



## Combinational effect of chemical treatments on quality of litchi (*Litchi chinensis*) during storage

K S DHAMI<sup>1\*</sup> and V R SAGAR<sup>1</sup>

ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

Received: 04 February 2020; Accepted: 13 April 2021

### ABSTRACT

Attractive red-coloured pericarp is one of the most important factors in the consumer decision to purchase litchi (*Litchi chinensis* Sonn.). Red colour of the pericarp turns brown within 2-3 days after harvest which reduces the marketability and commercial value of the fruit drastically and finally incurring huge financial losses to growers. This study was carried out to evaluate the possibility of using combinational application of sodium hypochlorite with sodium chlorite and carnauba wax on the quality of harvested litchi during storage (2016–17). Postharvest treatments included sequential dipping in sodium hypochlorite (0.2%) (T<sub>1</sub>), sodium hypochlorite (0.2%) + sodium chlorite (0.05%) (T<sub>2</sub>), sodium hypochlorite (0.2%) + carnauba wax (10%) (T<sub>3</sub>) and untreated (control) (T<sub>4</sub>). Treated fruit were then packed in plastic punnets and stored at 2°C and 90-95% relative humidity (RH). All the treatments significantly reduced pericarp browning over control. The most remarkable effect was obtained in fruits treated with sodium hypochlorite (0.2%) in combination with sodium chlorite (0.05%) as evidenced by delayed anthocyanin degradation, lower polyphenol oxidase activity, fruit decay and weight loss. This treatment also maintained better fruit quality as indicated by higher total soluble solids and phenolic content in fruits, thus can be used as a cost-effective method to reduce pericarp browning and prolong marketable life of litchi up to 25 days.

**Keywords:** Litchi, Carnauba, Sodium chlorite, Sodium hypochlorite, Storage, Quality

Litchi (*Litchi chinensis* Sonn.) which is popular for its attractive deep red colour, tasty juicy aril and refreshing taste belongs to the Sapindaceae family. Litchi contains abundant amount of vitamin C and minerals like magnesium, potassium, calcium and phosphorous. India produces 686 thousand MT of litchi from 92000 ha annually, of which Bihar contributes almost 40% of total production followed by West Bengal, Jharkhand, Assam, Punjab and Uttarakhand (Anonymous 2017). Red-skin colour is the most important factor that consumers consider before purchase of litchi fruit, but the red colour of the pericarp turns brown within 2-3 days of harvesting of the fruits. Pericarp browning reduces the market value of the fruit drastically. The main reasons for pericarp browning are desiccation, mechanical injury and microbial or pathogenic infection. The rapid degradation of anthocyanin pigments by enzymes along with oxidation of phenolic compounds is found to be the main cause of browning of pericarp (Jiang 2000).

Lot of efforts in postharvest handling of litchi have been directed towards control of pericarp browning but each effort had its certain limitations either pertaining to tedious and costly method of applications or short duration effect or human health concern. Sodium hypochlorite is generally used as a disinfectant in postharvest management of fruits and vegetables due to its established disinfectant and fungicidal property (Cerioni *et al.* 2009). Surface coatings, including carnauba-based wax, are known to maintain the quality of stored fruit crops by suppressing moisture loss, improving the strength of peel tissue and controlling ripening by modifying CO<sub>2</sub> and O<sub>2</sub> concentrations inside the fruit (Baldwin 2003, Lobo and Yahia 2017). Sodium chlorite (SC) which generates chlorine dioxide (ClO<sub>2</sub>) in an acidic environment reported to reduce enzymatic browning and microbial contamination of fruits and vegetables (Liu *et al.* 2006, Luo *et al.* 2011). The present study was conceptualized with the aim to evaluate the possibility of using these chemicals and carnauba wax as a combinational method to inhibit the pericarp browning and control decay of litchi fruits under storage system.

