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PRESERVING QUALITY OF LOQUAT FRUIT DURING STORAGE BY MODIFIED ATMOSPHERE PACKAGING

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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) with 0.09 mm thickness, low density polyethylene (LDPE) with 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 stage. Fruits were washed, sorted, packed in different polyethylene packages, and stored at 4˚C in a cold store. Changes in weight loss, firmness, total soluble solids (TSS), titratable acidity (TA), vitamin C content and browning index (BI) as affected by different treatments were studied. LDPEP retained significantly the highest firmness (1.21 kgf) and the lowest TA (0.32%). The lowest values for weight loss (0.17%), TSS (10.5%) and firmness (1.00 kgf) were exhibited by HDPE. Browning index was the minimum in LDPE. Control had significantly highest values for TSS (13.4%), BI (22.06%) and weight loss (2.43%).
Keywords: Loquat, storage, shelf life, fruit firmness, packaging material

INTRODUCTION

Loquat (*Eriobotrya japonica* Lindl.), originated in China, is available in many countries of the world including Japan, Pakistan India, Italy, Spain, Brazil, Turkey, America and Australia. It is an important fruit crop of two provinces of Pakistan viz. Punjab and Khyber Pakhtunkhwa which contribute 98% of the total loquat production (Hussain *et al*., 2011). After harvest, there is a rapid deterioration in the quality of loquat fruit (Lou *et al*., 2012). 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. Modified atmosphere packaging (MAP) is very useful in maintaining the fruit quality during storage and can significantly prolong the shelf-life (Ilyas *et al*., 2007; Palma *et al*., 2012). 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 important factor, as very high concentration of CO_2 and / or low concentration of O_2 may induce physiological damage which badly affects the quality of fruit (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 (Palma *et al*., 2012).

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. According to Ding *et al.*(1998) loquat fruit packed in 0.15% perforated polyethylene bags retained their freshness for 30 days by storing at 1 and 5°C. 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, the study was planned to analyze changes in quality parameters in loquat fruit during MAP storage by using polyethylene and find the most appropriate PE package to maintain fruit quality and extend its shelf life.

MATERIALS AND METHODS

Loquat fruit cultivar 'Surkh' was harvested at maturity and transported to the laboratory. After sorting and washing with distilled water the fruit was packed in polyethylene bags (20 x 30 cm size) having different density and perforation. These treatments included control, High Density Polyethylene (HDPE) bags of 0.09 mm thickness, Low Density Polyethylene (LDPE) bags of 0.03 mm thickness, HDPE bags (0.09 mm) with 0.25% perforation (HDPEP) and 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 kept at 4°C in cold storage. Observations were recorded at weekly intervals on the following parameters.

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

Weight loss (%) = [(A−B)/A] x 100

Where A stands for the fruit weight at harvesting and B indicates the fruit weight after different storage intervals.

Fruit firmness: Fruit firmness was determined using ten fruits from each treatment with the help of a Wagner Fruit Firmness Tester, model FT-327, equipped with a plunger of 8 mm tip. Values of firmness were expressed in kilogram force (kgf).

Total soluble solid: Total soluble solids (TSS) were determined by the method of Dong *et al.* (2001). One slice of uniform size from ten fruits was taken in each treatment. All these slices were juiced collectively to form a composite sample. TSS in % was determined by a hand refractometer (Abbe® model 10450).

Titratable acidity: Ten grams of the pulp was homogenized in distilled water (40 ml) and filtered to get the juice. About 2 to 5 drops of phenolphthalein were included in this juice. An aliquot (10 ml) was titrated against NaOH (0.1N) till the appearance of light pink colour. Calculation of percent acidity as malic acid was done by using the following formula:

% TA = A/B

Where A = (ml NaOH used) (Normality of NaOH) (Equivalent wt. of malic acid)

B = (wt. of sample) (vol. of aliquot taken)

Ascorbic acid content (Vitamin C): Determination of ascorbic acid was done according to Hans (1992). Loquat pulp (5g) from ten fruits of each replication in a treatment was mixed with 5ml 1.0% HCl (w/v) and centrifuged for ten minutes at 10,000 x g. The supernatant was collected as vitamin C extract. Absorbance was measured at 243 nm by means of a spectrophotometer (Model Optima 3000 plus).

Browning index: Assessment of browning index was done at weekly intervals according to Wang *et al*. (2005) by measuring of browning area on the 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:

Browning Index = $[(1xN_1+2xN_2+3xN_3+4xN_4) / (4xN)] \times 100$

Where N = total number of fruits observed, while N_1, N_2, N_3 and N_4 indicate the number of fruits exhibiting the different extent of browning.

Relative electrical conductivity (REC): Measurement of relative electrical conductivity was done using the method demonstrated by Fan and Sokorai (2005) with a little modification. Discs of flesh tissue were excised from 10 fruits by a stainless steel cork borer of 10mm diameter. They were washed, dried, and put into conical flasks containing 50ml of distilled water. Initial electrolyte leakage was recorded using Orion 420A+ (Thermo Electron Corp., USA) conductivity meter, at 1 min (C_1) and 60 min (C_{60}) of incubation. Samples were autoclaved for 25 minutes at 121°C. The total conductivity (C_T) of bathing solution was then measured. Relative electrical conductivity (REC) was measured with the following equation:

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

Experiment was conducted using Complete Randomized Design. Data was subjected to ANOVA and means were compared by Duncan's multiple range test.

