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Horticulture

Effect of Calcium and Shrink Film on Post-Harvest Behavior of Cold Stored Plum Fruits

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Abstract

Effect of post-harvest treatments of calcium and shrink film packaging on plum cv. Satluj Purple was studied. Uniform and healthy fruits were selected and treated with aqueous solutions of calcium chloride (1%, 2% and 3%) and calcium nitrate (2%) for 5 minutes. After drying, treated 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) and stored at low temperature (0-1°C with 90-95% RH) for 40 days. Observations on palatability rating, spoilage, TSS: acid, reducing sugars and non- reducing 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 best fruit quality by maintaining palatability rating, reducing sugars and non-reducing sugars and lowering spoilage and TSS: acid during 40 days of storage.

Highlights

Plum fruits treated with $CaCl_2$ @ 2% + shrink film tray packaging maintained the best fruit quality during cold storage.

Keywords: Plum, calcium chloride, calcium nitrate, shrink film, storage

Plum is an important temperate zone fruit. In Punjab, Japanese plum cultivars having low chilling requirement (below 300 hours) are cultivated. Varieties like Satluj Purple and Kala Amritsari are grown commercially in the state, from these two varieties 'Satluj Purple' is an exotic variety. It occupies a key position because of its high yield, big fruit size, excellent color and taste. It ripens during summer month (May). Extremely high temperature and low humidity during this period shortens its post-harvest shelf-life. Tsuji *et al.* (1984) noted that at 40°C plum maintained the market quality for 3-4 days. This short period is not enough to transport the plum fruits to distant markets. The fruit quality and shelf-life is also highly affected due to various injuries during harvesting and packaging operations. Therefore, there is need to ascertain a post-harvest technique for the regular supply of good quality fruits over longer periods. Several growth regulators and chemicals have been reported to delay the ripening and extend the post-harvest life of mango (Khadar *et al.* 1988), strawberry (Martinez *et al.* 1994) and pear (Schirra *et al.* 1999). Calcium is an important element, deficiency of which may cause a range of postharvest disorders in many fruits and vegetables (Shear 1975).

Packaging plays a very important role in enhancing the quality and storage life of fruits. Improper packaging of fruits may cause injury or loss of product freshness. Properly packed fruits help in attracting the consumers in the market, as it adds value to the commodity during its marketing. Packaging of fruits can help in preserving quality and palatability till consumption and is also safe and economically profitable. To meet these requirements, shrink-packaging, which is a new technique, has been used to reduce post-harvest losses and to extend the shelf-life in some fruits (Ladaniya and Singh 2001). The available literature reveals that a little research work has been done on shrink packaging of fruits in India. In the present study, an experiment was planned to see the effect of chemicals and shrink packaging on the storage life and fruit quality at low temperature storage.

Materials and Methods

The present study was conducted in the Post-harvest Laboratory, Department of Fruit Science, Punjab Agricultural University, Ludhiana during the year 2014. The fruits of plum *cv.* Satluj Purple were harvested at color break stage from Fruit Research Farm, PAU, Ludhiana. Uniform and healthy fruits were treated with aqueous solutions of calcium chloride (1%, 2% and 3%) and calcium nitrate (2%) for 5 minutes. Experiment comprised ten treatments viz., T_1 - Calcium chloride @ 1%, T_2 - Calcium chloride @ 2%, T_3 - Calcium chloride @ 3%, T_4 - Calcium chloride @ 1% + shrink film tray packaging , T_5 - Calcium chloride @ 2% + shrink film tray packaging , T_6 - Calcium chloride @ 3% + shrink film tray packaging, T_7 - Calcium nitrate @ 2%, T_8 - Calcium nitrate @ 2%+ shrink film tray packaging , T_9 - Untreated + shrink film tray packaging and T_{10} - Control. Fruits from unpacked treatments (T_1, T_2, T_3, T_7 and T_{10}) were packed in corrugated fibre board (CFB) boxes and stored at low temperature (0-1^{o}C with 90-95% RH) for 40 days. Observations on palatability rating, spoilage, TSS: acid, reducing sugars and non-reducing sugars were recorded at 10 days interval. The fruits were estimated for palatability rating by a panel of 3 judges on the basis of general appearance, taste and flavor using Hedonic scale (1-9) described by Amerine *et al.* (1965) as: 9 (Extremely desirable), 8 (Very much desirable),7 (Moderately desirable), 6 (Slightly desirable), 5 (Neither desirable nor undesirable), 4 (Slightly undesirable),3 (Moderately undesirable), 2 (Very much undesirable),1 (Extremely undesirable). The spoilage per cent of fruits was calculated by counting the spoiled fruits and total number of fruits in each replication of each treatment. TSS/Acid was calculated by dividing the value of total soluble solids (TSS) with that of the corresponding titratable acidity. The reducing sugars were determined by the method suggested by AOAC (2000). The non-reducing sugars present in the sample were determined by subtracting the values of total sugars and reducing sugars The data were statistically analyzed by Factorial Completely Randomized Block Design (CRD) as described by Singh *et al.* (1998) with 10 treatments having 3 replications per treatment.

