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Postharvest Hot Water Treatments on Poststorage Quality of Mango Fruits (*Mangifera indica* L.) Variety Diab

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Abstract: Mango fruits have a short shelf life and hot water is considered as one of some techniques to improve general appearance and maintain fruits quality. The effect of postharvest applications of hot water treatments were applied to Diab mango fruits at the two successive seasons of 2015 and 2016. Hot water dipping (HWD) at a range of treated temperatures at 50°C or 45°C for 5 and 10 min were applied to mangoes cv. Diab after harvest and some were also left on control without hot water dipping. Both treated and untreated fruits (control) were stored at 10°C for 3 weeks and then ripened at 20°C for 7 days. The fruits quality properties (weight loss, decay percent, fruit firmness, ethylene production, soluble solid content (SSC), titratable acidity (TA) and ascorbic acid content) were investigated periodically for a storage period of 7 days for 3 weeks and after ripe at 20°C. the results clear that, Fruit loss percentage was lower in fruit treated with HWD treatments as compared to control (untreated) which having higher percent. On the other side, treated fruits indicated less weight loss at 10°C and higher weight loss in ripening at 20°C. Mango fruits dipped in hot water at 50°C or 45°C for 5 and10 min had no decay percent at 10°C of storage for one week. All HWTs achieved the highest value of firmness with significant differences compared with untreated fruits (control) at the end of storage period and ripening at 20°C Moreover, mango fruit which dipped in hot water at 50 °C for 10 min showed firmer fruits than those dipped at 45°C. Mango fruits treated with hot water at 50°C for 10 min showed a little rise in production of ethylene during the storage period at 10°C and ripening at 20°C for 7 days. Fruits treated with HWD at 50°C for 10 min recorded the better content of soluble solid and the lower titratable acidity. In addition, significant decline in content of ascorbic acid was observed during storage period at 10°C as well as ripening at 20°C compared with a sharp reduction in control fruit.

Key words: Postharvest hot water treatments · Ethylene production · Diab mango · Fruit quality

INTRODUCTION

Mango (*Mangifera indicia* L.) is an evergreen tree grown during subtropical and tropical regions. Mango is the oldest trees, most popular and the best marketing fruit. Mangoes observed as a source of antioxidants comprising ascorbic acid (mangoes give around 50% of vitamin C) and total carotenoids, which are responsible of mango yellow color [1]. The mangoes life usually does not exceed 2-3 weeks and is limited by physiological deterioration of the fruit related to over ripening and by disease development leading to decay. So, there is a need to monitor the disease severity during the shelf life of mangoes to prevent the spread of diseases. Tropical mangoes fruits destined for importance are commonly required to have a thermal treatment against invasive pests and preserve fruit quality [1, 2].

Postharvest heat treatment inhibited softening, ripening and improved fruit quality. Heat treatments offers a pesticide-free method to kill or reduce plant pathogens and maintain fruit storage quality [3]. Hot water rinsing (HWR) as new technology has been proposed for simultaneously cleaning and disinfecting fruits. Recently, HWR treatments are studied extensively prior to higher temperature and lower exposure time than traditional hot water immersions or dips. HWR treatments could not only

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disposal of heavy dirt, fungal spores and pesticides on the freshly produce harvested, but also improve general appearance and maintain quality of product [4].

Pretreatments of moderate heat, such as 38°C, induce tolerance of fruit to the higher temperatures necessary to kill insects. [2, 5, 6]. Postharvest hot water treatments have increased prior to prevent fungal rots, control insect pests and increase chilling injury resistance [7, 8]. Hot water treatments were effectively inhibited the anthracnose visible appearance during ripening. Mangoes must be subject to hot-water treatment process that involves their immersion in hot water over a period of time to control fruit quality and killing the "fruit fly" [9]. The effects of HWT depend on some factors such as cultivar, maturity stage, temperature and duration.

The main goal of this study was to determine the effects of postharvest heat treatments with both heat storage and hot water immersion on mango fruits "Diab" variety to prolong ripening duration and fruit quality preserve.

