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Effect of salicylic acid on post-harvest quality of tomato (*Solanum lycopersicum* L.) Fruit

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Abstract
Tomato is a climacteric fruit and has a relatively short postharvest life. Every year approx. 25-40% tomato losses occur due to lack of suitable methods of post-harvest storage. Salicylic acid has high potential in monitoring post-harvest losses as a natural and safe phenolic compound. Therefore, the present research was planned to study the effect of salicylic acid (0.5 mM, 0.75 mM, 1.0 mM, 1.25 mM and 1.5 mM) on the biochemical changes in tomato cultivar Hisar-Arun at turning stage during storage at room temperature. A progressive increase in physiological loss in weight, total soluble solids, lycopene content, β-carotene content, total sugars, reducing sugars and non-reducing sugars was observed. The results suggested that 0.75 mM concentration of salicylic acid was most effective in delaying the ripening related physico-biochemical changes. Hence, exogenous application of salicylic acid is an effective approach in enhancing the shelf life of tomato fruits upto 4 to 6 days.

Keywords: Salicylic acid, Shelf-life, Tomato, Post-harvest

Introduction
Tomato (*Solanum lycopersicum* L.) is a climacteric fruit and has a relatively short postharvest life. Every year approx. 25-40% tomato losses occur due to lack of suitable methods of post-harvest storage. For producers and traders, losses due to post harvest decay during storage have been a great concern. The onset of ripening in tomato is highly dependent on the continuous presence of ethylene and ethylene-mediated actions [1]. Salicylic acid (SA) has been reported to play an important role in wide range of physiological and metabolic responses including retardation of ripening and reducing decay of number of climacteric fruits such as mango [2], banana [3], reduced chilling injury of tomato [4], peach [5]. SA causes the delay in ripening perhaps through inhibition of synthesis of ethylene which results into the increment of post-harvest life of fruits. A number of studies have been reported on the post-harvest effect of SA on delaying ripening of fruits. The objective of present work was to explore the effect of exogenous SA treatment on the post harvest life and quality of tomato fruit.

Materials and methods
Tomato fruits (*Solanum lycopersicum* L.) variety Hisar-Arun at turning stage were collected manually from the farms of Department of Vegetable Sciences, CCS Haryana Agricultural University, Hisar. Fruit color and maturation level was precisely selected according to the biological color chart of USDA (1991) and were selected for uniformity of color, shape and size of the fruit. During harvesting and transportation maximum care was taken to minimize the mechanical damage. Upon sorting, fruits were gently washed with tap water containing 2% (w/v) sodium hypochlorite solution, rinsed with double distilled water and dried at ambient air condition. Dried fruits were used for the salicylic acid treatment.

Preparation and application of salicylic acid solution: Dried fruits from each variety were immersed in five different concentration of salicylic acid (SA, Sigma) *viz.* 0.5 mM, 0.75 mM, 1.0 mM, 1.25 mM and 1.5 mM solution separately at 20 °C for 20 min with double distilled water as control. Treated fruits were stored separately at room temperature of 25°C ± 1 and relative humidity 75 ± 5% and samples were analyzed at every 3rd day till complete decay of tomato fruit.

Physical Analysis: The weight of freshly harvested fruits was recorded at the time of harvesting (0 days of storage) and termed as initial weight. On each day of observation, the stored fruit was again weighed and termed as final weight on that particular day of

observation. The percent loss in weight (PLW) on each sampling date was calculated using the following formula:

$$PLW\ (\%) = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Biochemical Analysis: The pulp of three randomly selected fruits per treatment was crushed for extracting juice. *Total soluble solids* (TSS) of juice was measured with the help of hand refractometer (0-32ºbrix) and expressed as percent total soluble solids. *For lycopene, h*omogenized 5gm tissue of tomato fruit and to 100 µl of homogenized sample added 8 ml of hexane: ethanol: acetone (2:1:1) solution. Vortexed the solution immediately, incubated out of bright light for 1 hour. Added 1.0 ml water to each sample and vortexed again. After 10 minutes, phases were separated. Rinsed the cuvette with the upper layer from one of the blank samples. Discarded, then used a fresh blank to calibrate the spectrophotometer at 503 nm. Determined the A_{503} of the upper layers of the lycopene samples. *β-Carotene* was estimated by the method of AOAC [6]. Ten-gram fresh fruit sample was dispersed in 50 ml water-saturated n-butanol to make a homogenous suspension. Shaken gently and kept to stand overnight (16 h) at room temperature in dark. The suspension was shaken again and filtered through whatman filter paper No. 1. The volume of filtrate was made to 100 ml and the absorbance of the clear filtrate was measured at 440 nm in Spectrophotometer using saturated n-butanol as a blank. The amount of β-carotene was calculated from the standard calibration curve of β-carotene (0.5-5.0 µg). *Total sugars* were estimated by the modified method of Dubois [7]. Reducing sugars were determined by the method of Nelson [8] as modified by Somogyi [9] and non-reducing sugars was calculated by subtracting the reducing sugars from the total sugars.

Statistical Analysis: Data from the analytical determinations were subjected to analysis of variance (ANOVA). Mean comparisons were performed using Least Significant Difference (LSD) Test. Differences among means of data were compared by Differences at 0.05 were considered significant. All analyses were performed with SAS software package.

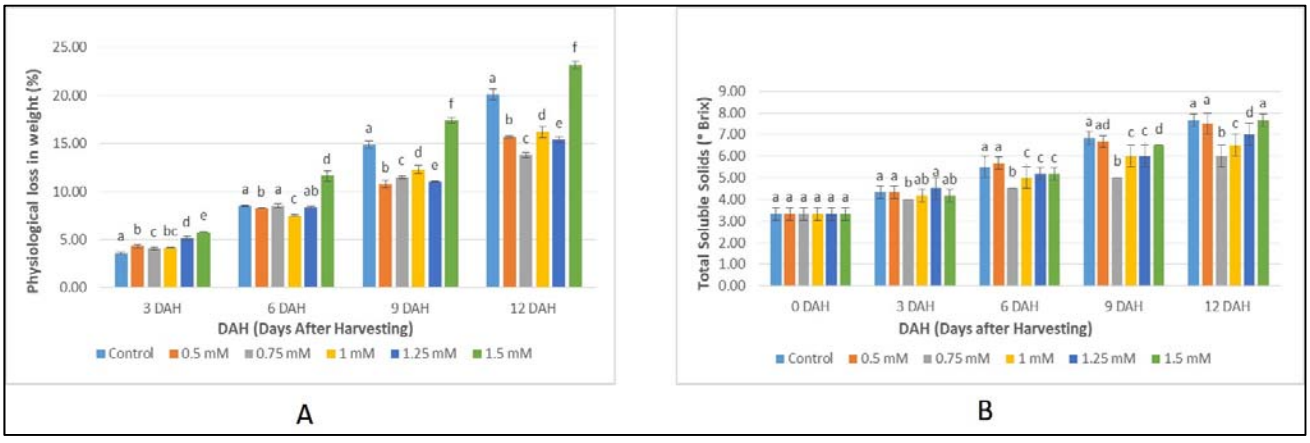
Results and discussion

Physical Analysis

Physiological Loss in weight (PLW): A progressive increase in the PLW (Fig. 1A) was observed with increase in the days of storage. PLW increased significantly with storage time upto 12 DAH (3.58% at 3 DAH to 20.11% at 12 DAH). 0.75 mM concentration of salicylic acid was most effective which decreased the PLW significantly up to 19% at 12 DAH. The loss in weight of tomatoes was primarily due to the metabolic processes such as transpiration and respiration which causes loss of water. Transpiration causes evaporation of water during increase in storage period and respiration causes the loss of metabolites [10]. The less increase may be due to the inhibitory effect of SA against ethylene production and reduced respiration [11, 12].

Total Soluble Solid: TSS **c**ontent (Fig. 1B) increased progressively during the storage period of tomato fruits. TSS content of control fruits increased from 3.33 º Brix at 0 DAH to 7.67 º Brix at 12 DAH. Treatments of salicylic acid caused the delay in increase in the TSS content where most effective concentrations were 0.75 mM and 1.0 mM. The delay was approx. 22 % in case of treatment 0.75 mM at 12 DAH. Similar effect of SA on Banana [3], apple [13], pomegranates [14], sweet cherries [15] and strawberry [16] have been reported.

