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Effect of Hot Water Treatment on Quality and Incidence of Postharvest Disease of Mango (*Mangifera indicia* L.) Fruits

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Abstract: Mango (*Mangifera indica* L.) is an evergreen tree grown throughout subtropical and tropical regions. The mango fruit is one of the highly consumed and popular fruits throughout the world. As a fruit, it is liable to postharvest losses as a result of physiological deterioration and pathogen infection. In order to minimize the postharvest losses and extend shelf life, postharvest treatments are given to the fruit after harvest. Among the postharvest treatments, hot water treatment is the one and should be applied at the beginning of the packing or packing process for improved quality and shelf life of mango. Mango anthracnose, a major postharvest disease, induces huge losses in mangoes and threatens mango export and consumption. The objective of this study was to evaluate the effect of hot water treatment on the quality and control of postharvest fungal disease. The experiment was carried out in the laboratory of postharvest physiology, Jimma University from April to May 2014, using CRD factorial arrangement of treatments replicated three times. Two factors were considered as a treatment; temperature and time (duration) of treatment. There were three levels of temperature (48, 50 and 52°C) and two levels of time (5 and 10 min). Accordingly, the experiment had six factorial and one control treatments with three replications making a total of 21 experimental units. Mango fruits of local variety were used for the study that was brought from Sarboo district, Jimma zone. The result of the study showed that hot water treatment highly significantly ($p<0.001$) affected weight loss and disease incidence (anthracnose) during storage time. In addition, hot water treatment significantly ($p<0.05$) affected the pH and TA value of mango fruit but had no significant effect on the total soluble solids and sugar acidity ratio of the fruits.

Key words: Hot water treatment, mango, postharvest disease, quality, weight loss

INTRODUCTION

Mango (*Mangifera indicia* L.) is an evergreen tree grown throughout subtropical and tropical regions. It is considered to be the oldest and best fruit in the world market. It belongs to the family Anacardiaceae which has 75 genera and 700 species (Lizada, 1993). The world production rate is roughly about 35 million tons (UNCTAD, 2014). Mango is consumed both as fresh and processed form. The storage life of the mango depends on the stage of maturity at which the fruit is harvested, mango fruits are generally harvested at physiologically matured stage to get optimum fruit quality. The production, marketing and consumption of mango fruits are restricted due to improper handling, in adequate transport and storage facility, disease problems and sensitivity to low storage temperature (Mitra and Baldwin, 1997).

Growing and marketing of fresh produce in Ethiopia are complicated by postharvest losses both in terms of quantity and quality between harvest and consumption. The quality of fresh fruits depends on the postharvest handling during harvesting, transportation and storage (Haidar and Demisse, 1999). Compared with several temperate fruits, the tropical and subtropical fruit such as mango presents greater problems in storage and transportation because of its perishable nature (Mitra and Baldwin, 1997). The postharvest loss of perishable commodities is estimated to be as high as 50% in Ethiopia (FAO, 1981). Although, the figures are old, no much improvement is expected as the intervention is not that much significant so far. The production, marketing and consumption of mango fruits are restricted due to improper handling, inadequate transport and storage facility, disease problems and sensitivity to low storage temperature (Mitra and Baldwin, 1997). Eventhough, Ethiopia is experiencing huge postharvest losses, very little emphasis has been laid on the postharvest handling (Tadesse, 1991). Several mango postharvest handling techniques have been developed for controlling disease

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and insects and for protection against injury during packaging and storage (Pinto *et al*., 2004). Good handling during harvesting can minimize mechanical damage and reduce subsequent wastage due to microbial attack (Wills *et al*., 1998).

Reducing storage temperature improves the shelf life of perishable commodities mainly due to its effect on physiological activity leading to retarded senescence of fruit in storage (Pinto *et al*., 2004). Mango is the largest produced tropical fruit in Ethiopia. Its largest production and availability is restricted to only a few months due to its poor shelf life and farmers has not been gained proper income from the crop. Mango is rich in vitamin A, vitamin C and also iron and potassium. Higher intake of these vitamins and minerals are needed to reduce the higher percentage of night blindness and anemia prevalent among children (Sauco, 1993).

