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# Effect of Preharvest Calcium Chloride Sprayed on Growth and Development and Quality of Mulberry Fruit

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Effect of preharvest calcium chloride ($CaCl_2$) application on growth and quality of mulberry fruit were studied. The thirty two of mulberry trees were hard pruned and divided into 2 groups of 16 each non-sprayed and sprayed with 2% $CaCl_2$. After mulberry tree developed new branches for about 50 cm length, new flower started blossom. After fruits developed to about 0.5-1 cm fruits diameter, fruits were spray with 2% $CaCl_2$ every week for 4 week (set A), while another set B were non-sprayed. Fruit were harvested at ripe stage (purple red color), selected with uniform shape and size. All samples were packed in PE bag, then stored at 5 ℃ for 24 days. The experimental design was Completely Randomized Design (CRD), fruit growth, development and fruits quality included weight loss, firmness, total soluble solids (TSS), titratable acidity (TA), color change and anthocyanin content were recorded every 6 days. The results showed that, mulberry fruit sprayed with 2% $CaCl_2$ resulted in significantly different in number of fruit and number of branch, non-significantly different in number of leaf, branch length and fruit size. Fruit sprayed with 2% $CaCl_2$ had lower in percentage of weight loss (0.28%) when compared to non-sprayed fruit (1.61%). Significantly differences between non-sprayed and sprayed with 2% $CaCl_2$ were found in fruit firmness and TSS/TA ratio, sprayed fruits had higher in fruit firmness and lower in TSS/TA ratio than non-sprayed fruits. L* and a* values decreased throughout the shelf life, rapidly decreased in non-sprayed fruits. Development of anthocyanin content in fruit was reduced by $CaCl_2$, 2 time lower content than non-sprayed at the accumulation peak (days 12 in storage). Thus, $CaCl_2$ could enhanced number of fruits and delayed the ripening of mulberry fruits during storage.

**Keywords:** anthocyanin, firmness, total soluble solids, quality, ripening

## Introduction

Mulberry (*Morus alba* Lin.) is a plant in the same family as jackfruit, paper mulberry and banyan tree (Moraceae). Mulberry is widely grown in Europe and West Asia as edible fruits (Ercisli, 2004) and the growing area is more than 95% in the Northeast of Thailand. Mulberry fruit is a collactive fruit, the ripe mulberry will look succulent. The proportion of sour and sweet balance

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is commonly eaten as a fresh or processed product. Lou *et al*. (2012) reported the assessment of total phenols, total flavonoids, sugars and antioxidant activity in mulberry fruits vary with different skin color intensities, which correspond to different development levels of the fruits. For fresh consumption, fruit is purple-red or purple-black color must be harvest. If left until fruit turns black will decreased shelf life during storage.

Mulberry fruit has high in were water content, easily damaged and short shelf life. Storage at low temperatures can only be kept for 1-2 days. Calcium chloride solution is especially used in ready-to-eat fruit, helps to maintain the firmness of the strawberry by interfere with the pectin in the cell wall, the pectin structure adheres more closely (Chen *et al*., 2011; Suutarinen *et al*., 2000). Use of calcium chloride solution can reduce the severity of chilling injury and browning (Manganaris, 2007). Extend the shelf life of fresh mulberry fruit for consumption, slow down the effects of postharvest and preserve the ingredients contained within the fruit. Moreover, calcium is considered to be an important mineral element that regulates fruit quality, maintenance of fruit firmness (Lruie *et al*,. 2009; Machado *et al*., 2008). The objective of this research was to study the effect of preharvest calcium chloride sprayed on growth and quality of fresh mulberry fruits.

## Materials and methods

### *Plant meterials*

Two years of 32 mulberry tree were used for this study. All tree were pruned then divided into 2 groups of 16 each. After mulberry tree developed new branches for about 50 cm length, new flower started blossom. After fruits developed to about 0.5-1 cm fruits diameter (Figure 1E), fruits were spray with 2% $CaCl_2$ every week for 4 week (set A), while another set B were non-sprayed. Mulberry were harvest at ripe stage (purple red color), selected with uniform shape and size. All samples were packed in polyethylene (PE) bag, then stored at 5 ℃ for 24 days (Figure 1A-F).

