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Research Article

Effect of pre-storage hot air and hot water treatments on post-harvest quality of mango (*Mangifera indica* Linn.) fruit

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Abstract

Mature, green and fresh mango fruits were harvested from an orchard and sorted before they were subjected to hot air (HA) and hot water (HW) treatments. Before treatment, the fruits were washed with clean water, disinfected for 10 min in 0.385% m/v of sodium hypochlorite and allowed to air-dry at 26 °C before they were separately immersed in HA and HW at 52 and 55 °C for 1, 3 and 5 min each before storage at 28 ± 2 °C and 75 ± 5% relative humidity inside sterilized desiccators where the fruit peel colour change was evaluated at intervals of 5days for 20 days while fruits that were not heat treated served as control. Each treatment contained a replicate of five fruits. After 20 days in storage, the heat-treated fruits were then assessed for post-harvest quality characteristics including weight loss, firmness, titratable acidity (TA) and total soluble solids (TSS). Only fruits treated with HA at 52 °C-3 min and 55 °C-3 min retained the mango peel greenness for 20 days while those treated with HW at 55 °C -1min and 55 °C -3 min equally retained the peel greenness but for 15 days in storage. Thus, they were considered as effective and interestingly, the weight loss, firmness; TA and TSS of the treated fruits were not significantly affected by these effective treatments as compared with untreated fruits.

Keywords: attributes; heat treatment; temperature; time; shelf life

Introduction

Mangoes (*Mangifera indica*) are juicy stone fruits (drupe) from numerous species of tropical trees belonging to the flowering plant genus, *Mangifera*. The fruits are delicate and tasty, popular on the international markets and are cultivated mostly for their edible fruits (Jacobi *et al.*, 2001). They are one of the highly consumed fruits throughout the world and are rich in vitamins A and C, and have very good food value (Lauricella *et al.*, 2017). It is a crucial tropical fruit which is consumed as fresh and processed form. In fact, according to Lauricella *et al.* (2017), mango fruits are highly nutritious fruits containing carbohydrates, proteins, fats, minerals, vitamins, particularly vitamin A (beta carotene), B1, B2 and vitamin C (ascorbic acid). In spite of the growing worldwide demand for mango fruit, its productivity is affected by pre harvest and postharvest diseases, which reduce the fruit quality and cause severe losses, because they leave them as unmarketable fruits (Diedhiou *et al.*, 2007). Rapid flesh softening, wounding due to poor picking and -handling practices as well as unhygienic conditions during packaging, storage and transportation were identified as major factors that affect the fruits after harvest (Yahia, 1998). Disease attack poses a serious threat because the

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postharvest life of mangoes usually does not exceed 7 days and is limited by physiological deterioration of the fruit related to over ripening and by disease development leading to decay (Kumah *et al.*, 2011). Postharvest diseases result in major losses on both international and domestic markets and effective control measures are required to retain product quality so as to ensure profitable production and trade.

There are different strategies that can be employed for the management of postharvest diseases in mango fruits and these include the controlled environment, use of fungicides, handling and storage, irradiation and heat treatments (Schirra *et al.*, 2000). Among these, fungicides have been used extensively for postharvest disease control in mango fruits. They can be applied as dips, sprays, fumigants, treated wraps and box liners or in waxes and coatings. Nevertheless, use of chemical treatments has been reported to leave toxic residues on fruits as this poses a significant health risk to consumers and also the environmental risks associated with some synthetic pesticides which make them very much restricted by regulatory bodies (Kumah *et al.*, 2011).

Hence, the use of heat treatments (HT) to control postharvest diseases of fruits and vegetables provides a suitable alternative and has since been extensively reviewed (Janisiewich and Korsten, 2002; Wisniewski *et al.*, 2007). The heat treatment can be applied in form of dry hot air, humid hot air or hot water. The advantages of HT except for being an environmentally friendly method, include that it can easily be implemented into the supply chain and can be practiced by any size farming enterprise with success. On this basis, the objective of this research is to investigate effect of heat treatments on the overall mango fruit quality after harvest.

Materials and Methods

Source of material

Mature, green healthy mango fruits were harvested from an orchard in Oluwatuyi, Akure South, Nigeria (7.2146 °N and 5.1641 °E). Fruits of uniform size and colour were selected. Before treatment, the fruits were washed with clean water, disinfected for 10 min in 0.385% m/v of sodium hypochlorite and allowed to air-dry at 26 °C and thereafter subjected to heat treatments.

