | | | |
|---|---|---|---|---|---|
| | 10°C ± and 85-90% RH. | MAP | Late Swelling peache | Lowered change in firmness, color and acidity content. Lowered percentages of weight loss, unmarketable fruits and off-flavor incidence | Saeed et al. (2019) |
| **Nectarine** | 0-1°C and 90% relative humidity | MAP+KMNO 4 | Bayramiç Beyazı | delayed ripening, reduced respiration and retained of higher firmness throughout 40 days of storage | Bal (2018) |
| | 0 °C for 40 days | | **Maria Aurelia** | significantly reduced incidence of chilling injury and polyphenol oxidase, polygalacturonase and pectin methyl esterase activities as well as lower hue angles, total soluble solid contents and respiration rates. Also maintained firmness | Özkaya et al. (2016) |
| | 4 °C. | MAP | Big Top | overall quality (mainly turgidity) was preserved along the entire storage of 8days | Cozzolino et al. (2018) |
| | 0°C with 90% RH | MAP+SA | - | Reduced weight loss, retarded softening, increased shelf life, and maintained higher overall fruit quality. | Bal (2018) |
| | 0 °C | MAP+EO | Florda | Reduced the decay incited by B. cinerea and R. stolonifer. maintained highest fruit quality characteristics such as fruit firmness, total soluble solids, titratable acidity and reduced fruit losses. | Rashid & Abdel-Rahman (2019) |
| **Sweet cherry** | 1°C | MAP | - | Effective in preserving quality parameters suchs as firmness, colour, Total Soluble Solids content, Titratable Acidity and bioactive compounds total polyphenols, total anthocyanins and total antioxidant activity after 15days | Giacalone & Chiabrando (2013) |
| | 0 °C and 90 ± 5% relative humidity | GA3 + CaCl2 + MAP | - | MAP application had a positive effect on the losses of other phenolic compounds after 21 days | ÖZTÜRK et al. (2019) |
| | –1 to +1 °C and from 80 to 85% relative humidity | MAP | - | 10% CO2 reduce rotting rate, maintain firmness, delay the change of soluble solids and vitamin C, reduce the activity of polyphenol oxidase and peroxidase after 120 days | Xing et al. (2020) |
| | 25±2 °C, RH 70% and 3 ±1 °C, RH 80% | Gamma irradiation + MAP | Misri and Double | significantly effective in maintaining the storage quality and delaying the decaying | Wani et al. (2018) |
| | 0 ±0.5°C and 90 ±5% RH | MAP | 0900 Ziraat | effective in prevention of weight loss, decays and other quality losses | AĞLAR (2018) |

### Gases used in MAP

Modified Atmosphere Packaging (MAP) for food relies on a combination of three essential gases, namely oxygen (O2), nitrogen (N2), and carbon dioxide (CO2). The specific requirements of the food item determine the usage of two or three gases in varying proportions. In the case of food products that do not undergo respiration and where the primary concern is microbial growth leading to spoilage, a commonly employed composition comprises 30%–60% CO2, with the remaining portion consisting of either pure N2 (suitable for O2-sensitive foods) or a mixture of N2 and O2. Conversely, for products undergoing respiration, the typical gas levels encompass approximately 5% for both CO2 and O2, while the predominant gas component is usually N2, with the objective of minimizing the respiration rate (Tajeddin et al., 2018).

### Polymeric Films for MAP Application

The choice of packaging materials significantly impacts the storage duration of a product (Tajeddin et al., 2018). In Modified Atmosphere Packaging (MAP), the flexible materials or polymers most commonly used include low-density polyethylene (LDPE), polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), polyvinylidene chloride (PVDC), and polyethylene terephthalate (PET) (Yahia 2007). The design of MAP necessitates a meticulous selection of the film, package type, and size that are specifically tailored to the particular product (Farber et al., 2003). When choosing a film for MAP, it is imperative to take into account factors such as the permeability to oxygen (O2), carbon dioxide (CO2), and water vapor transmission rate. Table 2 provides information on the permeability of commonly utilized films in modified atmosphere packaging. These permeabilities play a crucial role in determining the composition of the package atmosphere and humidity, thus influencing the rate at which the product deteriorates (Ares et al., 2007).

