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SHORT COMMUNICATION

Effectiveness of postharvest treatment with salicylic acid and mineral nutrients in the control of gray mould rot of strawberry

Hare Krishna*, B.L. Attri and Akhilesh Kumar
Central Institute of Temperate Horticulture-Regional Station Mukteshwar-263 138, District-Nainital, Uttarakhand
* Present address: Central Institute for Arid Horticulture, Bikaner-334 006, Rajasthan

Strawberry (*Fragaria x ananassa*) is a non-climacteric fruit with a very short postharvest life. Loss of quality in this fruit is mostly due to its relatively high metabolic activity and sensitivity to fungal decay (Hernandez-Munoz *et al.*, 2008). Grey mold, caused by *Botrytis cinerea* Pers. Fr., is the most economically significant postharvest pathogen of strawberry fruits. The use of synthetic chemical fungicides has been the main method for reducing postharvest disease. However, consumer concern over pesticide residues on foods, along with pathogen resistance to many currently used pesticides, has increased the need to find alternative methods for decay control (Karlidag *et al.*, 2009).

Research has shown the promise for application of calcium (Ca) and boron (B) on resistance of fruits to pathogenic fungi during storage (Krishna *et al.*, 2012). It is well known that Ca plays a major role in maintaining the quality of fruits and vegetables. Increasing the Ca content in the cell wall of fruit tissue can help to delay softening and mold growth and decrease the incidence of pathogenic fungi (Hernandez-Munoz *et al.*, 2008). There are a few bio-regulators such as salicylic acid (SA), which is thought to affect the shelf life of fruits. Application of SA has been observed to improve fruit quality during storage, retard ripening and spoilage of fruits (Krishna *et al.*, 2012). SA, a natural compound, has a high potential in suppressing ethylene production and fungal decay in harvested fruits. SA is an acquired systemic resistance activator that can elicit activation of genes involved in plant defense and pathogenesis-related proteins (Karlidag *et al.*, 2009). The purpose of the present investigation was to determine the effects of different nutrients (Ca and B) and bio-regulator (SA) on strawberry shelf life and fruit quality at harvest and storage.

Fruits of strawberry cultivar Steel Master were harvested from the Experimental Farm of Central Institute of Temperate Horticulture-Regional Station, Mukteshwar, Uttarakhand. Strawberries were selected for the absence of any physical damage and fungal infection, uniformity in size and degree of ripening (2/3 red color on surface).

B. cinerea was isolated from an infected strawberry and cultured on a potato dextrose agar medium following the method of Zhang *et al.* (2007). Spore suspensions were prepared by removing the spores from the sporulating edges of a 12-week-old culture incubated at 27 °C with a bacteriological loop, and suspending them in sterile distilled water.

The experiment consisted of three postharvest treatments, besides control with 20 fruits per replication. The concentration of different nutrients and bio-regulators used in the experiment were SA @ 400 mgl^{-1}, Ca as Ca-EDTA @ 1000 mgl^{-1} and B as Boric acid @ 0.2 %. Strawberries were pooled together and randomized, and then immersed for 5 min. in a 5 L volume of the respective solutions. Strawberries immersed in deionised water were used as the control. After the treatments, the fruit were dried in air for 1 h followed by dip in spore suspension of fungus for 10s. Later, fruits were arranged in small plastic boxes. These were then stored for 3 days at 25 ± 1 °C, 7580% RH.

The pH of the fruit juice was determined using a pH meter (Inolab pH 730, Merck Specialities Pvt. Ltd., India). The soluble solids content (SSC) was determined in the juice of strawberries by means of Abbe's hand refractometer calibrated at 20 °C.

Fungal decay index was calculated as per the method suggested by Babalar *et al.* (2007). According to the amount of the fungal mold on fruit surface scales from 1 to 5 were given to the each treatment group where; 1 = normal (no decay on fruit surface), 2 = trace (up to 5% of fruit surface were decayed), 3 = slight (520% of fruit surface were decayed), 4 = moderate (2050% of fruit surface were decayed), and 5 = severe (>50% of fruit surface were decayed).

