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Pre and Postharvest Treatment of Salicylic Acid to Improve the Fruit Quality and Shelf Life of Mango (*Mangifera indica* L.)

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Abstract

Mango (*Mangifera indica* L.) is the 2nd major fruit crop of Pakistan and has a short shelf life after ripening. Salicylic acid is naturally synthesized in plants and play important role to activate the defense system against pathogens and reduce the decay of fruits. This study was conducted to evaluate the pre and postharvest application of salicylic acid on storage life and quality of mango cultivar 'Kensington Pride'. Fruits were harvested at full mature stage (shoulder development) and treated with CaC_2 (2g) to initiate the ripening process. After four days of treatment partially ripened fruits were immersed in four concentrations of salicylic acid (0, 8, 12 and 16 mM) for 5 minutes. Fruits were stored at 12°C for 15 days. The results showed that fruit weight loss significantly reduced in all treated fruits as compared to control. It was also observed that SA 16 mM showed minimum reduction in TSS, vitamin C, reducing, non-reducing, total sugars, total antioxidants, total phenolic and total flavonoids. Our research proposed that pre and postharvest treatment of SA 16 mM can be used to reduce the postharvest storage losses of mango and also maintained the quality of mango during shelf life.

INTRODUCTION

Mango (*Mangifera indica* L.) is a vital fruit of sub-tropical and tropical areas of the world and is grown in more than 100 countries (Sauco, 1997). It has been cultivated in Burma and Eastern India for more than 4000 years (Singh, 1960). Mango belongs to class Dicotyledonae, subclass Archichlamydeae, order Sapindales and family Anacardiaceae (Fernald, 1950). Mango is a commercial fruit crop in many countries such as South-East Asia, including India, Pakistan, Philippines, Indonesia, Malaysia, Thailand and Burma. Mango is also known as king of fruits and it is one of the choicest fruit crops of the world (Singh and Rajan, 2009).

It has been a main fruit due to its specific climatic requirements, however, its pleasant taste, distinctive flavor with high nutritive value has made it equally popular and its demand is arising quickly in the world. Mango is one of the leading fruit crops of Asia and presently occupies 5th place regarding world in total production among the main fruits, after Musa species (Bananas), Citrus species (citrus), Vitis spp. (grapes) and Pyrus malts (apple) (Anonymous, 2005). Although, mango is grown between 30° latitude

North and South in almost all tropical and sub-tropical parts of the world except Spain, France and Portugal (Abourayya, 2011), but commercial production is limited to only a few countries.

The family Anacardiaceae contains 400 species and 60 genera, most of the species are in the tropics but some of them are in the temperate zone in both western and eastern hemispheres (Bailey, 1949). Since the establishment of this genus, a large number of species have been recorded and at present there are 41 species (Mukherjee, 1951). Out of them only 13 species bear edible fruit of inferior quality out (Gangolly *et al*., 1957). Anacardiaceous species also produce other valuable products like gums, wood, wax, resins, etc. and is well recognized for the dermal irritation produced by some of its members such as Oaks (Rphus spp.) and toxic Ivies etc. (Bompart and Schnell, 1997).

Mango (*Mangifera indica L*) cultivar 'Kensington pride' fruits were sprayed at the concentration of 100 mg/L with Salicylic Acid to reduce the Anthracnose disease (*Colletotrichum gloeosporioides*). Postharvest treatment of SA at the concentration of 200 mg L^{-1} was applied in second season of fruiting to control the Anthracnose disease. But high dose of SA at the concentration of 200 mg L^{-1}, reduce the Anthracnose disease in second season and changes of fruit skin color and firmness also reduce significantly (Zainuri et al., 2001). The dose of SA 100 mg L^{-1} reduced the Anthracnose disease significantly when sprayed on mango inflorescence. They had explained no inhibitory effects of SA on spore germination and colony growth. It is concluded that SA induces the resistant against the Anthracnose disease (*Colletotrichum gloeosporioides*) in Mango fruits (Jianliang *et al*., 2003). This study is focused to investigate the pre- and postharvest effects of SA on the shelf life and quality of mango cultivar 'Kingston'.

MATERIALS AND METHODS

The proposed study was conducted at Experimental Fruit Orchard Square No. 32, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan. The cultivar of mango 'Kingston' with twelve plants was selected and tagged. Similar cultural practices i.e. fertilizers, irrigation and plant protection measures were carried out during the research. Two preharvest sprays (30 and 15 days before harvesting) of salicylic acid were applied on all the selected plants. Fruits were harvested at full mature stage (shoulder development) and treated with calcium carbide to initiate the ripening process. After 4 days of CaC_2 treatment fruits were dipped for 5 min in different concentration of SA then stored for 15 days at 12°C in Postharvest Research Centre, AARI, Faisalabad. There were four treatments each with three replications.

