Effect of heat treatment on the preservation of *Chaenomeles speciosa* (Sweet) Nakai

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Abstract: Heat treatment was used to extend the shelf life of postharvest *Chaenomeles speciosa* (Sweet) Nakai (*C. speciosa*), its effects on the quality and physiological properties of *C. speciosa* were studied. The results showed that heat treatment reduced the weight loss, inhibited the decline of titratable acids (TA), maintained a higher activity of peroxidase (POD) and catalase (CAT), compared to untreated *C. speciosa*. Treatment in hot water dipping at 50°C for 2-4 min maintained the better quality of postharvest *C. speciosa* stored at 0°C for 120 days, which indicated that heat treatment is an effective preservation technology to prolong the shelf life of *C. speciosa*.

1 Introduction

C. speciosa, a fruit of the *Rosaceae* family, has been planted for more than 3000 years in China. It is native to China and distributed in Shandong, Anhui, Gansu, Chongqing, Yunnan and Zhejiang provinces [1]. It is rich in nutrients and biological active components (flavonoids, oleanolic acid, ursolic acid, saponins, organic acids) [2]. *C. speciosa* possesses important medicinal application value and great potential for development. During storage of *C. speciosa*, nutrients and medicinal quality decreased. Therefore, it is necessary to find an effective preservation technology to prolong the shelf life of *C. speciosa*.

Common post-harvest preservation methods for fruits and vegetables include chemical, physical and biological methods. However, chemical methods have residues and environmental problems, and the biological methods require complex operating environments and high costs. Physical methods are extensively studied in commercial applications. Heat treatment is a simple, secure and effective physical method for controlling the physiological changes. This approach can delay the decline of sensory quality of fruits, postpone the aging of fruits, inhibit the occurrence of diseases, and adjust the physiological metabolism of fruits and vegetables after harvest [3]. Heat treatment enhanced the activity of antioxidant enzymes (catalase, peroxidase, superoxide dismutase, ascorbic acid peroxidase) [4]. Therefore, heat treatment can inhibit peroxidative damage, maintain the integrity of cell membranes, and thereby reducing cold damage to fruits and vegetables. Nasef [5] noted that

cucumbers with short hot water dipping at 55°C could maintain the better sensory quality, alleviate chilling injury and induce antioxidant enzymes. In addition, heat treatment have a direct inhibitory effect on brown rot control in peach fruit and dragon fruit [6]. At present, there is no study on the effect of heat treatment on the preservation of *C. speciosa*.

The objective of this work is to determine the hypothesis that the application of heat treatment on *C. speciosa* could maintain the quality and prolong the storage period, this study will provide theoretical support for the further development of safe, green and efficient preservation technology of *C. speciosa*.

2 Materials and methods

2.1 Plant materials

Materials: *C. speciosa* with similar maturity, size, without diseases or mechanical injuries, were picked from Linyi, Shandong, China.

2.2 Treatments and storage conditions

C. speciosa were completely submerged in hot water at 45°C, 50°C, 55°C for 2 min, 4 min, and 6 min, respectively. And then dried and wrapped with polyethylene plastic bags (0.03 mm thick), and stored at 0±1°C with the relative humidity of 85%–90%. The samples without heat treatment were considered as the control. The experiment was repeated three times for each treatment group.

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2.3 Methods

2.3.1 Weight loss

The weight loss was measured using an electronic scale during the storage of 120 days with an interval of 30 days, and the results expressed as the percentage weight loss using the following equation:

$$\text{Weight loss (\%)} = \frac{(W_1 - W_2)}{W_1} \times 100 \quad (1)$$

Where W_1 was the fruit weight in the beginning. W_2 was the fruit weight at the time of sampling.

2.3.2 Titratable acid (TA)

TA of *C. speciosa* was measured by titrating the juice (5 mL) against 0.1 M NaOH using 1% phenolphthalein solution as an indicator [7]. The results were expressed as the percentage of malic acid.

2.3.3 CAT activity

The CAT activity was analyzed based on the reported literature with some modifications [8]. CAT activity was expressed as a change of 0.01 in OD240 per gram FW per minute.

2.3.4 POD activity

POD activity was determined by a modification of the procedure described by Han *et al* [9]. One unit of POD activity was defined as a change of 0.001 in OD470 per gram FW per minute.