### MATERIALS AND METHODS

Litchi fruits (cv. Shahi) were harvested from the experimental farm of ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar during 2016–17 at correct

Present address: <sup>1</sup>ICAR-Indian Agricultural Research Institute, New Delhi. \*Corresponding author e-mail: karandhami4u@yahoo.com.

harvest maturity and transported to laboratory of Division of Food Science and Post Harvest Technology, IARI, New Delhi in CFB boxes. Upon arrival at the laboratory within 28 hr, sorting was done to remove the spoiled fruits and only healthy and unblemished fruits were used for the study. Thereafter, the following combination of treatments were applied: T<sub>1</sub>: Sodium hypochlorite (NaOCl, 0.2%); T<sub>2</sub>: Sodium hypochlorite (NaOCl, 0.2%) + Sodium chlorite (NaClO<sub>2</sub>, 0.05%); T<sub>3</sub>: Sodium hypochlorite (NaOCl, 0.2%) + Carnauba wax (10%); and T<sub>4</sub>: No treatment (Control). Treatment was applied by sequentially dipping the fruits in each chemical solution for 5 min. On completion of sequential dip treatment fruits were completely surface dried, and thereafter, packed in CFB boxes and stored under cold storage conditions (2°C and 85–90% relative humidity). The fruit samples were analysed for physio-chemical attributes at 5 days intervals and for PLW at 2 days intervals until the fruits became unmarketable.

Pericarp browning of litchi was visually assessed by measuring the total browned area on the pericarp taking 50 fruits of each treatments using following scale: 0: No browning (Excellent quality); 1: Slight browning; 2: < ¼ Browning; 3: ¼ – ½ Browning; 4: ½ – 1/3 Browning; 5: > 1/3 Browning (poor quality). The browning index was calculated as BI =  $\sum$  (Browning scale × % of corresponding fruits within each class). Fruits having browning index above 2.0 were considered as unacceptable for marketing. Physiological loss in weight was calculated as the difference between the initial weight and the final weight at the time of measurement and expressed as the percentage of initial fruit weight. Fruit quality attributes such as total soluble solids (TSS) and total phenolics content were determined following standard methods (Ranganna 2008). The total anthocyanins content was determined using the pH-differential method (Wrolstad *et al.* 2005) using two buffer systems—potassium chloride buffer, pH 1 (0.025 M) and sodium acetate buffer, pH 4.5 (0.4 M). Polyphenol oxidase activity was assayed according to the method of Zauberman *et al.* (1991) with catechol as a standard. The fruit decay percentage was determined by visually counting the number of infected/spoiled fruits and expressed as per cent of total number of fruits.

The experiment was conducted in a factorial completely

randomized design (CRD) with three replications, each replication having 50 fruits. The data were analyzed using the WASP 2.0 (Web Agri Stat Package) and the results were compared from ANOVA by calculating the critical difference (CD) at 5% level of significance.

## RESULTS AND DISCUSSION

*Physiological loss in weight:* Fruits treated with sodium hypochlorite followed by sodium chlorite showed better results than the carnauba wax treated fruits. Fruits treated with sodium hypochlorite (0.2%) followed by sodium chlorite (0.05%) had no significant difference in water loss and total soluble sugars content with that of carnauba wax coated fruits. These two treatments may have possibly maintained cell integrity and permeability of tissues, thereby hindering the loss of moisture from the surface than that of the control fruits (Table 1).

*Total soluble solids (TSS):* There was gradual increase in TSS up to 10 days in all the treatments but decreased in later part of storage (Table 2). The initial increase in TSS may be due to dehydration and breakdown of starch and polysaccharides into simple sugars. But, biochemical activities like utilisation of reducing sugars and other organic metabolites may have decreased TSS content in the fruits later (Marboh *et al.* 2012).

*Anthocyanin content:* Degradation of anthocyanin pigments was found in all the fruits with the advancement of storage period. However, fruits treated with sodium chlorite had highest anthocyanin content (18.9 mg/100 g) followed by fruits treated with carnauba wax (17.6 mg/100 g) as compared to control fruits (13.4 mg/100 g) after 25 days of storage (Table 2). Higher concentration of anthocyanins in sodium chlorite-treated fruits may be due to reduced water loss maintaining membrane integrity (Bhushan *et al.* 2015) and reduced pH because of acidic nature of chlorite, thus, improving red coloration in the fruit pericarp (Underhill and Critchley 1995).

