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Reducing postharvest pericarp browning and preserving health promoting compounds of litchi fruit by combination treatment of salicylic acid and chitosan

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ABSTRACT

Litchi (*Litchi chinensis* Sonn.) is one of the important fruit crops of the subtropical region. The fruit is highly perishable in nature and losses its commercial value within 1–2 days after harvest due to pericarp browning and deterioration in fruit quality. In the present study, effect of postharvest treatment with salicylic acid (0.5 mM and 1.0 mM) and chitosan (2%) on reducing pericarp browning and preserving functional and sensory quality of litchi fruit was investigated. Physiologically mature litchi fruits (cv. Purbi) were treated with salicylic acid (0.5 mM and 1.0 mM) and chitosan (2%) alone or in combination by dipping method for 5 min. Following treatments, fruits were air-dried and stored at 4 °C for 6 days. The results showed that among the applied treatments, salicylic acid (1.0 mM) in combination with chitosan (2%) was highly effective in reducing pericarp browning, weight loss, decay loss and maintaining higher anthocyanins, phenolics, flavonoids, ascorbic acid and antioxidant capacity than control fruits. This treatment showed 1.4-fold lower pericarp browning, 1.6-fold lower weight loss and 6.7-fold lower decay loss than control. It also maintained 88% higher anthocyanin, 47% higher total phenolics, 29% higher total flavonoids and 35% higher total antioxidant capacity than control fruits. It also delayed increase in total soluble solids content in litchi fruit during storage. There was no significant effect of treatments on titratable acidity during storage but ascorbic acid content was maintained higher in treated fruits. Thus, combination treatment of 1.0 mM salicylic acid and 2% chitosan can be used to reduce pericarp browning and preserving quality of litchi fruit during postharvest storage.

1. Introduction

Litchi (*Litchi chinensis* Sonn.) is an evergreen fruit crop of subtropical region, having high commercial value due to its pleasing flavoured translucent aril, refreshing taste and nutritive value. Litchi fruits are non-climacteric in nature and do not develop full flavour after detaching from the parent plant for which, it is harvested at ripe stage (Swart, 1983). Generally, development of red colour on peel and flattening of tubercles are the main visual symptoms for harvesting the litchi fruits. Once the fruit is harvested, its attractive red coloured pericarp rapidly turns brown and losses its commercial value and consumer acceptance within 1–2 days. Pericarp browning is the major limitation for long term storage of litchi fruit following harvest. Rapid losses of moisture from peel, oxidation of phenolic compounds along with breakdown of anthocyanin pigments by the enzymes polyphenol oxidase (PPO) and/or peroxidase (POD) are the main causes of pericarp browning (Jiang et al., 2005). Commercially, litchi fruits after harvest are fumigated with sulphur dioxide to minimize browning of fruit pericarp during storage. But, this treatment adversely affects consumers and packhouse workers by causing health hazards. This treatment also alters the fruit taste by increasing its acidity. During fumigation with sulphur dioxide, fruits absorb 30–65% of applied sulphur which is beyond the maximum permissible limit of 10 ppm, permitted by

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litchi importing countries like Europe, Japan and Australia (Kumar et al., 2012). Due to these reasons, numerous approaches have been tried by several researches to develop an alternative safe treatment to the existing sulphur fumigation, to minimize postharvest pericarp browning of litchi.

Salicylic acid (SA), also known as monohydroxy benzoic acid belongs to a group of phenolic compounds, present ubiquitously in the plant kingdom (Raskin, 1992a). It is a signal molecule, also proposed to be a plant hormone, plays an important role in various physiological processes in plants (Raskin, 1992a). SA is involved in seed germination, photosynthesis, transpiration, stomatal closure, thermogenesis, cell growth, ion uptake and local and systemic resistance to diseases (Klessig and Malamy, 1994; Clarke et al., 2004; Harper and Balke, 1981). Recently, SA has received particular attention in postharvest management of horticultural crops due to its anti-ripening, anti-senescence and enhancing resistance to various biotic and abiotic stresses (Asghari and Aghdam, 2010).

Chitosan is a biologically safe compound, derived from waste exoskeleton material of crab and shrimps harvest (Hadwiger, 2013). It is a natural polymer having antifungal and antibacterial properties. It also plays an important role in biochemical and molecular activity such as oxidative burst (Paulert et al., 2010), pathogenesis related gene (Loschke et al., 1983), hypersensitivity response (Hadwiger and Beckman, 1980) etc. Chitosan coating forms cellophane like structure on the fruit surface and prevent the fruit from microbial attacks. It releases reactive oxygen species (ROS) and acts as signalling molecule between different plant–pathogenic interaction (Bolwell and Daudi, 2009). The present study was conducted to explore the possibility of SA and chitosan treatment of litchi fruit to reduce pericarp browning against sulphur dioxide fumigation and also to understand its effect on various fruit quality attributes during storage.