### *Data recorded*

Fruit growth and development included number of fruit, number of branch, number of leaf, leaf area, branch diameter and branch length were recorded. Fruits quality included, weight loss, firmness, total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, color change (L*, a* and b* values), anthocyanin content were also determined. The experimental design was Completly Randomized Design (CRD). Data were analyzed using analysis

of variance (ANOVA). Differences among treatments means were separated according to LSD ($P \leq 0.05$).

## Results and Discussion

The growth rate of mulberry tree after pruned and sprayed with 2% calcium chloride, showed non significantly different in number of leaf, leaf area, branch diameter and branch length (Table 1). Fruits sprayed with 2% calcium chloride had significantly different in number of branches and number of fruits when compared to non sprayed (Figure 2).

During storage, mulberry fruits had weight loss about 0.2-0.6% throughout the shelf life, mulberry sprayed with 2% $CaCl_2$ had lower in weight loss 0.28% than non-sprayed 0.61% (Figure 3A). Karemera and Habimana (2014) reported that maximum weight loss of fruits occurred in control treatment while lower weigth loss was recorded in 1.50% $CaCl_2$ sprayed trees. In addition, Turmanidze *et al*. (2016) found that maximum lost was observed for untreated fruits and minimum lost was observed for fruits treated with 2% $CaCl_2$. Bender (1998) have also reported that treatment with 0.6-2.0% calcium nitrate and $CaCl_2$ delayed ripening after harvest, lower weight loss and reduced respiration rates. Fruits storability was also improved by $CaCl_2$ under cold storage (Wahdan *et al*., 2011). The pre and postharvest application of $CaCl_2$ and $Ca(NO_3)_2$ are known to influence the quality and shelf life of fruits during storage (Gill *et al*., 2005). The loss in fruit weight is mainly due to water loss as a result of evaporation and transpiration. (El-Badawy, 2012). $CaCl_2$ reduced the percentage of weight loss during storage of sapotas (Choudhury *et al*., 2003), nectarines (Serrano *et al*., 2004), apples and peaches (Hafez and Haggag, 2007; Mahmoud, 2008). This problem was greatly reduced due to preharvest sprays of calcium in the form of calcium chloride at 0.3-7.5%.

Fruit firmness tended to increase in all treatments during storage. Mulberry sprayed with 2% $CaCl_2$ solution had higher in firmness (10.90 N), but non significantly different from non-sprayed (Figure 3B). Calcium solution could delayed loss of firmness in strawberry fruit grown in Spain (Hernandez-Munoz *et al*., 2006). Calcium contributes to improving the rigidity of cell wall; retard tissue softening also reduces the accessibility of cell wall degrading enzymes to their substrates (Vicente *et al*., 2009). Application of calcium sprays during the growing season reduction in fruit softening of stored rasberries (Eaves *et al*,. 1972). Postharvest treatment of Japanese plums with calcium chloride solution reduced the physiological response to mechanical damage (Serrano *et al*,. 2004). Postharvest application of calcium chloride increased the flesh calcium concentration of cherries and improved the texture and the incidence of pitting resulting from impact damage (Lidster *et al*., 1979)

Fruits sprayed with 2% $CaCl_2$ solution and non-sprayed had significantly difference in TSS/TA ratio, higher in non-sprayed 11.46% than in sprayed treatment 8.41% (Figure 3C).

L* and a* values decreased during storage with significantly different, on the last day of storage and lower in non-sprayed fruits (Figure 3D,E). During ripening progressed, the L* and b* values decreased, while a* values increased until the middle stage and decreased at the last stage (Lee *et al*., 2017).

Development of anthocyanin content in fruit was reduced by $CaCl_2$. Non-sprayed mulberry had 2 time lower content at the accumulation peak on days 12 in storage (Figure 3F). Bae and Suh (2007), reported that mulberry and other deep-coloured fruits have higher contens of polyphenols including flavonoids, anthocyanins, and carotenoids. Liang *et al*. (2012) reported that the content of total anthocyanins and total flavonoids varied widely across different species. \

**Table 1.** The growth rate of mulberry plants after pruned on number of leaf, leaf area, branch diameter, branch length.