**Table 2: Recommended modified-atmosphere conditions for stone fruits**

| Stone fruits | Temperature (°C) | (O2) % | (CO2) % | Potential |
|---|---|---|---|---|
| Cherry | 0–5 | 3–10 | 10–15 | Good |
| Nectarine | 0–5 | 1–2 | 3–5 | Good |
| Peach | 0–5 | 1–2 | 3–5 | Good |
| Plum | 0–5 | 1–2 | 0–5 | Good |
| Apricot | 0-5 | 2-3 | 3-3 | fair |

(Adapted from Soltani et al., 2015)

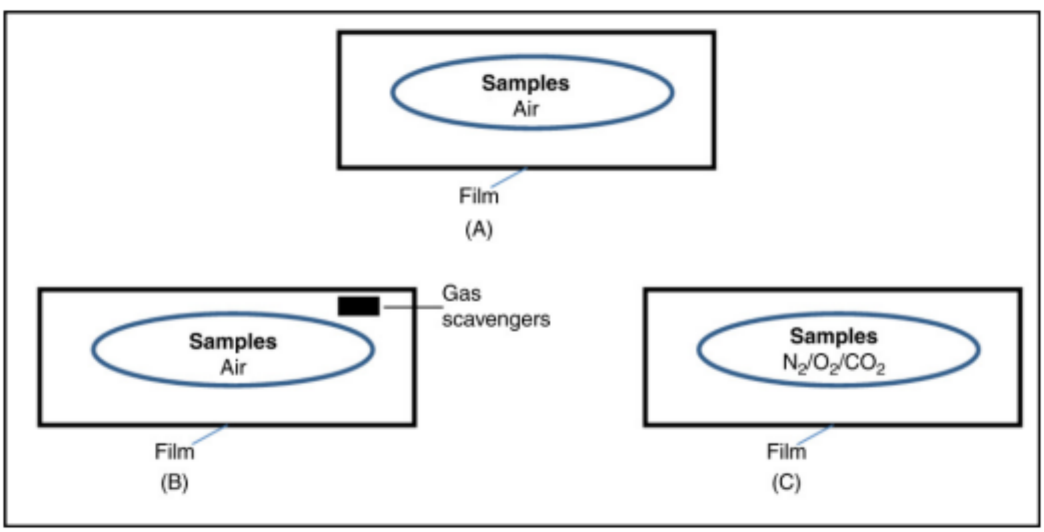
### TYPES OF MODIFIED ATMOSPHERE PACKAGING

Modified Atmosphere Packaging (MAP) comprises two primary categories: passive MAP and active MAP. The choice between these techniques is contingent upon the particular needs of the product, the desired shelf life, and the packaging criteria. Schematic Diagrams of Passive and Active MAP are depicted in Figure 2.

In passive MAP, the atmosphere inside the packaging is naturally altered through the respiration and metabolic processes of the packaged food. The packaging material is designed to facilitate the exchange of gases between the interior and exterior of the package. Films with specific permeability properties are employed to regulate the passage of oxygen, carbon dioxide, and other gases. This approach is commonly utilized for fresh produce, such as fruits and vegetables, as well as certain meat and seafood products.

On the contrary, active MAP involves the utilization of external devices or mechanisms to actively manage and maintain the desired atmosphere within the packaging. Various technologies are employed to introduce or eliminate gases from the packaging. Techniques like gas flushing inject a predetermined mixture of gases into the package, while gas scavenging involves a device that absorbs excess gases produced by the packaged product. Active MAP is often employed for a wider range of food products, including processed meats, dairy items, and ready-to-eat meals. It provides more precise control over gas composition, enabling better customization based on the specific requirements of different food items.

Both passive and active Modified Atmosphere Packaging (MAP) possess distinct advantages and disadvantages. Passive MAP excels in terms of its simplicity and cost-effectiveness, although it may not offer the same degree of atmosphere control as active MAP. Conversely, active MAP permits greater flexibility in adjusting gas levels, rendering it well-suited for a broader assortment of products. The decision between these two methods depends on the specific requirements of the product, the desired level of control, and the budgetary considerations associated with the packaging process.




Schematic Diagrams of Passive and Active MAP (Tajeddin et al., 2018). (A) A kind of passive MAP, (B) a kind of active MAP, and (C) a kind of active MAP.

