Original Research Article

PHYSICOCHEMICAL ATTRIBUTES IN MANGO (*MANGIFERA INDICA*) FRUIT AS INFLUENCED BY STORAGE TEMPERATURE AND HOT WATER TREATMENT, DURATION AND INTERACTION.

ABSTRACT

The temperature being the most important environmental factor that influences the deterioration of perishable commodities. It is often critical that fresh produce rapidly reach the optimal pulp temperature for short term storage if it is to maintain its highest visual quality, flavour, texture and nutritional content (Kader, 2013). The effects of storage temperature and hot water at various temperature and duration on chemical and textural characteristics of the Keitt mango fruit were evaluated for the 2015/16 growing season in Botswana. The treatments were fruits dipped in distilled water at room temperature (25 ± 2 ˚C- control), fruits dipped in hot water at 50 and 55 ˚C for a duration of 3, 5 and 10 minutes, and storage temperatures at 4, 7, 10, 13, or 25 ± 2 ˚C, plus 95% RH. The results showed that as the storage temperature and water temperature decreased, the proline content and electrolyte leakage increased significantly ($P \leq 0.0001$). The interactions of storage temperature and hot water temperature, and duration in which mango fruit was treated with hot water, significantly ($P \leq 0.01$) maintained vitamin C content, firmness and reduced fruit weight loss during storage and seven days after storage when the fruit was kept at room temperature.

Keywords: mango, temperature, interaction, textural characteristics, proline content,

1.0 INTRODUCTION

Mango (*Mangifera indica* L) belongs to the family Anacardiaceae is also known as the cashew family with about 75 genera and 700 species, mostly tropical with subtropical and temperate species (Nakasone and Paull, 1998; Derese et al., 2017). Mango is one of the world's most popular fruit crops cultivated in the tropical and subtropical climate (FAO, 2004; Lauricella et al., 2017). Fresh mango has an irresistible combination of flavours and textures that brings new excitement to recipes. Mangoes are an excellent source of vitamins A and C and a good source of fibre. Many studies have shown that free radicals in the living organisms cause oxidative damage to different molecules such as lipids, proteins, nucleic acids and these are involved in the interaction phases of many degenerative diseases. The mango peel extract exhibited good

antioxidant activity in different systems and thus may be used in nutraceuticals (Asula *et al*., 2007; Lourenço et al., 2019). In addition to that, mangoes are best noted for their vibrant flesh colour, juicy texture and sweet flavour along with important nutrient combination for their phytochemicals. Fruits are living tissues and are diverse in morphology, structure, composition and general physiology. Due to high moisture content, active metabolisms, tender nature and rich in nutrients, they are vulnerable to dehydration, physiological disorders, environmental stress, mechanical injury and pathological breakdown therefore usually considered to be highly perishable (Kader, 2005). Therefore, these characteristics limit the storage life of the fruits and vegetables and cause significant deterioration following harvest. Most fruits that originated from the tropical or subtropical regions are chilling sensitive (Gross *et al*., 2002; Pio et al., 2019). Chilling injury is a storage disorder that occurs at temperatures below the critical threshold but non-freezing temperature (Hardenburg *et. al*., 1986; Mercer and Smittle, 1992; Sharom *et al*., 1994). The problem limits the use of low storage temperature to manage postharvest ripening because the temperatures that are low enough to delay ripening, decay and senescence may also be damaging to the fruit. Chilling injury is known to significantly change the microstructure of the tissue which in severe cases may lead to tissue breakdown due to failure to carry normal metabolic processes (Han *et al*., 2006). Various physiological, biochemical alteration and cellular dysfunction occur in chilling sensitive species in response to chilling stress (Wang, 1982). These alterations include increased membrane permeability and alteration of activities of membrane proteins. Temperature management plays a critical role in ensuring that high-quality mangoes are delivered. Avoiding high temperature and reducing temperature to the optimum reduces the rate of physiological and biochemical changes that occur in mango after harvest, minimizes water loss from the fruit and slows the growth of decay-causing micro-organism like anthracnose (Brencht and Cecilia, 2012). However, there is a limit to the low temperature that mango can tolerate due to their susceptibility to chilling injury, a disorder that results in flavour loss, surface blemishes and inhibition of ripening. Heat treatment induces heat shock proteins which protect the product from both heat and chilling injury, suppresses oxidative activity and maintain membrane stability. High levels of reducing sugars and proline were also found to correlate positively with the resistance to chilling injury (Purvis, 1981). The high levels of proline could be associated with the heat shock proteins which assist in protection against stresses by controlling the proper folding and conformation of the cell membrane and enzymatic

