Pak. J. Bot., 45(1): 247-251, 2013.

MAINTAINING QUALITY OF LOQUAT (*ERIOBOTRYA JAPONICA* LINDL.) FRUIT AFTER HARVEST

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Abstract

Loquat (*Eriobotrya japonica* Lindl.) is a highly perishable, non climacteric fruit and requires very careful handling. To extend the shelf life of loquat, the effectiveness of different packages including high density polyethylene (HDPE) 0.09 mm thickness, low density polyethylene (LDPE) 0.03 mm thickness, 0.25% perforated high density polyethylene (HDPEP) and 0.25% perforated low density polyethylene (LDPEP) were studied. Loquat fruit of "Surkh" cultivar was picked at mature ripe stage. Fruits were washed, sorted, packed in different polyethylene packages, placed in soft board cartons and stored in a cold store at 4 ˚C. Changes in weight loss, total soluble solids (TSS), ascorbic acid (AA), browning index (BI), firmness and titratable acidity (TA) as affected by different treatments were studied. LDPEP retained significantly highest firmness (1.21 kgf) and lowest TA (0.32%). Lowest values for weight loss (0.17%), TSS (10.5%) and firmness (1.00 kgf) were exhibited by HDPE. Browning index was lowest in LDPE. Control had significantly highest values for TSS (13.4 %), BI (22.06%) and weight loss (2.43%).

Introduction

Loquat (*Eriobotrya japonica* Lindl.) originated in China and spread to many countries including Japan, Pakistan India, Italy, Spain, Brazil, Turkey, America and Australia. Presently, a number of loquat genotypes are being grown in the loquat growing areas of Punjab and Khyber Pakhtunkhwa Province of Pakistan (Hussain *et al*., 2009). Loquat fruit has a short shelf life and its quality deteriorates rapidly after harvest (Akhtar *et al*., 2010). Decay and mechanical damage leading to browning are the prime problems of loquat after harvest (Ding *et al*., 2002). The use of suitable postharvest storage practices may affect the senescence process and lengthen the shelf life of fruits. The use of modified atmosphere packaging (MAP) is a useful tool to maintain fresh fruit quality during post harvest storage (Banara *et al*., 2005;Beaudry, 1999). Sealing fruits in low permeable polyethylene (PE) bags creates a modified atmosphere and is a low-cost alternative to controlled atmosphere storage (Ding *et al*., 2002). The selection of appropriate film is an essential factor, since very high CO_2 concentration and / or low O_2 concentration can induce physiological damage and anaerobic metabolism which adversely affects fruit quality (Beaudry, 2002). A film of insufficient permeability will cause anaerobic respiration resulting in off-flavors, odors and susceptibility to decay (Durand, 2006). Modified atmosphere packaging also lowers water loss and maintains firmness (Batu & Thompson, 1998).

Polyethylene films are widely used for packaging due to their flexibility, durability and insulation. Moreover, they are effective in moisture retention, resistant to chemicals and good insulators. High density polyethylene (HDPE) is non stretching, limits gas exchange and act as a vapor barrier. They are comparatively cheaper than low density polyethylene (LDPE). Low density polyethylene facilitates gas exchange and is more flexible. Loquat fruit packaged in 0.15% perforated polyethylene film bags have been found to retain their freshness for 30 days by storing them at 1 and 5°C (Ding *et al.,* 1998). Zheng *et al*., (2000) reported a decrease in respiration rate of loquat fruit stored in polyethylene bags of 0.04 mm thickness and containing 90% O_2 at 1ºC for 35 days.

Keeping in view the popularity and low cost of PE packages, this study was planned to analyze changes in quality parameters in loquat fruit during postharvest MAP storage by using PE films and find the most appropriate PE package to maintain fruit quality and extend its shelf life.

