ENHANCING DISEASE RESISTANCE AND IMPROVING QUALITY OF PAPAYA (*CARICA PAPAYA* L.) BY POSTHARVEST APPLICATION OF SILICON

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ABSTRACT

Papaya (Carica papaya L.) is a less firmer fruit with high nutritional value and susceptible to many diseases especially anthracnose, causing higher postharvest losses. The present study was carried out to investigate the effect of postharvest application of silicon on anthracnose disease development, physicochemical parameters and the shelf life of papaya fruit.

Mature green fruits (colour breaker stage) harvested from a locally available papaya garden and were dipped in 0, 1000, 2500, 5000 and 7500 mg/L solutions of sodium silicate for 20 minutes and subsequently, were air dried. Fruits were challenged inoculated with Colletotrichum gloeosporioides by placing 25µl drops of spore suspension at three different places along the longitudinal axis of each papaya fruit. The fruits were kept in moisture chambers at ambient conditions and area of inoculated spots, fruit firmness, pH, ºbrix, and titratable acidity were measured in fruits at full orange (CI-6) stage. However, there was no significant difference (p<0.05) observed in firmness, pH, ºbrix, and titratable acidity of silicon treated fruit compared to untreated control. There was a significant reduction (50-60%) in disease development in fruits treated with 5000 mg/L and 7500 mg/L sodium silicate compared to control fruits. The shelf life was increased up to 4-5 days in fruits treated with 2500 and 5000 mg/L sodium silicate compared to control fruits. In conclusion, postharvest dip treatment at 5000 mg/L sodium silicate has significantly reduced the anthracnose disease development and increased the shelf life of the fruit.

Keywords: Papaya, Sodium silicate, Shelf life, Anthracnose, Quality

Introduction

Papaya (*Carica papaya* L.) belongs to the family *Caricaceae*, one of the most important fruits cultivated throughout the tropical and subtropical regions in the world. The fruit is known for various purposes, it has high nutritive value and medicinal properties. It is a good source of vitamin A, vitamin C and minerals (Verma and Sharma, 1999). Ripe papaya is used to produce various food products such as jam, jelly, marmalade and mixed beverages. (Matsuura *et al.*, 2004. Saran & Choudhary, 2013).

However, mechanical damages caused during harvesting, transport and postharvest diseases resulted in considerable postharvest loss of papaya fruits. Postharvest losses of papaya in Sri Lanka are reported to be about 45% (Sarananda *et al.*, 2004). Mechanical damage and postharvest diseases are the major causes for postharvest lossess in papaya fruits. *Colletotrichum gloeosporioides* is the main causal organism of anthracnose disease in papaya and symptom development generally occurs after harvest, especially when the fruit is ripened (Wijeratnam *et al.*, 2008). The export market required high quality fruits to obtain the market accessibility. Therefore, the export market has unique challenges that require specialized postharvest treatment to increase the shelf life and to maintain the fresh quality of the papaya fruits.

Silicon is a most abundant element on the earth's crust and in soils and it has long been associated with disease resistance in plants. There are many pre harvest applications of silicon for fruit and vegetable than postharvest applications. Significantly higher amount of tomato fruit yield was gained, due to the treatments with the silicon-enriched nutrient solution (Jarosz, 2014). Some researchers proved "root supplement of silicon was effective over foliar spraying against anthracnose disease development in *Capsicum annuum L*. 'Muria F1'." (Jayawardana *et al.*, 2014). Silicon treatment as a form of potassium silicate increased shelf life and fruit quality of avocado fruits (Bertling *et al.*, 2009). Therefore, this study was carried out to evaluate the disease resistance, shelf life extension and improving quality of papaya fruits by postharvest application of Sodium silicate.

Research design

Plant material

Mature, medium size papaya fruit (Carica papaya L.) were hand-harvested in the morning from a locally available papaya garden. Fruits were selected for uniformity, shape, colour and size and any blemished or diseased fruits were discarded. These fruits were immediately transported to the food processing laboratory at the Department of Food Science and Technology, Wayamba University of Sri Lanka.

Treatments

The fruits were washed with 0.5% chlorox solution for one minute and followed by distilled water. The fruits were separately dipped in five different concentrations 0, 1000, 2500, 5000 or 7500 mg/L of sodium silicate (Na_2SiO_3) solutions for 20 min to allow penetration of the solution and thereafter fruits were allowed to air dry.

A suspension of (10^5–10^6 conidia per mL) *C. gloeosporioides* was prepared by using 5-6 days old pure cultures. Each fruit was inoculated by placing drops of (25µl) conidia suspension at three different places along the longitudinal axis of each papaya fruits. Inoculated fruits were maintained in moist chambers (95-100% relative humidity at 28±2 °C). The average lesion area (cm^2) was measured for each fruit.

