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Improvement in storability and quality of peach Cv. Flordaprince with post-harvest application of various chemicals

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Abstract
To present a solution for improving the postharvest storage life of peach, the present investigation entitled, Improvement in storability and quality of peach cv. Flordaprince with post-harvest application of various chemicals was conducted in the laboratory of Department of Horticulture, Khalsa College, Amritsar during the year 2017-18. The fruits were harvested at the commercial ripening stage and were immersed in $CaCl_2$ (2, 4 and 6 percent), putrescine and salicylic acid (1, 2 and 3 mmol) as well as distilled water (control) for 5 minutes, then after air drying the fruits were packed in corrugated fibre boxes (CFB) and stored at 2 ºC and 95% relative humidity for 28 days. The changes in weight loss, spoilage percentage, fruit firmness, total soluble solids, titratable acidity, sugars and carotenoids were estimated after 0, 7, 14, 21 and 28 days during storage. Present experiment was laid out in Factorial Randomized Block Design (RBD factorial). The results of the study revealed that the physiological weight loss, spoilage percent, total soluble solids were increased significantly while the fruit firmness, titratable acidity and carotenoids decreased significantly during storage. The salicylic acid 3 mmol reduced significantly the physiological weight loss and retained their firmness, fruit colour and palatability. In this condition, the highest and lowest of sugar contents were observed in treatments of putrescine 3 mmol and control respectively. The data revealed that the quality and storability was improved by the use of salicylic acid and putrescine treatments due to its effect on delaying the ripening processes.

Keywords: Carotenoids, ripening, cold storage, corrugated fibre boxes, spoilage, putrescine, salicylic acid

Introduction
Peach (*Prunus persica* (L.) Batsch) is one of the most important stone-fruit of family Rosaceae and sub-family Prunoideae. It is an important fruit crop of the world which originated in China or north-west China. Its unique flavour and delicious taste with high nutritional value has popularized it across the world. The main peach producing countries are U. S. A., Italy, Greece, Spain, France, Russia, China and India. In India, the main peach producing regions are Jammu & Kashmir, H.P., high hills of U.P., Punjab and Haryana. The low-chilling peach cvs. grow in sub-mountains and plains of Jammu, H.P., and in Punjab, Haryana & U.P. (Iordanescu *et al.* 2015) [12]. Peaches are a rich source of carbohydrates, sugars (sucrose), proteins (all amino acids), vitamins (carotene, thiamine, niacin and riboflavin) and minerals (potassium, sodium, calcium, magnesium, iron and zinc). They are also an excellent source of antioxidants and fiber. Chlorogenic acid, an antioxidant, works as an anti-inflammatory in the body whereas fiber present in it helps in digesting food and prevents constipation (Khan 2015) [18]. Peach is a 'climacteric' fruit having a short storage life. Thus, it tends to ripen rapidly even after harvest at ambient/room temperature, which results in quick post-harvest decay and wastage during handling and transportation. Peaches are stored in cold-storage as it not only ensure regular supply to the market, but also will lead to the increase in export-potential of the peaches. Shelf-life of peach can thus be extended by optimizing the environmental conditions, minimising the mechanical damage, applying certain chemicals/growth regulators, use of certain ionizing radiations, etc. (Serrano *et al.* 2004). A higher endogenous level of putrescine (PUT) is associated with delayed fruit ripening. When exogenously applied, it inhibits the ethylene production, thus retarding the increase of malondialdehyde content and membrane permeability and postponing the occurrence of chilling injury (Zhang *et al.* 2000) [40]. Calcium is one of the important elements affecting quality and post-harvest life of many fruits. It helps in reduction of weight-loss and maintains firmness, acidity and vitamin A content during storage (Gupta *et al.* 2011) [10]. SA is a safe chemical, used to control post-harvest quality maintenance of horticultural produces. It also checks post-harvest quantity losses of perishable

crops (Tareen *et al.* 2012; Awad 2013; Khademi *et al.* 2013; Razavi *et al.* 2014) [35, 3, 28], Keeping in view the above facts, *i.e*., the perishability of peach fruits, the promising results by these chemicals and the further need to standardize their concentration in this cultivar, in combination with cold storage conditions.