| Growth parameters | Treatments | Day after prunning | | | Growth rate |
|---|---|---|---|---|---|
| | | 30 | 45 | 60 | |
| **Number of leaf** | Non-sprayed | 335.89b | 392.69b | 561.36a | 225.47a |
| | 2% calcium chloride | 412.29a | 475.25a | 656.92a | 244.63a |
| **Leaf area ($cm^3$)** | Non-sprayed | 63.60a | 66.48a | 71.08a | 7.48a |
| | 2% calcium chloride | 60.99a | 67.12a | 71.95a | 10.96a |
| **Branch diameter (mm)** | Non-sprayed | 4.61a | 5.20a | 6.08a | 1.47a |
| | 2% calcium chloride | 4.80a | 5.12a | 6.04a | 1.24a |
| **Branch length (cm)** | Non-sprayed | 40.16a | 45.27a | 48.37a | 8.21b |
| | 2% calcium chloride | 39.32a | 42.62a | 51.34a | 12.02a |

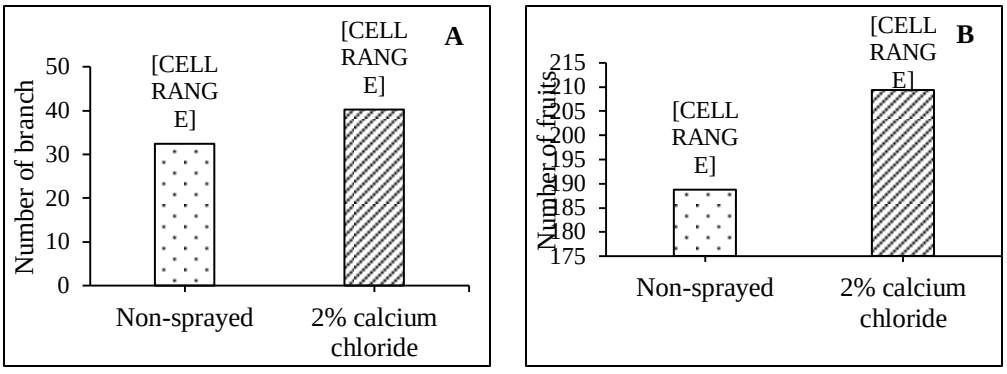


**Figure 2.** Number of branch (A) and Number of fruit (B) of mulberry fruits with and without 2% $CaCl_2$ sprayed before harvest