Isolation of *C. gloeoporioides*

The causative organism *C. gloeoporioides* present in the anthracnose lesion of papaya fruits were used to isolate *C. gloeosporioides*. Small pieces (5-6 mm^2) of diseased tissues were cut using a sterile scalpel blade and dipped in the 10% chlorox solution for 2 min and dipped in distilled water for 2 min to wash well. The fruit tissues were put on the sterile tissue paper to remove the wetness and put on the PDA medium. The plates were sealed and incubated at 28°C. The resulting fungus was sub cultured on fresh PDA plates and identified by their cultural and morphological characters using CMI (Commonwealth Mycological Institute) descriptions (Wijeratnam *et al.*, 2008).

Preparation of suspension of *C. gloeosporioides*

Suspension of conidia was prepared by suspending mycelia scraped from 5-6 day old cultures of *C. gloeosporioides* in 3mL sterile distilled water and shaking for 2 min. The resulting suspension was filtered through sterile cotton wool. The concentration of spore suspension was adjusted using a hemocytometer to 10^5-10^6 conida per mL (Wijerathnam *et al.*, 2008).

Physico-chemical characteristics of fruit

pH of the papaya pulp was measured using an electronic pH meter (EUTECH instrument pH 510, Malaysia) Total Soluble Solids (TSS) was determined using a hand held refractometer (ATAGO, N-580, Japan). Total titratable acidity of the pulp was determined by titrating against 0.01M NaOH. 1% phenolphthalein was used as an indicator. The results were expressed as percentage citric acid.

Firmness of fruit was measured with penetrometer (FT011, made in United Kindom) and 11mm fruit plunger was used to take the measurements, were taken three times on each fruit on its three sides and the average was taken. Peel colour was determined using a colour index. (1-Dark green, 2- Light green, 3- More green than yellow, 4- More yellow than green, 5- Yellow, 6- Orange)

Shelf life of fruits was measured by number of days taken by fruit peel to reach orange (CI-6) from the day that fruits were placed in moisture chambers.

Statistical Analysis

Statistical analyses were performed with ANOVA using GLM procedure of SAS. Data from separate experiments were combined when statistical analyses determined that variances were homogeneous. Significant differences ($p < 0.05$) between treatments were determined with the least significant difference.

Results and Discussion

The present study was carried out to investigate the effect of postharvest silicon application on postharvest quality traits (firmness pH, TSS, %TA), and, disease resistance to anthracnose and shelf life of silicon treated fruits. There was no significant difference among pH, TSS and titratable acidity (%) of the fruits treated with silicon compared to non-treated control fruits. There was a significant effect on firmness of papaya fruits treated with silicon compared to control fruits. The highest mean value of firmness (17.7 N) was observed in fruits treated with 7500 mg/L Sodium silicate and was significantly different ($p<0.05$) from other treatments for firmness.

Table1. Effect of different concentrations of silicon treatment on pH, TSS, titratable acidity and firmness of ripened fruits

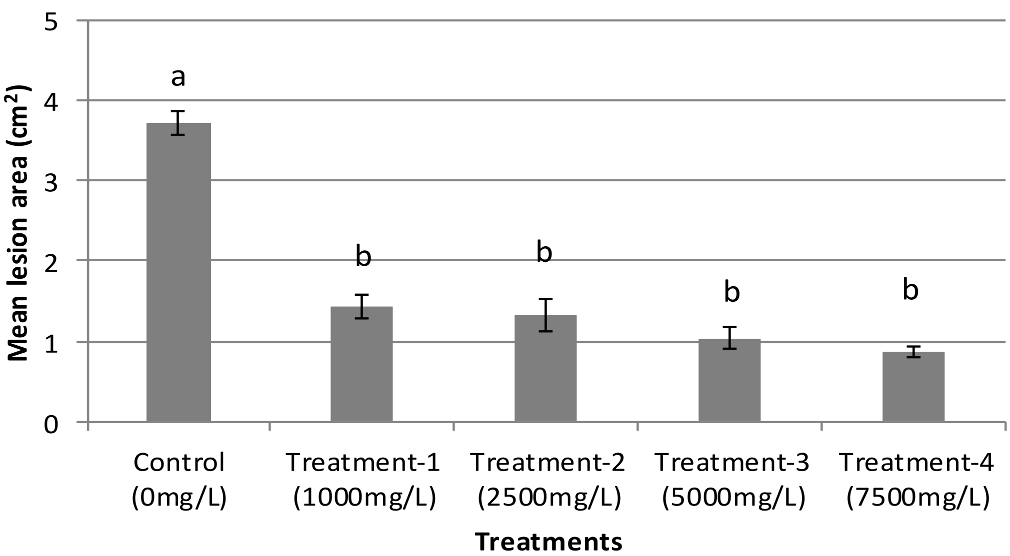
Treatment	Firmness x10^4 (N)	pH	TSS	%TA
Control	8.31±3.19	5.35±0.0391	10.24±1.012	0.0130±0.0021
Treatment 1	7.79±2.35	5.44±0.0962	10.00±0.577	0.0125±0.0012
Treatment 2	7.22±1.62	5.39±0.0519	10.37±1.314	0.0122±0.0017
Treatment 3	8.37±1.16	5.44±0.0275	10.50±1.080	0.0125±0.0012
Treatment 4	17.70±2.34	5.37±0.0632	10.87±0.478	0.0135±0.0005