Materials and Methods

The present study entitled Improvement in storability and quality of Peach cv. Flordaprince with post-harvest application of various chemicals was carried out in the laboratory of Department of Horticulture, Khalsa College, Amritsar during the year 2017-18. The material used for the present experiment were freshly harvested mature peach fruits of cv. Flordaprince. In the present study, 10 treatments (Calcium chloride ₋ 2% 4% and 6%; Putrescine and Salicylic acid @1Mm, 2Mm and 3Mm each) were used for application on peach fruits on the date of picking. The fruits of peach cv. Flordaprince were dipped for a period of 5 minutes in each concentration of all chemicals. The control fruits were dipped in water for some period of time. The treated fruits were air dried and two kilograms of fruits from each replication of each treatment were packed in corrugated fibre board (CFB) boxes respectively. The fruits after the treatments and packaging were kept in the cold storage and these were stored for 7.14,21 and 28 days at 0° to 3.3 °C at 90% relative humidity. The fruit samples from each treatment were analyzed for physico-chemical characteristics after 7, 14, 21 and 28 days of cold storage period.

Results and Discussion

According to the data the fruits which were treated with various chemicals as post-harvest treatments showed significantly less physiological loss in weight as compared to control. Minimum mean PLW (2.75%) was recorded after 7 days of storage which increased to 6.21 percent and 10.96 percent after 14 and 21 days of storage. Maximum mean PLW (14.95%) was observed after 28 days of storage, the differences were found to be statistically significant which might be due to loss of water from fruits after harvest due to transpiration and respiration triggered by physiological metabolic or enzymatic activities. Similar trend of PLW was noticed by Gupta *et al.* (2011) [10] in peach fruits of cv. Earli Grande, Mohla (2001) [26] in Patharnakh pear, Bajaj (2004) [6] in Baggugosha pear, Singh (2005) [32] in ber fruits cv. Umran, Kaur (2006) [16] in Punjab Nectar pear and Kaur *et al.* 2013 [13] in Punjab Beauty pear. Minimum mean PLW (6.56%) was noted in salicylic acid (SA) 3 mmol treated fruits and maximum weight loss observed in control was probably because of loosing piles from the fruit surface which affected peach storage life. The effect of salicylic acid in causing minimum loss in weight with salicylic treatments have also been reported by Tareen *et al.* (2012) [35] and Khademi and Ershadi (2013) [17] in peach fruits cv. Flordaking and cv. Elberta. Ilic *et al.* (2001) [14] reported that decrease in transpiration might be associated with the reduction in hydrolytic cell wall enzymes' activity, greatly influenced by salicylic acid, which acted as an electron donor, producing free radicals and prevented normal respiration. Significant interaction between the treatments and storage period was observed during the whole research. Minimum PLW (1.76%) was recorded in SA 3.0 mmol treated fruits after 7 days of storage showing the same trend after 21 and 28 days of storage while maximum PLW (20.56%) was recorded in untreated fruits after 28 days of storage.

Table 1: Effect of various post-harvest chemicals on PLW (%) in peach cv. Flordaprince

Treatments	Storage interval (Days)				Mean
	7	14	21	28	
T1 : $CaCl_2$ 2%	2.94	6.74	11.30	14.33	8.83
T2 : $CaCl_2$ 4%	2.64	5.31	10.33	14.50	8.19
T3 : $CaCl_2$ 6%	1.92	4.56	9.52	13.94	7.48
T4 : PUT 1.0 mmol	3.15	7.30	12.60	14.75	9.45
T5 : PUT 2.0 mmol	3.36	7.54	13.11	14.78	9.70
T6 : PUT 3.0 mmol	3.48	7.77	14.11	15.25	10.15
T7 : SA 1.0 mmol	2.37	5.48	9.25	14.21	7.83
T8 : SA 2.0 mmol	1.85	4.35	8.21	13.80	7.05
T9 : SA 3.0 mmol	1.76	3.58	7.48	13.41	6.56
T10 : Control-Plain water	4.08	9.47	13.63	20.56	11.94
Mean	2.75	6.21	10.96	14.95	