Overall quality (percentage of fruit surface area decayed, shrunken and adversely affected) was evaluated following the method of Babalar *et al.* (2007) using a 15 scale, where 1 = unacceptable (>50% surface affected), 2 = bad (2050% surface affected), 3 = acceptable (520% surface affected), 4 = good (up to 5% surface affected), and 5 = excellent (no decay, shrinkage or any other adverse effects on fruit surface were seen). Results were expressed as an overall quality index. The experiment was conducted with completely randomized block design with three replications. Data obtained were subjected to the analysis of variance.

*Corresponding author's e-mail: kishun@rediffmail.com

Changes in the SSC of strawberries over storage time are shown in Fig. 1. With the progress of time, SSC content was observed to increase in strawberry fruits, irrespective of treatments; however, the SSC of treated fruits fell slightly toward the end of the storage period. Increase in TSS content indicates conversion of polysaccharides presents in fruits into soluble sugars by the action of various hydrolyzing enzymes. The reduction in SSC at 3-day post-storage period may be attributed to the catabolism of sugars by respiration. Absence of reduction in SSC content at 3-day in salicylic acid treated fruits could be ascribed to inhibition of respiration rate by action of salicylic acid as reported by Krishna *et al.* (2012). As shown in Fig. 2, the pH of treated fruits increased during later stages of storage, irrespective of the treatments; while no significant differences were observed at first day. This has agreement with the findings of (Hernandez-Munoz *et al.*, 2008) with strawberries treated with calcium and chitosan. Hernandez-Munoz *et al.* (2008) reported that application of salicylic acid resulted in increased content of soluble solids and total acidity of strawberry fruits at the end of storage period without affecting the other vital parameters of fruit quality.

The progress of fungal decay was slower in treated fruits (Fig. 3). This was more conspicuous in SA treated fruits. Studies have shown that salicylic ac d treatment can enhance disease resistance in treated fruits (Babalar *et al.*, 2007). In our study too, salicylic acid treatment prevented pathogenic infection as evidenced by less spoilage in treated fruits, confirming the fact that SA leads to plant defense system activation against pathogens. Pre or postharvest use of Ca and B has shown promise in

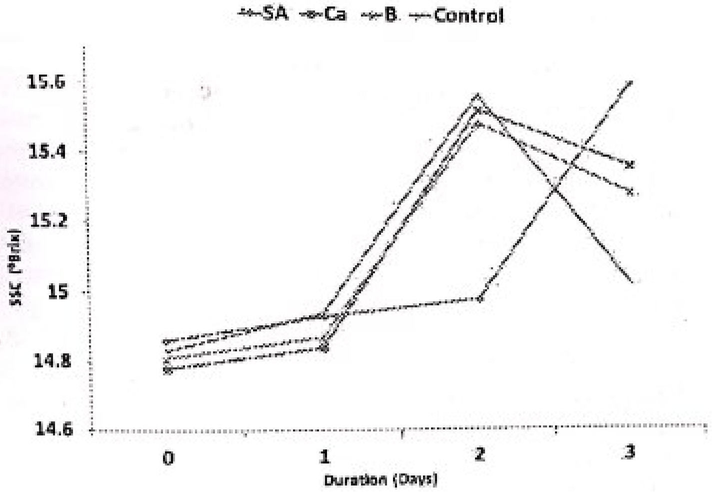

Fig. 1. Effect of different treatments on soluble solid content (°Brix) content of strawberry fruits at different storage periods.

