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Influence of Post Harvest Calcium Chloride Application, Ethylene Absorbent and Modified Atmosphere on Quality Characteristics and Shelf Life of Apricot (*Prunus armeniaca* L.) Fruit During Storage

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Abstract: The effect of different concentrations of $CaCl_2$ (1, 2 and 3%) with the combination of oxidizing agent like Potassium permanganate ($KMnO_4$) on storage life of apricot fruit packaged in sealed Polyethylene bags was investigated at ambient temperature (Relative humidity 60-63% and temperature 28-30°C) during storage. The quality characteristics such as weight loss, total soluble solids, titratable acidity, ascorbic acid and sensory parameters like color, texture, taste, flavour and overall acceptability were studied at an interval of 2 days (0, 2nd, 4th, 6th, 8th and 10th day) for a total period of 10 days during storage. All of the 9 treatments had shown a highly significant effect ($p<0.05$) on storage life and quality parameters of fruits. However, the treatment T_4 ($KMnO_4$ + 3% $CaCl_2$ + Polyethylene bags) was most effective in the retention of higher contents of vitamin C (11.47 mg/100 g), total soluble solids (12.58%), titratable acidity (0.72%) and sensory parameters like colour (4.97), texture (6.23), taste (6.52), flavour (6.38) and the higher overall acceptability score (6.72) with minimum weight loss (3.66%) in T_4. Compared to control fruit showed maximum weight loss (9.5%), lower vitamin C (9.55 mg/100 g), titratable acidity (0.67%), total soluble solids (10.58%) and lower quality score like colour (3.92), texture (4.83), taste (4.79), flavour (4.43) and the lower score (4.6) of overall acceptability during storage whereas the Treatment T_3 (3% $CaCl_2$+Polyethylene bags) was found better to all other treatments during storage. The treated apricot fruit have increased storage life up to 10 days as compared to control which was un acceptable after 6th day of the storage.

Key words: Apricot, storage life, ethylene absorbent, packaging material, coating, sensory evaluation, overall acceptability, post harvest

INTRODUCTION

Apricot (*Prunus armeniaca L.*) is very important fruit not only as nutritional point of view (Parmer and Kaushal, 1982) but also play a role in maintenance of human health, because fruit contain carotene and lycopene that protect the heart and eyes, as well as disease fighting effects of fiber that prevent digestive condition called diverculosis and having antipyretic, antiseptic, emetic, and ophthalmic properties (Haydar *et al.*, 2007; Parmer and Kaushal, 1982). Apricot is perishable fruit having storage life (3-5 days) at ambient conditions, 2-4 weeks at cold storage, depending on variety. The short storage life of this fruit is due to short time period from commercial ripening to the degradation process characteristic like senescence (Egea *et al.*, 2007; Agar and Polate, 1995). Calcium (such as Calcium Chloride) conserved the qualities of fruits, prevented physiological disorders, reduced the rate of respiration, lessens the solubilization of pectic substance, maintaining the firmness and slows down the ripening process (Burns and Pressey, 1987; Salunkhe and Desai, 1984; Magee *et al.*, 2002). Polyethylene bags maintained the high humidity, reduced the loss of weight and consequently slow down the drying process (De-Souza *et al.*, 1999). It maintained the organoleptic properties of fruit (Kolev, 1977). Potassium permanganate was found to extend the shelf life of Climacteric fruit (Nwufo *et al.*, 1994). Due to increase in apricot production and export during last two decades, practical method of packaging and coating are necessary to improve the post harvest quality of apricots (Agar and Polate, 1995). Due to the mishandling, inadequate storage or lack of post harvest technical knowledge producers and traders have to face about 20-30% or even up to 40% losses of fruits in Pakistan that is estimated to a value of more than 3 billion rupees loss in the country (Rathore *et al.*, 2007). The apricot produced in Rawalakot is of high quality and nutritious fruit. It is necessary to reduce the loss of these nutrients during a longer period of storage. For this purpose simple and cheap techniques should be adopted to make sure the availability of the fruit to non producing area. Unfortunately at present there was no research work on the post harvest techniques to maintain the quality characteristics and post harvest life of apricot produced in Rawalakot, or even in AJ and K is available. Therefore, this research has been carried out to study the influence of post harvest calcium chloride application, ethylene absorbent and modified atmosphere on quality characteristics and shelf life of apricot fruit during storage at ambient temperature.