CD at 5% level of significance

Days : 0.10
Treatments : 0.17
Interaction : 0.33

The spoilage increased significantly with the advancement of storage period. The maximum mean spoilage (6.69%) was recorded after 28 days of storage. It might be attributed to the fact that ripening, ageing, fungal infection and biochemical changes in post harvest fruits lead to softening, spoilage and deterioration of the fruits. The results are advocated by the findings of Kaur *et al.* (2015) [15] in plum cv. Satluj Purple, Kaur (2001) [14] and Bajaj (2004) [6] in Baggugosha pear, Kaur (2006) [16] in pear cv. Punjab Nectar and Ayn *et al.* (2014) in Bartlett pear. Significantly minimum mean spoilage (1.76%) was recorded in fruits treated with putrescine 3 mmol. Maximum mean spoilage (5.87%) was recorded under control. The reduction in spoilage in post-harvest putrescine treated peach fruits might be due to the fact that polyamines' metabolism might have altered in plants responding to biotic stress and to undergo profound changes in plants, interacting with fungal and other pathogens. Anti-pathogenic function of exogenous putrescine has been reported in strawberry fruits (Khosroshahi *et al.* 2007) [5]. SA treatment was probably effective in inducing a defense system through enhancing activities of antioxidant enzymes (Xu and Tian 2008) [38], resulting in improved resistance against fungal attack in treated fruits. Microbial induced decay has been reported to be reduced in SA treated fruits of apricot cv. Habi (Sartaj *et al.* 2013), Sweet cherry (Valero *et al.* 2011) [36], Kiwi fruit (Aghdam *et al.* 2009) [1]. Significant interaction between the treatments and storage period was observed during the analysis of data. No spoilage (0.00%) was recorded after 7 days of cold storage under all treatments. However maximum spoilage loss (14.34%) was recorded in treatment T_{10} in untreated fruits after 28 days of storage.

Table 2: Effect of various post-harvest chemicals on spoilage (%) in peach cv. Flordaprince

Treatments	Storage interval (Days)				Mean
	7	14	21	28	
T1 : $CaCl_2$ 2%	0.00	2.37	4.33	6.43	3.28
T2 : $CaCl_2$ 4%	0.00	2.14	4.81	7.50	3.61
T3 : $CaCl_2$ 6%	0.00	2.52	6.51	10.97	5.00
T4 : PUT 1.0 mmol	0.00	1.26	2.37	4.61	2.06
T5 : PUT 2.0 mmol	0.00	1.33	2.20	4.04	1.89
T6 : PUT 3.0 mmol	0.00	1.30	2.04	3.71	1.76
T7 : SA 1.0 mmol	0.00	1.57	2.44	5.41	2.36
T8 : SA 2.0 mmol	0.00	1.30	2.72	4.48	2.12
T9 : SA 3.0 mmol	0.00	1.85	4.52	5.42	2.95
T10 : Control-Plain water	0.00	2.44	6.71	14.34	5.87
Mean	0.00	1.81	3.86	6.69	

CD at 5% level of significance

Days	:	0.25
Treatments	:	0.40
Interaction	:	0.80

Maximum mean fruit firmness (6.07 kg/cm^2) was recorded after 7 days of storage. It was observed that with the advancement of storage period the firmness decreased which might be due to the increased rate of senescence stage, which promoted respiration, transpiration and other microbial activities. The results are in agreement with Malik *et al.* (2006) [21] in Kingston Pride mango, Manganaris *et al.* (2007) [23] in Andross cv. of peach, Kaur (2013) [13] in pear cv. Punjab Beauty and Ayn *et al.* (2014) in Bartlett pear who also reported a decrease in fruit firmness with advancement in storage period. Maximum mean fruit firmness (5.42 kg/cm^2) was recorded in salicylic acid 3 mmol and minimum fruit firmness (4.15 kg/cm^2) was recorded in control fruits. According to Srivastava and Dwivedi (2000) [34], Zhang *et al.* (2003) [39] and Wang *et al.* (2006) [37] reports, rapid softening of fruits during ripening was simultaneous with rapid decrease in endogenous salicylic acid of fruits and exogenous application of salicylic acid prevents fruit softening. It affects cell swelling which leads to higher firmness of fruits. Softening of peach as a climacteric fruit depends on the internal ethylene production. It has been demonstrated that salicylic acid decreases ethylene production (Babalar *et al.* 2007) [5] and inhibits cell wall and membrane degrading enzymes such as polygalacturonase (PG), lipoxygenase, cellulase and pectin methyl esterase (PME), leading to decreased fruit softening rate (Asghari and Aghdam 2010, Razavi *et al.* 2014) [4, 28], thus maintaining higher firmness. These results are also in agreement with the study of Dashqapu *et al.* (2011) [9] in which they treated fruits of peach cv. J.H. Hale with $CaCl_2$ which showed higher fruit firmness during storage. The result thus obtained might be due to the mechanism of calcium bonding with pectin compounds leading to a physically stabilized cell wall. Similar results were noticed by Mahajan and Dhatt (2004) [20] in $CaCl_2$ treated pear fruits and by Sharma *et al.* (2011) in Japanese plum cv. Santa Rosa. The interaction effect of treatments, and storage period on fruit firmness were also significant. Maximum firmness (7.34 kg/cm^2) was recorded in putrescine 3 mmol treated fruits on day of harvest and minimum firmness (1.34kg/cm^2) was recorded in untreated fruits after 28 days of cold storage.