MATERIALS AND METHODS

Fruits: Mature fresh fruits of mango (*Mangifera indica* L.) cv. Diab were obtained from a private orchard (Nemous), Katta district, Giza Government. Mango fruits were harvested at the mid of September (2015 and 2016 seasons) from trees were 15 years old, grown in sand-loam soil and were similar in growth and received common horticulture practices. Fruits were collected and transported carefully to the laboratory of ADS project, Faculty of Agriculture, Cairo University. Upon arrival at the laboratory, the pedicels were cut back and selected fruits uniformity of shape, color and size with absence of visible wounds and blemished or diseased fruits were washed in chlorinated water (100 ppm free chlorine) for 10 min., dried and randomly distributed for each hot water treatments.

Treatments: The hot water treatment was performed by subjected mango fruits to hot water dipping (HWD) at 45 or 50°C for 5 and10 min. and cooled for 10 min. too. During HWT, fruit core temperature was confirmed by using digital thermometer with an electronic probe. After treatments, fruits in each trial were packed in corrugated cardboard boxes. All HWD and non-treated fruits (control) were stored at 10°C±2°C as shipping simulation with 90-95% relative humidity for 3 weeks and ripening at 20°C. Each treatment constituted three replications for each sampling date (7 days) and each replicate consisted of 3 fruits. Fruits quality measurements were assessed after each sampling date (7 days) and after ripened at 20°C as follow:

Physical Characteristics: The weight loss percent was calculated by standard procedure as mentioned in A.O.A.C [10]. Decayed fruits by different physiological and pathological factors were periodically counted and discarded. Then the decay percentages were calculated in relation to total number of fruits during whole storage Firmness of the pulp was recorded (Ib/inch^2) Ametek pressure tester, fitted with an 8 mm hemispherical probe (probe penetration 2 mm). period.

Ethylene Production: Ethylene production was determined according to Jeffery and Kipping [11] using Perkin Elmer Simms 3B gas chromatography Carla with flame ionization detector, equipped with porapak Q colum (activated alumina). The chromatograph was isothermally adjusted at 80°C for oven colum temperature and 800C for both detector and injector. The ethylene production was calculated as μ C_2H_4/ Kg/hr.

Chemical Characteristics: The soluble solid content (SSC) was measured by using a T/C hand refractometer according to A.O.A.C method [12]. Total acidity (expressed as malic acid) was determined by titrating 5 ml juice with 0.1N sodium hydroxide using phenolphthalein as an indicator. Ascorbic acid content (Vitamin C) was determined using 2, 5-6 dichlorophenol indophenols' titration methods as described by A.O.A.C. [13].

Statistical Analysis: The design for this experiment was a completely randomized design (CRD) with three replications. Data were analyzed with the analysis of variance (ANOVA) procedure of MSTATC program [14].

RESULTS AND DISCUSSION

Physical Characteristics: Data presented in Fig. (1) indicated that all postharvest hot water (HW) treatments did not give any discarded fruits (decay percent) until one week of storage period. However, after 3 weeks of storage period, the control fruits (untreated) exhibited the highest value of decay percentage (21.42 %) followed by treatment of hot water (HWT) at 45°C/5 min. (18.20%), while the least value of decay percent (9.50%) was recorded by HWT at 50°C/10 min. On the other side, there were differences significantly between decay percent for mango fruits (Diab cv.) treated by different hot water

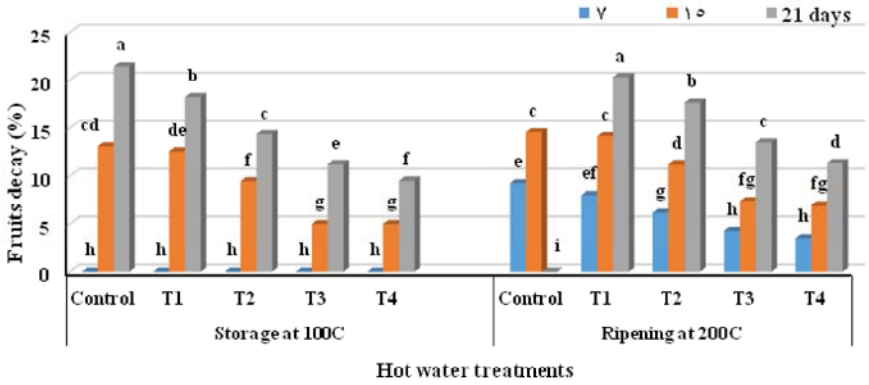

Fig. 1: Fruit decay percent of mango fruits affected by hot water dipping (HWD) treatments for 3rd week of storage period and ripening at 20°C (average of two seasons).