Materials and Methods

Fruit of "Surkh" cultivar of loquat (*Eriobotrya japonica* Lindl.*)* was picked at mature stage from the orchard of Hill Fruit Research Station, Tret, Murree (73° 17' 00"E longitude and 33° 50' 00"N latitude) and transported to the Post Harvest Laboratory of the Department of Horticulture, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi. The fruits were sorted, washed with distilled water and packed in polyethylene bags (20 x 30 cm size) having different density and perforation as described below:

i. High Density Polyethylene (HDPE) bags of 0.09mm thickness
ii. Low Density Polyethylene (LDPE) bags of 0.03mm thickness
iii. HDPE bags (0.09mm) with 0.25% perforation (HDPEP)
iv. LDPE bags (0.03mm) with 0.25% perforation (LDPEP)

Ten fruits were placed in one bag. There were ten bags in each treatment, every treatment replicated three times. The bags were then placed in soft board cartons and stored at 4°C in the cold storage. Observations were recorded at weekly intervals during the storage period. Data on the following parameters was taken.

Weight loss: To evaluate weight loss separate samples in three replicates were kept in similar conditions as for all other treatments in the cold store. The same fruits were evaluated for weight loss on each sampling interval until the end of experiment. Weight loss of fruits was determined at weekly intervals with the help of following formula:

$$\text{Weight loss (\%)} = [(A-B)/A] \times 100$$

where A indicated the fruit weight at harvesting time and B was the fruit weight after different storage intervals.

Fruit firmness: Fruit firmness was determined by peeling the fruit at two equatorial sites and measuring firmness by means of a Wagner® Fruit Firmness Tester, model FT-327, equipped with an 8mm plunger tip, using ten fruits from each treatment. Values were expressed in kilogram force (kgf).

Total soluble solid: Total soluble solids (TSS) were measured by the method described by Dong *et al*., (2001). One wedge shaped slice of uniform size from ten fruits per replication in all treatments was taken and all the slices were juiced together for a composite sample. TSS in % was measured by a hand refractometer (Abbe® model 10450).

Titratable acidity: Loquat pulp (10g) was homogenized in 40 ml distilled water and filtered to extract the juice. Two to five drops of phenolphthalein were added in this juice. A 10 ml aliquot was titrated against NaOH (0.1N) till permanent light pink color appeared. Three readings were recorded from each replication of a treatment and percent acidity as malic acid was calculated.

Ascorbic acid content (Vitamin C): Ascorbic acid was determined according to Hans (1992). Loquat pulp (5g) from ten fruits of each replication in a treatment was blended with 5 ml 1.0% Hydrochloric acid (w/v) and the homogenate centrifuged at 10,000 x g for 10 minutes. The supernatant was collected as vitamin C extract. The absorbance of the extract was measured at 243 nm by means of a spectrophotometer. For the calibration process, the standard solutions were prepared in the same manner from 100 µg ml^{-1} AA solution in 1% HCl. Then, calibration lines of absorbance vs. concentration of AA were derived. The Ascorbic acid content was calculated as mg/100 g edible portion.

Browning index: Browning index was assessed weekly according to Wang *et al*., (2005) by measuring the extent of browning area on each fruit, using 30 fruits on the following scale:
0= no browning; 1=less than ¼ browning; 2= ¼ to ½ browning; 3= ½ to ¾ browning; 4= more than ¾ browning. The browning index was calculated using the following formula:

$$\text{Browning Index} = [(1 \times N_1 + 2 \times N_2 + 3 \times N_3 + 4 \times N_4) / (4 \times N)] \times 100$$

where N = total number of fruits observed and N_1, N_2, N_3 and N_4 will be the number of fruits showing the different degrees of browning.

Relative electrical conductivity: Relative electrical conductivity was measured by the method described by Fan & Sokorai (2005) with a slight modification. Ten discs of flesh tissue were excised from ten fruits of each replicate in a treatment by a 10mm diameter stainless steel cork borer. The disks were washed, dried with filter paper, and put into 100ml conical flasks containing 50ml of distilled water. Initial electrolyte leakage was determined using Orion 420A+ (Thermo Electron Corp., USA) conductivity meter, at 1 min (C_1) and 60 min (C_{60}) of incubation. The samples were then autoclaved at 121°C for 25 minutes. The solution was then cooled and re-adjusted to a volume of 50 ml. The total conductivity (C_T) of bathing solution was then measured. The Relative electrical conductivity in percent (REC) was calculated with the following equation:

$$\text{REC (\%)} = (C_{60} - C_1)/C_T \times 100$$

Statistical analysis: The experiment was a completely randomized design (CRD) with factorial arrangement. Data was subjected to ANOVA and comparison between means was evaluated by Duncan's multiple range test at 5% level of significance.