Heat treatments

The disinfected fruits were then separately immersed in hot air oven and hot water at 52 and 55 °C for 1, 3 and 5 min each before storage at 28 ± 2 °C and 75 ± 5% relative humidity inside sterilized desiccators for 20 days while fruits that were not heat treated served as control. Each treatment contained a replicate of five fruits.

Assessment of peel colour of heat-treated mango fruits

Fruits were assessed for peel colour change at 5 days intervals in storage for 20 days following treatment. The peel colour change was ranked using the scale of Shorter and Joyce (1998) but with slight modification where 100% = completely green; 2 = 75% green and 25% yellow; 3 = 50% green and 50% yellow; 4 = 75% yellow; 5 = 100% yellow. To obtain a weighted average for the colour change per treatment, the number of fruits with each colour rating was multiplied by the rating and divided by the number of fruits.

Determination of fruit weight loss

Fruits weight losses were calculated after 20 days in storage following treatment using a digital Mettler Balance and the weight loss (%) from each fruit was calculated as shown below:

$$\text{Weight loss (\%)} = \frac{initial\ weight - current\ weight}{initial\ weight} \times 100$$

Firmness test

Fruits from each treatment lot after 20 days of storage were tested for firmness using fruit penetrometer (GY-3 model). The penetrometer was put on the fruit uprightly, pressed into the fruit and stopped when its plunger entered into the fruit and the observed value was recorded.

Determination of titratable acidity (TA)

TA determination was done separately with juice of each fruit per treatment after 20 days in storage. 10 milliliters of freshly extracted, undiluted juice from each treated fruit was titrated against 0.1 N Sodium Hydroxide to pH 8.23 in a beaker (D'Aquino *et al.,* 1998). Amount of citric acid (g/100ml juice) was estimated using the following relation:

$$\text{Amount of citric acid (g/100ml juice)} = \frac{(volume\ of\ base\ used) \times 0.007\ x\ 100}{(volume\ of\ juice\ taken)}$$

Where 1 ml of 0.1 N NaOH is equivalent to 0.007 g citric acid.

Determination of total soluble solid (TSS)

TSS of fruits was determined after 20 days in storage following treatment. Three drops of thoroughly mixed fresh juice from each treated fruit was dropped on the transparent glassy surface of a Japanese ATANGO hand refractometer instrument (D'Aquino *et al.*, 1998). The surface was covered and the TSS read on the instrument in degree Brix (°Brix) through its eye piece.

Statistical analysis

The data obtained for peel colour change and other post-harvest quality parameters were subjected to statistical analysis using Analysis of Variance and where significant, the means were compared at 5% level of probability using Duncan's Multiple Range Test (SPSS Version 20).

Results

Effect of hot air treatment on peel colour change of mango fruits

Results of the effect of hot air treatment on peel colour change of mango fruits, stored at 28 ± 2 °C and 75 ± 5% relative humidity were shown in Table 1. On day 5 of storage, the peel colour change of control and all treated fruits were not significantly different ($p<0.05$) and ranged from 1.00 ± 0.00 for control and fruits treated at 55 °C-1 min to 1.40 ± 0.25 for fruits treated at 55 °C-5 min which thus implied that the fruits were 100% green. As storage duration proceeded to day 10, the peel colour change of both control and all treated fruits at 52 °C for 1 and 3 min, 55 °C for 1 and 3 min were not significantly different ($p<0.05$) from each other having 1.60 ± 0.25, 1.60 ± 0.25, 1.00 ± 0.00, 1.80 ± 0.37, 1.00 ± 0.00 as their respective peel colour values which implied that the fruits were still 100% green. However, the peel colour change of fruits treated at 52 °C and 55 °C for 5 min each were significantly different ($p<0.05$) having mean peel colour values of 2.00 ± 0.55 and 2.20 ± 0.37 respectively, indicating that the fruits were 75% green and 25% yellow (Table 1).