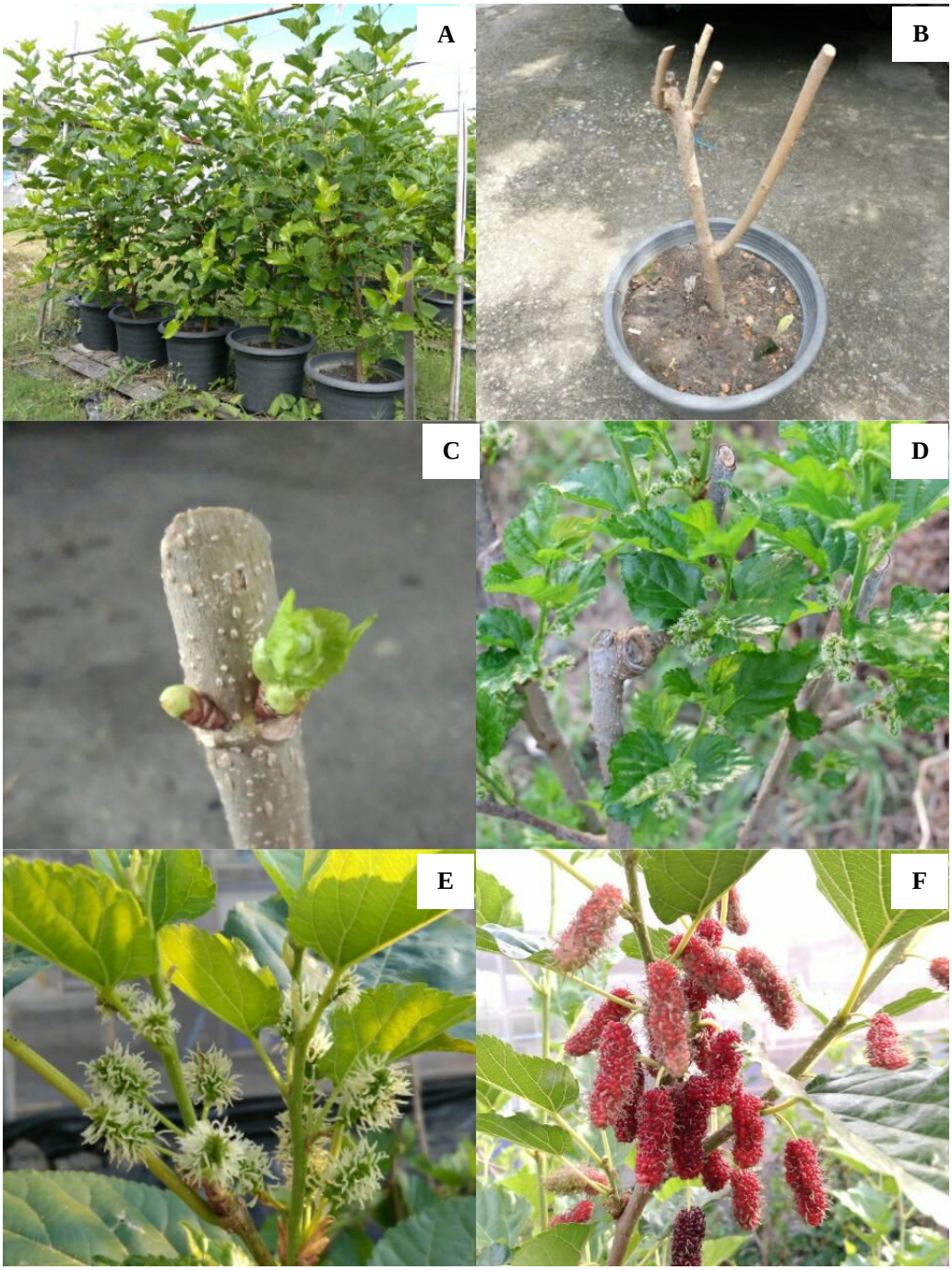


**Figure 1**. Mulberry tree were grown in plastic pot (A), hard pruned (B), then the new brances had developed (C), the flowers were blossom (D), then fruit started setting (E) and developed to the pink color stage (F).