Heat treatment can have several advantages. It can delay ripening and control decay and insects attack. Heat treatment can be applied in the form of dry hot air humid hot air or in the form of hot water. Hot water is commonly used in several countries to disinfect mango from fruit flies. For this purpose, the fruit is dipped in water at 48°C for 5-10 min, depending on type and weight of mango fruit (Brecht *et al*., 2004). Hot water treatment should be applied at the beginning of the packing or packing process. It can be applied on a moving belt (most common and practical) or in tanks. However, these treatments should not be used when fruit is harvested over-mature or with serious bruises or mechanical injury, since that heat would augment these injuries. Fruit should be cooled right after heat treatment, commonly with ambient water followed by forced air cooling. Decay control is accomplished with an adequate pre harvest and postharvest integrated program. In postharvest, washing water usually contains about 100 ppm of sodium hypochlorite. The water also can contain fungicides depending on the extent of the problem. Careful handling of the fruit, removal of mechanically injured, rapid cooling, maintenance of low (optimum) temperature and maintenance of hygienic conditions are essential for decay control (Wills *et al*., 1998).

The most prevalence disease in Ethiopia is Anthracnose (*Colletotrichum gloeosporioides*). This is the most serious disease in most mango growing regions of Ethiopia, especially those with high rainfall and humidity. Infection can be found on the fruit but also on blossoms, leaves, twigs and young branches. In addition to attack through the wounds, the organism can penetrate the fruit through the cuticle and natural openings on the fruit surface (Couey, 1980). Short hot water treatment used for decay control consists of temperatures of 48-55°C for 3 to 15 min, depending on the variety and the extent of the problem. Treatment is applied right after collecting and washing the fruit in ambient water. Immediately after hot water treatment, fruit should be cooled in ambient or cold water. Hot water treatments can damage the fruit if the fruit is not treated properly (Couey, 1980). Among the postharvest heat treatment, hot water treatment is one of the heating methods for quality and shelf life mango. It is an effective heat transfer medium and within a short time, a uniform temperature profile will be maintained (Couey, 1980). The additional benefit of hot water treatment is that it can control postharvest diseases such as anthracnose and stem end rot. This treatment is cheaper than any other heat treatment and is also effective on commercial scale in the USA (Couey, 1980; McGuire, 1991). Therefore, the objective of this study was to evaluate the effect of hot water treatment on the quality of mango fruit and control of postharvest fungal disease.

MATERIALS AND METHODS

Experimental material: A local variety of mango (*Mangifera indica* L.) fruits was obtained from Sarboo district, Jimma Zone. It was brought by using open truck covering with carton.

Experimental design and treatment: The experiment was carried out in the Laboratory of Postharvest Physiology at Jimma University College of Agriculture and Veterinary Medicine from April to May 2014. The treatments were assigned to contain two factors with CRD, temperature and time (duration) of treatment. There were three temperature levels (48, 50 and 52°C) and two levels of time (5 and 10 min). Accordingly, the experiment had 3 by 2 factorial designs, seven treatments (48°C/5 min, 48°C/10 min, 50°C/5 min, 50°C/10 min, 52°C/5 min, 52°C/10 min and control (non-treated one) with three replications, that gives a total plot number of 21. Mature green, uniformly-size and free from any defects mango fruit were selected for the experiment. Before the fruits were treated by hot water, the fruits were washed by using water with soap and allowed to air dry. Then except the control treatment, all fruits were treated by hot water according to a given scale of temperatures and time. After, the fruits treated by hot water stored in storage container for 15 days at room temperature. Some quality parameters were taken in the first day of hot water treatment and disease incidence and weight loss were observed for 3 times at 5 day interval.

Data collection

Physiological Weight Loss (PWL): The initial weight of the treated and control fruits were taken before storing at room temperature after treatment. Then, the weights of the fruits were recorded after storing at room temperature at five day interval. Hence, the sum of the weight loss taken as the five days interval gives total weight loss which has been converted to percentage weight loss using the following Eq. 1:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight of mango (g)-Weight after interval (g)}}{\text{Initial weight of mango (g)}} \times 100 \quad (1)$$

Percentage of Disease Incidence (PDI): Disease incidence was calculated as number of diseased fruit per total number of fruits. The fruits were observed visually for rotting and microbial infection. Percent disease incidence was identified and calculated using the following Eq. 2:

$$\text{Disease incidence (\%)} = \frac{\text{No. of diseased fruit}}{\text{Total number of fruits}} \times 100 \quad (2)$$

Titrable Acid (TA): Mango juice was extracted from the sample with a juice extractor and clear juice was used for the analysis of TA by the methods described by Maul *et al.* (2000). Finally, the percentage acidity was determined by using the following Eq. 3:

$$\text{Acid (\%)} = \frac{\text{Titer} \times 0.0064 \text{ (citric acid factor)}}{\text{1 mL juice}} \times 100 \quad (3)$$

Total Soluble Solid (TSS): Total soluble solid was measured from the already extracted juice using hand refractometer (model 45-02). Recording of TSS started at the first day of storage up to the end of experiment.

pH value: pH value of mango juice measured by pH meter. To determine the pH value of mango juice, calibrate probe and meter following the manufacturer's specifications. Read the pH measurement of each sample from the probe according to the manufacturer's specifications.

