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INTEGRATED EFFECT OF CALCIUM SALTS AND PACKAGING ON PHYSICO-CHEMICAL AND ENZYMATIC CHANGES IN STORED PLUM FRUITS

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ABSTRACT

Fruits of plum cv. Satluj Purple were harvested at color break stage. The healthy and uniform sized fruits were selected and treated with aqueous solutions of calcium chloride (1%, 2% and 3%) and calcium nitrate (2%) for 5 minutes. Treated fruits were dried under shade before packaging. Fruits from treatment no. T_4, T_5, T_6, T_8 and T_9 were packed in trays with shrink film and fruits from treatment no. T_1, T_2, T_3, T_7 and T_{10} were kept unpacked in corrugated fiber board (CFB) boxes (5% perforation) with paper lining and stored at 0-1^{0}C with 90-95% RH for 40 days. Observations on physiological loss in weight (PLW), firmness, total soluble solids (TSS), titratable acidity, total sugars and pectin methyl esterase (PME) activity were recorded after 10, 20, 30 and 40 days of storage.Results revealed that fruits treated with $CaCl_2$ @ 2% + shrink film tray packaging exhibited least PLW (0.91%) & PME activity (1.52 ml 0.02 N NaOH used) and maintained higher fruit firmness (2.63 lbf), TSS (13.03%), titratable acidity (0.61%) & total sugars (9.10%) as compared to other treatments after 40 days of storage.

KEY WORDS
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INTRODUCTION

Plum is a delicious fruitrich in sugars and vitamin-A. Japanese plum cultivars having low chilling requirement (below 300 hours) are cultivated in Punjab. 'Satluj Purple' is considered as the potential cultivar of plum because of its high yield, big fruit size, excellent color and taste. It ripens during summer months in the state, when other kind of fruits are not available. But, high temperature and low humidity during the harvesting period leads to short post-harvest shelf-life and huge post-harvest losses. Therefore, there is need standardize the post-harvest technique for assuring the regular supply of good quality fruits to domestic and distant markets over longer periods. The post-harvest application of calcium chloride has been reported to extend storage life of pears & bananas (Wills and Tirmazi 1982), Jamuns (Vandana *et al.,* 2015) and apples (Sams and Conway 1993). Calcium nutrition of fruits has received considerable attention in recent years due to its various positive effects on fruit quality, ripening, senescence & respiration processes (Sharma *et al.,* 1996). Calcium chloride helps to control the various physiological disorders by stabilizing the membrane systems and Ca-pectate that increases the rigidity of the middle portion of cell walls of fruits. Post-harvest calcium applications retain strawberry firmness (Garcia *et al.,* 1996).

Now a days, in fruit industry, packaging plays a very important role during storage and marketing activities. Suitable packaging of fruits can help in preserving quality and palatability till consumption and is also economically profitable and safe. The use of shrink film wrapping to enhance the storage life and quality maintenance of plum seems to be promising since it retards various post-harvest losses (Ladaniya and Singh 2001). Abdel Hamid *et al*. (2012) reported that 10-20% reduction in transpiration rate is possible by shrink film packaging under ambient conditions.A possible combination of Calcium and shrink film packaging may extend the storage life of plum fruits with acceptable quality. Keeping the above fact in view the present study was conducted with the objective to extend post-harvest life of Satluj Purple plum fruits with the use of calcium salts and shrink film packaging under low temperature storage conditions.

MATERIALS AND METHODS

The experiment was conducted in the Post-harvest laboratory, Department of Fruit Science, Punjab Agricultural University, Ludhiana during the year 2014. Physiologically mature fruits of plum *cv*. Satluj Purple were harvested at color break stage from Fruit Research Farm, PAU and Ludhiana. Diseased, bruised and injured fruits were sorted out and healthy fruits were selected. Selected fruits were treated with calcium chloride (1%, 2% and 3%) and calcium nitrate (2%) for 5 minutes. Treated fruits were dried under shade. Treated fruits were packed in trays with shrink film in treatment no. T_4, T_5, T_6, T_8 and $T_9$and fruits from treatment no. T_1, T_2, T_3, T_7 and T_{10} were kept unpacked in CFB boxes (5% perforation) with