MATERIALS AND METHODS

Collection of sample and preparatory operations: Yellowish-green and firm ripe apricot fruit was directly harvested from farmer's field of Rawalakot Azad Kashmir. After collection, the fruit was immediately transferred to laboratory. The fruits were washed in running tap water, cleaned and dried with a piece of muslin cloth. After drying sorted fruit was divided into equal lots and lot was coated with different concentration of calcium chloride and sealed in polyethylene bags containing sponge cubes soaked in saturated potassium permanganate solution. Total 10 treatments such as Control (T_1), 3%$CaCl_2$+Cardboard Box (T_2), 3% $CaCl_2$ + Polyethylene (T_3), 3% $CaCl_2$ + Polyethylene + $KMnO_4$ (T_4), 2% $CaCl_2$ + Cardboard box (T_5), 2% $CaCl_2$ + Polyethylene (T_6), 2% $CaCl_2$ + Polyethylene + $KMnO_4$ (T_7), 1% $CaCl_2$ + Cardboard box (T_8), 1% $CaCl_2$ + Polyethylene (T_9), 1% $CaCl_2$ + Polyethylene + $KMnO_4$ (T_{10}) were studied during storage at ambient conditions (Relative humidity 60-63% and temperature 28-30°C).

Physical and chemical analysis: The quality characteristics such as weight loss, total soluble solids, titratable acidity, ascorbic acid were determined by using standard procedures according to AOAC (1990) and sensory parameters like color, texture, taste, flavour and overall acceptability of apricot fruit were evaluated by a panel of five judges selected from the Department and nine point hedonic scale was used for sensory evaluation as described by Larmond (1977). The data obtained was statistically analyzed using two-factor factorial in complete randomized design as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Weight loss: DMR test indicated that all of the treatments and their interactions had highly significant effect ($p<0.05$) on weight loss percentage except T_8 and T_5 (7.09-7.35%) or T_6, T_7 and T_{10} (5.53-5.55%) showed insignificant effect, however these treatments were significantly different to each other during storage at ambient temperature (Table 1). The minimum 3.6 percent weight loss was observed in those apricot fruits treated with 3% $CaCl_2$, packaged in Polyethylene bag having $KmnO_4$ (T_4), followed by 3% $CaCl_2$ with Polyethylene bags without $KMnO_4$ (T_3) having 4.20 percent loss as compared to control (T_1) had maximum weight loss 9.5% during storage. The reduction in weight loss percentage might be due to the barrier of moisture such as polyethylene bags and using of calcium chloride and potassium permanganate retard ripening, ethylene production and respiration during storage and therefore less weight loss occur in these treated fruit during storage. These results can be correlated with findings of Agar and Polate (1995) and Antunes *et al.* (2003) who had observed that less percent loss occur in apricot packaged in polyethylene bags also depending on varieties of apricot during storage. These results are also in line with the finding of Ibrahim (2005) who had used $CaCl_2$, polyethylene bags with $KMnO_4$ showed a significant decreasing of weight loss in apricots fruit. Due to the rapid weight loss the control sample was become unacceptable at 6^{th} day of storage (Table 1).

Total soluble solids (tss): It is obvious from Table 1 that all treatments and their interactions had highly significant effect on total soluble solids contents from each other except T_2, T_5, T_7 and T_9 with insignificant difference having similar TSS (10.12%) contents during storage. DMR test shows that the maximum TSS contents were noted in T_3 (12.88%) followed by T_4 (12.58%), T_6 (12.48%), T_{10}(12.42%), T_8(10.33%) as compared to control having lower concentration of TSS (10.05%) during storage. The higher retention of TSS contents in these treated fruits with combination of 3% $CaCl_2$ + $KMnO_4$ packaged in polyethylene bags was might be due to delay in the ripening process in modified atmosphere having lower ethylene level and decrease in respiration or other metabolic processes during storage (Table 1). These results are in line with (Arthey and Philip, 2005) who had described that the higher retention of TSS is due to the slower alteration in cell wall structure and breakdown into simple sugars. These results are also an agreement with Agar and Polate (1995) Antunes *et al.* (2003) Su-Jinle *et al.* (2004) and Ibrahim (2005) who had used oxidizing agents like $KMnO_4$, $CaCl_2$ and polyethylene packaging obtained the similar results.