proteins. Since low temperature can alter the solubility and folding properties of many proteins, this chaperone activity plays an important role for protection against chilling injury (Vierling, 1991; Saltveit, 2005; Sevillano *et al*., 2009). In addition to that, mango shelf-life is reduced by high temperature and as such, there is a need to be conscious with the temperature at which mango is being stored to prolong its postharvest shelf-life and maintain its quality. Postharvest losses resulting from CI are higher than have been recognized. This dilemma results in tremendous postharvest losses for CI-sensitive crops (tropical crops). It is, therefore, important to alleviate CI in tropical crops but without compromising the chemical and textural characteristics of the fruit hence the significance of the current study. The objective of the study is to evaluate the effects of storage temperature and hot water treatment and duration on the chemical and textural characteristics of the mango fruit.

2.0 MATERIALS AND METHODS

2.1 Experimental site

A laboratory experiment was conducted from February and May 2015 at Botswana University of Agricultural and Natural Resources, Sebele. Sebele lies about 10km from the centre of Gaborone city on latitude 24°34'S and longitude 25°57'E elevated at 994m above sea level.

2.2 Experimental design

A 5 × 3× 3 factorial experiment laid down in completely randomized design was used with three replications. The treatments were storage temperature, hot water at different temperatures and time of exposure to hot water. The mango fruits were dipped in distilled water at room temperature (25 ˚C), mango fruits dipped in hot water at 50 and 55 ˚C; duration (time) in water treatments were 3, 5 and 10 minutes, and storage temperatures at 4, 7, 10, 13 and 25 ± 2 ˚C. Mango fruits dipped in water at various temperatures and durations were then stored in the temperatures indicated above. In each storage temperature, there were 135 fruits. Mango fruits were packed in perforated paper board cartons for each treatment. The mango cultivar Keitt was used for the study. The fruits were at physiological maturity with the flesh yellow in colour but peel still green and hard.

2.3 Variable assessment

Dependent variables analyzed were vitamin C, fruit weight loss, fruit firmness, electrolyte leakage and proline content. The above variables were determined both immediately after removal from cold storage and after seven days' storage at ambient temperature (25± 2 ˚C).

2.3.1. Fruit weight loss

Nine mango fruits were weighed before and after storage to calculate the per cent of the fresh weight loss. This was determined by subtracting the actual average weights of the fruits in each replication. The formula below was used to calculate per cent weight loss.

$$\% \text{ weight loss} = \frac{\text{Initial average weight} - \text{Actual average weight after storage}}{\text{Initial average weight}} \times 100$$

2.3.2 Fruit firmness

Mango fruit flesh firmness was determined using a hand-held Effegi penetrometer (Alfonsine, Italy) with 8 mm tip diameter. Nine fruit per replicate were used. Measurements were taken from two opposite sides of the fruit (red and green) with skin removed.

2.3.3 Electrolyte leakage

Electrolyte leakage was determined according to the method of Chan *et al*. (1985). Five discs taken with a 10 mm diameter cork borer from the peel and pulp tissue, then sample tissues were rinsed with deionized water to eliminate the electrolyte at the cut surface. The samples were placed in a flask containing 25 ml of 0.4 M mannitol. Incubation for 30 minutes at 25 ˚C was done where the electrical conductivity was measured in a suspending solution with an EC meter as an initial reading. The samples in a flask were heated at 98 ˚C for 15 minutes and the electrical conductivity was re-measured after cooling. Membrane permeability was calculated using the formula given below:

$$\% \text{ Electrolyte leakage} = \frac{\text{initial ion leakage reading at initial temperature}}{\text{Final ion leakage reading at the final temperature}} \times 100$$

2.3.4 Vitamin C

Vitamin C was determined by titration and results expressed as mg ascorbic acid per 100 g.