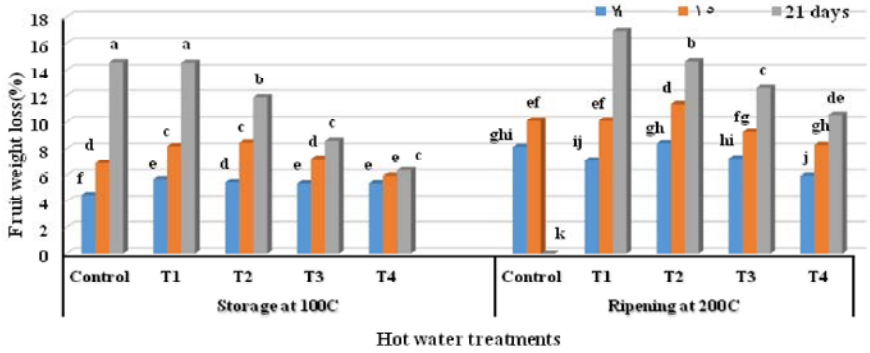

Fig. 2: Fresh weight losses percent of mango fruits affected by hot water dipping (HWD) treatments for 3rd week of storage period and ripening at 20°C (average of two seasons).

treatments during ripening at 20°C. The highest percent of decay was obtained by control fruits (14.52%) after two weeks ripening at 20°C. On the contrary, HWT at 50°C/10 min was the best treatment which recorded the least value of decay percent (11.33%).

The fruit weight loss considerable as a quality index in postharvest life. The reduction in weight is attributed to the physiological weight loss (PWL) due to respiration, water transpiration and other biological changes taking place in the fruit. Results illustrated in Fig. (2) showed progressive increase in weight loss percentage occurred for mango fruits cv. Diab throughout postharvest hot water (HW) treatments by prolonging the storage periods and ripening at 20°C. Untreated fruits having the higher decay percent (14.60 %) at the end of storage period (21 days). The minimum reduction of weight loss percentage was recorded by hot water treatment at 50°C/10 min. in the third week of storage period. Meanwhile, the maximum weight loss was obtained by treated fruits with (HWT) at 45°C /5 min. The same trend was observed during ripening at 20°C.

Pulp firmness of mango fruits cv. Diab were affected significantly by using different postharvest hot water treatments (HWTs). All of different HWTs achieved the highest value of firmness with significant differences compared with untreated fruits (control) at the end of storage period and ripening at 20°C during 2015 and 2016 seasons at Fig (3). Mangoes dipping in hot water at 50°C for 10 min. was more effective in keeping fruit firmer after 21d (9.87 Ib/inch^2) followed by fruit dipped at 50°C for 5 min (9 Ib/inch^2 Ib/inch^2). while, the least pulp firmness was recorded by fruit dipped at 45°C for 5 min (6.5 Ib/inch^2) at the end of storage period. A similar decline in fruit firmness was found in mangoes after ripening at 20°C at the third week

The ratio of sugar to acid plays a significant role in the determination of ripeness stage and taste of the fruit. A slight and significant decrease in soluble solid content of two weeks then increase mango fruits cv. Diab throughout the storage period at 10°C and ripening at 20°C due to different postharvest treatments of hot water dipping (HWDTs) were showed at Fig.(4) during 2015 and