Titratable acidity: The results revealed that all treatments and their interactions had highly significant difference on percent titratable acidity of apricot from each other except T_{10} and T_4 (0.72%-0.73%), T_9 and T_6 (0.68%). It is clear from DMR test that the maximum titratable acidity was observed in T_{10} (0.73%) followed by T_4 (0.72%), T_3 (0.71%), T_2 (0.70%) as compared T_9 and T_6 (0.68%) or control T_1 (0.67%) had lower concentration of titratable acidity during storage. Our studies show that higher retention of titratable acidity in apricot packaged in polyethylene bags with the combination of higher concentrations of $CaCl_2$ and $KMnO_4$. Whereas, as the lower concentration of $CaCl_2$ alone did not show much effective to retain the acidity (Table 1). The retention of acidity in higher concentrations of $CaCl_2$ and $KMnO_4$ might be due to reduction in metabolic changes of organic acid into carbon dioxide and water. These results are in agreement with those of Ibrahim (2005) who have used the $CaCl_2$, $KMnO_4$ and showed higher

Table 1: Influence of post harvest calcium chloride application, ethylene absorbent and modified atmosphere on quality characteristics and shelf life of Apricot (*Prunus armeniaca* L.) fruit during storage

	Treatments									
Parameters	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Weight Loss	9.500 A	6.167 D	4.199 F	3.660 G	7.098 B	5.536 E	5.536 E	7.352 B	6.749 C	5.550 E
Total Soluble Solids	10.05 E	10.01 E	12.88 A	12.58 B	10.08 E	12.48 BC	9.992 E	10.33 D	10.12 E	12.42 C
Titratable acidity	0.6711 C-E	0.7011 A-C	0.7050 AB	0.7200 A	0.6550 DE	0.6783 B-D	0.6128 F	0.6400 EF	0.6794 B-D	0.7300 A
Ascorbic acid	9.550 C	10.27 BC	11.17 AB	11.47 A	10.22 BC	11.81 A	9.356 C	9.383 C	9.617 C	11.43 A
Colour	3.922 E	3.997 DE	4.887 A	4.957 A	4.045 D	4.798 B	3.920 E	3.807 F	3.837 F	4.435 C
Texture	4.837 E	4.785 E	6.045 B	6.228 A	4.860 E	5.818 C	4.860 E	5.032 D	4.622 F	5.840 C
Taste	4.790 F	4.737 F	6.347 B	6.520 A	4.823 F	5.118 D	4.788 F	4.997 E	4.608 G	5.502 C
Flavour	4.438 G	4.667 F	6.273 B	6.385 A	4.673 F	6.180 B	4.750 EF	4.832 DE	4.870 D	6.037 C
Overall acceptability	4.6 G	4.817 F	6.517 B	6.717 A	5.183 D	6.100 C	4.933 EF	5.050 DE	4.933 EF	6.167 C

•Means followed by the same alphabets are not significantly different from one another based on alpha 0.05

retention of acidity in apricot during storage. Whereas, the same results were observed by Mohammad and Campbell (1993) in banana fruit stored in low density polyethylene bags with ethylene absorbent showed higher retention of acidity. Agar and Polate (1995) also observed that the titratable acidity was higher in apricot stored in plastic bags.

Ascorbic acid: The amount of ascorbic acid (mg/100 g) was significantly affected by the treatments and their interactions except the T_6, T_4 and T_{10} (11.43-11.81 mg/100 g) and similar behavior was also observed in T_2 and T_5 (10.22-10.27 mg/100 g as compared to T_9, T_8 and T_7 (9.35-9.61 mg/100 g) or control (9.55 mg/100 g) which have lower concentration of ascorbic acid during storage at room temperature (Table 1). DMR test shows that the highest retention of ascorbic acid was observed in T_6 (11.81mg/100 g) followed by T_4 (11.47 mg/100 g), T_{10} (11.43 mg/100 g) and T_3 (11.17 mg/100 g). This retention of ascorbic acid might be due to the lowering of respiration of fruit or oxidation of ascorbic acid content of the treated fruits 3% $CaCl_2$ which had reduced the loss of ascorbic acid content which is an agreement with those of Mapson (1970). It was also observed that the combination of $CaCl_2$ with ethylene absorbent like $KMnO_4$ and fruit packaging in polyethylene bags have reduced the loss of ascorbic acid for a prolonged life might be due to the creation of modified atmospheric storage in sealed polyethylene bags in which the production of higher concentration of carbon dioxide and low oxygen, conjunction with $KMnO_4$ had destroyed ethylene and reduce the ripening process by maintaining ethylene at lower level and ascorbic acid content was maintained. These results are in line with Wills *et al.* (1989) and Su-Jinle *et al.* (2004) who had used the same materials ($CaCl_2$, $KMnO_4$ and polyethylene packaging). The decline in ascorbic acid in all treatments was observed in this study that is also in line with Egea *et al.* (2006), Yagi (1980) and Rana *et al.* (1992).