On day 15 of storage, the peel colour values of treated mango fruits at 52 °C-3 min (1.20 ± 0.20) and 55 °C-3 min (1.20 ± 0.20) still implied the fruits were 100% green. The values were however significantly different ($p>0.05$) from the control (3.40 ± 0.25) and other treated fruits at 52 °C-1 min (3.40 ± 0.25), 52 °C-5 min (2.20 ± 0.37), 55 °C-1 min (2.60 ± 0.25) and 55 °C-5 min (3.0 ± 0.25). As the storage duration progressed to day 20, the peel colour values of fruits treated at 52 °C-3 min and 55 °C-3 min were not significantly different ($p<0.05$) from each other having 1.60 ± 0.25 and 1.80 ± 0.20 as their respective mean peel colour values which implied the fruits were still 100% green. However, these values were significantly different ($p>0.05$) from the peel colour values of control (4.60 ± 0.24) and other treated fruits at 52 °C-1 min (4.20 ± 0.37), 52 °C-5 min

(4.20 ± 0.37), 55 °C-1 min (4.00 ± 0.32) and 55 °C-5 min (4.40 ± 0.40), all indicating that the fruits were 25% green and 75% yellow (Table 1).

Table 1. Effect of hot air (HA) treatment on peel colour change of mango (*Mangifera indica* Linn.) fruits

HA treatment (°C-min)	Storage duration (days)/ Peel colour values			
	5	10	15	20
52-1	1.00 ± 0.00a	1.60 ± 0.24ab	3.40 ± 0.24bc	4.20 ± 0.37b
52-3	1.00 ± 0.00a	1.00 ± 0.00a	1.20 ± 0.20a	1.60 ± 0.24a
52-5	1.20 ± 0.20a	2.00 ± 0.45bc	2.20 ± 0.37b	4.20 ± 0.37b
55-1	1.20 ± 0.20a	1.80 ± 0.37ab	2.60 ± 0.24b	4.00 ± 0.32b
55-3	1.00 ± 0.00a	1.00 ± 0.00a	1.20 ± 0.20a	1.80 ± 0.20a
55-5	1.40 ± 0.24a	2.20 ± 0.37bc	3.00 ± 0.24c	4.40 ± 0.40b
Control	1.00 ± 0.00a	1.60 ± 0.24ab	3.40 ± 0.24bc	4.60 ± 0.24b

Note: Each value represents a mean of 5 replicates and where significant, the means were separated using Duncan multiple range test (DMRT) at p≤ 0.05. Values with the same alphabet in the same column are not significantly different *(p≤0.05)*. **1=** 100% green; **2=** 75% green and 25% yellow; 3= 50% green and 50% yellow; 4= 25% green and 75% yellow; 5= 100% yellow

Effect of hot water treatment on peel colour change of mango fruits

Similarly, results of the effect of hot water treatment on peel colour change of the mango fruits were presented in Table 2. On day 5 of storage, the peel colour value of control fruits (1.00 ± 0.00) were not significantly different (p<0.05) from all other treated fruits. The peel colour values of fruits treated at 52 °C for 1, 3 and 5 min were 1.40 ± 0.25, 1.20 ± 0.20 and 1.40 ± 0.25 respectively and 1.00 ± 0.00, 1.20 ± 0.20 and 1.40 ± 0.25 for fruits treated at 55 °C for 1, 3 and 5 min respectively (Table 2) which showed that the fruits were 100% green (Table 2). As storage duration progressed to day 10, there was no significant difference in the peel colour values between the control fruits (2.60 ± 0.25) and fruits treated at 52 °C-3 min (1.40 ± 0.25), 55 °C-1 min (1.00 ± 0.00) and 55 °C-3min (1.20 ± 0.20), indicating the fruits were still 100% green. However, the values were significantly different when compared with the peel colour values of other treated fruits at 52 °C – 1 min (2.00 ± 0.45), 52 °C-3 min (1.40 ± 0.25) and 52 °C-5 min (2.60 ± 0.25), implying such fruits were 75% green and 25% yellow (Table 2).

On day 15 of storage, the peel colour value of control fruits (3.40 ± 0.24) were significantly different (p>0.05) from all the treated fruits. Nevertheless, the peel colour values of fruits treated at 52 °C-1 min (2.20 ± 0.37), 52 °C-3 min (2.20 ± 0.37) and 52 °C-5 min (2.80 ± 0.20) were not significantly different (p<0.05) from one another (Table 2). Interestingly, fruits treated at 55 °C for 1 and 3 min still maintained 100% greenness by having peel colour values of 1.20 ± 0.00 each (Table 1). On day 20 of storage, the peel colour value of the control fruits (4.60 ± 0.60) was significantly different (p>0.05) from the peel colour values of all other fruits treated at 52 °C-1 min (3.00 ± 0.00), 52 °C-3 min (3.40 ± 0.51) and 52 °C-5 min (3.40 ± 0.51) while fruits treated at 55 °C for 1, 3 and 5 min recorded peel colour values of 3.00 ± 0.32, 3.00 ± 0.00 and 3.40 ± 0.51 respectively (Table 2), all indicating that the treated fruits were 50% yellow and 50% green while the control fruits were 25% green and 75% yellow (Table 2).

