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# Physico-Chemical and Enzymatic Changes in Low Temperature Stored Plum Fruits in Response to Boric Acid Application

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## Abstract

Plum is a perishable fruit and its ripening coincides with the hot and dry summer months under north Indian conditions. It has very short storage life at ambient temperature and high post-harvest losses. Keeping in view, an experiment was planned to extend the post-harvest life of plum fruits with boric acid application under cold storage conditions. Physiologically mature and uniform fruits of plum *cv*. Satluj Purple were dipped in different solution concentrations of boric acid (1.0, 2.0 and 3.0% ) as well as distilled water (control) for 5 minutes. Treated fruits were air dried in shade and packed in corrugated fiber boxes with paper lining before storage at 0-1°C and 90-95% RH for 35 days. Results revealed that fruits treated with boric acid 3.0% retained the acceptable quality by reducing physiological loss in weight, spoilage, pectin methyl esterase activity and maintaining the fruit firmness, sensory quality, total soluble solids, titrable acidity, total sugars, reducing sugars and non-reducing sugars up to 28 days of storage.



### Keywords

Post-harvest; Boric acid; Satluj purple; Cold storage; Plum


## Introduction

Plum belongs to genus *Prunus*, family *Rosaceae*. It includes the European species (*Prunus domestica* L.) and the Japanese species (*Prunus salicina* Lindl.). Japanese plum is native to China that bears the edible juicy fruits. Under sub-tropical conditions of north India it ripens in the first fortnight of May and hot & dry climate during this period leads to short post-harvest life of plum fruits. Plum is a climacteric fruit and its storage life is limited even at low temperature because of high susceptibility to physiological disorders. Several chemicals have been reported to delay ripening and extend the shelf life of fruits. Boric acid is a mild acid that is commonly used for sterilization and disinfection. Due to its disinfectant, bactericidal and wall strengthening properties boric acid reduces the post-harvest rotting in many fruits. Wang [1] had been observed that boric acid inhibited the ethylene production, ripening process and disease incident. The inhibition of ethylene production, ripening and disease incidence were observed in tomato fruits [2]. The storage life of ber fruits was enhanced with boric acid treatment under cold storage conditions [3]. Jawandha [4] reported that post-harvest treatment of boric acid and LDPE packaging increased the shelf-life of kinnow fruits at ambient conditions. Tarabih [5] identified the effect of boric acid and jojoba oil on storage life of 'Washington Navel' fruits and observed highest palatability rating in treated fruits as compared to control during 45 days of storage. Hence, the present investigation was carried out to study the effect of post-harvest treatments of sodium benzoate on physico-chemical and enzymatic changes of Satluj Purple plum fruits under low temperature storage.

## Material and Methods

Physiologically mature and uniform fruits of plum *cv.* Satluj Purple were harvested from Fruit Research Farm, Punjab Agricultural University, Ludhiana in May, 2015. Selected fruits were treated with aqueous solution containing different concentrations of boric acid at 1.0 (T1), 2.0 (T2), 3.0 (T3) and 0.0 (T4)% . Each treatment was replicated thrice and comprised of 1.0 kg fruit/ replication. Treated fruits were air dried in shade and packed in corrugated fibre board (CFB) boxes with paper lining. Packed fruits were kept at 0-1°C and 90-95 percent RH for 35 days. For various physico-chemical and enzymatic changes stored fruits were analysed at weekly interval. The percent loss in weight after each interval of cold storage was calculated by subtracting final weight from the initial weight of the fruits and then converted into percentage value. The cumulative loss in weight was calculated on fresh weight basis. The fruit colour was recorded with the help of colour difference meter (Model: Mini Scan XE Plus, Made: Hunter lab, USA) and expressed as $a^*$ value [6]. Firmness of randomly selected fruits is measured with the help of a panetrometer (Model FT-327, USA) using stainless steel probe. About one square centimeter of the peel in each fruit from the shoulder end on both sides was removed with the help of peeler and firmness of pulp was recorded and expressed in terms of lbf. The sensory quality evaluation of the fruit was conducted by a panel of judges following the Hedonic scale (0-9). Spoilage percentage of fruits was calculated by counting the rotten fruits and total fruits in each treatment replication on each storage interval. Total soluble solids (TSS) were determined with the help of hand refractrometer at room temperature and expressed in per cent. These reading were corrected with the help of temperature correction chart at 20°C temperature.Titratable acidity, total sugars, reducing sugars and non-reducing sugars were estimated by the standard methods described by AOAC [7]. Pectin methyl esterase enzyme activity was determined by using standardized method of Mahadevan [8]. The data obtained was subjected to statistical analysis by following Factorial Completely Randomized Block Design (CRD).