2.3.5 Proline

Mango fruit pulp was cut and homogenized in 10 ml of 3% aqueous sulfosalicylic acid. The homogenate was filtered through Whatman filter paper (grade 1). Then 2 ml of the filtrate was

reacted with 2 ml acid-ninhydrin and 2 ml glacial acetic acid in a test tube for an hour at 100 °C in a water bath to develop the colours. Soon after removal from the water bath, the test tube was cooled in an ice bath and proline extracted with 4 ml toluene, mixed vigorously with a test tube stirrer for 15-20 seconds. The chromophore containing toluene was aspirated from the aqueous phase, warmed to room temperature and the absorbance was read in a UV 160 IPC spectrophotometer (Parnomex Inc. New Dehli) at 520 nm using toluene as a blank. Proline content in mango fruit pulp was determined using the formula given below (Bates *et al*., 1973):

µmole proline/g of fresh weight = (µg proline/ml × ml toluene /115.5 µg/mole) / (g sample)

2.4 Data analysis

The data collected were subjected to analysis of variance (ANOVA) using the Statistical Analysis System (SAS). Treatment means were separated using the Least Significant Difference (LSD) at P=0.05.

3.0 RESULTS AND DISCUSSIONS

3.1 Vitamin C content

In the current study, storage temperature and water temperature interaction significantly ($P \leq 0.0001$) affected the vitamin C content of the mango fruits (Table 1 and 2), as the storage temperature and hot water temperature increased, the vitamin C content decreased significantly ($P \leq 0.0001$). Also as the storage temperature and duration in which mango fruit was held in hot water increased the vitamin C content significantly ($P \leq 0.0001$) decreased (Table 1). Loss of vitamin C can occur by irreversible conversion of dehydroascorbic acid to 2,3-dioxo-L-gluconic acid, which is then further metabolized. The reaction is pH-dependent, being slow in acid pH, rapid at neutral pH and extremely rapid at alkaline pH (Kays *et al*., 2004). The decrease in vitamin C content with increase in storage and the water temperature was attributed to decrease in juice pH and titrable acidity observed in the current study since the loss in vitamin C is pH and temperature-dependent, having rapid loss of vitamin C at higher fruit pH and temperature. Storage of fruits and vegetables at temperatures below 5 °C is reported to decrease the loss of

vitamin C (Hardenburg *et al*., 1986; Kays *et al*., 2004). The rate of loss of vitamin C is higher with higher storage temperature, an effect associated with loss of acidity (Kays *et al*., 2004). Mangoes stored at 24-26˚C for 6 days has been reported to result in a drop in vitamin C content from the initial 71 mg/100g to 63.9 mg/100g (Kays *et al*., 2004). Lee and Kader (2000) reported that the loss of vitamin C in fresh commodities is enhanced by extended storage and high temperature. Yousef *et al*. (2012) reported that ascorbic acid content decreased gradually and significantly during storage at 8, 10, 13 ˚C as well as in mango fruits dipped in hot water at 48 and 52 ˚C for 10 minutes.