Sugar/Acidity Ratio (SAR): To determine the sugar to acid ratio, the sugar (TSS) concentration in °Brix was divided by percentage acid as shown in Eq. 4:

$$\text{Sugar acid ratio} = \frac{\text{Brix value}}{\text{Percentage acid}} \quad (4)$$

Statistical analysis: All the recorded quantitative data was subject to analysis of variance using GenStat 12th edition (VSN International, 2010).

RESULTS AND DISCUSSION

Effect of hot water treatment on weight loss of mango fruits during storage: The weight loss of mango fruits were showed highly significant differences among the treatments in day 10 and 15 ($p<0.001$). There was no significant differences observation in day five recorded weight loss among treatments (Table 1). The highest weight loss was recorded from all fruits that was not treated by hot water compared to treated one (Table 1). There was a high tendency of weight loss increment at day 15 compared to weight loss recorded at day 5 and 10 (Table 1). The trends in the change of percentage of weight loss were consistent during the storage period. These result supported by Tefera *et al.* (2007), according to their information, the highest percentage weight loss was recorded in fruits that did not treated by hot water and were stored at ambient temperatures while least percentage weight loss was observed in fruits disinfected with hot water and hot water treatment is effective in keeping a higher percentage of marketability of mangoes. Moreover, Gonzalez-Aguilar *et al.* (2001) said that mango heat tolerance varies due to a number of factors including origin, species, fruit maturity, shape, size and weight. The USDA has recognized that inherent differences exist among fruits and thus variable thermal quarantine times are prescribed, ranging from 65-110 min at 46.1°C (USDA-APHIS, 2002).

Effect of hot water treatment on disease incidence of mango fruits during storage: The main diseases observed on mango fruits through the experimental period were *Anthracnose* which is caused by a fungus (*Colletotrichum gloeospoiriodes*). Hot water treatment is accepted as an effective disease control technology, particularly anthracnose. Percentage of disease incidence showed that highly significant differences ($p<0.001$) among the treatments and storage period (Table 2). At day 5 of storage, any symptom of anthracnose infestation was not observed almost all hot water treated fruits.

Table 1: Effect of hot water treatment on the physiological weight loss of mango fruits

	Weight loss (%)		
	5	10	15
Treatment (temperature/time)	Day		
52°C/5 min	18.00	36.00^{a}	65.00^{a}
52°C/10 min	18.67	37.67^{b}	70.00^{b}
50°C/5 min	19.00	38.00^{b}	73.33^{bc}
50°C/10 min	20.00	38.00^{b}	73.33^{bc}
48°C/5 min	20.00	40.00^{c}	75.00^{c}
48°C/10 min	20.00	40.00^{c}	76.00^{c}
Control	20.00	40.00^{c}	85.00^{d}
LSD (5%)	NS	0.756	3.81
CV (%)	7.900	2.400	6.30

NS: Non-significant

However, the highest disease incidence (40, 55 and 70% at day 5, 10 and 15, respectively) was observed in the control (non-treated) treatment than treated one (Table 2). Mango fruits treated by hot water at 52°C/5 min and 52°C/10 min actually did not shown any remarkable symptoms of anthracnose infestation at days 5, 10 and 15 in storage. At the end of day 15, all of the treatments showed a number of symptoms with a little variation between each treatment. Fungal and bacterial infections on fruits results in loss in quality which eventually reduces consumer acceptability and their economic value (Spalding *et al*., 1988). Generally, from this result, the fruits treated by highest temperature (52°/5 and 10 min) showed that almost non symptoms of anthracnose infestation. This indicated that hot water treatment is the most favorable treatment for controlling anthracnose, the similar observations were observed by Chaplin *et al*. (1991), who found that hot water treatment is effective against fungal infection in fruits.