## EFFECT OF MODIFIED ATMOSPHERE PACKAGING ON QUALITY AND SHELF LIFE

### Plums

In a study conducted by Bi et al. (2022), it was discovered that the combination of natamycin (NT) and 1-methylcyclopropene (1-MCP) with modified atmosphere packaging significantly prolonged the storage duration of 'Cuihongli' plums for 120 days at 4 °C and 21 days at 25 °C. Similarly, Avcı et al. (2022) observed that 'Black Amber' plums, when stored under specific conditions, maintained respiration rate, firmness, hue angle, soluble solids, vitamin C, and antioxidant properties for a period of 35 days. In another study conducted by Nunes et al. (2019), 'Laetitia' plums stored under Modified Atmosphere Packaging conditions with the addition of ethanol vapor (EV) exhibited preserved flesh firmness, reduced red coloring evolution, and increased enzyme activity. Peano et al. (2017) also found that 'Angeleno' plums stored in active Modified Atmosphere Packaging conditions experienced reduced mass loss and maintained their biochemical and nutraceutical attributes throughout a 60-day cold storage period at 1 °C. Stanger et al. (2017) reported an extended cold storage life for 'Laetitia' plums when stored in low-density polyethylene MAP bags equipped with a $CO_2$ absorber. Khan et al. (2013) conducted experiments involving the use of colored wraps and discovered that transparent films reduced weight loss and decay index, yellow films retained the highest ascorbic acid content, and overall sensory acceptability was higher for fruits wrapped in transparent film. Additionally, Giuggioli et al. (2016) demonstrated that 'Ariddo di Core' and 'Ramasin' European plums stored in Modified Atmosphere Packaging conditions at a temperature of 1 °C for a period of 21 days exhibited delayed color changes, increased firmness, higher soluble solids content, total acidity, and chlorophyll contents.

**Peaches**

In a study conducted by Mendes et al. (2018), the effects of passive MAP treatments utilizing low-density polyethylene (LDPE) films (60 µm or 80 µm) at 0ºC for 30 days on the antioxidant compounds and postharvest quality of 'Douradão' peaches under cold storage conditions were investigated. The results indicated that all treatments, except for the control group, were successful in reducing woolliness and internal browning. LDPE MAP treatment led to an enhancement in polygalacturonase (PG) activity, phenolic compound levels, and antioxidant capacity. Behrouzi et al. (2014) also demonstrated that MAP, incorporating various gas combinations and two types of packaging films (Low-density polyethylene - LDPE and Polypropylene - PP), preserved the postharvest quality and storage life of 'Elberta' peaches under the storage conditions of 1°C and 90% relative humidity for a period of 9 weeks. Mir et al. (2018) suggested that the utilization of an ethylene absorber with four perforations yielded the most favorable outcomes in extending the shelf life of 'Shan-I-Punjab' peach fruits wrapped with LDPE film. Additionally, Mahajan et al. (2015) reported that the use of paper mold trays for packing peaches (cv. 'Shan-I-Punjab') and wrapping them with cryovac heat shrinkable RD-106 maintained good quality for a duration of 9 days under supermarket conditions (18—20°C, 90—95% RH). Acevedo et al. (2021) discovered that MAP (5% $CO_2$ and 8% $CO_2$) demonstrated enhanced antioxidant properties for fresh-cut Tropic Beauty peaches stored at a low temperature (5ºC) for up to 10 days in LDPE film. Similarly, Mahajan et al. (2015) stated that the use of shrink film aided in reducing weight loss, firmness loss, decay incidence, while simultaneously maintaining various quality attributes such as total soluble solids, sugars, acidity, and ascorbic acid content during the shelf life of 'Shan-i-Punjab' peaches.