Experiment was laid out according to RCBD design with four treatments and three replications. Treatments were T_0 = Control, T_1 = 8.0 mM salicylic acid, T_2 = 12 mM salicylic acid and T_3 = 16 mM salicylic acid. Data was analyzed under LSD at 5% level of probability after ANOVA by using MSTAT-C software (Steel et al., 1997). To determine fruit weight, fruits (n=10) were randomly selected from each treatment unit. These fruits were weighted as fresh and at 15 days interval during the storage period and weight was calculated using the following formula.

$$\text{Fruit weight loss (\%)} = \frac{\text{Original fruit weight- final fruit weight after storage x 100}}{\text{Average fruit weight}}$$

Digital refractometer (Atago Japan PAL-1) was used for determination of total soluble solids. Ascorbic acid in the mango pulp was determined using method reported by Ruck (1969). Method given by Hortwitz (1960) was used to determine the sugar contents (reducing, non-reducing and total sugars) in mango fruits. The mango fruit pulp was assessed by measuring their scavenging abilities to 2, 2-diphenyl-1-picrylhydrazyl stable radicals used by (Lalel et al., 2003). Flavonoids were determined by the method of Kim et al. (2003). Total phenolic contents were calculated by using Folin-Ciocalteu reagent method as reported by Ainsworth and Gillespie, (2000).

RESULTS AND DISCUSSION

Total Soluble Solids (°Brix)

The analyzed data presented in figure 1 showed statistically significant differences at $p \leq 0.05$ regarding the effects of treatments and storage periods while interaction between them was found non-significant for total soluble solids in the fruits. The fruits those were sprayed with salicylic acid @ 16 mM showed higher TSS of 12.40°Brix as compared to the fruits of other treatments. While minimum TSS of 10.49°Brix was recorded in the fruits of T_1 (control). The fruits those were analyzed after 15 days of storage showed higher TSS value of 12.86°Brix than the fruits those were analyzed after 10 and 5 days of storage where TSS values were 12.07 and 11.35°Brix, respectively. While lower TSS of 8.97°Brix was noted in the fruits analyzed at 0 days of storage. The results are in line two year's study, SSC in strawberry fruits, were increased when plants were sprayed with SA than control (Karlidag et al., 2009).

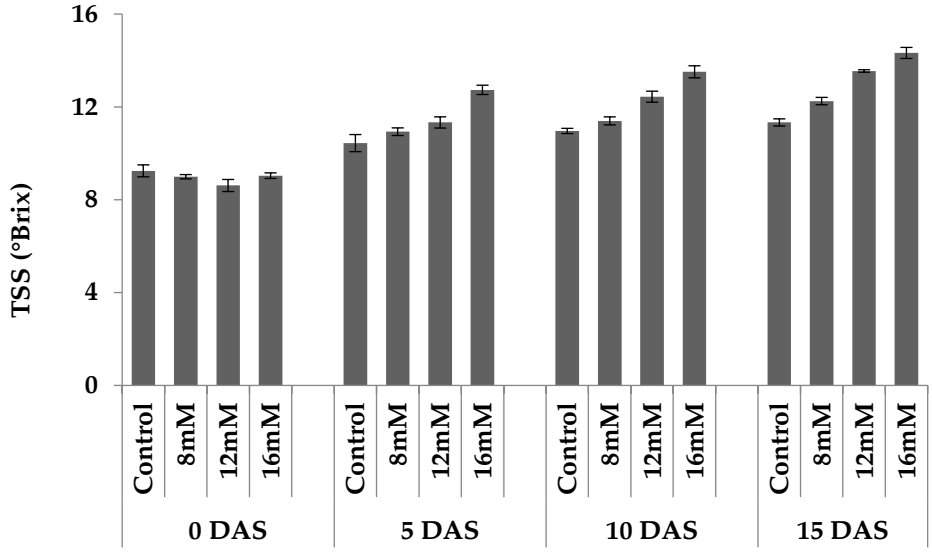

Figure 1: Pre- and postharvest effects of salicylic acid on fruit TSS (°Brix) of mango cv. Kingston during storage at 12°C±S.E.