## Results and Discussions

Physiological loss in weight (PLW) of plum fruits increased with increase in storage interval (Table 1). The maximum PLW was recorded in untreated fruits, whereas minimum PLW was found in boric acid @ 3.0% treated fruits during the entire storage period. All the treatments showed significantly less PLW as compared to control. Weight losses are due to metabolic activity, respiration and transpiration. According

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to Yaman [9], the vapour-phase diffusion driven by a gradient of water vapour pressure is a reason for moisture loss from fresh fruits and vegetables. Jawandha [4] reported that kinnow fruits treated with boric acid followed by packaging in low density polyethylene bags showed a reduction in weight loss when compared with untreated & unpacked fruits after 45 days of storage.

Plum fruit color is associated with the accumulation of carotenoids and anthocyanin's. Both groups of pigments are more abundant in the peel but anthocyanins are mainly responsible for the surface color of the fruit. The color development was improved with the advancement of storage period. The maximum $a^*$ value (plum color) was recorded in untreated fruits, whereas minimum $a^*$ value was observed in boric acid @ 3.0% treated fruits during the entire storage period (Table 1). The result obtained in present study are in agreement with the finding of Singh [10] who reported that pre-harvest spray on ber fruits with boric acid @ 1.0 percent followed by post-harvest packaging with polybags reduced the fruit colour development at ambient conditions. This treatment recorded merely 66% of darker fruits that the control treatments (100%). Kaur [11] also reported that post-harvest applications of boric acid delayed the change in colour of lemon fruits stored at ambient conditions.

Spoilage during storage leads to quantitative and qualitative losses of fruits. Boric acid application significantly reduced the spoilage in fruits during storage. After 14 days of cold storage only untreated fruits showed the rotting. However, the fruits those received boric acid treatments showed a little spoilage only after 35 days of storage. At the end of storage, maximum spoilage was noticed in control fruits and minimum spoilage was observed in fruits treated with boric acid at 3.0% (Table 1). The reduction in spoilage by boric acid treatments might be due to bactericidal and disinfectant properties of boric acid. Jawandha [4] also observed least rotting and best appearance of kinnow fruits treated with boric acid + LDPE packaging at ambient conditions. Coatings of 'Washington Navel' fruits with boric acid and jojoba oil gave maximum reduction in disease infection caused by *P. digitatum* and *P. itelicum* [5].

Fruit softening is a suitable predictor of potential shelf-life for plums. The decrease in fruit firmness during storage was inhibited significantly by post-harvest treatments of boric acid. Boric acid application suppressed and delayed softness of plum fruits during storage. Reduction in fruit firmness was progressively decreased with increasing boric acid concentrations (Figure 1). The reduction in fruit softening with boric acid application may be due to decrease in PLW and cell wall degenerating enzyme (PME) activity. During the entire storage period, the boric acid @a 3.0% treated fruits retained the maximum fruit firmness and the minimum fruit firmness was recorded in untreated fruits. Softening of fruits is caused either by the breakdown of insoluble protopectins into soluble pectins or by the cellular disintegration leading increased membrane permeability [12]. This higher fruit firmness might be due to reduced physiological weight loss from fruits. The more fruit firmness in boric acid treated fruits, might be due to the function of boron in synthesis of cell wall components [13]. The results are in confirmation with the finding of Kaur [14] who reported that boric acid @ 2% was effective to maintain the peel thickness of kinnow during storage. Tarabih [5] also studied the effect of boric acid and edible coatings on shelf life of 'Washington Navel' fruits at ambient conditions and observed significantly higher

**Table 1**: Effect of post-harvest treatments of boric acid on physiological loss in weight (PLW), fruit color and spoilage of Satluj Purple plum during cold storage.