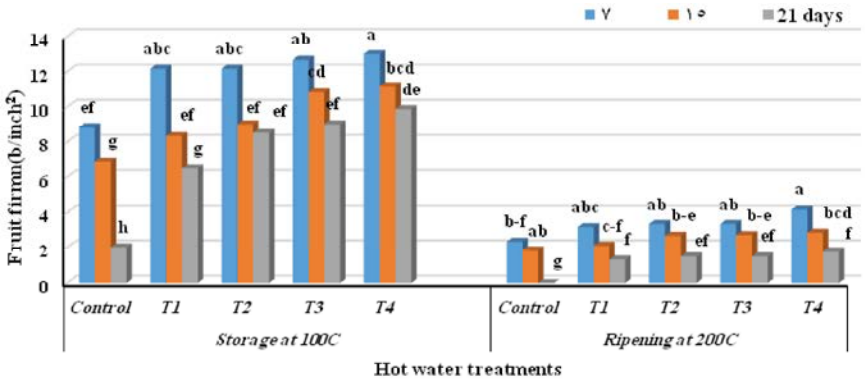

Fig. 3: Fruit firmness (Ib/inch^2) of mango fruits affected by hot water dipping (HWD) treatments for 3rd week of storage period and ripening at 20°C (average of two seasons).

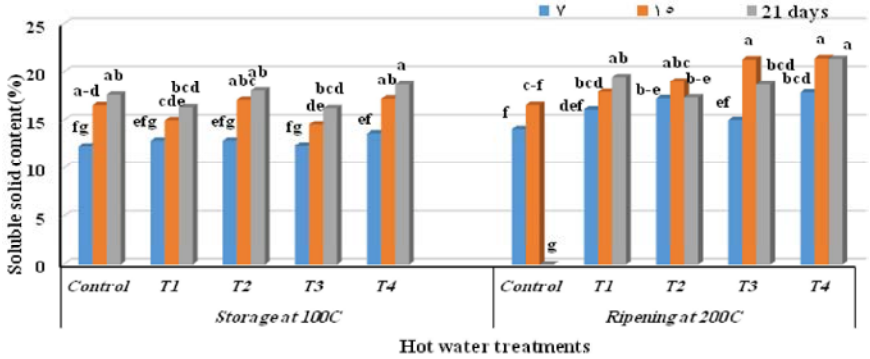

Fig. 4: Soluble solid content of mango fruits affected by hot water dipping (HWD) treatments for 3rd week of storage period and ripening at 20°C (average of two seasons).

2016 seasons. Also, untreated fruits (control) showed the same direction and gave the lowest level of soluble solid content after 21d storage period and 7d to ripe at 20°C. Meanwhile, HWDT at 50°C for 10 min. recorded the better content of soluble solid after 21 days of storage and 7 days to ripe at 20°C followed by 45°C for 10 min, 45°C for 5 min and 50°C for 5 min (19.2, 17.2, 18.4 and 17.5, respectively).

These results are in harmony with Jacobi and Giles [15] showed that, mango fruits cv. Kensington which treating with HWT at 53 °C for 5 min declined disease incidence, while of fruit injury severity was lower in HW + VHT than in VHT alone. Kumah *et al*. [16] reported that, Hot water treatments at 52°C/10 min, 52°C/5 min, 50°C/10 min and 50°C/5 min proved to be effective in controlling anthracnose disease on Keitt fruits after 7 days in storage, whereas the control showed the highest incidence. The best treatment to controlled anthracnose in mango fruits cv. Keitt was hot water treatment at 52°C after 21 days in storage for 5 minutes Yousef *et al*. [11].

A significant effect of mango cv. Dusheri storage had an increasing trend of average weight loss percent (0.00 to 36.1 %). Meanwhile, control fruit showed higher percentage of mass losses (19.88%) at ambient temperature (32-35°C with 53.6-78.8% RH) during 15 days storage reported Rathore *et al*. [18]. Hot water treatments at 52°C/10 min, 52°C/5 min, 50°C/10 min and 50°C/5 min proved to be effective in controlling anthracnose disease on Keitt fruits after 7 days in storage reported by Yousef *et al*. [19]. The quality of mango fruits during export was greatly improved by hot water dipping treatments as quarantine against invasive pests for expanding the market and shelf life duration [19].