Vitamin C (mg/100 g)

The analyzed data presented in figure 2 showed statistically significant differences at $p \leq 0.05$ regarding the effects of treatments, storage periods and their interaction on vitamin C contents in the fruits. The fruits those were sprayed with

salicylic acid @ 16 mM showed higher vitamin C of 37.37 mg/100 g as compared to the fruits of other treatments. While minimum vitamin C of 32.12 mg/100 g was recorded in the fruits of T_1 (control). The fruits those were analyzed after 15 days of storage showed lower vitamin C value of 25.21 mg/100 g than the fruits those were analyzed after 10 and 5 days of storage where vitamin C values were 29.86 and 38.51 mg/100 g, respectively. While higher vitamin C of 44.53 mg/100 g was noted in the fruits those were analyzed at 0 days of storage. These findings are very much in accordance with results of Akhtar et al. (2010) those reported that Vitamin C in loquat fruits was reduced constantly to a great extent for ten weeks storage period.

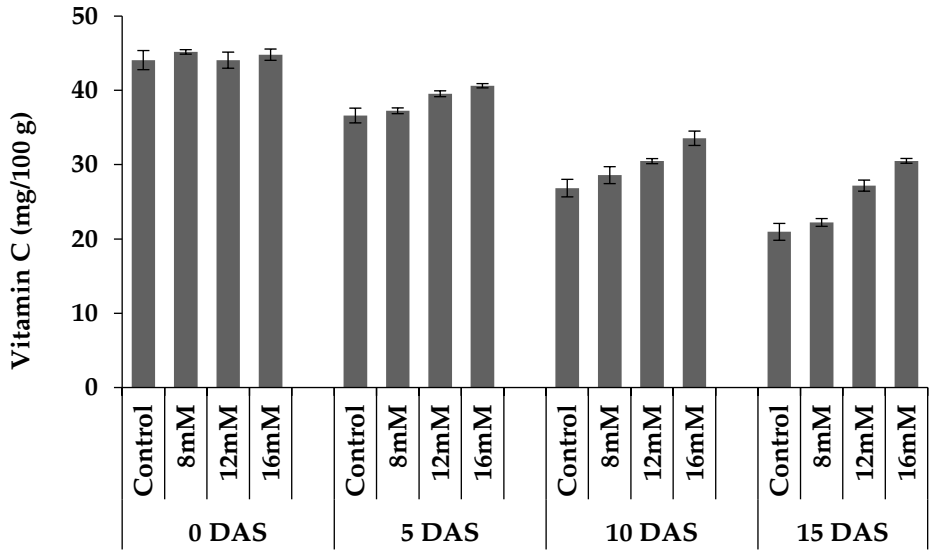

Figure 2: Pre- and postharvest effects of salicylic acid on vitamin C (mg/100 g) of mango cv. Kingston during storage at 12°C±S.E.

Total Sugars (%)

Statistically significant results were found at $p \leq 0.05$ regarding the effects of treatments, storage periods and their interaction on total sugar content (Figure 3). Higher total sugar contents of 23.32% were noted in the fruits of T4 while lower total sugar contents of 19.46% were recorded in the fruits of T_1 (control). The fruits those were analyzed after 15 days of storage showed higher total sugar contents of 23.34% as compared to the fruits those were analyzed after 10 and 5 days of storage where total sugar contents were 22.51 and 21.21%, respectively. While lower value of total sugar contents of 17.65% was recorded in the fruits those were analyzed at 0 days of storage. The results are in line with King et al., 1995.

Reducing Sugars (%)

The analyzed data presented in Figure 4 showed statistically significant results at $p \leq 0.05$ regarding the effects of treatments and storage periods while interaction between them was found non-significant for reducing sugar contents (Figure 4). Higher reducing sugar contents of 8.40% were noted in the fruits of T4 while lower reducing sugar contents of 7.99% were recorded in the fruits of T_1 (control). The fruits those were analyzed after 15 days of storage showed higher reducing sugar contents of 8.42% as

compared to the fruits those were analyzed after 10 and 5 days of storage where total sugar contents were 8.27 and 8.11%, respectively. While lower value of reducing sugar contents of 7.86% was recorded in the fruits those were analyzed at 0 days of storage. The reason was same as described in total sugar.

