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The effects of modified and palliflex controlled atmosphere storage on postharvest quality and composition of 'Istanbul' medlar fruit

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ABSTRACT

Medlar (*Mespilus germanica* L. cv. Istanbul) fruit were stored in palliflex controlled atmosphere storage systems of 21% O_2 + 0.03% CO_2 (PL-1, control), 2% O_2 + 5% CO_2 (PL-2), 3% O_2 + 10% CO_2 (PL-3) and modified atmosphere packaging (MAP) at 0 °C for 60 days to determine the effects of different O_2 and CO_2 concentrations on physiological properties, quality attributes and storability. Every 15 days, three replicates of each treatment were evaluated for weight loss, fruit firmness, decay, external browning index, skin color, pH, titratable acidity, total soluble solids, total phenolics, total flavonoids, total condensed tannins, ascorbic acid, antioxidant activity and organic acid and sugar contents. Taste analysis of the fruit was performed after 30, 45 and 60 days of storage. The CO_2 and O_2 concentrations created by the MAP stabilized at 7% and 14%, respectively. Weight loss of fruit stored in MAP was lower (<0.4% at 60 days) than for other treatments. Off-flavors were not detected in any treatment. Storage of medlar fruit under PL-3 was the least effective treatment in delaying fruit ripening (flesh firmness). The incidence and severity of browning, loss of skin color (*Ch*°) and retaining acceptable taste during 60 days were found the most effective in PL-2 and PL-1 compared to other treatments. Fruit pH increased and titratable acidity decreased during the storage period. Total soluble solids and sugar contents first increased then decreased in all treatments by the end of storage. The fruit stored in PL-2 had higher titratable acidity, total soluble solids and sugar contents than fruit stored in PL-1, PL-3 and MAP at all evaluations. Concentrations of total phenolics, total flavonoids, total condensed tannins, ascorbic acid, associated antioxidant activity and organic acids were affected by the storage atmosphere, decreased during storage. The concentrations of total phenolics, total flavonoids, and antioxidant activity were found the highest in PL-2, PL-1 and MAP treatments, respectively. However, in terms of ascorbic acid and total condensed tannins retention, PL-2 was the most effective treatments. The results indicated that 60 days storage of medlar fruit in the palliflex storage system at 0 °C maintained physiological and biochemical properties of medlar fruit.

1. Introduction

Medlar (*Mespilus germanica* L.) is a member of the Rosaceae family and is native to southeastern Europe, Anatolia, Crimea, Caucasia and the northern parts of Iraq and Iran. Medlar is a small deciduous tree or shrub, growing to a height of 2–3 m in the wild and 4–6 m when cultivated. The brown pear- and apple-shaped fruit are subglobose or pyriform and crowned by foliaceous sepals. The fruit ranges in diameter from 1.5 to 3 cm and weighs from about 10 g (very small) to more than 80 g (large) (Browicz, 1972). The fruit are hard when mature, and they become brown, soft, sweet and edible after harvest (Dirr, 1990).

Medlar fruit are widely consumed in Turkey and especially in northeast Anatolia where the people use fruit from the wild and domesticated cultivars in different ways. The astringency of the fruit is well known and it has been reported that pulp or syrup of the ripened fruit was a popular remedy against enteritis and has many human healing properties (Baytop, 1999; Bignami, 2000). The medlar fruit is also used as treatment of constipation, as a diuretic and to rid the kidney and bladder of stones (Baytop, 1999).

The medlar is a typical climacteric fruit which has increased value in human consumption and commercial importance in recent years. Several studies have described physical, physicochemical and chemical changes (de Pascual-Teresa et al., 2000; Romero-Rodriguez et al., 2000), polyphenol oxidase and peroxidase

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activities (Aydin and Kadioglu, 2001; Dincer et al., 2002), fatty acid composition (Ayaz et al., 2002; Glew et al., 2003b), sugars, organic acids and amino acids (Glew et al., 2003a), mineral composition (Glew et al., 2003c), volatile components of its seeds (Pourmortazavi et al., 2005), physical and chemical parameters (Hacıseferogulları et al., 2005), polyphenoloxidase and total phenolic contents (Ayaz et al., 2008), ascorbic acid, minerals and total phenolic compounds (Rop et al., 2011), phenolic acid contents and radical scavenging activity (Gruz et al., 2011), antioxidant activity (Nabavi et al., 2011) and polyphenol contents and antioxidant properties (Gulcin et al., 2011).

Medlar fruit are harvested from October through November. Medlar fruit is a climacteric, highly perishable pome fruit and loses commercial acceptability within 3 to 5 days after harvest. In the last two to three decades there have been major changes in food consumption habits, including a significant increase in the consumption of fresh fruit and vegetables due to health concerns (Yahia, 2010). These changes have created the need for the development and application of new technologies to prolong transportation and storage potential and maintain the postharvest quality of these perishable commodities. Controlled atmospheres (CA), with low-O_2 and high-CO_2, have been used successfully to reduce decay, maintain quality and extend storage life in many fruit (Saltveit, 2003).