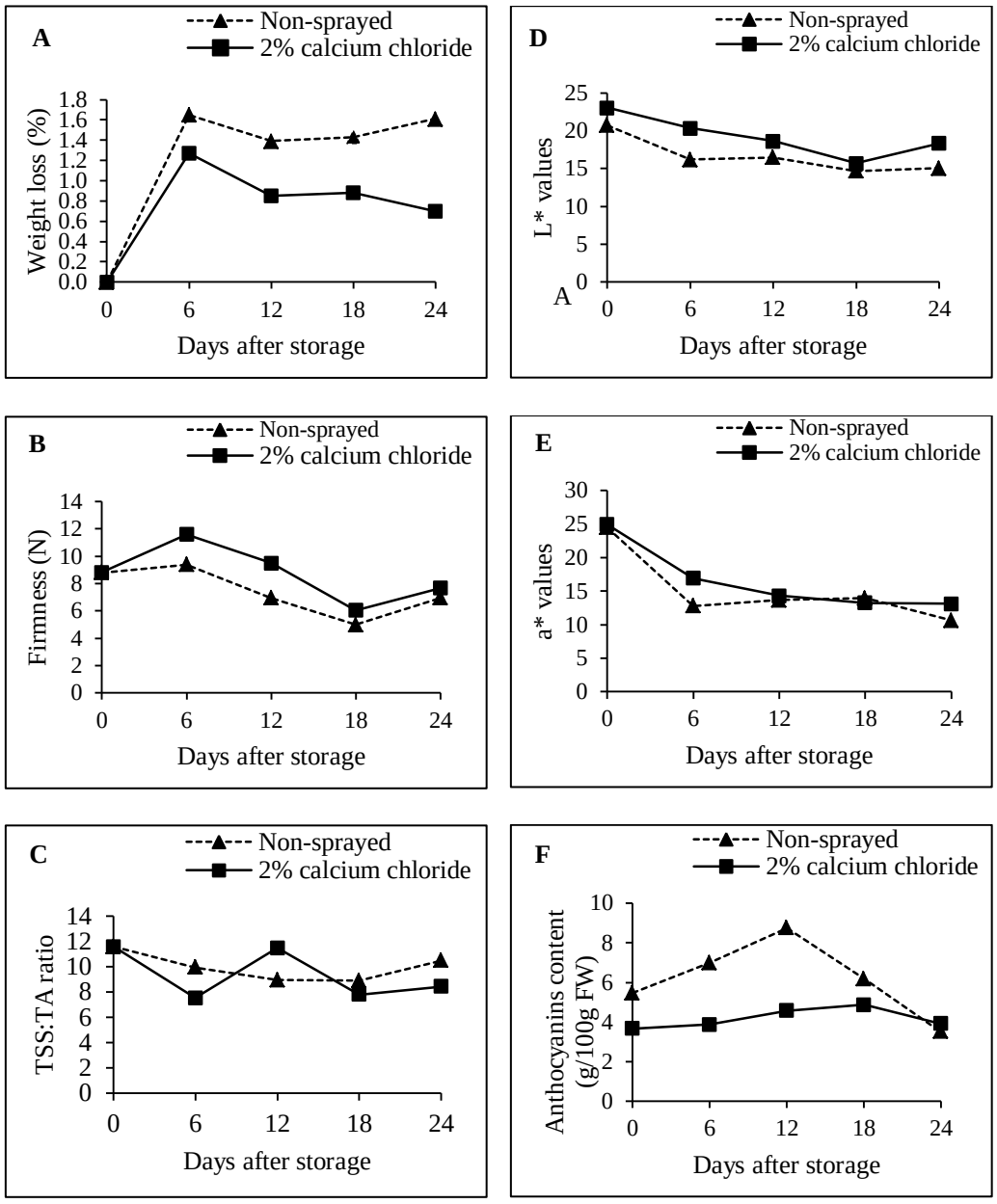


**Figure 3.** Weight loss (A), firmness (B), TSS:TA ratio (C), L* values (D), a* values (E) and anthocyanins content (F) of mulberry fruits from non-sprayed and sprayed with 2% calcium chloride before harvest

## Conclusion

Mulberry fruits sprayed with 2% $CaCl_2$ increased number of branches and number of fruits. Anthocyanin content also affected, slightly increased by calcium sprayed. Edible quality parameter as showed by TSS/TA ratio had lower in fruit sprayed with $CaCl_2$ than non-sprayed fruits.

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## References

Bae, S. H., and Suh, H. J. (2007). Antioxdant activities of five different mulberry cultivars in Korea. LWT-Food Science and Technology. 40: 955-962.

Bender, R.J. (1998). Elevated $CO_2$ in controlled atmosphere storage and regulation of mango ripening. Annual Review of Phytopathology. 7: 97-112.

Chen, F., H. Liu, H. Yang, S. Lai, X. Cheng, Y. Xin, B. Yang, H. Hou, Y. Yao, S. Zhang, G. Bu and Y. Deng. (2011). Quality attributes and cell wall properties of strawberries (*Fragaria annanassa* Duch.) under calcium chloride treatment. Food Chemistry. 126: 450-459.

Choudhury, S., Ray, D.P., Das, B.K. and Sahu, G.S. (2003). Effect of pre and postharvest chemical treatments on ripening, quality and storage life of sapota [*Manilkaraachras* (Mill.) Forberg] cv. 'Pala'. Orissa Journal of Horticulture. 31(2): 54-57. 8.

Eaves, C.A., Lockhart, C.L., Stark, R. and Craig, D.L. (1972). Influence of preharvest sprays of calcium salts and wax on fruit quality of red raspberry. Jouranl of the American Society for Horticultural Science. 97: 706-7.

El-Badawy, H.E.M. (2012). Effect of chitosan and calcium chloride spraying on fruits quality of florida prince peach under cold storage. Research Journal of Agriculture and Biolofical Sciences. 8(2): 272-281.

Ercisli, S. (2004). A short review of the fruit germplasm resources of Turkey. Genetic Resources and Crop Evalution. 51: 419-435.

Gill, P.S., Nav, S. and Jawandha, S.K. (2005). Postharvest handling of mango, Review of Punjab Agricultural University. 4: 150-160.