*Total phenolic content:* Dramatical decrease in total phenolic content was found in all the fruits during storage which might have due to oxidation and causing the brown colour during the browning process. However, all the treated fruits retained phenolic content where highest phenolic

Table 1 Effect of different treatments on physiological loss in weight (%) of cold stored litchi fruits

| Treatment      | Storage days |      |      |      |      |      |      |      |       |       |       |       |      |
|----------------|--------------|------|------|------|------|------|------|------|-------|-------|-------|-------|------|
|                | 2            | 4    | 6    | 8    | 10   | 12   | 14   | 16   | 18    | 20    | 22    | 24    | Mean |
| T <sub>1</sub> | 2.13         | 4.23 | 5.36 | 6.29 | 7.14 | 8.13 | 8.73 | 9.48 | 10.04 | 10.68 | 11.21 | 11.79 | 7.93 |
| T <sub>2</sub> | 2.08         | 3.92 | 5.17 | 5.83 | 6.70 | 7.44 | 7.85 | 8.38 | 8.95  | 9.40  | 9.73  | 9.93  | 7.12 |
| T <sub>3</sub> | 1.55         | 3.84 | 5.15 | 5.86 | 6.79 | 7.48 | 7.92 | 8.49 | 9.18  | 9.57  | 9.87  | 10.04 | 7.15 |
| T <sub>4</sub> | 2.38         | 4.53 | 6.01 | 6.58 | 7.46 | 8.30 | 8.84 | 9.50 | 10.11 | 10.70 | 11.31 | 11.93 | 8.14 |
| Mean           | 2.04         | 4.13 | 5.42 | 6.14 | 7.02 | 7.84 | 8.34 | 8.96 | 9.57  | 10.09 | 10.53 | 10.93 |      |
| CD (P=0.05)    |              |      |      |      |      |      |      |      |       |       |       |       |      |
| Treatment (A)  | 0.624        |      |      |      |      |      |      |      |       |       |       |       |      |
| Storage (B)    | 0.967        |      |      |      |      |      |      |      |       |       |       |       |      |
| A × B          | 2.163        |      |      |      |      |      |      |      |       |       |       |       |      |

Details of treatments are given in Materials and Methods.

Table 2 Effect of different treatments on chemical constituents of cold stored litchi fruits