paper lining and stored at low temperature (0-1°C with 90-95% RH) for 40 days. Observations on PLW, firmness and quality parameters like TSS, titratable acidity, total sugars and PME activity etc., were recorded at 10 days interval. The experiment was laid out in factorial completely randomized block design (CRD) as described by Singh *et al*. (1998) with 10 treatments having 3 replications per treatment. The percent physiological loss in weight was calculated by subtracting final weight from the initial weight of fruits and then converted into percentage value. Firmness of ten randomly selected fruits was measured with the help of a penetrometer (Model FT-327, USA) using stainless steel probe and expressed in terms of lb force.For total soluble solids, the juice of ten randomly selected mature fruits was extracted and strained through muslin cloth. Total soluble solids content (TSS) of juice was determined with the help of *Erma* hand refractrometer in terms of Brix (%) at room temperature.Titratable acidity was determined by taking 2 ml of strained fruit juice, which was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The end point was noted with change in colour from colorless to light pink. For calculating the total sugars, AOAC (1994) method was followed. Pectin methyl esterase activity was measured by the method given by Mahadevan and Sridhar (1982).

RESULTS AND DISCUSSION

Physiological loss in weight (PLW)

An increase in physiological loss in weight of the fruit with the advancement of storage period was recorded in all the treatments (fig-1). After 10 days of storage the minimum percent loss in weight (0.40%) was noticed in fruits treated with calcium chloride @ 2% + shrink film tray packaging, which was followed by calcium chloride @ 1% + shrink film tray packaging. But the maximum physiological loss in weight (4.67%) was found in untreated and unpacked fruits. Similar trend in percent loss in physiological weight was observed at 2nd, 3rd and 4th interval i.e. after 20, 30 and 40 days of storage. Increase in physiological loss in weight with the increase in storage period in apples has also been reported by Hussain *et al*. (2008), in citrus by Ladaniya and Singh (2001) and in strawberry by Asrey*et al*. (2008). Kaur *et al*. (2005) studied the effect of calcium chloride and wrapping material on pear *cv*. Baggugosha and found that calcium chloride (6%) in combination with individually seal packing with polyethylene film (100 gauge) proved to be the most effective treatment in reducing the weight loss. Vandana *et al*. (2015) also reported that pre-harvest treatment of 1% calcium chloride recorded minimum value of loss in weight in Jamun fruits. Ben-Yehoshua *et al*. (1998) reported that shrink films were found more effective in reducing PLW, it might be due to creation of modified atmosphere around apples by the shrink films.

Fruit firmness

A continuous decrease in fruit firmness was observed with the advancement of storage period irrespective to the treatments (fig-2). After 10 days of storage maximum (4.98 lbf) fruit firmness was observed in calcium chloride @ 2% + shrink film tray packaging, followed by calcium chloride @ 1% + shrink film tray packaging (4.92 lbf). But minimum (4.15 lbf) fruit firmness was noticed in control fruits. Similar trend was also observed on 2nd, 3rd and 4th interval *i*.e. after 20, 30 and 40 days of storage. Softening of fruits is caused either by the breakdown of insoluble protopectins into soluble pectins or by the cellular disintegration leading to increased membrane permeability (Matoo *et al*., 1975). Gunes *et al*. (2001) reported that treatments with calcium chloride avoided softening and maintained the structures of cell walls through cross-linking of pectic acid in cell wall.Changhoo *etal*. (2001) reported that post-harvest calcium treatments inhibited the decrease in flesh firmness of kiwifruit during low temperature storage. Nanda *et al*. (2001) while working on pomegranate fruits *cv*. Ganesh studied that fruits wrapped in shrink film maintained their firmness to a greater extent than the fruits coated with sucrose polyester as well as unwrapped fruits. Further the higher efficiency of shrink films in maintaining the better fruit firmness might be due to better retention of CO_2 gas and restriction of external O_2.

Total soluble solids (TSS)

Storage period and treatments displayed a significant effect on the TSS content of plum fruits (fig. 3). TSS content of plum fruits increased up to 20 days and thereafter a decrease was observed in all the treatments except calcium chloride @ 2% + shrink film tray packaging, calcium chloride @ 1% + shrink film tray packaging and calcium nitrate @ 2% + shrink film tray packaging. In these treatments gradual increase in TSS was recorded up to 30 days of storage. After 40 days of storage $CaCl_2$ @ 2% + shrink film tray packed fruits retained the maximum (13.03%) TSS content and control fruits showed minimum (12.05%) TSS content. Increase in TSS with increase in storage has also been reported by Asrey *et al*. (2008) in strawberry. Calcium chloride treatments in pomegranate fruits showed lower soluble solid content as compared to control after 4 months of storage (Ramezanian *et al*. 2010). Ben-Yehoshua *et al*. (1998) also reported positive influence of heat shrinkable films on TSS in citrus fruits. The increase in TSS content with the advancement of storage period may be due to water loss and hydrolysis of starch and various other polysaccharides to soluble form of sugar.