Table 3: Effect of various post-harvest chemicals on fruit firmness (kg/cm^2) in peach cv. Flordaprince.

Treatments	Storage interval (Days)					Mean
	0	7	14	21	28	
T1 : $CaCl_2$ 2%	7.29	6.12	4.82	3.44	2.34	4.80
T2 : $CaCl_2$ 4%	7.27	6.35	5.85	4.85	2.37	5.34
T3 : $CaCl_2$ 6%	7.26	6.73	5.88	4.50	2.60	5.39
T4 : PUT 1.0 mmol	7.34	5.62	4.18	3.27	2.55	4.59
T5 : PUT 2.0 mmol	7.24	5.84	4.85	3.22	2.15	4.66
T6 : PUT 3.0 mmol	7.14	5.77	4.09	2.10	1.84	4.19
T7 : SA 1.0 mmol	7.20	6.11	5.25	4.80	2.06	5.08
T8 : SA 2.0 mmol	7.25	6.45	5.94	4.83	2.43	5.38
T9 : SA 3.0 mmol	7.26	6.37	5.96	4.96	2.57	5.42
T10 : Control-Plain water	7.26	5.33	4.51	2.33	1.34	4.15
Mean	7.25	6.07	5.13	3.83	2.23	

CD at 5% level of significance

Days	:	0.06
Treatments	:	0.09
Interaction	:	0.20

It is an indication from the perusal of the data that the total soluble solids of peach fruits were significantly affected by the storage period and chemical treatments. Maximum mean TSS (12.55%) was observed in $CaCl_2$ 2 percent whereas, minimum mean TSS (10.08%) was recorded in fruits under control where fruits were kept in storage without any treatment. The higher TSS in fruits treated with calcium was probably due to slowing down the respiration and metabolic activities. Present results of significant increase in TSS in $CaCl_2$ treatment in peach fruits are in agreement with the findings of Antunes *et al.* (2003) [2] and Masoumeh *et al.* (2015) [24] The interaction between days of storage and treatments were found to be statistically significant. Maximum TSS (15.43%) was recorded after 21 days of storage in fruits treated with $CaCl_2$ 2 percent while the minimum (11.03%) in fruits under control after 21 days of cold storage. These results are in conformation with the findings of Sidhu *et al.* (2009) [31] in pear cv. Punjab Beauty and Ayn *et al.* (2014) in Bartlett pear respectively.

Table 4: Effect of various post-harvest chemicals on TSS (^{0}Brix) in peach cv. Flordaprince

Treatments	Storage Interval (Days)					Mean
	0	7	14	21	28	
T1 : $CaCl_2$ 2%	8.97	9.30	15.00	15.43	14.03	12.55
T2 : $CaCl_2$ 4%	8.77	9.23	13.00	13.50	14.03	11.71
T3 : $CaCl_2$ 6%	8.83	9.57	13.60	13.53	14.23	11.95
T4 : PUT 1.0 mmol	8.77	9.83	13.23	13.50	10.60	11.19
T5 : PUT 2.0 mmol	8.87	9.27	13.80	14.37	14.43	12.15
T6 : PUT 3.0 mmol	8.67	11.03	14.03	14.33	12.37	12.09
T7 : SA 1.0 mmol	8.70	11.33	14.33	14.40	13.03	12.36
T8 : SA 2.0 mmol	8.67	12.23	14.17	14.40	11.07	12.11
T9 : SA 3.0 mmol	8.67	9.80	13.57	13.83	13.20	11.81
T10 : Control-Plain water	8.73	10.53	13.27	11.03	6.83	10.08
Mean	8.76	10.21	13.80	13.83	12.38	

CD at 5% level of significance

Days	:	0.14
Treatments	:	0.20
Interaction	:	0.44

Maximum mean acidity (0.79%) was observed in fruits treated with salicylic acid 3 mmol. However, least acidity (0.55%) was recorded in putrescine 2 mmol. Similar observations were reported by Molla *et al.* (2011) [25] in mango fruits. Fruits of apricot cv. Habi treated with salicylic acid showed a significant decrease in titratable acidity because salicylic acid affects the respiration process and metabolic changes related to ripening, hence acidity decreased during storage.The interaction between days of storage and treatments were found to be statistically significant

Table 5: Effect of various post-harvest chemicals on titratable acidity (%) in peach cv. Flordaprince