| Parameter                         | Treatment (A)  | Storage days (B) |       |       |       |       |       | Mean  | CD (P=0.05) |       |       |
|-----------------------------------|----------------|------------------|-------|-------|-------|-------|-------|-------|-------------|-------|-------|
|                                   |                | 0                | 5     | 10    | 15    | 20    | 25    |       | A           | B     | A × B |
| Total soluble solids (°B)         | T <sub>1</sub> | 17.7             | 18.1  | 18.6  | 18.4  | 18.4  | 17.9  | 18.2  | 0.16        | 0.20  | 0.40  |
|                                   | T <sub>2</sub> | 17.8             | 18.2  | 18.7  | 18.5  | 18.3  | 18.0  | 18.3  |             |       |       |
|                                   | T <sub>3</sub> | 17.6             | 18.0  | 18.5  | 18.3  | 18.3  | 17.9  | 18.1  |             |       |       |
|                                   | T <sub>4</sub> | 17.7             | 18.1  | 18.6  | 18.3  | 18.2  | 17.8  | 18.1  |             |       |       |
|                                   | Mean           | 17.7             | 18.1  | 18.6  | 18.4  | 18.3  | 17.9  |       |             |       |       |
| Anthocyanin content (mg/100 g)    | T <sub>1</sub> | 38.8             | 32.8  | 26.3  | 22.6  | 17.5  | 14.9  | 25.5  | 4.23        | 5.18  | 10.37 |
|                                   | T <sub>2</sub> | 38.6             | 34.0  | 30.1  | 26.9  | 22.6  | 18.9  | 28.5  |             |       |       |
|                                   | T <sub>3</sub> | 39.0             | 33.4  | 29.8  | 25.7  | 21.2  | 17.6  | 27.8  |             |       |       |
|                                   | T <sub>4</sub> | 38.6             | 31.3  | 25.8  | 21.6  | 17.0  | 13.4  | 24.6  |             |       |       |
|                                   | Mean           | 38.7             | 32.9  | 28.0  | 24.2  | 19.6  | 16.2  |       |             |       |       |
| Total phenolic content (µg GAE/g) | T <sub>1</sub> | 315.0            | 256.8 | 223.8 | 196.1 | 160.4 | 129.9 | 213.7 | 19.87       | 24.34 | 48.68 |
|                                   | T <sub>2</sub> | 314.6            | 267.7 | 238.8 | 217.0 | 188.3 | 156.2 | 230.4 |             |       |       |
|                                   | T <sub>3</sub> | 315.1            | 267.5 | 236.6 | 213.4 | 180.7 | 149.6 | 227.2 |             |       |       |
|                                   | T <sub>4</sub> | 314.6            | 253.7 | 220.4 | 191.2 | 152.9 | 116.6 | 208.2 |             |       |       |
|                                   | Mean           | 314.8            | 262.4 | 229.9 | 204.4 | 170.5 | 138.0 |       |             |       |       |

Details of treatments are given in Materials and Methods.

content (156.7 µg GAE/g) was found in sodium chlorite followed by carnauba wax (149.6 µg GAE/g) in comparison to control fruits (116.6 µg GAE/g) at 25 days of storage (Table 2). Increasing trend in PPO activity in litchi fruit might have lowered the phenolic content in the fruits due to oxidization of phenolic compounds (Duan *et al.* 2007). In contrast, higher content of phenolic compounds in sodium chlorite treated fruits may be due to lower PPO activity. A similar trend of phenolic content has also been reported in litchi (Liang *et al.* 2012).

*Polyphenol oxidase activity:* There was significant

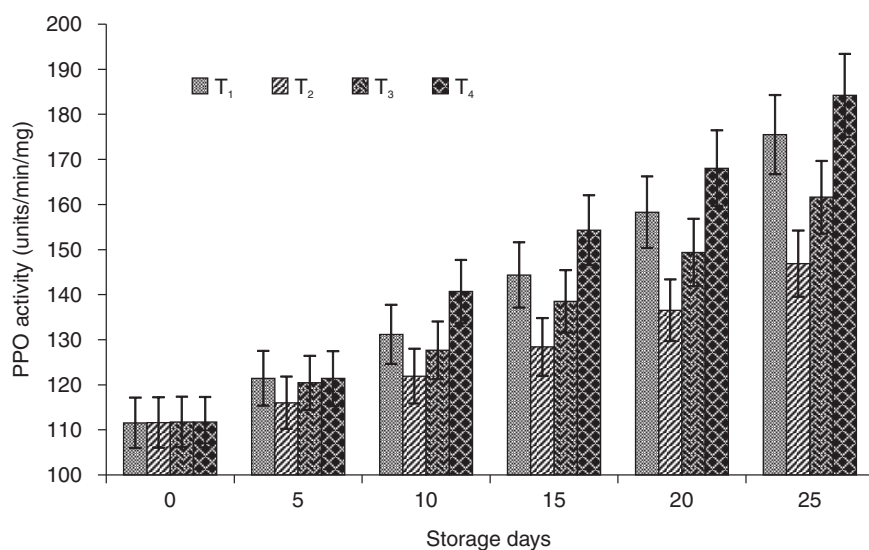


Fig 1 Effect of different treatments on PPO activity of litchi stored at 2°C and 90–95% RH.