Titratable acidity

A decrease in the titratable acidity was observed with the advancement of storage period (fig-4). After 10 days of storage maximum (1.07%) titratable acidity was observed in $CaCl_2$ @ 2% + shrink film tray packaging and minimum (0.64%) was noticed in control fruits. Same trend was found on 2nd, 3rd and 4th interval *i*.e. after 20, 30 and 40 days of storage. The decrease in acidity during storage period may be due to the utilization of various organic acids in pyruvate decarboxylation reaction occurring during ripening process of fruits. Bhattarai and Gautam (2006) reported that during storage the fruit itself might utilize the acids so that the acid in the fruits during storage period decreases. Similarly, Devi (2007) stated a slow decline in titratable acidity in peach with calcium treatments. Kaur *et al*. (2005) reported that the rate of decrease in titratable acidity was slower in pear fruits treated with calcium chloride solution and wrapped individually in polyethylene film. The maintenance of higher titratable acidity in calcium treated and shrink film tray packed fruits may be due to the decreased hydrolysis of organic acids and subsequent accumulation of

organic acids which were oxidized at lower rate because of decreased respiration.

Total sugars

Treatments and storage period showed a significant difference (Fig. 5). Total sugars showed an increase up to 20 days of storage, but after this a decrease was recorded in all the treatments except calcium chloride @ 2% + shrink film tray packaging, calcium chloride @ 1% + shrink film tray packaging and calcium nitrate @ 2% + shrink film tray packaging treatments, in these treatments increase in total sugars was noticed up to 30 days of storage. After 40 days of storage maximum (9.10%) total sugars were observed in calcium chloride @ 2% + shrink film tray packaging and minimum (8.40 %) in control fruits. The increase in content of total sugars with the extension of storage period may be a consequence of breakdown of complex organic metabolites into simpler molecules or hydrolysis of starch into sugars. At later stages of storage a decline in sugar content may be due to the utilization of sugars along with other organic acids as substrate in respiration process. Tsomu *et al*. (2015) also observed the same trend when fruits of sapota *cv*. Kalipatti were treated with $CaCl_2$at different concentrations. Badshah *et al*. (1994) also reported that post-harvest treatment of calcium chloride solution to apple fruits at different concentrations (4% and 8%) resulted in slow increase in total sugars as compared to control under cold storage. Kaur *et al*. (2005) while working on pear *cv*. Baggugosha by using different concentrations of calcium chloride solutions (4, 6 and 8%) and thereafter, individually wrapping in different wrappers, viz. newspaper, polyethylene and butter paper, reported an increase in total sugars in fruits at ambient temperature.

Pectin methyl esterase (PME)

Calcium salts and shrink film packaging retarded the PME activity (Fig. 6). Results revealed that, PME activity showed an increase up to 20 days of storage, but after this a decrease was recorded in all the treatments except calcium chloride @ 2% + shrink film tray packaging, calcium chloride @ 1% + shrink film tray packaging and calcium nitrate @ 2% + shrink film tray packaging treatments. After 40 days of storage, maximum (1.52 ml 0.02N NaOH used) PME activity was recorded in calcium chloride @ 2% + shrink film tray packaging treated fruits and minimum (1.38 ml 0.02N NaOH used) was recorded in control fruits. It might be due to the presence of high substrate level for PME activity at later stages in calcium chloride @ 2% + shrink film tray packed fruits which was already decomposed to the higher extent at the early stages of storage in other treatments. Decrease in PME activity at later stages of storage was also reported by Jawandha *et al*. (2012) in ber fruits. Alandes *et al*. (2009) reported that calcium compounds strengthen the structure of cells by maintaining the fibrilar packaging in cell wall thus reinforcing the cell to cell contact which is related to formation of calcium pectate and counteracts the PME activity.

It can be concluded that calcium chloride @ 2% + shrink film tray packaging maintained low PLW & PME activity and higher fruit firmness, TSS, titratable acidity & total sugars as compared to other treatments under low temperature conditions (0-1°C and 90-95% RH).

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