Results and Discussion

Effect on weight loss: Highest weight loss occurred in control while HDPE retained maximum weight after the end of ten weeks storage (Table 1). Both polyethylene treatments with perforations had more weight losses compared to non perforated treatments. Weight loss increased till the sixth week and then started to decrease till the end of tenth week (Fig. 1). Weight loss is mainly regulated by respiration, transpiration and metabolic activities in fruits. Modified atmosphere packaging (MAP) have been known to reduce weight losses in loquat (Ding *et al*., 1998., Ding *et al*., 2002., Amaros *et al*., 2008) mainly by maintaining high moisture levels inside the packages thus preventing weight loss. Greater weight loss in control might be due to rapid moisture loss, whereas lower weight loss in different packages might be due to retention of moisture by the PE packages.

Table 1. Effect of polyethylene packages on quality characteristics of loquat.

Treatments	Wt. loss (%)	Firmness (kgf)	TSS (B %)	TA (%)	Vit C (mg/100g)	BI (%)	REC (%)
Control	2.43a	1.04cd	13.4a	0.33d	2.26b	22.06a	52.67a
HDPE	0.17e	1.00d	10.5e	0.52a	3.05a	17.93b	43.39b
HDPEP	0.54c	1.10bc	11.0d	0.42c	3.02a	11.57c	42.44b
LDPE	0.27d	1.13b	11.4c	0.47b	2.98a	8.47d	41.64b
LDPEP	0.63b	1.21a	11.6b	0.32d	2.91a	10.54cd	41.21b
LSD	0.07	0.06	0.16	0.02	0.14	2.45	2.19

HDPE= High density polyetheleneHDPEP= High density polyethylene (perforated)
LDPE= Low density polyethylene LDPEP= Low density polyethylene (perforated)
Means followed by a same letter within column are not significantly different at *p=0.05(DMRT)*