2.4 Statistical analysis

All the data were plotted as the mean of three replications $\pm$ standard errors (SE). One-way factorial analysis of variance (ANOVA) and differences between mean values were assessed by Statistical differences. And the treatment differences were compared by Duncan's multiple range test. Significance was defined at $p < 0.05$.

3 Results and discussion

3.1 Weight loss

Fig. 1. Effect of heat treatment on the weight loss.

The weight loss is supposed to be the major determinant of postharvest quality. The weight loss is due to the metabolic activities, evaporation and respiratory consumption [10]. As shown in Fig.1, the weight loss of *C. speciosa* increased with prolonged storage days, and the weight loss of *C. speciosa* with heat treatment was lower than that of unheated *C. speciosa*. The increase rate of the weight loss was faster during 60 days storage, and the increase rate of the weight loss was slower with prolonged storage days from 60 to 120 days. While the weight loss of *C. speciosa* with heating at 55°C for 2-6 min was relatively higher. The 55°C, higher temperature than 50°C and 45°C, might destroy the wax on the surface of *C. speciosa* leading to the loss of the protective layer and more water. The weight loss of *C. speciosa* with heat treatment was lower than that of the control at 120th day. The weight losses of *C. speciosa* with heating at 45°C for 2 min and 50°C for 2 min were lowest and the difference between them is not significant ($p > 0.05$).

3.2 TA content

Fig. 2. Effect of heat treatment on the TA content.

TA is one of the important qualities of fruit, and it also affects the storage resistance of fruit. As can be seen from Fig.2, TA in *C. speciosa* showed a gradual decline trend with the extension of storage time. During 120 storage days, the TA content of *C. speciosa* with heat treatment was significantly ($p < 0.05$) higher than that of the control

one. Moreover, the TA content of *C. speciosa* treated with 50°C for 2 min was the highest. And heat treatment may have an effect on the enzyme activity of tricarboxylic acid cycle. This could be used for explaining the decline of TA content for *C. speciosa* with heat treatment. This result indicated that heat treatment effectively delayed the decline of TA content of *C. speciosa*. Therefore, it is considered that *C. speciosa* should be stored at a lower temperature, and consumption of organic acids reduced due to inhibiting the activity of enzymes related to respiration at the lower temperature.

3.3 CAT activity

Fig. 3. Effect of heat treatment on the CAT activity.

CAT is one of the important enzymes of antioxidant system which protects the cells membrane from damage. It can decompose hydrogen peroxide in plant tissue, alleviate the damage of hydrogen peroxide to fruit tissues, and inhibit membrane lipid peroxidation. Heat treatment induced rapid increase of CAT activity in the first 30 days and inhibited the decrease of CAT activity from the 30 to 120 days (Fig.3). The CAT activity reached maximum value in the 30th day. It was showed that CAT activity was highest in the *C. speciosa* treated with 50°C for 2 min. The CAT activity of *C. speciosa* after heat treatment is significantly higher than that control one ($p < 0.05$). It was indicated that heat treatment increased the activity of CAT. This result was in agreement with previous studies on other commodities such as Valencia oranges [11].

3.4 POD activity

Fig. 4. Effect of heat treatment on the POD activity.

POD played a significant role in catalyzing the removal of poisonous hydrogen peroxide from plant tissues. POD enhanced capacity of antioxidant and scavenging reactive oxygen species (ROS) free radicals under external stress. The improvement of POD activity could reduce the damage to cell membranes and consequently delay the senescence of plants [12]. At the same time, the increasing of POD activity can enhance the fruit defense response against pathogens [13], which is conducive to extending the shelf life. In Fig.4, the POD activity of *C. speciosa* showed increasing trend firstly, then decreasing. The heat treatment group was significantly higher than the control group ($p < 0.05$). *C. speciosa* treatment with 50°C stored at 120th day, showed higher POD activity than *C. speciosa* treated with other temperature. POD activity was highest in the group treated at 50°C for 4 min, followed by the group treated at 50°C for 2 min.

4 Conclusions

Heat treatment technology is favored for its simple operation and low cost. The treatment used in this work showed that 50°C for 2-4 min treatment had a good effect on maintaining the postharvest quality of *C. speciosa* and extending the shelf life. The study will provide an important theoretical basis for the green pollution-free preservation technology of *C. speciosa* by heat treatment.

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