Fruit firmness ranged from 1.7 to 2.1 lb in the first season and from 1.8 to 2.1 lb in the second seasons of 'Awais' mango fruits after irradiation and hot water after four weeks of cold storage, reported by El-*Salhy et al*. [20] In addition, Jha *et al*. [21] indicated that fruit firmness was declined after the 5th day of storage at ambient temperature (27±2°C) on mango hybrids. Mangoes dipped in hot water at 52°C for 10 min showed firmer fruits than

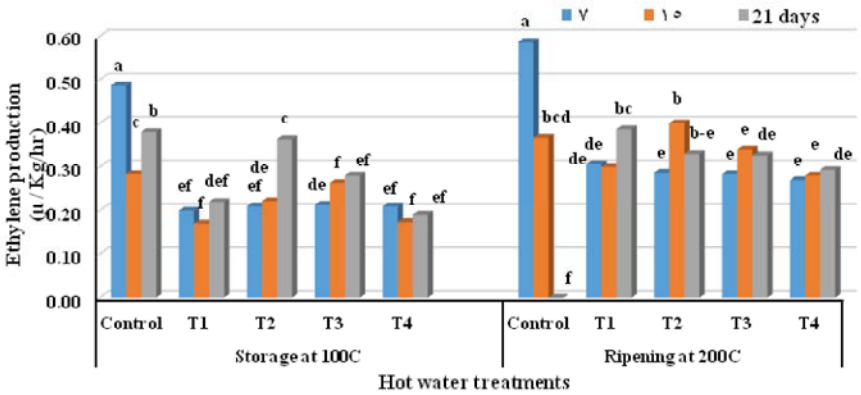

Fig. 5: Ethylene production of mango fruits affected by hot water dipping (HWD) treatments for 3rd week of storage period and ripening at 20°C (average of two seasons).

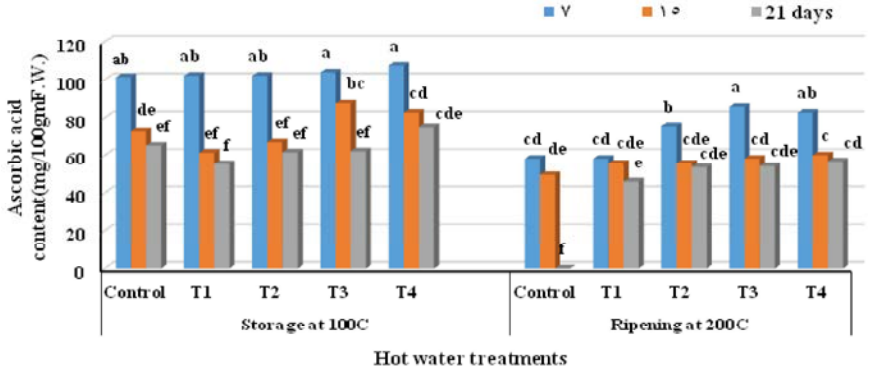

Fig. 6: Ascorbic acid content of mango fruits affected by hot water dipping (HWD) treatments for 3rd week of storage period and ripening at 20°C (average of two seasons).

those dipped at 48°C. Yousef *et al.* [17]. Loss in fruit firmness was also high in temperatures of 25°C compared to 7°C in both varieties (Nam doc mai and Keitt) but Nam doc mai variety retained fruits firmness better than the Keitt fruits found by Abdul-Rahaman *et al.* [19]. Similar results were obtained by Jacobi *et al*., [22] who reported that mango fruits cv. Kensington accelerated fruit ripening, increased Brix compared to untreated fruits and other treatments at 45°C for 30 min or 47°C for 15 min. The increase in SSC could be attributed by the breakdown of carbohydrate into simple sugar and glucose [23]. Also, Djioua *et al*. [1] showed that the final TSS value was higher after 9 days of storage by hot water dipping for 50°C at 30 min. (Keitt cv).

Ethylene production: Climactic fruits has a major role of ethylene hormone during ripening and ethylene hormone biosynthesis increase with the ripening process. Ethylene production changes of mangoes are shown in Fig. (5). The climacteric ethylene peak of untreated fruits was reached after 14 days of cold storage. Conversely, fruit treated with different treatments of hot water showed the climacteric ethylene peak after 21 days of storage. Mango fruits treated with hot water at 50°C for 10 min showed a small rise in ethylene production during the whole storage period at 10°C and ripening at 20°C for 7 days followed by 50°C for 5 min. Meanwhile, treated fruits by hot water at 45°C for 10 min showed a high rise in ethylene production compared to untreated fruits (control) which recorded the highest rise in ethylene production during the whole storage period at 10°C and ripening at 20°C for 7 days. The high ethylene production measured in HWT mangos likely resulted from a response to heat stress [24].