Internal quality parameters of mango fruits treated at the most effective hot air treatments and stored for 20 days at 28 ± 2 °C and 75 ± 5% relative humidity

Results revealed that hot air treatment of the mango fruits at 52 °C-3min and 55 °C-3 min in terms of peel colour (greenness) were adjudged to be the most effective among all the treatments investigated. By day 20 of storage, the mean weight loss (%) of the fruits before treatment (0.00 ± 0.00) was not significantly different (p<0.05) from the mean weight losses of fruits treated at 52 °C-3 min (0.64 ± 0.26) and 55 °C-3 min (0.88 ± 0.16) (Table 3). Also, firmness (kgcm^{-3}) of fruits before treatment (6.46 ± 0.02) was not significantly different, though higher, from the firmness of treated fruits at 52 °C-3 min (6.35 ± 0.03) and 55 °C-3 min (6.45 ± 0.02). For titratable acidity (TA), results also showed that the TA (gml^{-1}) of fruits before treatment (6.36+0.03) was not significantly different, though higher, from TA of treated fruits at 52 °C-3 min (6.31 ± 0.02) and 55 °C-3 min (6.17 ± 0.08). Similarly, the TSS (°Brix) of fruits before treatment (10.62 ± 0.25) was not significantly different, though lower, from TSS of treated fruits at 52 °C-3 min (10.74 ± 0.30) and 55 °C-3 min (10.89 ± 0.69) (Table 3).

Table 2. Effect of hot water (HW) treatment on peel colour change of mango (*Mangifera indica* Linn.) fruits

HW treatment (°C-min)	Storage duration (days)/ peel colour values			
	5	10	15	20
52-1	1.40 ± 0.25a	2.00 ± 0.45bc	2.20 ± 0.37bc	3.00 ± 0.00ab
52-3	1.20 ± 0.20a	1.40 ± 0.25ab	2.20 ± 0.37bc	3.40 ± 0.51ab
52-5	1.40 ± 0.25a	2.60 ± 0.25d	2.80 ± 0.20c	3.40 ± 0.25ab
55-1	1.00 ± 0.00a	1.00 ± 0.00a	1.20 ± 0.00a	3.00 ± 0.00ab
55-3	1.20 ± 0.20a	1.20 ± 0.20ab	1.20 ± 0.00a	3.00 ± 0.00ab
55-5	1.40 ± 0.25a	2.20 ± 0.37cd	2.20 ± 0.37bc	3.40 ± 0.51ab
Control	1.00 ± 0.00a	1.60 ± 0.25abc	3.40 ± 0.24d	4.60 ± 0.60c

Note: Each value is a mean of 5 replicates and where significant, the means were separated using Duncan multiple range test (DMRT) at p≤ 0.05. Values with the same alphabet in the same column are not significantly different (p≤0.05). 1 = 100% green; 2 = 75% green and 25% yellow; 3 = 50% green and 50% yellow; 4 = 25% green and 75% yellow; 5 = 100% yellow

Table 3. Internal quality parameters of mango fruits treated at the most effective hot air (HA) treatments

HA Treatment (°C-min)	Weight loss (%)	Firmness (kgcm^{-3})	TA (gml^{-1})	TSS (°Brix)
Before treatment	0.00 ± 0.00a	6.46 ± 0.02a	6.36 ± 0.03a	10.62 ± 0.25a
52-3	0.64 ± 0.26a	6.35 ± 0.03a	6.31 ± 0.02a	10.74 ± 0.30a
55-3	0.88 ± 0.16a	6.45 ± 0.02a	6.17 ± 0.08a	10.89 ± 0.09a

Note: Each value represent mean of 5 replicates and where significant, the means were separated using Duncan multiple range test (DMRT) at p≤ 0.05. Values with the same alphabet in the same column are not significantly different (p≤0.05). TA - Titratable acidity; TSS - Total soluble solids