Results and Discussion

Palatability rating: Palatability rating of fruits increased continuously up to 20 days of storage in all the treatments after that a decline was registered (Table 1). Fruits treated with calcium chloride @ 2% + shrink film tray packaging, calcium chloride @ 1% + shrink film tray packaging and calcium nitrate @ 2% + shrink film tray packaging showed a gradual increase in palatability rating up to 30 days of storage and afterward decline was observed, whereas the fruits from other treatments and control showed an increase in palatability rating only up to 20 days of storage, after that it declined, but this decline was more steep in untreated fruits. After 10 and 20 days of storage, the maximum palatability rating was found in control fruits and minimum was recorded in fruits treated with calcium chloride @ 2% + shrink film tray packaging. But, after 30 day of storage, the fruits treated with calcium chloride @ 2% + shrink film tray packaging recorded maximum (8.07) palatability rating and minimum (6.03) palatability rating was observed in control. Similar trend was followed at 4th interval i.e. after 40 days of storage. Ladaniya and Singh (2001) also reported better palatability rating in shrink-wrapped citrus fruits control ones. The higher palatability rating in film packed fruit might be attributed to the reduction in fruit ripening and softening processes that led to the development of better flavor and texture as compared to control. Kaundal *et al.* (2000) reported high palatability in calcium chloride treated plum fruits. The quality deterioration of fruits with storage may also be due to disturbed TSS: acid ratio and development of off flavors.

Spoilage: Results showed that the spoilage percentage increased with the progression of storage period (Table-2). There was no spoilage after 10 days of storage in all the treatments. After 20 days of storage only control fruits showed spoilage at the tune of 1.87%. After 40 days of storage minimum (0.27%) spoilage percentage was recorded in fruits treated with calcium chloride @ 2% + shrink film tray packaging and maximum (9.17%) in control. Elmer *et al.* (2000) reported that calcium promotes the synthesis of phytoalexins and phenolic compounds which are involved in resisting the fungal attack and it also minimizes the risk of micro cracks in the cuticle which is known as the direct site for fungal infection. Reduction in spoilage percentage of apples packed in LDPE films have also been reported by Lambrinos *et al.* (1995). Minimum spoilage of pear fruits was reported with calcium chloride treatment (8%), whereas maximum was under Stafresh 960 and control treatment (Sandhu *et al.* 2004).

TSS: acid: an increase in TSS: acid ratio was observed with the prolongation of storage period (Table 3). After 10 days of storage minimum (11.29) TSS: acid was observed in calcium chloride @ 2% + shrink film tray packed fruits and maximum (21.05) in control. Same trend was observed after 2nd, 3rd and 4th interval i.e. after 20, 30 and 40 days of storage. Shirzadeh *et al.* (2011)

Table 1. Effect of different post-harvest treatments on palatability rating of plum fruits during cold storage

Treatment	Palatability rating (1-9) Storage interval (Days)				
	10	**20**	**30**	**40**	**Mean**
T_1 - Calcium chloride @ 1%	7.57	8.38	6.50	6.07	**7.13**
T_2 - Calcium chloride @ 2%	7.51	8.29	6.65	6.16	**7.15**
T_3 - Calcium chloride @ 3%	7.72	8.67	6.14	5.65	**7.05**
T_4 - Calcium chloride @ 1% + shrink film tray packaging	7.06	7.55	7.64	6.90	**7.29**
T_5 - Calcium chloride @ 2% + shrink film tray packaging	6.93	7.29	8.07	7.10	**7.35**
T_6 - Calcium chloride @ 3% + shrink film tray packaging	7.29	7.93	7.11	6.37	**7.18**
T_7 - Calcium nitrate @ 2%	7.61	8.62	6.27	5.90	**7.10**
T_8 - Calcium nitrate @ 2% + shrink film tray packaging	7.16	7.56	7.58	6.82	**7.28**
T_9 - Untreated + shrink film tray packaging	7.34	8.20	6.86	6.23	**7.16**
T_{10} – Control	7.93	8.75	6.03	5.40	**7.03**
Mean	**7.41**	**8.12**	**6.89**	**6.26**	