3.2 Proline content

There was a significant ($P \leq 0.0001$) effect of the storage temperature and water temperature interaction on mango proline content immediately after removal from cold storage and seven days after cold storage on fruit held at room temperature (Table 1 and 2). As the storage temperature and water temperature decreased, the proline content increased significantly ($P \leq 0.0001$). Mangoes dipped in water at 25 ˚C and stored at 4 ˚C, had the highest proline content of 25 µmole/g, while those dipped at 55 ˚C but stored at 13 ˚C had significantly ($P \leq 0.0049$) lower proline content of 0.23 µmole/g. As storage temperature decreased from 25 to 4˚C, irrespective of water temperature, the proline content significantly ($P \leq 0.0001$) increased from 0.71 to 18.82 µmole/g, respectively, accounting for the 23.7-fold increase in proline content. Mango fruits stored in the non-chilling temperatures of 13 and 25˚C and dipped in hot water at 50 or 55˚C had the lowest proline content in the range of 0.23-0.93 µmole/g. The high proline content in mango fruit stored at 4, 7 or 10˚ C was attributed to chilling injury caused by the low temperatures. The high accumulation of proline in mango fruit stored below 13˚C in the current study was to enhance chilling injury tolerance to 'Keitt' mango fruits (Shang *et al*., 2011; Li *et al*., 2014). High proline content in chilled mango fruit in the current study was also attributed to either enhanced protein degradation at chilling temperatures and/or proline synthesis (Kumar *et al*., 2003; Shang *et al*., 2011; Cao *et al*., 2012; Li *et al*., 2014). As the hot water temperature increased from 25˚C to either 50 or 55˚C, the proline content decreased from 9.89 µmol/g to either 5.87 or 4.32 µmol/g, respectively. The decrease in proline content at high water temperatures higher than 25 ˚ C was attributed to by degradation of proline by the high temperatures (Shang *et al*., 2011; Cao *et al*., 2012).

Table 1.0 Effects of storage and hot water temperature, and hot water duration on mango chemical and textural characteristics immediately after removal from the storage regimes.

Treatments	**Chemical and textural attributes**				
	Vit C (mg/100 g)	Proline (µmole /g)	EL (%)	Firmness (N)	Weight loss (%)
Storage temperature °C					
4	39.1[a]	16.82[a]	57.08[a]	67.34[a]	10.57[e]
7	32.76[b]	12.31[b]	48.77[b]	45.91[b]	12.49[d]
10	28.31[cc]	5.51[c]	44.95[c]	42.84[c]	13.44[c]
13	23.63[dd]	1.13[d]	35.31[d]	34.69[d]	14.80[b]
25	21.31[d]	0.72[d]	21.36[e]	34.16[d]	15.68[a]
Significance	**	**	**	**	**
Hot water °C					
25	24.27[aa]	11.67[aa]	55.12[a]	45.62[a]	14.22[a]
50	23.23[a]	11.08[a]	47.67[b]	41.43[b]	14.96[b]
55	21.35[b]	10.89[aa]	40.44[c]	35.26[c]	15.20[c]
Significance	**	**	**	**	**
Hot water duration(minutes)					
3 minutes	23.19[a]	8.05[aa]	42.92[a]	46.39[aa]	13.11[c]
5 minutes	22.98[a]	7.11[aa]	41.36[b]	45.84[a]	13.34[b]
10 minutes	22.67[a]	6.74[a]	40.19[c]	42.74[b]	13.74[a]
Significance	ns	ns	**	**	**
Interactions					
Storage temperature × hot water	**	**	**	**	**
Storage temperature × hot water duration	**	ns	**	ns	**
Hot water × hot water duration	ns	ns	ns	**	**
Storage temperature × hot water × hot water duration	ns	ns	*	*	**

** Highly significant at $p<0.01$, * significant at $p<0.05$ and [ns] non-significant at $p>0.05$. Means separated using Least Significant Difference (LSD) Test at $p\leq0.05$, Means within columns followed by the same letters are not significantly different.