The palliflex storage system is suitable for short and long term storage under CA and ultra low oxygen (ULO) conditions. In this storage system, it is possible to set desired O_2 and CO_2 compositions in individual pallets by creating CA conditions. O_2 and CO_2 can be automatically injected or removed based on operator set points programmed into the controller. This system is suitable for different fruit and vegetables in the same storage room, because it can provide different atmosphere compositions for individual pallets. The palliflex storage system is similar to CA and extends the useful marketing period of fresh produce during storage, transportation, and distribution by maintaining quality, nutrition, and market value of the produce beyond that achieved via the use of cold storage alone.

Changes in physical, physicochemical and chemical parameters during development and ripening have been studied in medlar fruit (Romero-Rodriguez et al., 2000; de Pascual-Teresa et al., 2000; Glew et al., 2003a; Hacıseferogulları et al., 2005). However, the biochemical changes of this fruit during long term storage have not been studied. In this study we aimed to investigate the effects of different storage conditions, such as palliflex storage (PA) with low-O_2 and high-CO_2 atmospheres (MAP) on physiological properties, quality attributes and storability of 'Istanbul' medlar fruit.

2. Materials and methods

2.1. Fruit and postharvest treatments

Medlar (*M. germanica* L. cv. Istanbul) fruit were harvested at commercial harvest maturity [total soluble solids (TSS) 15.17%; total titratable acidity (TTA) 1.13%; firmness 14.70 N] at the end of October. Fruit were hand-picked and packed in cardboard boxes of about 10 kg, transported to the postharvest laboratory of the Akdeniz University, Antalya within 2 h in a refrigerated vehicle at 2 °C. Medlars were sorted to eliminate damaged fruit and selected for uniform size and color.

The experiment was arranged as a completely randomized design. Fruit were sized and divided equally into polypropylene plastic punnets: 10 cm × 12 cm. Packaged fruit were separated into 4 groups (n = 40). The first group were stored in palliflex containing air (21% O_2 + 0.03% CO_2) and were designated PL-1 as control group. The second group were stored in palliflex containing 2% O_2 + 5% CO_2 (PL-2), and the third group were stored in palliflex containing 3% O_2 + 10% CO_2 (PL-3). The fourth group of punnets were individually packaged using polyethylene film bags, 0.04 mm thick, 35 cm × 50 cm for 1 kg fruit (MAP), and stored in palliflex containing air. Three replicates were used per treatment. Medlar fruit were stored at 0 ± 0.5 °C at 90 ± 5% RH for 60 days and sampled on 0, 15, 30, 45, and 60 days. For each evaluation, three punnets (n = 120; forty fruit per punnet) from each treatment were weighed and processed. Initial O_2 and CO_2 levels in the palliflexs were established by a flow-through system, mixing N_2, CO_2 and air via pressure regulators, automatically controlled and regulated by the analyzer. The gas mixtures were monitored twice daily to ensure desired composition.

2.2. Measurement of CO_2 and O_2 concentrations in MAP

The CO_2 and O_2 concentrations inside the MAP were monitored using a gas analyzer (Servomex Oxygen analyzer 570 A Inj. and Bühler CO_2 analyzer IR Analysator typ-3000). Three replicates and three bags for each replication were used to measure CO_2 and O_2 concentrations in the bags.

2.3. Weight loss

Weight loss was determined by weighing the punnets at the beginning of the experiment (day 0) and at 15 day intervals. Cumulative weight loss was expressed as percentage loss of the initial total weight.

2.4. Taste analysis

Taste analysis was assessed in fruit taken out of storage after 30, 45 and 60 days. Fruit were equilibrated to 20 °C before sampling. A taste panel of five experts trained evaluators used a scale of 1–5, where 1 indicates extremely low taste and 5, extremely good taste 1 = very poor; 2 = poor (limit of acceptable taste); 3 = good; 4 = very good; 5 = excellent.

2.5. Firmness

Flesh firmness was measured using a hand-held penetrometer (Digital Force Gauge, Chatillon 20755, Florida, USA) equipped with a conical probe (12 mm in diameter), measuring the peeled equatorial surface on 3 sides of the fruit. The results were expressed as Newtons. For each test, 30 randomly selected fruit were used.

2.6. Decay incidence

Fruit decay was visually evaluated during the experiment. Any medlars with visible mold growth were considered decayed. Decay was expressed as a percentage of total fruit.

2.7. External browning index

Fruit browning was determined in 40 fruit with 3 replications. General appearance was estimated by measuring the extent of the browned area on fruit skin. The external browning index (EBI) was rated as 1 = none (excellent quality); 2 = slight (browning area <5%); 3 = moderate (browning area 5–25%); 4 = moderately severe (browning area 25–50%); 5 = extreme (browning area >50%). The EBI was calculated as $\Sigma\{$(browning rating) × (number of fruit with the browning rating)$\}$/(total number of fruit in the sample).