Chemical Characteristics: Fruits are a natural source of ascorbic acid and it is known that its level decreases during the ripening process. The ascorbic acid content of mango fruits subjected to different postharvest hot water dipping treatments (HWDT) is shown in Fig (6). The results demonstrated that ascorbic acid content decreased gradually and significantly during storage at 10 after hot water treatments at 50 and 45°C for 5 and 10 min.

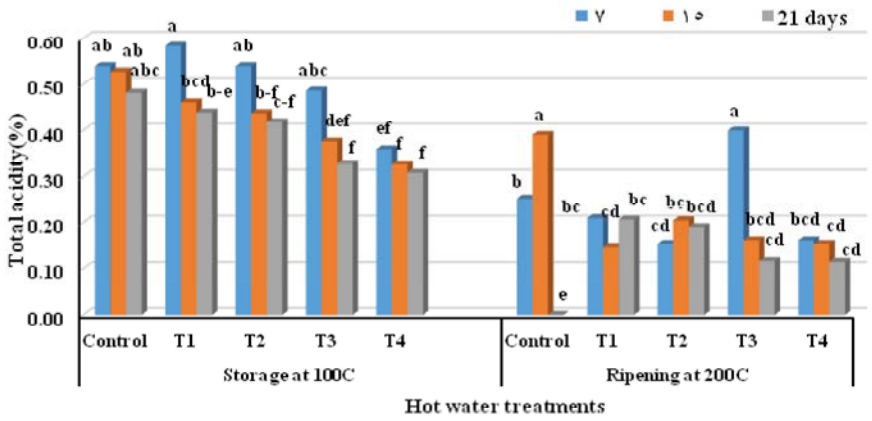

Fig. 7: Total acidity content of mango fruits affected by hot water dipping (HWD) treatments for 3rd week of storage period and ripening at 20°C (average of two seasons).

as well as ripening 20°C reached its minimum values at 3rd week storage. The highest ascorbic acid losses were recorded in the untreated fruits at the end duration of storage period. Meanwhile, the highest content of ascorbic acid was recorded by mangos dipped at 50°C for 10 min followed by 50°C for 5 min compared with control fruits. Mango fruit kept only at 20°C showed wide decrease in ascorbic acid content from 63.96 to 57.72 after 3rd week of storage period.

Total acidity of mangoes cv. Diab revealed significant and gradual decrease through the storage period at 10°C due to postharvest hot water dipping (HWD) treatments at 45 or 50°C for 5 and 10 min. Meanwhile, the percent of total acidity increase up to 2 weeks then decrease up to 3 weeks after ripening at 20°C during the two successive seasons at Fig. (7). The highest percent of total acidity was showed in the control fruits at the end of storage period. Meanwhile, the least total acidity content was recorded by mangos dipped at 50°C for 10 min (0.31%) at the third week of storage followed by 50°C for 5 min (0.33%) compared with control fruits (0. 47%). The relatively higher temperature of storage led to higher TA reduction during mango storage.

Whole and fresh-cut 'Ataulfo' mango fruit showed a little decrease in ascorbic acid during15 days storage [25]. Similarly, ascorbic acid content decreased continuously during ambient temperature stored for 12 days for 'Brokin', 'Julie' and 'Peter' mango varieties [26]. Jacobi *et al.* [22] showed that mango fruits cv. Kensington treated by HW treatment of 45°C for 30 min or 47°C for 15 min accelerated fruit ripening, lowered titratable acidity compared to other heat treatments and untreated fruits. These results coincided with those Doreyappa-Gowda and Huddar [27] who reported the similar pattern in different varieties of mango fruit stored at 18-34°C were considerably increased in pH from 2.85 to 4.38 and declined in acidity from 2.71 to 0.04% during ripening. These results further correspond with Srinivasa *et al.* [28] who found that Alphonso mango fruits showed a decreasing trend of titratable acidity values from 2.17% to 0.08% on 12th day during stored at 27±1°C and 65% RH.

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