Base value: 5.12

CD at 5% level

A (treatments) = 0.16

B (storage) = 0.12

AB (treatments × storage) = 0.51

Table 2. Effect of different post-harvest treatments on spoilage of plum fruits during cold storage

Treatment	Spoilage (%) Storage interval (Days)				
	10	**20**	**30**	**40**	**Mean**
T_1 - Calcium chloride @ 1%	0.00	0.00	0.77	2.63	**0.85**
T_2 - Calcium chloride @ 2%	0.00	0.00	0.63	2.27	**0.73**
T_3 - Calcium chloride @ 3%	0.00	0.00	1.13	3.73	**1.22**
T_4 - Calcium chloride @ 1% + shrink film tray packaging	0.00	0.00	0.00	0.34	**0.09**
T_5 - Calcium chloride @ 2% + shrink film tray packaging	0.00	0.00	0.00	0.27	**0.07**
T_6 - Calcium chloride @ 3% + shrink film tray packaging	0.00	0.00	0.15	0.92	**0.27**
T_7 - Calcium nitrate @ 2%	0.00	0.00	0.78	3.33	**1.03**
T_8 - Calcium nitrate @ 2% + shrink film tray packaging	0.00	0.00	0.11	0.36	**0.12**
T_9 - Untreated + shrink film tray packaging	0.00	0.00	0.17	0.97	**0.29**
T_{10} – Control	0.00	1.87	6.77	9.17	**4.45**
Mean	**0.00**	**0.19**	**1.05**	**2.40**	

Base value: 0.00

CD at 5% level

A (treatments) = 0.10

B (storage) = 0.16

AB (treatments × storage) = 0.51

Table 3. Effect of different post-harvest treatments on total soluble solids and acid ratio of plum fruits during cold storage

Treatment	TSS: Acid				
	Storage interval (Days)				
	10	20	30	40	Mean
T_1 - Calcium chloride @ 1%	15.92	21.27	23.30	27.50	**22.00**
T_2 - Calcium chloride @ 2%	14.98	20.62	22.50	26.60	**21.18**
T_3 - Calcium chloride @ 3%	19.86	22.63	24.76	28.40	**23.91**
T_4 - Calcium chloride @ 1% + shrink film tray packaging	12.38	15.52	17.80	21.88	**16.90**
T_5 - Calcium chloride @ 2% + shrink film tray packaging	11.29	15.21	17.56	21.28	**16.34**
T_6 - Calcium chloride @ 3% + shrink film tray packaging	13.76	17.54	20.16	23.55	**18.75**
T_7 - Calcium nitrate @ 2%	19.52	21.81	23.95	27.83	**23.28**
T_8 - Calcium nitrate @ 2% + shrink film tray packaging	12.96	16.39	19.01	22.82	**17.80**
T_9 - Untreated + shrink film tray packaging	14.63	18.64	20.88	24.60	**19.69**
T_{10} – Control	21.05	23.68	26.20	29.38	**25.08**
Mean	**15.64**	**19.33**	**21.61**	**25.38**	

Base value: 9.64

CD at 5% level

A (treatments) = 0.13
B (storage) = 0.29
AB (treatments × storage) = 0.34

Table 4. Effect of different post-harvest treatments on reducing sugars of plum fruits during cold storage

Treatment	Reducing sugars (%)				
	Storage interval (Days)				
	10	20	30	40	Mean
T_1 - Calcium chloride @ 1%	6.76	6.97	6.36	5.88	**6.49**
T_2 - Calcium chloride @ 2%	6.75	6.84	6.39	5.92	**6.48**
T_3 - Calcium chloride @ 3%	7.06	7.15	6.27	5.84	**6.58**
T_4 - Calcium chloride @ 1% + shrink film tray packaging	6.32	6.52	6.64	6.24	**6.43**
T_5 - Calcium chloride @ 2% + shrink film tray packaging	6.22	6.45	6.65	6.35	**6.42**
T_6 - Calcium chloride @ 3% + shrink film tray packaging	6.54	6.65	6.55	6.08	**6.46**
T_7 - Calcium nitrate @ 2%	6.98	7.07	6.32	5.85	**6.56**
T_8 - Calcium nitrate @ 2% + shrink film tray packaging	6.45	6.55	6.64	6.14	**6.45**
T_9 - Untreated + shrink film tray packaging	6.65	6.75	6.47	6.02	**6.47**
T_{10} – Control	7.08	7.17	6.25	5.84	**6.59**
Mean	**6.68**	**6.81**	**6.45**	**6.02**	