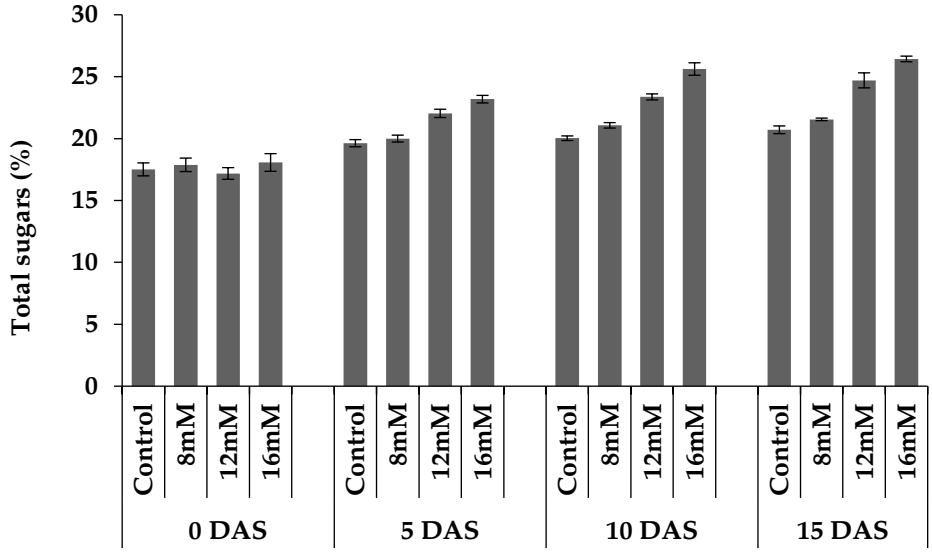

Figure 3: Pre- and postharvest effects of salicylic acid on total sugar contents (%) of mango cv. Kingston during storage at 12°C±S.E.

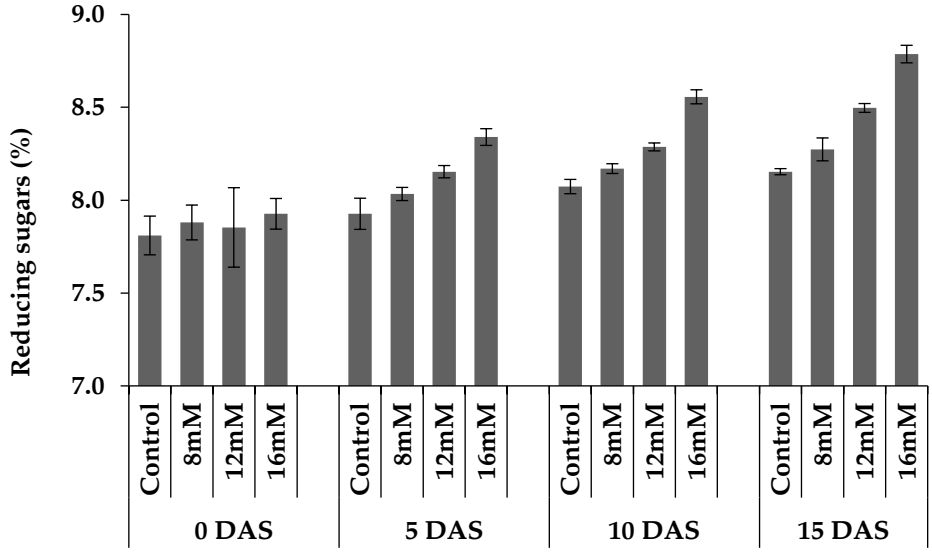

Figure 4: Pre- and postharvest effects of salicylic acid on reducing sugar contents (%) of mango cv. Kingston during storage at 12°C±S.E.

Non-Reducing Sugars (%)

Statistically significant results were found at $p \leq 0.05$ regarding the effects of treatments, storage periods and their interaction on non-reducing sugar contents (Figure 5). Higher non-reducing sugar contents of 14.92% were noted in the fruits of T4 while lower non-reducing sugar contents of 11.47% were recorded in the fruits of T_1 (control). The fruits those were analyzed after 15 days of storage showed higher non-reducing sugar contents of 14.92% as compared to the fruits those were analyzed after 10 and 5 days of storage where non-reducing sugar contents were 14.24 and 13.09%, respectively. While lower value of non-reducing sugar contents of 9.79% was recorded in the fruits those were analyzed at 0 days of storage. The reason was same as described in total sugar.