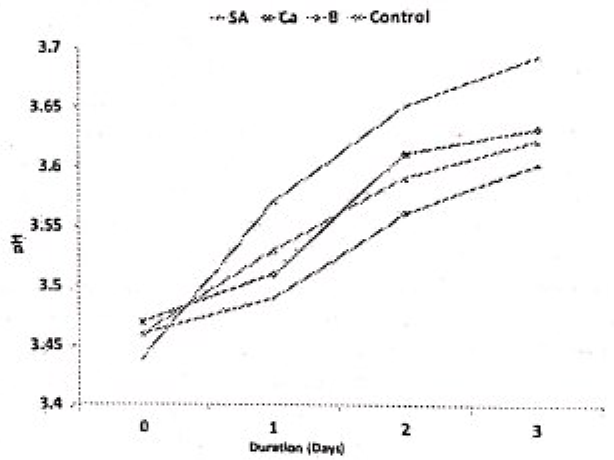

Fig. 2. pH of strawberries fruits as a function of storage time.

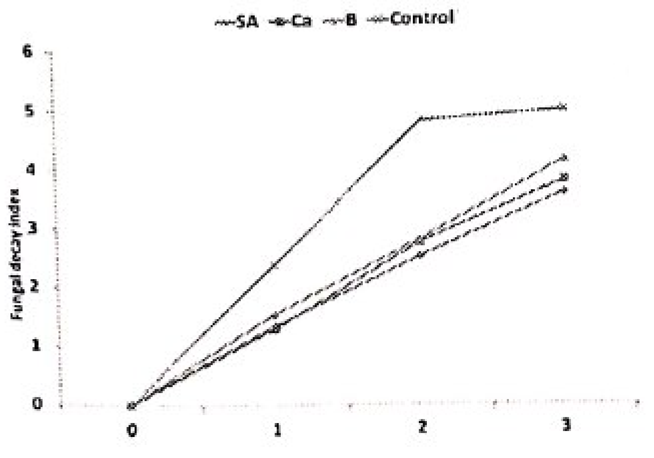

Fig. 3. Variations in fungal decay index as influenced by different treatments at various post-storage periods.

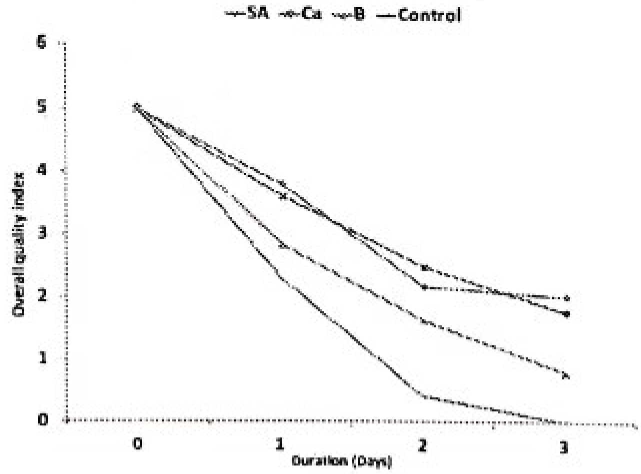

Fig. 4. Overall quality index of strawberry fruits as influenced by different treatments during storage.

reducing decay caused by diseases caused by various moulds (Babalar *et al.*, 2007; Hernandez-Munoz *et al.* 2008; Krishna *et al.*, 2012).

Likewise, SA significantly affected fruit overall quality index. This was followed by Ca and B treatments, respectively (Fig. 4). Overall quality is the most important factor in fruit marketability assessment. Fruits lacking any kinds of decay and shrivels with high red colour are considered as marketable. SA treatment effectively helped retaining the fruit overall quality. The effect of SA on fruit overall quality index retention could mostly be due to its adverse effect on fungal decay extension (Babalar *et al.*, 2007).

In summary, treatment with mineral nutrients like Ca & B and bio-regulator, SA was seen to delay fruit senescence and fungal decay of strawberry fruits stored at 25 ± 1 °C and 7580% RH. Least decay and improved overall quality index was noted in fruits treated with SA. Therefore, salicylic acid, a natural and safe phenolic compound, may be considered for its wide application in controlling postharvest losses of strawberry fruits.

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