| Treat-ment | PLW (%) | | | | | | Fruit colour (a* value) | | | | | | Spoilage (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Storage interval (Days) | | | | | | Storage interval (Days) | | | | | | Storage interval (Days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | Mean | 7 | 14 | 21 | 28 | 35 | Mean | 7 | 14 | 21 | 28 | 35 | Mean |
| T1 | 1.98 | 2.38 | 3.30 | 4.61 | 5.09 | 3.47 | 9.08 | 16.98 | 19.21 | 20.99 | 25.12 | 18.27 | 0.00 | 0.00 | 0.00 | 0.50 | 1.00 | 0.30 |
| T2 | 1.78 | 1.93 | 2.88 | 4.48 | 5.07 | 3.22 | 9.00 | 16.92 | 19.13 | 20.92 | 24.99 | 18.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.97 | 0.19 |
| T3 | 1.60 | 1.83 | 2.52 | 4.36 | 4.98 | 3.05 | 8.88 | 16.82 | 18.90 | 20.76 | 24.36 | 17.95 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.10 |
| T4 | 2.97 | 3.98 | 4.23 | 5.74 | 6.84 | 4.75 | 9.42 | 18.02 | 19.88 | 21.61 | 25.72 | 18.93 | 0.00 | 1.92 | 5.23 | 6.86 | 9.02 | 4.60 |
| Mean | 2.08 | 2.53 | 3.23 | 4.79 | 5.49 | | 9.09 | 17.18 | 19.28 | 21.07 | 25.04 | | 0.00 | 0.48 | 1.30 | 1.84 | 2.87 | |
| $CD_{0.05}$ Treatment (T) | 0.05 | | | | | | 0.06 | | | | | | 0.19 | | | | | |
| Storage intervals (S) | 0.08 | | | | | | 0.09 | | | | | | 0.21 | | | | | |
| TxS | 0.10 | | | | | | 0.14 | | | | | | 0.43 | | | | | |

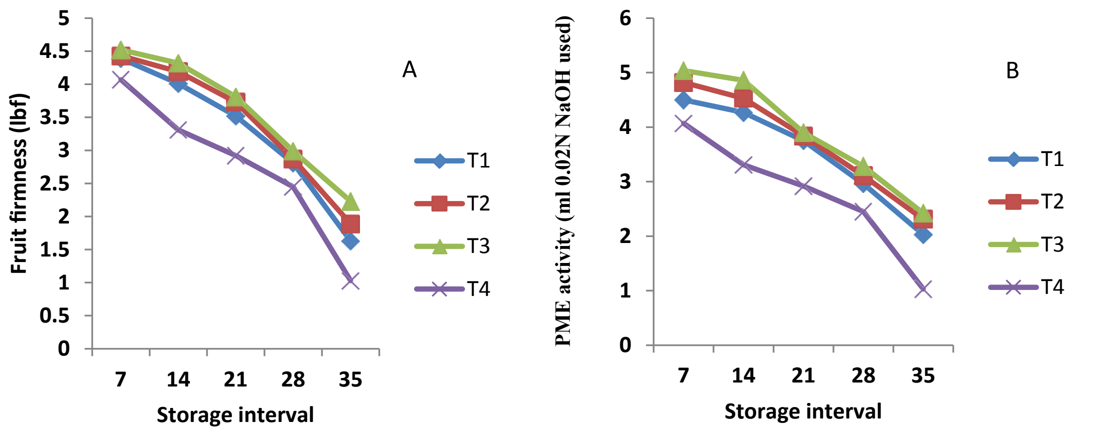


**Figure 1:** Effect of post-harvest treatment of boric acid on fruit firmness (a) and pme activity (b) of satluj purple plum during cold storage.

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peel thickness in fruits treated with boric acid combined with edible coatings than other treatments.

Plant cell walls comprises of cellulose micro fibrils embedded in complex matrix of pectic substances and hemicelluloses. The polysaccharides form the network and depolymerise to some extent during fruit ripening. Pectin methyl esterase is enzyme responsible for demethylating the 6th carbon of galacturonosyl residue where poly galactouronase acts on the methylated substrate [15]. Post-harvest treatment of boric acid @ 3% reduced the pectin methyl esterase (PME) activity in treated fruits as compared to control. After 21 days of storage, the maximum PME activity was recorded in control fruits and the minimum was noticed in boric acid @ 3% treated fruits (Figure 1). But after 28th and 35th days of storage the trend was reversed and the maximum PME activity was registered in fruits treated with boric acid @ 3% , while the minimum PME activity was noticed in the reference fruits. This might be due to the presence of high substrate level for PME activity at later stages in boric acid @ 3% treated fruits, which was already decomposed to the higher extent at the early stages of storage in other treatments. The decrease in PME activity at later stage of storage was also reported by Jawandha [16] in ber fruits.