Internal quality parameters of mango fruits treated at the most effective hot water treatments and stored for 20 days at 28 ± 2°C and 75 ± 5% relative humidity

In the same vein, results revealed that hot water treatment of the mango fruits at 55 °C for 1 and 3 min each in terms of peel colour (greenness) were adjudged to be the most effective among all the treatments investigated. By day 20 0f storage, the mean weight loss (%) of fruits before treatment (0.00 ± 0.00) was not significantly different (p<0.05), from the mean weight losses of fruits treated at 55 °C-1 min (0.30 ± 0.15) and 55 °C-3 min (0.31 ± 0.14) (Table 4). Also, the firmness (kgcm^{-3}) of fruits before treatment (6.00 ± 0.014) was not significantly different, though lower, from the firmness of treated fruits at 55 °C-1 min (5.89 ± 0.27) and 55 °C-3 min (5.50 ± 0.28). Results also showed that the TA (gml^{-1}) of the fruits before treatment (5.20+0.20) was not significantly different, though higher, from the TA of treated fruits at 55 °C-1 min (5.08 ± 0.22) and 55 °C-3 min (5.17 ± 0.17). Similarly, the TSS (°Brix) of fruits before treatment (9.73 ± 0.11) was not significantly different, though lower, from the TSS of treated fruits at 55 °C-1 min (9.74 ± 0.14) and 55 °C-3 min (10.74 ± 0.71) (Table 4).

Table 4. Internal quality parameters of mango fruits treated at the most effective hot water (HW) treatments

HW Treatment (°C-min)	Weight loss (%)	Firmness ($kgcm^{-3}$)	TA (gml^{-1})	TSS (°Brix)
Before treatment	0.00 ± 0.00a	6.00 ± 0.14a	5.20 ± 0.20a	9.73 ± 0.11a
55-1	0.30 ± 0.15a	5.89 ± 0.27a	5.08 ± 0.22a	9.74 ± 0.14a
55-3	0.31 ± 0.14a	5.50 ± 0.28a	5.17 ± 0.17a	10.74 ± 0.71a

Note: Each value is a mean of 5 replicates and where significant, the means were separated using Duncan multiple range test (DMRT) at $p \leq 0.05$. Values with the same alphabet in the same column are not significantly different ($p \leq 0.05$).
TA - Titratable acidity; TSS - Total soluble solids

Discussion

In this study, only fruits treated using HA at 52 °C-3 min and 55 °C-3 min when compared with other treated fruits and the control, maintained 100% greenness by day 20 in storage while fruits treated using HW at 55 °C for 1 and 3 min each equally maintained 100% greenness but by day 15 in storage. This observation was buttressed by several earlier reports that heat treatment retarded ripening related colour changes (Kaewsuksaeng *et al.*, 2007; Le *et al.*, 2010; Kaewsuksaeng *et al.*, 2015). According to Bard and Kaiser (1996), heat treatments have been decreasing rate of ripening and prolonging shelf life in a number of selected fruits. In fact, hot water treatment has been increasingly used in previous research to retard post-harvest physiological changes that could lead to ripening (McCollum *et al.*, 1995; Laamim *et al.*, 1998). Several authors have earlier reported that chlorophyll degradation leading to chlorophyll loss is one of the major issues in many post-harvest horticultural produces resulting to yellowing and senescence (Kasim and Kasim, 2008; Srilaong *et al.*, 2011). In fact, according to Moalemiyan and Ramaswamy (2012), chlorophyll constantly decreases during ripening of fruits, exposing the lighter yellow pigments. Grierson *et al.* (1986) also supported the claim that the loss of chlorophyll is a result of conversion from chloroplast to chromoplast which unmasks the various coloured compounds principally carotenoids which increase during ripening of fruits. Interestingly, observation from this study has been able to buttress these earlier reports because HA at 52 °C and 55 °C for 3 min each and HW at 55 °C for 1 and 3min each used in this work actually retarded chlorophyll degradation in the treated fruits, making them to be completely green (100% greenness) during storage.