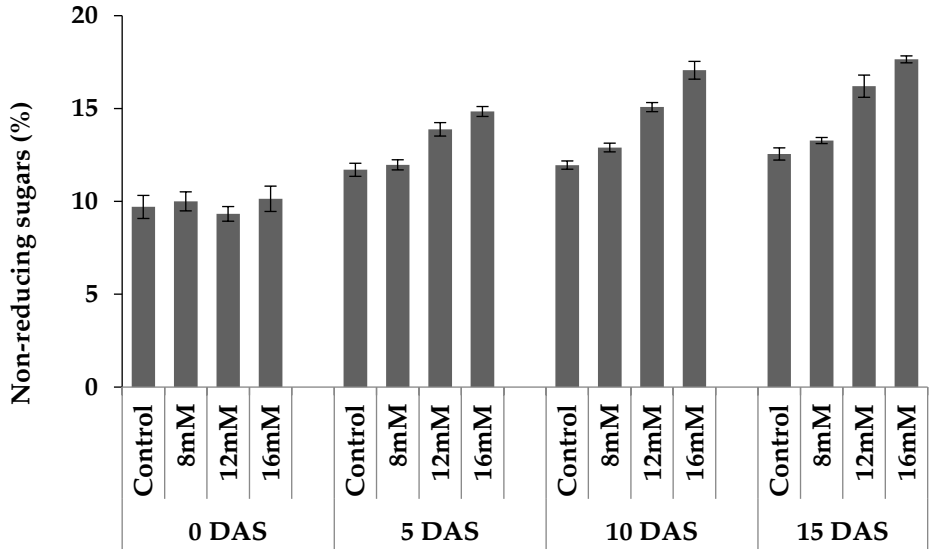

Figure 5: Pre- and postharvest effects of salicylic acid on non-reducing sugar contents (%) of mango cv. Kingston during storage at 12°C±S.E.

Total Antioxidants (%DPPH)

The analyzed data presented in Figure 6 showed statistically significant differences at $p \leq 0.05$ regarding the effects of treatments, storage periods and their interaction on total antioxidants. Higher total antioxidants of 56.22 %DPPH were noted in the fruits of T4 while lower total antioxidants of 46.49 %DPPH were recorded in the fruits of T_1 (control). The fruits those were analyzed after 15 days of storage showed higher total antioxidants of 57.06 %DPPH as compared to the fruits those were analyzed after 10 and 5 days of storage where total antioxidants were 52.33 and 49.19 %DPPH, respectively. While lower value of total antioxidants of 44.68 %DPPH was recorded in the fruits those were analyzed at 0 days of storage.There is also evident that exogenously applied SA with suitable dose enhanced the efficiency of antioxidant system in plants (Hayat et al., 2010).

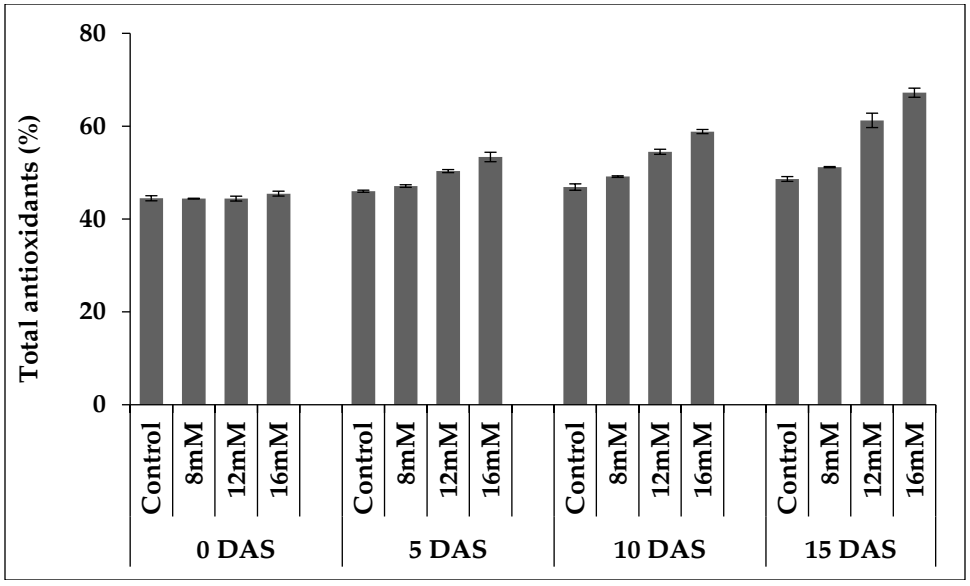

Figure 6: Pre- and postharvest effects of salicylic acid on total antioxidants (%DPPH) of mango cv. Kingston during storage at 12°C±S.E.