Effect of hot water treatment on some quality parameters (pH, TSS, TA and SAR) of mango fruits during storage: There was the significant difference among the treatments on some quality parameters of mango fruit (Table 3). Mango is a climacteric fruit that tends to have increased soluble solid concentration until a maximum is reached at the fully ripe stage, followed by a decreasing trend when the fruit reaches full senescence (Bustamante *et al*., 1997). During the first week of ripening, the increase in TSS of mango samples stored at ambient temperature could be due to excessive moisture loss as well as the hydrolysis of carbohydrates to soluble sugars (Waskar *et al*., 1999). Roy and Pal (1989) reported that the excessive increase in TSS of mangoes during storage is an indication of quality deterioration. The values for TSS varied between 1.8 and 3.5 °Brix during storage (Table 3). In these results, the effect of hot water treatment on the TSS was found to be non-significant difference among the treatments during storage period. On the other hand, hot water treated mangoes had higher TSS than the control mangoes (Table 3). Jacobi *et al*. (2001) also found that mangoes treated with hot water at various temperatures did not vary in TSS. In addition, according to Mitchell and McDonald (1997) findings, the TSS content of mangoes at the ripe stage were not influenced by heat treatments this is because of some heat treatments could delay or inhibit ripening in certain mango varieties.

The higher storage temperature led to higher rate of reduction in the TA during ripening and storage of mangoes. This could be associated with rapid ripening and senescence process of mangoes when stored at higher temperature. Changes in TA and pH are based on changes in citric, malic and ascorbic acid. Concentrations of these acids are known to diminish during ripening (Medlicott *et al*., 1986). This could be associated with the higher rate of respiration substrate for the catabolic process in mangoes (Seyoum and Woldetsadik, 2000). There were significant differences ($p<0.05$) among treatment on TA and pH of the fruits during the storage period (Table 3). The TA and pH of control treatments were found to be lower than in treated fruits (Table 3). Similar results were reported by Tefera *et al*. (2007). There was no significant difference among the treatments in SAR of the fruits but as discussed above the sugar acid ratio depend on the TSS value of the fruit and also percentage of acidity of the fruit. Similar results were reported by Medlicott *et al*. (1990).

Table 2: Effect of hot water treatment on mango fruits to control of disease incidence

	Disease incidence (%)		
	5	10	15
Treatment (temperature/time)	Day		
52°C/5 min	0.00^{a}	15.00^{a}	10.00^{a}
52°C/10 min	0.00^{a}	15.00^{a}	10.00^{ab}
50°C/5 min	0.00^{a}	20.00^{a}	30.00^{c}
50°C/10 min	0.00^{a}	20.00^{a}	50.00^{d}
48°C/5 min	0.00^{a}	20.00^{a}	60.00^{e}
48°C/10 min	12.00^{b}	40.00^{b}	65.00^{f}
Control	40.00^{c}	55.00^{c}	70.00^{g}
LSD (5%)	1.563	2.817	2.357
CV (%)	33.10	14.20	16.20

Table 3: Effect of hot water treatment on quality characteristics (pH, TSS, TTA and SAR) of mango fruits

	Quality parameters			
Treatment (temperature/time)	pH	TSS (°Brix)	TA (%)	SAR (%)
Control	3.8900^{abc}	1.8000	1.0667^{b}	1.14
48°C/5 min	4.1667^{ab}	2.0167	1.3667^{b}	1.30
48°C/0 min	4.2267^{a}	2.2500	1.4000^{ab}	1.40
50°C/5 min	4.3767^{ab}	2.4000	1.4000^{b}	1.60
50°C/0 min	4.4833^{abc}	2.8667	1.5000^{b}	1.97
52°C/5 min	4.5233^{c}	3.0000	1.6000^{b}	2.17
52°C/10 min	4.7333^{bc}	3.5000	2.1667^{a}	2.53
LSD (5%)	0.5374	NS	0.5862	NS
CV (%)	7	41.570	20.7300	51.44

TSS: Total soluble solid, TA: Titrable acid, SAR: Sugar to acid ratio, NS: Non significant

CONCLUSION

From the result discussed in this experiment, it can be concluded that hot water treatment considered as effective for postharvest disease control like anthracnose on mango fruit. Hot water treated fruits showed less disease incidence and weight loss compared to control (non-treated) fruits. In addition to that, hot water treatment help to improve the quality of mango fruits. The quality parameter such as pH and TA showed a significant difference among the treatment during the storage period. pH and TA of control treatments were found to be lower than in treated fruits. On the other hand, the effect of hot water treatment on the TSS was found to be non-significant difference among the treatments during storage period. Even, if there is no significant difference observation among the treatments in TSS, hot water treated mangoes had higher TSS than the control mangoes.

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