The data pertaining to sensory quality of plum fruits during storage is given in (Table 2). Sensory quality of stored fruits was improved up to three weeks of storage in all the treatments; afterwards a decline was noticed in all the treatments. After 21 days of storage highest sensory quality was recorded in untreated fruits, whereas after 28 days of storage highest sensory quality was recorded in boric acid @ 3.0% treated fruits (Table 2). Boric acid treated fruits had acceptable colour, glossy appearance, good flavor and taste that might be due to the fact that boric acid treatments retarded the moisture, respiration and transpiration losses. These results are also in agreement with the findings of Sandbhor [17], they reported that the ber fruits packed in polythene and treated with 10 ppm boric acid maintained the higher sensory quality rating as compared to control.

Total soluble solids (TSS) content is one of the major indicators to judge the quality of the plum fruits. Boron has the important role in many physiological processes specially transport of sugars and carbohydrate metabolism of plants [6]. TSS content in plum fruits increased up to 21 days of storage in all the treatments except boric acid @ 3% , afterwards a decrease in TSS content was observed at the end of storage period (Table 2). The mean minimum TSS content was recorded in fruits treated with boric acid @3% and the mean maximum TSS was noticed in control fruits. The increase in TSS with advancement of storage period may be due to the numerous catabolic processes taking place in the fruits during ripening and senescence processes. The increase in TSS could also be attributed to water loss, hydrolysis of starch and other polysaccharides to soluble form of sugar. Wills [18] reported that starch gets hydrolysed into mono and disaccharides, which in turn may lead to an increase in TSS. The result of present study are in agreement with the findings of Kaundal [19] who reported that during plum storage TSS and total sugars increased up to 20 days of storage and then declined progressively. Similarly Jawandha [4] and Kaur [11] recorded minimum soluble solids content in kinnow and lemon fruits treated with boric acid and followed by LDPE packaging during ambient storage.

Fruit acidity is another important factor affecting consumer acceptance. The titrable acidity of plum fruits showed a declining trend during the advancement of storage period. During the entire storage period the highest titrable acidity was maintained by the fruits treated with boric acid @3% and the lowest acidity was observed in control fruits (Table 2). The decrease in fruit acidity with the progress of storage is due to the higher utilization of acids in evapo-transpiration [20]. This view has been further supported by Ramana [21] by citing the reasons that the change in total titrable acids during storage was mainly due to the metabolic activities of living tissues during which depletion of organic acids takes place. Bhattarai [22] stated that during storage, the fruit itself might utilize the acids so that the acid in the fruits during storage decreases. Ball [23] suggested that decrease in titrable acidity of fruits is a result of breakup of acids to sugars during respiration. During storage of plum, increased respiration may result in declined concentrations of malic acid since it is the principal metabolic substrate along with the sugars [24]. Similarly, the higher acidity value was recorded in 'Washington Navel' fruits treated with boric acid and other edible coatings during 45 days of ambient storage [5].

The main sugars found in fresh plums are glucose, fructose and sucrose, although sorbitol (a sugar alcohol) is also present [25]. A detailed study of sugars showed that total sugars, reducing sugars and non-reducing sugars increased up to 21 days of cold storage in all the treatments, but after 28 days of storage this increase was recorded only in boric acid @ 3% treated fruits (Table 3). Kaur [14], Kaur [11] also reported that post-harvest treatment of boric acid in kinnow and lemon fruits resulted in low reducing sugars as compared to untreated fruits during storage.

From present study, it can be concluded that 'Satluj Purple' plum fruits, harvested at color break stage, followed by post-harvest treatment of boric acid @ 3.0% solution for five minutes, retained acceptable quality of plum fruits up to 28 days under cold storage conditions (0-1°C and 90- 95% RH).