Also, the weight loss of fruits before treatment was not significantly different from weight losses of treated fruits by day 20 in storage, although there was slight increase in the weight loss of the treated fruits as compared with the untreated. This finding agreed with the previous works of Schirra and D'hallewin (1997) who reported increase in fruit weight loss following hot water dipping on Fortune mandarin fruits and Mc Guire and Reeder (1992) who reported increase in fruit weight loss following hot air treatment on grape fruits. Again, the observation also confirmed the previous work of Park and Jung (1996) and Schirra *et al.* (1997) who reported rapid weight loss in citrus fruit exposed to heat treatments. The weight loss might not be unconnected with the fact that heat treated fruits showed expanded cell structure which probably have aided loss of water from the peel leading to weight loss. More so, heat treatment could keep high internal temperature, resulting in stomata opening and accelerating respiratory that affected the water exchange through the fruit skin (*Kasim and Kasim, 2011*).

Fruit firmness is one of the criteria of fruit quality determined by various researchers for different fruits (Le *et al.*, 2010). Therefore, after 20 days of storage both for the effective HA and HW treatments, all the treated fruits-maintained firmness that were not significant different from the control (untreated) fruits. This observation contradicts the previous reports of Jacobi *et al.* (1995, 1996) that untreated mango fruits tend to be firmer than heated fruits. Although, this earlier report may be unarguably right because Jacobi *et al.* (1995, 1996) worked on fruits that are at the ripe eating stage while this work that investigated fruits that were completely green following heat treatment and were still completely green during storage. According to Omoba and Onyekwere (2016), fruit softening is a biochemical process involving the hydrolysis of pectin and starch by enzymes, such as cell wall hydrolases. In that regard, the effective HA and HW obtained in this study might have inhibited the activities of these enzymes thereby maintaining the firmness of the treated fruits. Again, the observed firmness of the treated fruits, not significantly different from the control fruits, might be attributed to antifungal activity of the effective HA and HW which resultantly must have reduced infection, respiration and other ripening processes in the treated fruits.

The TA of the treated mango fruits with effective HA and HW was not significantly different from the TA of the control (untreated) fruits after 20 days in storage. This observation was buttressed by the report of Mansour *et al.* (2006) that there was no significant difference in TA among fruits of three different mango varieties treated with different heat treatments as compared with untreated fruits. It had been also earlier reported that total acidity of citrus fruits was not significantly affected by heat treatment. Meanwhile, the non-significant decline in TA of the treated fruits during storage confirmed the report of Alikhan *et al.* (2007) and Abdur *et al.* (2011) that heat treated fruits have lower values for organic acids. The decline in the TA of the treated fruits suggests that the heat treatment might have reduced the rate of respiration and delayed the utilization of organic acids which eventually resulted in decrease of acidity in the treated mango fruits and according to Hong *et al.* (2012), a reduction in acidity is expected in respiring fruits.

In the same vein, the TSS of the treated mango fruits with effective HA and HW was not also significantly different from TSS of the control (untreated) fruits after 20 days in storage. This is in agreement with the work of Jacobi *et al.* (2001) who treated mangoes with hot water and hot air at various temperatures and observed that the treated fruits did not vary in TSS. In fact, Mitcham and McDonald (1997) had earlier reported that total soluble solid content of mangoes even at the ripe stage were not influenced by heat treatments. Similarly, Shellie and Mangan (1994) and Ekran *et al.* (2005) equally reported that heat treatment has no consistent effects on TSS. Besides, Schirra *et al.* (1997) reported that the influence of heat treatment on physiological response of fruit (though on citrus) and its internal quality attributes was negligible. Meanwhile, the non-significant increase in TSS however observed in the treated fruits during storage was consistent with the works of Alikhan *et al.* (2007) and Sajnin *et al.* (2003) who reported, though on orange and cucumber fruits respectively, that TSS increased slightly with storage and might be due to the breakdown of starch to simple sugars (Yaman and Bayoindirli, 2002).

Conclusions

Mango fruits treated with HA at 52 °C-3 min; 55 °C-3 min and HW at 55 °C for 1min and 3 min remained completely green in terms of peel colour after 20 days in storage (for HA) and 15 days (for HW) without any significant difference in weight loss, firmness, TA and TSS as compared with untreated fruits. Heat treatments therefore seem to be more promising in extending the storage life of mango fruits for domestic markets, particularly in the tropics and developing countries, where cold chain infrastructure is not well established and problem of postharvest losses of fruits is of great concern to farmers, fruit-traders and consumers.

Authors' Contributions

Conceptualization: OO and FO; Investigation: OO and FO; Supervision: OO; Visualization: OO and FO; Writing original draft: OO; Writing-review and editing: OO and FO. Both authors read and approved the final manuscript.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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