RESULTS AND DISCUSSION

Weight Loss: The 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). 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.

Fruit firmness: LDPEP retained maximum firmness (1.21 kgf), 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 firmness of loquat fruit during storage is a controversial issue as different results have been obtained due to the storage conditions and cultivars (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.

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

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

Treatments	Wt. loss (%)	Firmness (kgf)	TSS (%)	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 polyethylene; HDPEP= High density polyethylene (perforated); LDPE= Low density polyethylene; LDPEP= Low density polyethylene (perforated)

Means followed by same letter within column are not significantly different at P=0.05(DMR test)

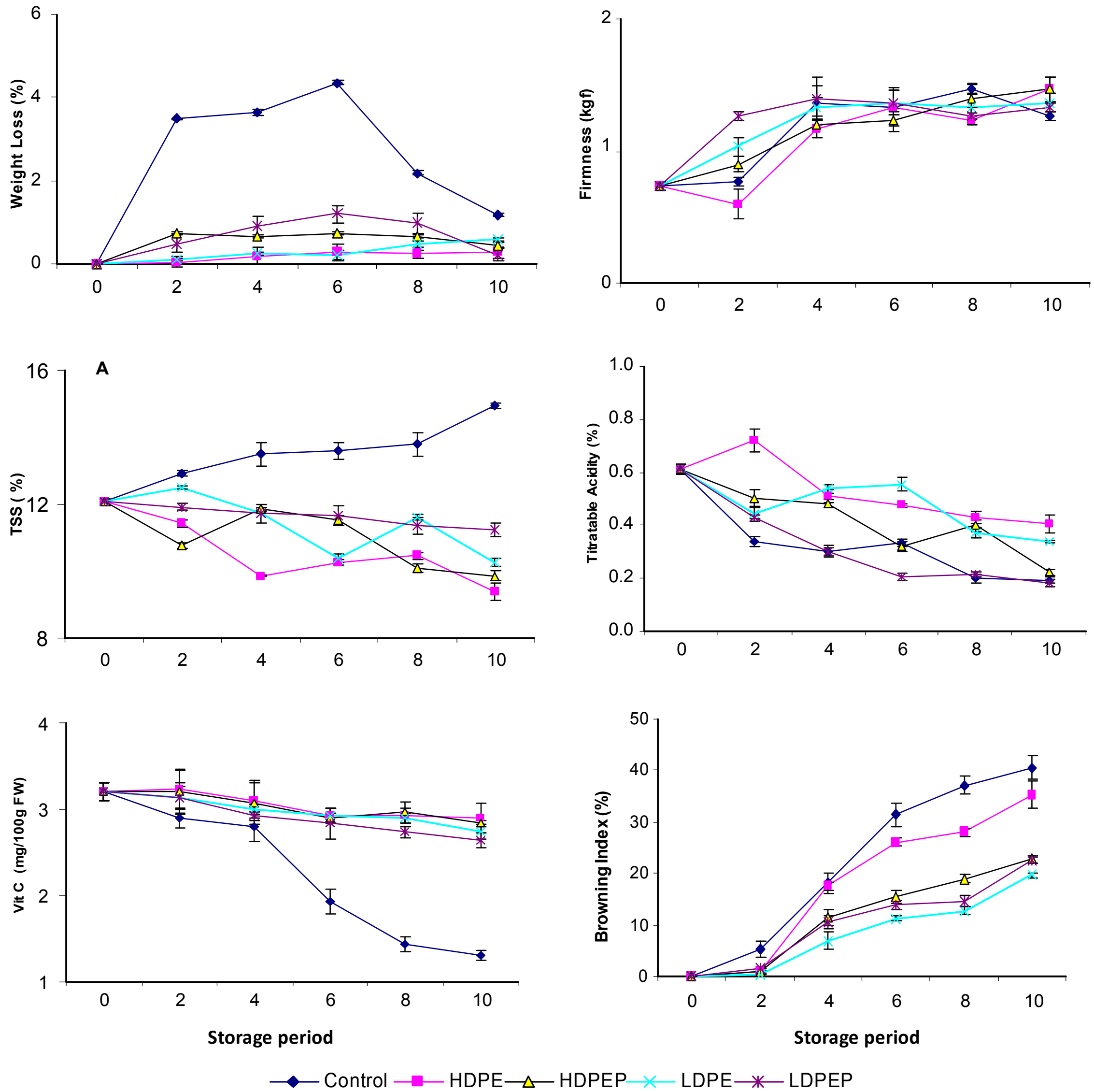

Figure 1. Effect of polyethylene packages on quality attributes of loquat cv. 'Surkh'

several studies have shown a decrease in TSS during storage (McGlone and Kawano, 1998; Vela *et al*., 2003). Numerous studies have reported that low O_2 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.

***Titratable acidity (TA)*:** During storage, titratable acidity decreased in all treatments (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. Malic acid is the principal acid in loquat that contributes 90% of the total organic acid content of fruit (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 retained their initial quality 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.

***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 O_2 as compared to polyethylene packages.

***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 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 developed internal browning and the browning incidence was more 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).

***Electrical conductivity (REC)*:** The 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). During ripening and senescing of loquat, leakage of ions increases from the tissues of the skin (Zheng *et al*., 2000) which may be caused by the attack of reactive oxygen species such as H_2O_2, O_2^- and OH^- (Tian *et al*., 2007).

This work depicts 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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