**Table 2:** Effect of post-harvest treatments of boric acid on sensory quality rating, total soluble solids and titrable acidity of Satluj Purple plum during cold storage.

| Treat-ment | Sensory quality rating (1-9) | | | | | | Total soluble solids (%) | | | | | | Titrable acidity (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Storage interval (Days) | | | | | | Storage interval (Days) | | | | | | Storage interval (Days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | Mean | 7 | 14 | 21 | 28 | 35 | Mean | 7 | 14 | 21 | 28 | 35 | Mean |
| T1 | 7.22 | 7.51 | 8.26 | 6.60 | 5.56 | 7.03 | 12.57 | 12.99 | 13.47 | 12.82 | 12.40 | 12.85 | 0.84 | 0.79 | 0.68 | 0.56 | 0.51 | 0.67 |
| T2 | 7.12 | 7.34 | 8.20 | 7.00 | 5.63 | 7.05 | 12.48 | 12.87 | 13.21 | 12.96 | 12.51 | 12.80 | 0.89 | 0.85 | 0.70 | 0.59 | 0.53 | 0.70 |
| T3 | 6.98 | 7.16 | 7.66 | 7.50 | 6.32 | 7.12 | 12.26 | 12.62 | 12.80 | 13.09 | 12.70 | 12.69 | 0.99 | 0.87 | 0.76 | 0.66 | 0.58 | 0.77 |
| T4 | 7.49 | 7.73 | 7.80 | 5.63 | 4.91 | 6.71 | 13.28 | 13.59 | 13.85 | 12.59 | 12.18 | 13.09 | 0.64 | 0.59 | 0.53 | 0.46 | 0.41 | 0.52 |
| Mean | 7.20 | 7.43 | 7.98 | 6.68 | 5.60 | | 12.64 | 13.01 | 13.33 | 12.86 | 12.44 | | 0.84 | 0.77 | 0.67 | 0.56 | 0.50 | |
| $CD_{0.05}$ Treatment (T) | 0.18 | | | | | | 0.05 | | | | | | 0.02 | | | | | |
| Storage intervals (S) | 0.12 | | | | | | 0.09 | | | | | | 0.04 | | | | | |
| TxS | 0.41 | | | | | | 0.11 | | | | | | 0.05 | | | | | |

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**Table 3:** Effect of post-harvest treatments of boric acid on total sugars and reducing sugars of Satluj Purple plum during cold storage.

| Treat-ment | Total sugars (%) | | | | | | Reducing sugars (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Storage interval (Days) | | | | | | Storage interval (Days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | Mean | 7 | 14 | 21 | 28 | 35 | Mean |
| T1 | 9.52 | 9.75 | 9.98 | 9.3 | 8.63 | 9.43 | 6.7 | 6.83 | 6.99 | 6.5 | 6.04 | 6.61 |
| T2 | 9.39 | 9.61 | 9.82 | 9.42 | 8.74 | 9.34 | 6.61 | 6.73 | 6.87 | 6.6 | 6.12 | 6.58 |
| T3 | 9.12 | 9.37 | 9.52 | 9.59 | 8.88 | 9.29 | 6.41 | 6.56 | 6.66 | 6.71 | 6.22 | 6.51 |
| T4 | 9.87 | 10.22 | 10.42 | 9.18 | 8.47 | 9.63 | 6.98 | 7.12 | 7.28 | 6.41 | 5.93 | 6.74 |
| Mean | 9.47 | 9.73 | 9.93 | 9.37 | 8.68 | | 6.67 | 6.81 | 6.95 | 6.55 | 6.07 | |
| $CD_{0.05}$ Treatment (T) | 0.05 | | | | | | 0.03 | | | | | |
| Storage intervals (S) | 0.09 | | | | | | 0.04 | | | | | |
| TxS | 0.10 | | | | | | 0.08 | | | | | |