increase in the activities of PPO enzyme during the 25 days of storage period however, the lowest PPO activity (146.9 units/min/mg) was found in the the fruits treated with sodium chlorite, whereas the control fruits had the highest (161.6 units/min/mg) PPO activity (Fig 1). PPO contains copper (Cu) which is essential for enzyme activity in its active site (McEviley *et al.* 1992) so, sodium chlorite might have affected the oxidation level of copper by binding with it causing alternation in the catalysis of PPO activity (Yoruk and Marshall 2003). Also, sodium chlorite delayed browning which may be due to reducing the pH of the product thus minimizing PPO activity (Suttirak and Manurakchinakorn 2010).

*Pericarp browning:* All the fruits showed increase in pericarp browning with the extending storage period of 25 days. However, fruits treated with sodium chlorite had lowest browning index (2.1) followed by carnauba wax treated fruits (2.2) when compared with control fruits (4.9) at 25 days of storage (Fig 2). This may be due to higher anthocyanin content and lower PPO activity in the fruits treated with sodium chlorite. In a similar study, Khunpon *et al.* (2011) reported that sodium chlorite treatment reduced PPO activity thus, delaying the exocarp browning in langan fruits cv. Daw.

*Fruit decay:* Sodium chlorite being the oxidizing as well as sanitizing

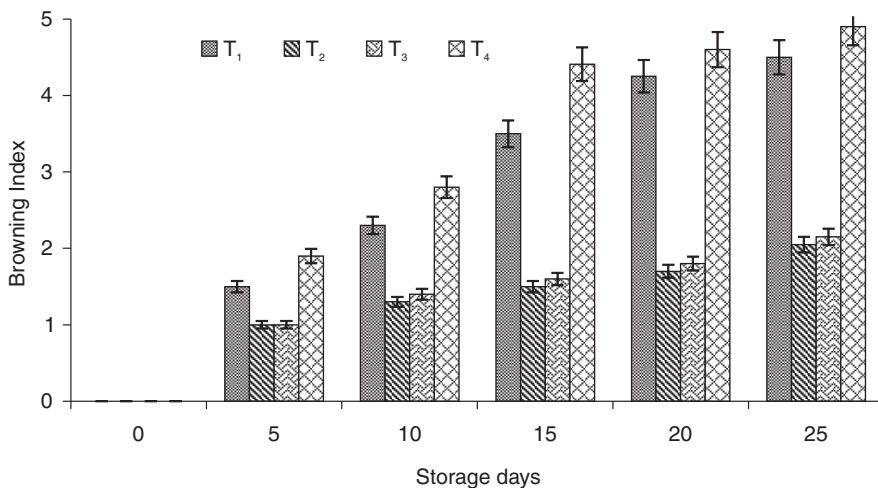


Fig 2 Effect of different treatments on pericarp browning of litchi stored at 2°C and 90–95% RH.

agent found to have least spoilage of fruits (10%) followed by carnauba wax coated fruits (14%) when compared to control fruits (55%) on 25<sup>th</sup> day of storage. Carnauba wax could not be as effective as sodium chlorite, which may be due to long period anaerobic storage of fruits causing them susceptible to some anaerobic microbes (Nigam *et al.* 2000).

The results showed that combination treatments of sodium hypochlorite with sodium chlorite or carnauba wax can be one of the effective methods in reducing the pericarp browning of litchi and retaining other quality parameters of litchi fruits during storage at 2°C for 25 days. However, the remarkable result was found with sodium hypochlorite (0.2%) in combination with sodium chlorite (0.05%) followed by carnauba wax (10%), which was effective in delaying anthocyanin degradation, polyphenol oxidase activity and weight loss as well as retaining total soluble solids and phenolic content having least decay percentage of fruits. It is concluded that the combinational treatment of sodium hypochlorite (0.2%) and sodium chlorite (0.05%) was able to extend shelf life up to 25 days and could be used as cost-effective alternative method to reduce pericarp browning and quality deterioration of litchi fruits during low temperature storage.

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