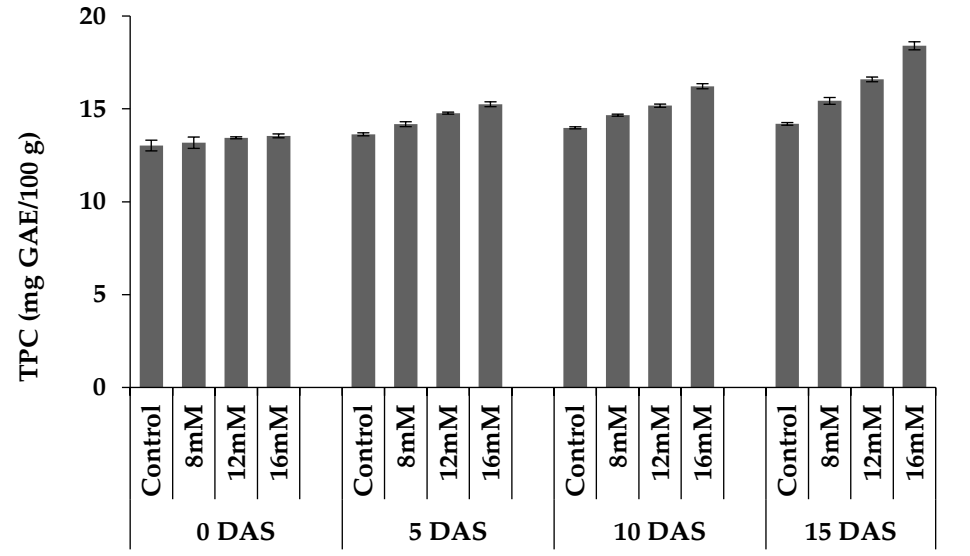

Figure 7: Pre- and postharvest effects of salicylic acid on total phenolic contents (mg GAE/100 g) of mango cv. Kingston during storage at 12°C±S.E.

Total Phenolic Contents (mg GAE/100 g)

The analyzed data presented in figure 7 showed statistically significant differences at $p \leq 0.05$ regarding the effects of treatments, storage periods and their interaction on total phenolic contents. Higher total phenolic contents of 15.85 mg GAE/100 g were noted in the fruits of T4 while lower total phenolic contents of 13.7 mg GAE/100 g were recorded in the fruits of T_1 (control). The fruits those were analyzed

after 15 days of storage showed higher total phenolic contents of 16.15 mg GAE/100 g as compared to the fruits those were analyzed after 10 and 5 days of storage where total phenolic contents were 15.00 and 14.45 mg GAE/100 g, respectively. While lower value of total phenolic contents of 13.29 mg GAE/100 g was recorded in the fruits those were analyzed at 0 days of storage. In our study the increase in phenolics are in line with Yao and Tian (2005) who demonstrated that SA stimulates phenylalanine ammonia lyase activity with consequent production of the main phenolic compounds and the synthesis of new polyphenolic substances in sweet cherry fruit.

Total Flavonoids Contents (mg CEQ/100 g)

Statistically significant differences were found at $p \leq 0.05$ regarding the effects of treatments, storage periods and their interaction on total flavonoids contents of Kingston (Figure 8). Higher total flavonoids contents of 43.03 mg CEQ/100 g were noted in the fruits of T4 while lower total flavonoids contents of 39.13 mg CEQ/100 g were recorded in the fruits of T_1 (control). The fruits those were analyzed after 15 days of storage showed higher total flavonoids contents of 43.23 mg CEQ/100 g as compared to the fruits those were analyzed after 10 and 5 days of storage where total flavonoids contents were 41.43 and 40.29 mg CEQ/100 g, respectively. While lower value of total flavonoids contents of 38.48 mg CEQ/100 g was recorded in the fruits those were analyzed at 0 days of storage. The results are in line with Wei et al., 2011.