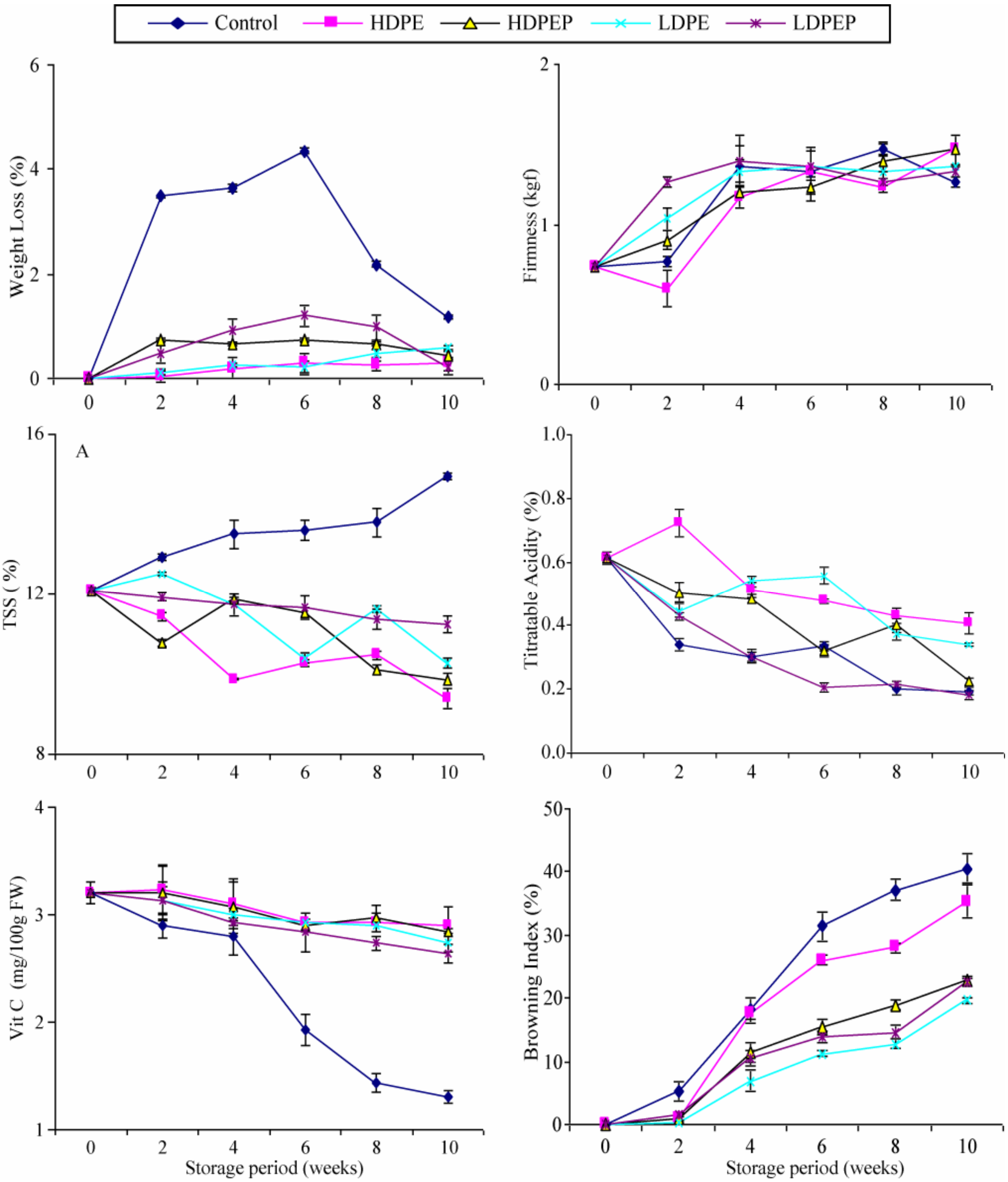

Fig. 1. Effect of polyethylene packages on quality attributes of loquat cv, 'Surkh'. Vertical bars represent SE of means. LSD for weight loss = 0.60, firmness = 0.06, total soluble solids = 0.50, titratable acidity = 0.05, ascorbic acid = 0.17, browning index = 3.96

Effect on firmness: LDPEP retained maximum firmness (1.21kgf), while the lowest firmness (1.00kgf) was observed in HDPE (Table 1). Storage period means show that firmness increased significantly during the first four weeks in all treatments after which no significant difference was observed till the end of storage (Fig. 1).

Changes in loquat fruit firmness during storage is a controversial issue because of different results obtained depending on the storage conditions and cultivar used (Amaros *et al*., 2008). Lower firmness in HDPE might be due greater retention of moisture. Chen *et al*., (2003) also recommended LDPEP for storage of loquat as it maintained the quality attributes during storage.

Effect on total soluble solids: TSS increased significantly in control (13.4%), while in all other treatments, TSS decreased gradually. LDPEP had the next higher TSS value (11.6%) after control. Lowest TSS was recorded in HDPE (Table 1). Although TSS is known to increase during storage when insoluble starch is transformed into soluble solids, however several studies have shown a decrease in TSS during storage (McGlone & Kawano, 1998; Vela *et al*., 2003). Numerous studies have reported that low O2 storage suppresses TSS increase (Lopez, 2002). Airtight polyethylene bags are known to reduce loss of moisture and hydrolysis of polysaccharides resulting in less increase in TSS. In this study, increased TSS in control may be due to the concentration effect because of higher water loss and higher respiration rates resulting in accumulation of different solutes in cell vacuoles, while decrease in TSS in PE treatments may be due to the fact that these treatments retarded the respiration and conversions of polysaccharides into disaccharides and monosaccharides. These results support the findings of Munoz *et al*., (2006) who reported that the soluble solids content decreased under cold storage as a result of respiration in strawberries.