Treatments	Storage Interval (Days)					Mean
	0	7	14	21	28	
T1 : $CaCl_2$ 2%	0.68	0.73	0.40	0.33	1.05	0.64
T2 : $CaCl_2$ 4%	0.67	0.77	0.33	0.36	0.97	0.62
T3 : $CaCl_2$ 6%	0.67	1.00	0.40	0.43	0.88	0.67
T4 : PUT 1.0 mmol	0.67	0.77	0.43	0.31	0.77	0.59
T5 : PUT 2.0 mmol	0.68	0.78	0.36	0.36	0.56	0.55
T6 : PUT 3.0 mmol	0.67	0.77	0.43	0.30	1.30	0.69
T7 : SA 1.0 mmol	0.67	0.87	0.36	0.44	0.83	0.63
T8 : SA 2.0 mmol	0.65	1.27	0.35	0.30	0.63	0.64
T9 : SA 3.0 mmol	0.65	1.44	0.40	0.50	0.98	0.79
T10 : Control-Plain water	0.67	0.67	0.63	0.33	0.72	0.60
Mean	0.67	0.91	0.41	0.37	0.87	

CD at 5% level of significance

Days	:	0.03
Treatments	:	0.04
Interaction	:	0.09

Maximum mean total sugars (8.48%) were recorded after 21 days of storage. It might be due to the hydrolysis of starch, yielding mono and disaccharides. Thereafter, decline could be attributed to metabolic breakdown and senescence of fruit as a result of moisture and firmness loss during storage. Similar findings were obtained by Kaur *et al.* (2015) [15] in plum cv. Satluj Purple, Mahajan and Dhatt (2004) [20] in Asian pear, Paul (2002) [27] in pear cv. Punjab Beauty, Singh *et al.* (2000) [33] in Haden cv. of mango fruits. Maximum mean total sugars (8.47%) were recorded in fruits treated with putrescine 3 mmol. However, minimum mean total sugars (6.56%) were recorded in control fruits. Data reveals that total sugars of untreated fruits which were fairly low initially increased to the maximum value and thereafter a decline was noticed indicating faster metabolic rates of the fruit. However, the fruits of peach given post-harvest dips in putrescine 3 mmol recorded more steady changes and registered maximum total sugars during storage and declined gradually thereafter (Bal 2013) [7]. Hydrolysis of starch yielding mono- and disaccharides could be one of the reasons for the increase in total sugars, This is because after complete hydrolysis of starch, no further increase occurs and subsequently a decline in this parameter is predictable as this is the primary substrate for respiration. Bhagwan *et al.* (2000) [18] and Malik *et al.* (2003) [22] also reported that post-harvest application of putrescine preserved sugar in tomatoes and mangoes respectively when compared with the control. The results are in agreement with findings of Awad (2013) [3] in peach cv. Flordaprince. The interactions between time of storage and treatments given were found to be statistically significant. Maximum total sugars (10.27%) were found in putrescine 3.0 mmol after 21 days and minimum (4.28%) in control after 28 days.

Table 6: Effect of various post harvest chemicals on total sugars (%) in peach cv. Flordaprince

Treatments	Storage Interval (Days)					Mean
	0	7	14	21	28	
T1 : $CaCl_2$ 2%	6.35	8.14	7.45	6.56	6.24	6.95
T2 : $CaCl_2$ 4%	6.76	6.49	7.26	7.46	6.84	6.96
T3 : $CaCl_2$ 6%	6.47	6.38	7.32	7.54	6.48	6.84
T4 : PUT 1.0 mmol	6.51	6.45	7.49	8.88	6.46	7.16
T5 : PUT 2.0 mmol	6.43	7.95	6.52	7.74	6.35	7.00
T6 : PUT 3.0 mmol	6.44	8.24	9.33	10.27	8.07	8.47
T7 : SA 1.0 mmol	6.40	7.26	10.47	9.94	7.23	8.26
T8 : SA 2.0 mmol	6.85	6.63	8.18	9.31	7.86	7.77
T9 : SA 3.0 mmol	6.68	6.76	7.17	9.51	7.75	7.57
T10 : Control-Plain water	6.59	7.53	6.82	7.58	4.28	6.56
Mean	6.55	7.18	7.80	8.48	6.76	

CD at 5% level of significance

Days	:	0.13
Treatments	:	0.19
Interaction	:	0.41

Conclusion

The present investigation revealed that the fruits treated with salicylic acid 3 mmol and putrescine 3 mmol were found to be moderately to very much desirable even after 28 days of storage. Salicylic acid 3 mmol was found effective in decreasing physiological loss in weight (PLW %), spoilage and titratable acidity during the entire storage period. Similarly, putrescine 3 mmol also maintained the quality attributes of peach fruits till the end of storage period. Hence it may be concluded that salicylic acid and putrescine may prove fresh market traits of peach during cold storage and may help to increase marketing options of peach.

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