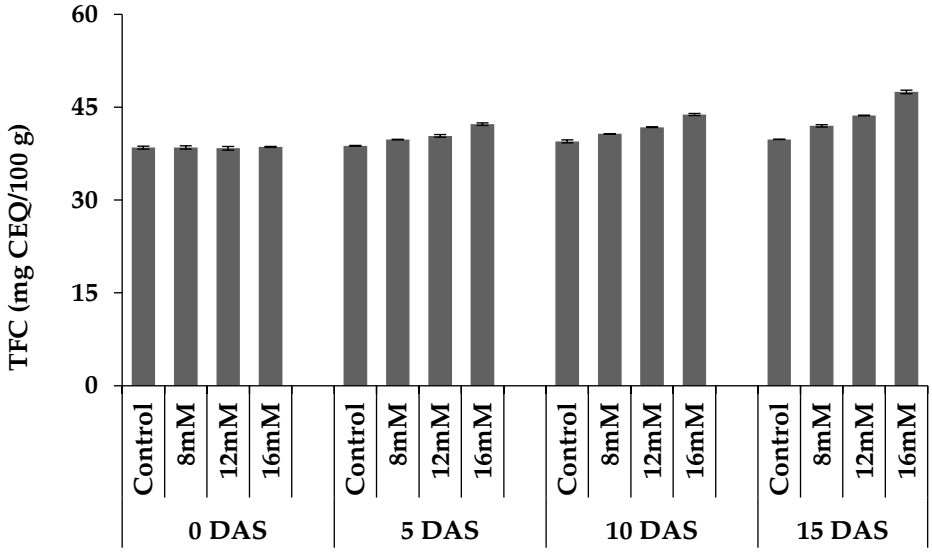

Figure 8: Pre- and postharvest effects of salicylic acid on total phenolic contents (mg CEQ/100 g) of mango cv. Kingston during storage at 12°C±S.E.

Fruit Weight Loss (%)

The analyzed data presented in figure 9 showed statistically significant differences at $p \leq 0.05$ regarding the effects of treatments, storage periods and their interaction on fruit weight loss. Minimum fruit weight loss of 3.83% was noted in the fruits of T4 while maximum fruit weight loss of 7.83% was recorded in the fruits of T_1 (control). The fruits those were analyzed after 15 days of storage showed greater fruit

weight loss of 11.25% as compared to the fruits those were analyzed after 10 and 5 days of storage where weight loss were 6.58 and 3.91%, respectively. While the fruits those were analyzed at 0 days of storage showed 0% fruit weight loss. These results are in agreement with those of Wang et al. (2006) in peaches and of Sayyari et al. (2009) in pomegranates where the higher concentrations of SA was more effective than lower ones to control the weight loss, chilling injury and fruit decay under storage as compared to control treatments.

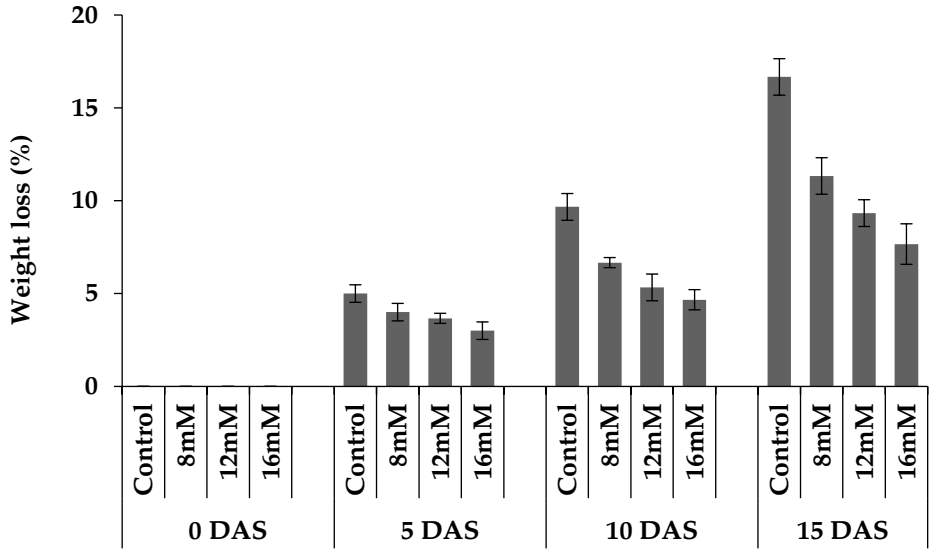

Figure 9: Pre- and postharvest effects of salicylic acid on fruit weight loss (%) of mango cv. Kingston during storage at 12°C±S.E.

CONCLUSION

Overall results indicate that cultivars of mango "Kingston" remained in better conditions after 15 days of storage at 12°C so It is concluded that SA @ 16 mM can be used to maintain the quality of fruit during storage. In future investigations, there is need to study the weekly and day to day changes under storage.

REFERENCES

Abourayya, M.S., N.E. Kassim, M.H. Al-Shiekh and A.M. Rakha. 2011. Fruit physical and chemical characteristics at maturity stage of Tommy Atkins, Keitt and Kent mango cultivars grown under Nubariya conditions. J. Am. Sci. 7:228-233.