**Apricot**

Moradinezhad and Jahani (2019) conducted a study and observed a significant reduction in weight loss in apricot cultivars packed in polyethylene trays with a thickness of 80µm at a temperature of 0.5±0.5˚C and relative humidity of 80%. Similarly, Dorostkar et al. (2022) found that MAP treatments, specifically 40% $O_2$/20% $CO_2$ and 5% $O_2$/80% $CO_2$, resulted in a notable decrease in weight loss and total soluble solids while maintaining fruit hardness in the 'Shahroudi' cultivar packed in low-density polyethylene (LDPE) bags at a temperature of 2°C and relative humidity of 85% for a duration of 28 days. Ezzat (2018) reported positive outcomes of MAP on 'jumbo cot' apricots stored at a temperature of 1°C for 10 days, which included reduced fruit weight loss, increased firmness, and decreased chilling injury and fruit decay. Nasr (2020) suggested that the use of 1 mM Salicylic Acid and 0.4% Polyethylene Glycol is effective in minimizing fruit quality losses, decay, and maintaining the quality of “Canino” apricot fruits stored in polypropylene film under a passive modified atmosphere at a temperature of 1±1ºC for a period of 21 days. Muftuoglu et al. (2012) achieved an extended storage life for the 'Kabaasi' cultivar of apricots by coating them with

5% NatureSeal@ and actively packing them in biaxially oriented polypropylene film (with 5% O2 and 10% CO2), enabling storage for up to 28 days at a temperature of 4°C.

**Sweet Cherry**

Özkaya et al. (2015) focused on the Özkaya et al. (2015) discovered that combined effects of a rapid cold chain and modified atmosphere–modified humidity packaging on early-harvested "0900 Ziraat" sweet cherries resulted in reduced weight losses, pitting amount, stem color changes, and better preservation of the initial fruit quality compared to the control group during storage. Moreover, the use of biodegradable films under MAP for a duration of 15 days of cold storage at 1°C proved to be beneficial in maintaining the quality of sweet cherries by delaying color changes and minimizing losses in firmness and acidity (Giacalone & Chiabrando, 2013). ÖZTÜRK et al. (2019) observed that MAP at a temperature of 0°C and a relative humidity of 90 ± 5% positively influenced the preservation of other phenolic compounds in sweet cherries after a storage period of 21 days. Xing et al. (2020) demonstrated that the inclusion of 10% CO2 in MAP reduced the rate of rotting, maintained firmness, delayed changes in soluble solids and vitamin C, and decreased the activity of polyphenol oxidase and peroxidase in sweet cherries after 120 days. AĞLAR (2018) affirms that MAP treatments are effective measures in averting weight loss, decay, and other quality deterioration in '0900 Ziraat' sweet cherries throughout cold storage at a temperature of 0 ± 0.5°C and a relative humidity of 90 ± 5% RH.

**Nectarine**

In a study conducted by Bal (2018), the impact of different dosages of KMnO4 on prolonging the postharvest lifespan of 'Bayramiç Beyazı' nectarines stored under modified atmosphere in cold storage at 0-1°C and 90% relative humidity was assessed. The treated fruits exhibited delayed ripening, reduced respiration, and maintained higher firmness over a period of 40 days. Cozzolino et al. (2018) ascertained that MAP maintained the overall quality, appearance, and olfactory properties of 'Big Top' nectarine slices during cold storage at 4 °C for 8 days. Bal (2018) also observed that the combined treatment of MAP and Salicylic acid (SA) under cold storage at 0°C with 90% RH presented a distinct advantage over other treatments, resulting in reduced weight loss, delayed softening, increased shelf life, and higher overall fruit quality. Furthermore, studies have indicated that the combination of either cinnamon oil with modified atmosphere offered the most effective treatments for suppressing decay caused by B. cinerea and R. stolonifer on 'Florda' nectarine fruits stored at 0°C for 45 days (Rashid & Abdel-Rahman, 2019).

**CONCLUSION & RECOMMENDATIONS**

The article investigates the current usage of Modified Atmosphere Packaging (MAP) for stone fruits, with a focus on its effectiveness in preserving postharvest quality and extending shelf life. Integrating MAP with emerging technologies could significantly reduce quality losses of stone fruits during storage. Although there have been numerous studies on the application of MAP for stone fruits preservation, however, there has been limited progress in translating these findings into commercial applications. Moreover, the authors suggest that deeper understanding is required for the underlying mechanisms that explain variations in product tolerance to different gas atmospheres. This knowledge will be essential for the development of innovative MAP systems that can respond to physiological and biochemical signals to maintain the highest possible product quality during storage and distribution. Furthermore, permeability measurements are typically performed at specific temperatures, such as 25ºC for O2 and CO2, and 38ºC for water vapor. However, the authors point out a lack of information in the existing literature regarding film permeability at other temperatures, particularly those commonly encountered during storage.

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