## References


1. Wang S, Morris SC (1971) Effects of Borax and Guazatine on ripening and post-harvest diseases of Tomato (cv. Floradade). Acta Hort 343: 331-33.
2. Sammi S, Masud T (2007) Effect of Different Packaging Systems on Storage Life and Quality of Tomato (Lycopersicon esculentum var. Rio Grande) during Different Ripening Stages. Int J Food Safety 9: 37-44.
3. Meena HR, Kingsli, Jain RK (2009) Effect of postharvest treatments on shelf life of ber fruits. Indian J Hort 66: 58-61.
4. Jawandha SK, Tiwana PS, Randhawa JS (2012) Effect of low density polyethylene packaging and chemicals on ambient storage of kinnow. As J Food Ag-Ind 5: 112-18.
5. Tarabih ME, El-Metawally MA (2014) Effect of jojoba oil and boric acid as post- harvest treatments on shelf life of Washington Navel orange Fruits. Intl J Agric Resc 9: 1-16.
6. Hansch R, Mendel RR (2009) Physiological of mineral micro-nutrients (pollen-Cu, Zn, Mn, Fe and Ni). Curi Opin Plant Bio 12: 259-66.
7. AOAC (2000) Official Methods of Analysis. Association of Official Analytical Chemists, Washington (D C), USA.
8. Mahadevan A, Sridhar R (1982) Methods in physiological plant pathology. Sivagami Publ Madras
9. Yaman O, Bayoindril L (2002) Effects of an edible and cold storage on shelf life and quality of cherries. Lebensm Wiss Und Technol 35: 146-150.
10. Singh S, Singh RS, Awasthi OP (2013) Influence of pre and post-harvest treatments on shelf-life and quality attributes of bear fruits. Indian J Hort 70: 610-15.
11. Kaur S (2014) Effect of chemicals and modified atmosphere packaging on storage life and quality of Baramasi lemon (Citrus limon L. Brum) fruits, PAU Ludhiana, India.
12. Matto AK , Murata T, Pantastico PE, Chachin K, Ogata K, Phan CT, et al. (1975) Chemical changes during ripening and senescence, in postharvest physiology, handling and utilization of tropical and sub-tropical fruit and vegetables. AVI Publishing, Westport, County Mayo, Ireland.
13. Gupta UC (1979) Boron nutrition of crops. Adv Agron 31: 273-307.
14. Kaur S (2000) Effect of high density polyethylene, chemicals and curing on quality and storage of kinnow. M.Sc. Thesis, PAU Ludhiana, India.
15. Koch LJ, Nevins DL (1989) Tomato fruit cell wall. Part 1. Use of purified tomato polygalactouronase and pectin methyl esterase to identify development changes in pectins. Plant Physiol 91: 816-822.
16. Jawandha SK, Gupta N, Randhawa JS (2012) Effect of Post-Harvest Treatments on Enzyme Activity and Quality of Cold Stored Ber Fruit. Not Sci Biol 4: 86-89.
17. Sandhbhor DR, Desai UT (1991) Influence of post-harvest treatment on the shelf life of ber (Zizyphus mauritiana Lamk) cv. Umran Mah J Hort 5: 24-28.
18. Wills RBH, Cambridge PA, Scott KJ (1980) Use of flesh firmness and other objective tests to determine consumer acceptability in delicious apples. Australian J Exp Agri Anim Husb 20: 252-56.
19. Kaundal GS, Mushtaq K, Minhas PPS, Bal JS (2000) Effect of growth regulators, nutrients and wax emulsions on storage behaviour of plum. J Res (Punjab Agricultural University) 37: 48-55.
20. Khader SESA , Singh BP , Khan SA (1988) Effect of gibberellic acid as a post-harvest treatments of mango fruit ripening, amylase and peroxidase activity and quality during storage. Scientia Hort 36: 261-266.
21. Ramana KVR, Setty GR, Murthy NVN, Saroja S, Nanjundaswamy AM (1979) Effect of ethephone, benomyl, thiobendazole and wax on color and shelf life of Coorg mandarin (Citrus reticulate Blanco). Trop Sci 21: 265-72.
22. Bhattarai DR, Gautam DM (2006) Effect of harvesting method and calcium on postharvest physiology of tomato. Nepal Agric Res J 7: 37-41.
23. Ball JA (1997) Evaluation of two lipid based edible coating for their ability to preserve post-harvest quality of green bell peppers. Virginia, USA.
24. Ackermann J, Fischer M, Amado R (1992) Changes in sugars, acids, and amino acids during ripening and storage of apples (cv. Glockenapfel). J Agric Food Chem 40: 1131-1134.
25. Meredith FI, Senter SD, Forbus WR, Robertson JA, Okie WR (1992) Postharvest quality and sensory attributes of Byron Gold and Ruby sweet plums. J Food Quality 15: 199-209.



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