Hafez, O.M. and Haggag, K.H.E. (2007). Quality improvement and storability of apple cv. Anna by preharvest application of boric acid and calcium chloride. Journal of Agriculture and Biology. 2(3): 176-183.

Hernandez-Munoz, P., Almenar, E., M.J. and Gavara, R. (2006). Effect of calcium dips and chitosan coatings on the postharvest life of strawberries (*Fragaria* × *ananassa*). Postharvest Biology and Technology. 39: 247-253.

Karemera, N.J. and Habimana, S. (2014). Effect of preharvest calcium chloride on post harvest behavior of mango fruits (*Mangifer Indica* L.) cv. alphonso. Universal Journal of Agricultural Research. 2(3): 119-125.

Lee, Y. and Hwang, K.T. (2017). Changes in physicochemical properties of mulberry fruits (*Morus alba* L.) during ripening. Scientia Horticulturae. 217: 189-196.

Liang, L. H., Wu, X.Y., Zhu, M. M., Zhao, W. G., Li, F., Zou, Y. (2012). Chemical composition, nutritional value, and antioxidant activities of eight mulberry cultivars from China. Pharmacognosy Magazine. 8: 215-224.

Lidster, P.D., Tung, M.A. and Yada, R.G. (1979). Effect of preharvest and postharvest calcium treatments on fruit calcium content and the susceptibility of 'Van' cherry to impact damage. Journal of the American Society of Horticultural Science. 104(6): 790-3.

Lou, H., Hu, Y., Zhang, L., Sun, P. and Lu, H. (2012). Nondestructive evaluation of the changes of total flavonoid, total phenols, ABTS and DPPH radical scavenging activities: and sugar during mulberry (*Morus alba* L.) fruit development by chlorophyll fluorescence and RGB intensity values. Food Science and Technology. 47: 19-24.

Machado, F.L.C., Alves, R.E. and Figueiredo, R.W. (2008). Application of 1-methylcycclopropene, calcium chloride and calcium amino acid cheleate on fresh-cut cantaloupe muskmelon. Pesquisa Agropecuaria Brasileira. 43: 569-574.

Mahmoud, M.M. (2008). Influence of gamma rays and some pre and post harvest treatment on behavior of some fruits during cold storage. M.Sc. Thesis, Environmental Sci., Institute of Environmental Studies and Research. Ain Shams Univ., Egypt.

Manganaris, G.A., M. Vasilakakis, G. Diamantidis and I. Mignani. (2007). The effect of postharvest calcium application on tissue calcium concentration, quality attributes, incidence of flesh browning and cell wall physicochemical aspects of peach fruits. Food Chemistry. 100: 1385–1392.

Serrano, M., Martinez-Romero, D., Castillo, S., Guillen, F. and Valero, D. (2004). Role of calcium and heat treatments in alleviating physiological changes induced by mechanical damage in plum. Postharvest Biology and Technology. 34: 155-67.

Serrano, M., Martinez-Romero, D., Castillo, S., Guillen, F. and Valero, D. (2004). Effect of preharvest sprays containing calcium, magnesium and titanium on the quality of peaches and nectarines at harvest and during postharvest storage. Journal of the Science of Food and Agiculture. 84(11): 1270-1276.

Suutarinen, J., Heiska, K., Moss, P. and Autio, K. (2000). The effects of calcium chloride and sucrose prefreezing treatments on the structure of strawberry tissues. LWT-Food Science and Technology. 33: 89-102.

Turmanidze, T., Gulua, L., Jgenti, M. and Wicker, L. (2016). Effect of calcium chloride treatments on quality characteristics of blackberry, raspberry and strawberry fruits after cold storage. Turkish Journal of Agriculture-Food Science and Technology. 4(12): 1127-1133.

Vicente, A.R., Manganaris, G.A., Sozzi, G.O. and Crisosto, C.H. (2009). Nutritional quality of fruit and vegetables. In W.J. Florkowski. R.L.Shewfelt, B. Brueckner, S.E. Prussia (Eds.), Postharvest Handling: A Systems Approach, Academic Press, USA. 57-106.

Wahdan, M.T., Habib, S.E., Bassal, M.A. and Qaoud, E.M. (2011). Effect of some chemicals on growth, fruiting, yield and fruit quality of "Succary Abiad" mango cv. Journal of Horticulture Science. 7(2): 651-658.

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