Ainsworth, E.A. and K.M. Gillespie. 2000. Estimation of total phenolic content and other oxidation substrates in plant tissues using folin ciocalteu reagent. Nat. Protoc. 2:875-877.

Akhtar, S., M. Riaz, A. Ahmad and A. Nisar. 2010. Physicochemical, microbiological and sensory stability of chemically preserved mango pulp. Pak. J. Bot. 42:853-862.

Anonymous, 2005. FAO production year book. Food and Agriculture Organization of the United Nations, Rome, Italy.

Bailey, L.H. 1949. Manual of Cultivated Plants. McMillan Co. New York.

Bompart, J.M. and R.J. Schnell. 1997. Taxonomy and systematics. In: Litz, R.E (Ed.). The Mango Botany, production and uses. CAB International, London. 21.
Fernald, M.L. 1950. Manual Botany, 8th ed. Grays book Co. New York.
Gangolly, S.R., R. Singh, S.L. Kalyal and D. Singh. 1957. The Mango. Indian Council of Agri. Res. New Delhi.
Hayat, Q., S. Hayat, M. Irfan, and A. Ahmad. 2010. Effect of exogenous salicylic acid under changing environment: A review. Environ. Expt. Bot. 68:14-25.
Hortwitz, W. 1960. Official and tentative methods of analysis. Association of the Official Agriculture Chemist. Washington, D.C. Ed. 9:320-341.
Jianliang, L., H. Xiaodan, F. Zhidong and H. Songlin. 2003. Induced resistance effect of salicylic acid on anthracnose of mango fruits (*Colletotrichum gloesporioides*).
Karlidag, H., E. Yildirim and M. Turan. 2009. Salicylic acid ameliorates the adverse effect of salt stress on strawberry. J. Agric. Sci. 66:271-278.
Kim, D.O., S.W. Jeong and C.Y. Lee. 2003. Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. Food Chem. 81:321-326.
King, G.A. and K.M. Davies. 1995. Cloning of a harvest-induced P-galactosidase from tips of harvested asparagus spears. Physiol. Planta. 8:419-420.
Lalel, H.J.D., Z. Singh and S.C. Tan. 2003. Distribution of aroma volatile compounds in different parts of mango fruit. J. Hort. Sci. Biotec. 78:131-138.
Mukherjee, S.K. 1951. Origin of Mango. Indian J. Genet. Pl. Breed. 11:49-55.
Ruck, J.A. 1969. Chemical Methods for Analysis of Fruits and Vegetables. Research Station Summerland, Canada Deptt. Agri. 1154.
Sauco, V. 1997. Mango World Production. Acta Horti. 455:15-20.
Sayyari, M., M. Babalar, S. Kalantari, M. Serrano and D. Valero. 2009. Effect of salicylic acid treatment on reducing chilling injury in stored pomegranates. Postharvest Biol. Technol. 53:152-154.
Singh, L.B. 1960. The Mango: Botany, Cultivation and Utilization. New York Interscience Publishers, Leonard Hill, London.
Singh, V.K. and S. Rajan. 2009. Changes in photosynthetic rate, specific leaf weight and sugar contents in mango (*Mangifera indica* L.) Open Horti. J. 2:40-43.
Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1997. Principles and Procedures of Statistics; A Biological Approach. 3rd ed. McGraw Hill Book Co. New York.
Wang, L.J., S.H.J. Chen, W.F. Kong, S.H.H. Li and D.D. Archbold. 2006. Salicylic acid pretreatment alleviates chilling injury and affect the antioxidant system and shock proteins of peach during cold storage. Postharvest Biol. Technol. 91:244-251.
Wei, Y., Z. Liu, Y. Su, D. Liu and X. Ye. 2011. Effect of salicylic acid treatment on postharvest quality antioxidant activities and free polyamines of asparagus. J. Food Sci. 76:126-132.
Yao, H. and S. Tian. 2005. Effect of pre and postharvest application of salicylic acid or methyl jasmonate on inducing disease resistance of sweet cherry fruit in storage. Postharvest Biol. Technol. 35:253-262.
Zainuri, D.C.J., H. Wearing, L. Coates and L. Terry. 2001. Effects of phosphonate and salicylic acid treatments on anthracnose disease development and ripening of 'Kensington pride' mango fruit. Aust. J. Exp. Agri. 4:805-813.