Lycopene: It is the most effective antioxidant which gives color to tomato fruit as maturity progresses. The lycopene content increased gradually and significantly during storage period (Fig 1C). SA concentration 0.75 mM application caused the delay most effectively among all treatments in increase in the lycopene content where delay was approx. 20 % at 12 DAH when compared to control fruits. This increase in the lycopene content during ripening was mainly due to the gradual degradation of chlorophyll and accumulation of carotenoids [17]. The results obtained in present investigation are in agreement with a number of studies [17–19]. Similar effect of SA on lycopene content of tomato fruits are reported in many studies [20, 21].



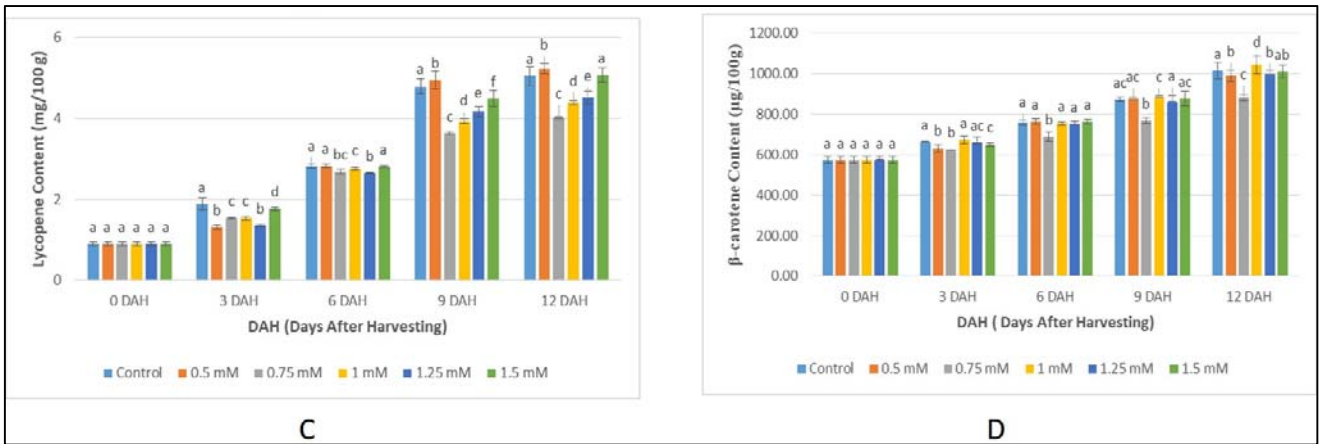


Fig 1: Effect of Salicylic acid treatment on (A) PLW (B) TSS (C) Lycopene (D) β-carotene in tomato fruits stored at turning stage

β-carotene: The β-carotene content of treated and control tomato fruits increased gradually. The β-carotene content (Fig. 1D) of control fruits increased from 573.38 µg/100g at 0 DAH to 1014.33 µg/100g at 12 DAH. The exogenous application of SA significantly affected the degradation of carotene content which resulted into postponement of increase in β-carotene content. SA concentration of 0.75 mM was more effective in retaining the carotene content among all treatments. The increase in the β-carotene may be due to the increase in the lycopene concentration [19]. The results obtained in present investigation are in agreement with many studies on various fruits like gac fruit [22], tomato [19, 23, 24] and mango [25].

Sugars: During storage of tomato fruits, the total soluble sugar content first increased significantly and thereafter decreased (Fig. 2A). Total sugar content increased from 13% at 0 DAH to 15.46% at 6 DAH and then it start decreasing to 13.65 % at 12 DAH. Salicylic acid concentrations 0.75 mM and 1.0 mM most effectively and significantly postponed the increase in total sugars from 6 DAH to 9 DAH in variety Hisar Arun. From the results displayed in the Fig. 2B, it is clear that the reducing sugars content followed the same trend as total sugars. Reducing sugars first increased significantly upto its maximum value and decreased thereafter. Control fruits expressed the increase in reducing sugar from 10.37 % at 0 DAH to 11.24 % at 6 DAH and reduced to 10.90 % at 12 DAH. Salicylic acid application was observed to delay in increase on reducing sugars from 6 DAH to 9 DAH. SA concentrations 0.75 mM was most effective. Non-reducing sugars (Fig. 2C) followed the same pattern of results as total sugars and reducing sugars. The results obtained are in agreement with other reports on various fruits such as tomato [26–28].