Colour: Table 1 reveals that all treatments and their interactions were significantly different in their colour score from each other during storage. However, DMR test showed a non significant difference of colour score in between T_4 and T_3, T_1 and T_7 or T_9 and T_8. The highest colour score was indicated in T_4 and T_3 (4.89-4.95) followed by T_6 (4.80), T_{10} (4.43), T_2 and T_5 (4.00) as compared to control T_1 (3.92) having minimum colour retention during storage. The higher colour retention in these treatments might be due to the slower change of chlorophyll into carotenoids in the presence of oxidizing agents like $KMnO_4$ and firming agent as $CaCl_2$ in a modified atmospheric storage in the sealed polyethylene bags. The results of this study are closely relate with those reported earlier by Mohammad and Campbell (1993) Antunes *et al.* (2003); Agar and Polate (1995) and Batu and Thompson (1998).

Texture: The treatments and their interactions had highly significant effect on texture score and DMR test revealed that the effect of treatments on texture scores differs from each other except T_7, T_5, T_1 and T_2 having (4.78-4.86) the similar score, or T_6 and T_{10} are also showing similar results (5.81-5.84). Whereas the maximum retention in texture score was observed in T_4 (6.23) followed by T_3 (6.05), T_6 and T_{10} (5.81-5.84), T_5 and T_7 (4.86) as compared to control having lower texture score (4.83) during storage. The maximum retention of texture score might be due to the presence of modified atmosphere with oxidizing agent like $KMnO_4$ and firming agent as $CaCl_2$ who have delay in changes occur in structural polysaccharide like pectic substance and maintained the firmness of the fruit for a long period during storage. These results coincide with the finding of Agar and Polate (1995) Antunes *et al.* (2003) and Ibrahim (2005). This may be attributed to pectin substance to soluble forms by a series of physico-chemical changes that caused by the action of pectin enzyme such as esterase and polygalacturonicdase (Weichmann, 1987).

Taste: All treatments and their interactions showed significant effect on taste score of apricot and DMR test showed that the treatments differ in taste score from each other except T_2, T_5 and T_7 (Table 1). Maximum taste scores was noted in T_4 (6.52) followed by T_3 (6.35), T_{10} (5.50), T_6 (5.12), T_8 (5.00) whereas the minimum but similar taste score (4.7-4.82) was observed in T_1, T_2, T_5 and T_7 respectively during storage and some treated fruits were unable to use due to bitter taste. T_4 have sweet taste during storage interval and T_3 also have a good taste might be due to the slow changes occur in modified atmosphere created by oxidizing agent, firming agent and packaging in polyethylene (3% $CaCl_2$ + Polyethylene bags + $KMnO_4$). The results of this study are in close agreement with those reported earlier by Zora-Singh *et al.* (2000) Akbudak and Eris (2004), Hayat *et al.* (2005) and Szczerbanik *et al.* (2005).

Flavour: The flavour score was significantly affected by treatments and their interactions during storage and DMR test in Table 1 indicates that all treatments are significantly different from each other except T_3 and T_6 (6.18-6.2), T_2, T_5 and T_7 (4.66-4.75) and T_8 and T_9 (4.83-4.87). The maximum flavour score was noted in T_4 (6.38) followed by T_3 (6.27) and T_{10} (6.04) as compared to control T_1 (4.44) or other treatments T_9, T_8, T_7, T_5 and T_2 having minimum flavor score (4.66-4.87) during storage. The highest scores of flavour observed in T_4, T_3 and T_6 might be due to the slower chemical reactions and higher retention of volatile compounds and other soluble sweeteners that maintained the flavour for a long time in a modified environment created in sealed polyethylene bags having (3% $CaCl_2$ + Polyethylene bags + $KMnO_4$). These results are in line with Robson *et al.* (1989) Zora-Singh *et al.* (2000) and Moghadam and Eslani (2005).

Overall acceptability: The Overall Acceptability score in Table 1 indicates a significant difference in treatments and their interactions except T_{10}, T_6, T_7 and T_2. DMR test revealed that the highest scores of overall acceptability value observed in T_4 (6.72), followed by T_3 (6.52), T_6 and T_{10} (6.10-6.17), as compared to T_5, T_8 and T_9 (4.93-5.18) or control (4.6) having minimum overall acceptability score at the end of storage (Table 1). The highest score of the overall acceptability in above mentioned treatments respectively is might be due to the use of oxidizing agent, firming agent and packaging in polyethylene (3% $CaCl_2$ + Polyethylene bags + $KMnO_4$) have created modified atmospheres and as a result the speed of changes were slow down during storage. These treatments helped in retention of overall acceptability and maintained the quality for a long period of apricot up to the end of storage. These results are in line with those of previous studies Moghadam and Eslani (2005) Robson *et al.* (1989) and Zora-Singh *et al.* (2000). Whereas, these treatments have increased storage life of apricot fruit up to 10 days as compared to control which was un acceptable after 6^{th} day of the storage. This is very encouraging news for those farmers producing apricot and may be recommended as coating material to increase the storage life of perishable fruits.

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