Effect on titratable acidity: Titratable acidity (TA) decreased in all treatments during storage (Fig. 1). Maximum TA (0.52%) was retained in HDPE. Minimum TA was recorded in control and LDPEP (Table 1). High density PE retained TA till the first two weeks compared to other treatments, after which it also started to decline.

The acidity of the fruit is an important character to determine its quality and acceptability (Abbasi *et al*., 2009). In loquat malic acid is the principal acid contributing 90% of the total organic acid content (Ding *et al.,* 1998). Studies show that use of polyethylene bags minimizes reduction in organic acids (Ding *et al*., 1997). Ding *et al*., (1998) reported that loquat fruit packaged in perforated polyethylene film bags (0.15% perforation) retained their initial quality and chemical components for 30 days when stored at 1°C and 5°C. Greater loss of acidity in control and perforated PE packages might be due to rapid consumption of malic acid by the microorganisms as a carbon source whereas decrease in acidity due to fermentation or break up of acids to sugars in fruits during respiration in storage conditions has been suggested by Ball (1997).

Effect on ascorbic acid content (Vit.C): Different densities of polyethylene, with or without perforations did not significantly alter the ascorbic acid (AA) content, however, all polyethylene treatments remained at par and had high AA content throughout storage compared to control (Table 1). Data indicated a continuous steady decrease in AA content of loquat fruits during storage, while a significant decrease was observed in control after the fourth week (Fig. 1).

Acid content in fruits is known to decrease during storage possibly due to utilization of organic acids during respiration or their conversion to sugars (Kader, 2002). Amaros *et al*., (2008) states that ascorbic acid content of loquat decreased slightly in MAP as compared to control treatments during six week storage. Greater decrease of AA content in control may be due to the fact that ascorbic acid is very susceptible to oxidative deterioration (Piga *et al*., 2003), which occurred at accelerated rate in control due to the presence of higher concentrations of O2 as compared to polyethylene packages.

Effect on browning index: Table 1 indicates that control had the highest BI (22.06%) followed by HDPE (17.93%), whereas LDPE had the lowest BI (8.47%). There was a gradual increase in the browning index during the ten week storage period (Fig. 1). Internal browning and brown surface spotting in loquat fruit stored in perforated or higher permeance PE bags have been known to develop during prolonged or high CO_2 storage (Ding *et al*., 1999). Ding *et al*., (1997) reported that packing loquat fruit in polyethylene film bags of different thickness (20, 30 and 50 µm) developed internal browning and the incidence was higher in the thicker bags. Significantly lower BI in perforated and low density PE as compared to HDPE may be due to the greater gas permeability which is in accordance with the findings of Ding *et al*., (2002).

Effect on relative electrical conductivity: Highest REC (52.67%) was recorded in control, which differed significantly from rest of the treatments. However, no significant difference was observed within different packaging treatments (Table 1). Electrolyte leakage is an index which can quantify the damage conceived by plant cell membrane. During ripening and senescing of loquat, leakage of ions increases from the tissues of the skin (Zheng *et al*., 2000 ; Cai *et al*., 2006) which may be caused by the attack of reactive oxygen species (ROS), such as O_2^-, OH^- and H_2O_2 (Tian *et al*., 2007). The prime targets of free radical reactions are unsaturated bonds in membrane phospholipids resulting in loss of membrane fluidity and potential cellular lysis (Opara & Rockway, 2006).

This study shows that REC increased both in control and packages treatments as the fruit senesce. However, greater rate of increase in control suggests that packages had a positive effect on REC. Increased REC in control indicates greater membrane breakdown, which may be explained by the fact that plasma membrane of the cell might have become unstable during storage leading to electrolyte leakage (Feng *et al*., 2005).

Conclusion

MAP could be used on commercial basis to extend shelf life of loquat with minimal reduction in quality. Weight loss was significantly reduced in both types of packages. All polyethylene packages except HDPE performed better. HDPE had significantly high browning index as compared with other packaging materials. High density polyethylene with perforation and Low density polyethylene with or without perforation can be useful in extending the shelf life of loquat while maintaining the quality up to 7 weeks.

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(Received for publication 12 February 2011)