Base value: 5.16

CD at 5% level

A (treatments) = 0.10
B (storage) = 0.23
AB (treatments × storage) = 0.42

Table 5. Effect of different post-harvest treatments on non-reducing sugars of plum fruits during cold storage

Treatment	Non-reducing sugars (%) Storage interval (Days)				
	10	20	30	40	Mean
T_1 - Calcium chloride @1%	2.73	2.79	2.60	2.39	**2.63**
T_2 - Calcium chloride @ 2%	2.71	2.76	2.61	2.40	**2.62**
T_3 - Calcium chloride @ 3%	2.81	2.88	2.53	2.36	**2.65**
T_4 - Calcium chloride @ 1% + shrink film tray packaging	2.55	2.63	2.67	2.48	**2.58**
T_5 - Calcium chloride @ 2% + shrink film tray packaging	2.50	2.55	2.71	2.53	**2.57**
T_6 - Calcium chloride @ 3% + shrink film tray packaging	2.64	2.68	2.65	2.42	**2.60**
T_7 - Calcium nitrate @ 2%	2.75	2.85	2.55	2.38	**2.63**
T_8 - Calcium nitrate @ 2% + shrink film tray packaging	2.59	2.65	2.67	2.47	**2.59**
T_9 - Untreated + shrink film tray packaging	2.67	2.74	2.62	2.42	**2.61**
T_{10} – Control	2.87	2.90	2.50	2.32	**2.66**
Mean	**2.68**	**2.74**	**2.61**	**2.42**	

Base value: 2.19

CD at 5% level

A (treatments) = 0.11
B (storage) = 0.23
AB (treatments × storage) = 0.45

observed that the TSS/TA increased with advancement of storage period. But dipping of fruits in calcium solutions at different concentrations prevented the increase of TSS/TA in comparison to control. Raja (2010) reported a low TSS: acid with calcium chloride @ 1.5% treatment in peach fruits as compared to control. An increase in TSS: acid ratio with the extension of storage period might be due to the increase in total soluble solids and reduction in acidity of fruits with the increase in storage period.

Reducing sugars: At the end of storage calcium chloride @ 2% + shrink film tray packaging maintained the reducing sugars (Table-4). An increase in reducing sugars in all the treatments up to 2nd interval i.e. after 20 days of storage, but after this there was decrease 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, where this increase was recorded up to 30 days of storage. After 40 days of storage maximum (6.35%) reducing sugars were observed in fruits treated with calcium chloride @ 2% + shrink film tray packaging and minimum (5.84%) in control. Kaur *et al.* (2005) while working on pear 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 and reducing sugars in fruits at ambient temperature. Singh *et al.* (1998) reported the effect of perforated polythene wrapping and pre-harvest application of calcium compounds on storage life of mango *cv*. Amrapali and observed that perforated polythene wrapping, calcium chloride (1.5%) and calcium nitrate (1.5%) treatments maintained the minimum reducing and total sugars during storage.

Non-reducing sugars: Calcium chloride @ 2% + shrink film tray packaging maintained the non-reducing sugar content in the cold stored plum fruits (Table 5). An increase in the non-reducing sugars was recorded with the advancement of storage period up to 20 days of storage, after this a decrease in non-reducing sugars 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, where this increase in non-reducing sugars was recorded up to 30 days of storage. After 40 days it was observed that calcium chloride @ 2% + shrink film tray packed fruits recorded maximum (2.53%) non-reducing sugars and control recorded minimum (2.32%) non-reducing sugars.

Tefera *et al.* (2008) investigated the integrated effect of packaging and evaporatively cooled storage on sugar content of mango fruit and revealed that packaging generally maintained higher levels of non-reducing content of fruits

It can be summarized that fruits treated with calcium chloride @ 2% + shrink film tray packaging maintained fruit quality in terms of least spoilage and TSS: acid and maintained higher palatability rating, reducing sugars and non-reducing sugars as compared to other treatments during 40 days of storage at low temperature conditions (0-1°C and 90-95% RH).

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