2. Materials and methods

Litchi fruits (cv. Purbi) were harvested at fully mature stage (90–100% of the pericarp showing red colour) from the orchard of Horticulture Garden, Department of Horticulture (Fruit and Fruit Technology), Bihar Agricultural University, Sabour, Bhagalpur, Bihar. Fruits of uniform size, shape, colour and free from disease, pest or physical injury were selected for the experiment. A total 300 fruits were taken for the experiment and divided into 6 lots having 50 fruits in each treatment. After that, fruits were treated with aqueous solutions of SA (0.5 mM, 1.0 mM) and chitosan (2%) alone or in combination while in control, fruits were treated with distilled water. Treatments of fruit were performed by dipping them in 10 L treatment solution containing Tween-20 (2 g L^{-1}) as surfactant, at 25 °C for 5 min. After treatment application, fruits were air-dried and stored at 4 ± 1 °C for 6 days. At 2 days interval, fifteen fruits from each treatment (each replicate contained five fruit) were sampled at random and analysed for various physico-chemical quality attributes on fresh weight basis.

2.1. Weight loss

To determine the weight loss (WL) of litchi fruit during postharvest storage, both treated and control fruits were weighed at different sampling intervals. Then WL was calculated as the difference between initial fruit weight and the fruit weight at the time of measurement and expressed as percentage (%).

2.2. Pericarp browning

Pericarp browning of litchi was determined visually by measuring the extent of total browned area on fruit pericarp. Browning was assessed as per the following scale: 0 = no browning (excellent quality); 1 = slight browning; 2 = <1/4 browning; 3 = 1/4 – 1/2 browning; 4 = 1/2 – 1/3 browning and 5 = >1/3 browning (poor quality) (Kumar et al., 2013). Finally, the browning index was calculated by multiplying the number of litchi fruit in a group with their respective score, summing the products and dividing by the total number of fruits.

2.3. Decay loss

Decay loss was calculated by dividing the number of fruits showed symptoms of decay, irrespective of severity by the total number of fruits under observation at the initial day of experiment and the results were expressed as percent (%).

2.4. Total anthocyanins content

Total anthocyanins content was estimated in the fruit pericarp following the method of Wrolstad et al. (2005). Fruit pericarp (2 g) was finely sliced and pigments were extracted by crushing with 80% ethanol. The extract was then centrifuged and supernatants were diluted with potassium chloride buffer (0.025 M, pH1.0) and sodium acetate buffer (0.4 M, pH4.5). Following that absorbance was recorded at 520 nm and 700 nm in a spectrophotometer (HALO DB-20S UV–vis Double beam spectrophotometer, Australia). Total anthocyanins content in the fruit pericarp was expressed as mg 100 g^{-1} of pericarp weight.

2.5. Total phenolics content

Total phenolics content in the edible portion of fruit was determined using Folin–Ciocalteu reagent (Singleton et al., 1999). For this, 2.9 ml of distilled water, 0.5 ml of Folin–Ciocalteu reagent and 2.0 ml of 20% Na_2CO_3 solution was added to 100 μl of sample extract (in 80% ethanol). After that, mixture was allowed to stand for 90 min and absorbance was recorded in a spectrophotometer at 760 nm wavelength. Finally, the results were expressed as μg gallic acid equivalent g^{-1} FW (fresh weight).

2.6. Total flavonoids content

Total flavonoids content was estimated using aluminium chloride method (Zhishen et al., 1999). To do this, 1 ml of litchi extract in methanol was taken in 4 ml of distilled water, 0.3 ml of 5% sodium nitrite ($NaNO_2$) and 0.3 ml of 10% aluminium chloride ($AlCl_3 \cdot 6H_2O$). The mixture was allowed to stand for 6 min at room temperature. Then, after adding 2 ml of 1 N NaOH, the solution was diluted to 10 ml with distilled water. Finally, the absorbance of the solution was recorded at 510 nm in a spectrophotometer against a reagent blank. The results were expressed μg Catechin equivalent g^{-1} FW.

2.7. Total antioxidant capacity

Total antioxidant capacity was determined following CUPRAC (Cupric reducing antioxidant capacity) assay of Apak et al. (2008). To do this, 0.1 ml of sample extract (in 80% ethanol) was added to 1 ml each of copper(II) chloride solution, neocuproine solution, ammonium acetate buffer solution and distilled water in a test tube. The mixture was then allowed to stand for 30 min and the absorbance was recorded at 450 nm in a spectrophotometer. The results were expressed as μmol Trolox equivalent g^{-1} FW.

2.8. Radical scavenging activity

The radical scavenging activity towards the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical was estimated following method of