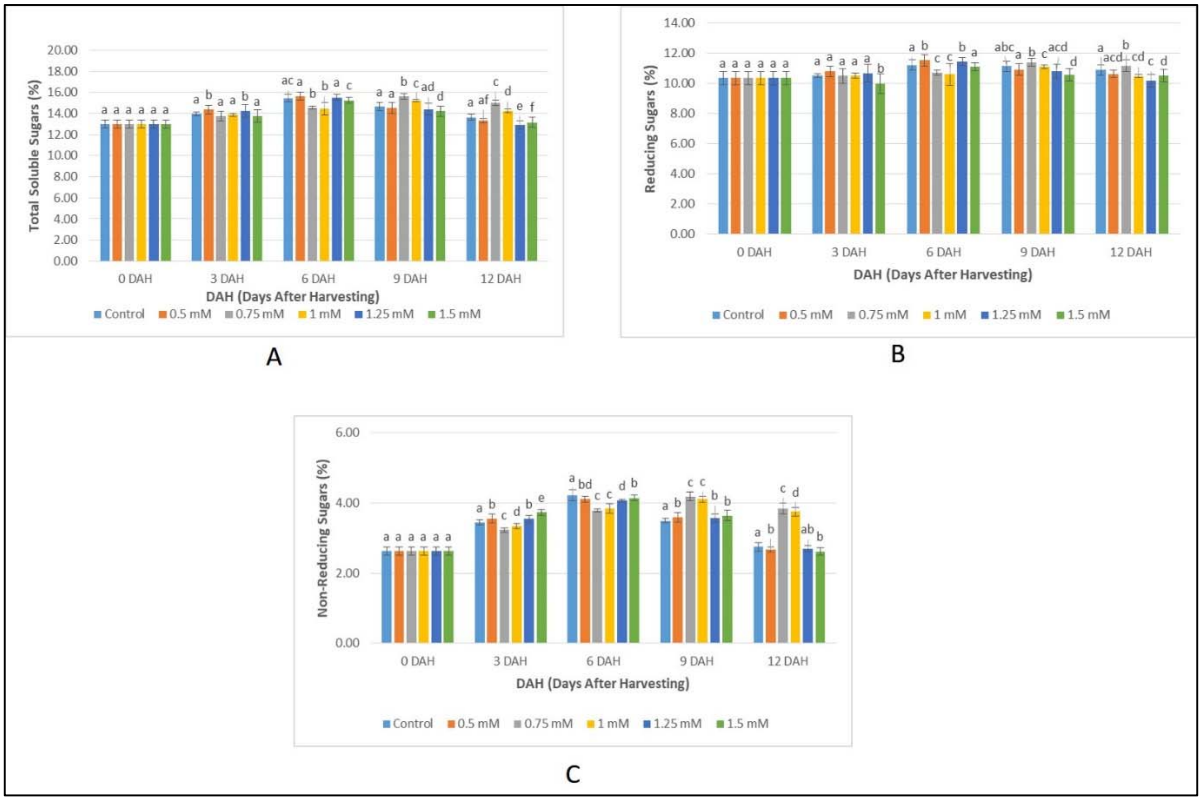


Fig 2: Effect of Salicylic acid treatment on (A) Total soluble sugars (B) Reducing sugars (C) Non-reducing sugars in tomato fruits stored at turning stage

Conclusion

The results obtained in the present research indicated that the 0.75 mM concentration of SA was most effective in delaying the ripening related biochemical and physical changes. SA extended the shelf life of both varieties upto 4 to 6 days. Therefore, it can be concluded that the exogenous application of SA is an effective approach in enhancing the shelf life of the fruits.

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