(treatment-1: 1000 mg/L, treatment-2: 2500 mg/L, treatment-3: 5000 mg/L, treatment-4: 7500 mg/L)

In addition, the disease susceptibility of silicon treated and non-treated control fruits were assessed by artificial inoculation of C. gleosporioides. It was found that there was a significant difference ($p<0.05$) in disease development in silicon treated fruits compared to non-treated control fruits. The mean lesion area was lowest (0.86 cm2) in fruits treated from 7500 mg/L Sodium silicate and the highest mean lesion area (3.72cm2) was found from non-treated control fruits. There was no significant difference in lesion diameter among the silicon treated fruits. These results confirm other reports evidencing, it can be summarized that silicon application to the tomato plant at growth or maturity stages, there was a significant effect on reducing anthracnose disease development in tomato fruits (David and Weerahewa, 2012). The enhanced disease resistance is associated with deposit of silicon on peel so as to form physical barrier to avoid pathogen penetration and activation of host defense response (Bowen et al., 1992). Postharvest treatment with Si proved effective for inhibiting fungus growth as well as inducing disease resistance in 'Hami' melons, thereby controlling decay and maintaining fruit quality (Bi et al., 2006).

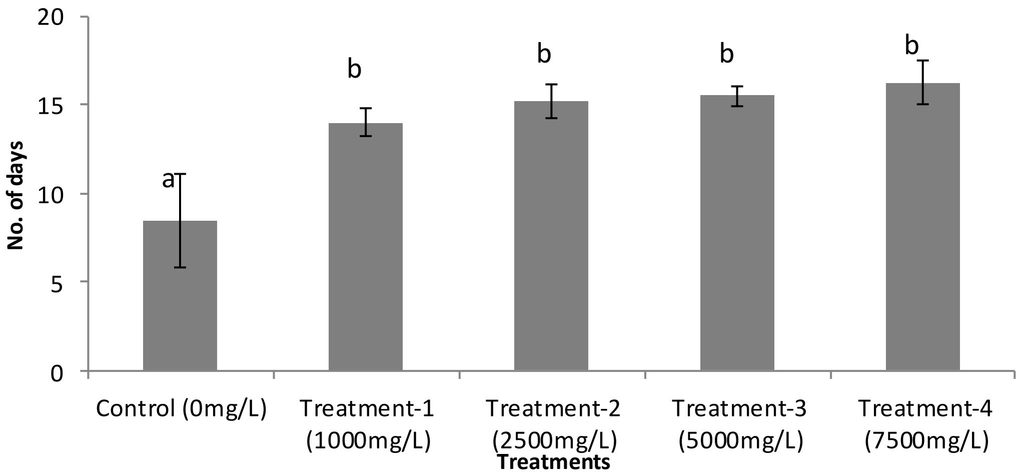
Fig.**1**. Effect of silicon treatment on disease development of papaya fruits.

(treatment-1: 1000 mg/L, treatment-2: 2500 mg/L, treatment-3: 5000 mg/L, treatment-4: 7500 mg/L)



Similarly, there was a significant difference ($p<0.05$) in extension of shelf life between silicon treated fruits and non-treated control fruits. The mean no. of days taken for the development of orange colour (CI-6) was lowest (9 days) in control fruits and the highest mean no. of days (16 days) were taken by fruits treated with 7500mg/L Sodium silicate. However, there was no significant difference ($p>0.05$) in shelf life extension of fruits among the different silicon treatments. Application of silicon can deposit on peel and suppress the respiration rate and ethylene production. This may be a reason to increase the shelf life of fruits.

Fig.2. Effect of different concentrations of silicon on the shelf-life of papaya (treatment-1: 1000 mg/L, treatment-2: 2500 mg/L, treatment-3: 5000 mg/L, treatment-4: 7500 mg/L)



Application of postharvest dip treatment of silicon at 5000 mg/L and 7500 mg/L significantly reduced (50-60%) the anthracnose development of papaya and increased the shelf life of the fruits by 4-5 days. However, there was no significant difference observed in physicochemical parameters in silicon treated fruit. Fruits treated at 7500 mg/L had significantly higher firmness than other fruits. It may be the reason for the extension of the shelf life and disease resistance in fruits. But further research studies will be beneficial to prove it. Therefore, based on this study it can be concluded that silicon treatment 5000 mg/L is very effective to increase anthracnose disease resistance and shelf life of papaya fruits.

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