3.3 Fruit weight loss

There was a significant ($P \leq 0.0001$) effect on mango fruit weight loss due to interaction between the storage temperature and water temperature, storage temperature and water treatment duration as well as water temperature and water treatment duration (Table 1). As the storage temperature and water temperature increased, the percentage weight loss of the fruits increased significantly ($P \leq 0.0001$). Also, the interaction of storage temperature and water treatment duration significantly ($P \leq 0.0001$) increased the mango fruit weight loss. As the storage temperature increased from 4 to 25 ˚C and water treatment duration increased from 3 to 10 minutes, the percentage weight loss of the fruits significantly ($P \leq 0.001$) increased. The higher fresh weight loss of mango fruit at high storage and water temperatures, and longer duration in hot water at 50 or 55˚C nd their interactions was attributed to higher evapotranspiration rate and respiration rate at the higher temperatures. Kumah *et al*. (2011) reported that there was a gradual increase in the cumulative weight loss in 'Keitt' mango fruit after the 4th day of storage and continued with the rapid increase in weight until 21 days after storage. 'Keitt' mango fruits treated in hot water for 52˚C for 5 minutes, 50˚C for 5 and10 minutes, and 48˚C for 10 minutes showed a rapid increase in fruit weight loss in comparison to control fruit (Kumah *et al*., 2011). They attributed the sharp rise in cumulative weight loss to high temperature and low relative humidity. Yousef *et al*. (2012) reported a progressive increase in fresh mass loss of mango fruit cultivar 'Copania' throughout the storage period and hot water treatments at 46 or 50˚C for 10 minutes. The results of the current study are further in line with Perez *et al*. (2004) who found that, in avocado fruits, the mass losses were 4.3% at 20 °C for 8 days and 3% at 10 °C for 22 days. A significant effect of storage ($P \leq 0.05$) on Dusheri cultivar of mango was observed and had an increase of weight loss of 36% after 15 days of storage (Rathore *et al*., 2007). Roongruangsri *et al*. (2013) reported that the percentage of weight loss increased and moisture content of the peel decreased in two tangerine cultivars at a higher temperature and longer duration of storage. Low-temperature storage at 5 ˚C, reduced the losses of tangerine fruit weight loss and moisture content better than at 25 ˚C storage (Roongruangsri *et al*., 2013). Wang (1993) found that weight loss was most severe in squash stored at 15 ˚C than squash kept at 5 ˚C. This weight loss was attributed to rapid ripening and senescence due to high temperature (Wang, 1993).

Table 2.0 Effects of storage and hot water temperature, and hot water duration on mango chemical and textural characteristics 7 days after storage at ambient temperature after immediate removal from different treatment temperatures.

Treatment				
	Vit C (mg/100 g)	Proline (µmole /g)	EL (%)	Firmness (N)
Storage temperature °C				
4	28.89[a]	14.88[a]	59.98[a]	36.56[a]
7	24.78[b]	9.46[b]	51.29[b]	33.81[b]
10	21.51[cc]	1.47[c]	46.75[c]	28.38[cc]
13	21.49[c]	0.90[dd]	42.58[d]	27.48[c]
25	18.09[d]	0.69[d]	27.09[e]	23.08[d]
Significance	**	**	**	**
Hot water °C				
25	20.36[a]	9.02[a]	52.87[a]	35.88[a]
50	18.01[b]	4.46[b]	44.33[b]	28.60[b]
55	17.21[bb]	2.95[c]	39.41[c]	25.10[c]
Significance	**	**	**	**
Hot water duration(minutes)				
3 minutes	18.41[aa]	6.25[a]	47.76[a]	32.28[a]
5 minutes	18.02[a]	5.53[b]	45.89[b]	29.80[b]
10 minutes	17.96[aa]	4.65[c]	42.96[c]	27.50[c]
Significance	ns	**	**	**
Interactions				
Storage temperature × hot water	**	**	**	**
Storage temperature × hot water duration	ns	**	ns	ns
Hot water × hot water duration	ns	ns	ns	**
Storage temperature × hot water × hot water duration	ns	*	ns	*

** Highly significant at $p<0.01$, * significant at $p<0.05$ and [ns] non-significant at $p>0.05$. Means separated using Least Significant Difference (LSD) Test at $p\leq0.05$, Means within columns followed by the same letters are not significantly different.

3.4 Electrolyte leakage

Membrane damage can be measured by the ion leakage, which in the present study the electrolyte leakage was significantly ($P \leq 0.0001$) higher in mango fruit stored in temperatures of 4, 7 or 10 ˚C than fruit stored at 13 or 25 ˚C. Also fruit treated with hot water at 50 or 55 ˚C, irrespective of storage temperature had lower electrolyte leakage and chilling injury incidence and severity than fruit treated with water at 25 ˚C. As the storage temperature and water temperature increased, the mango electrolyte leakage decreased on fruits assessed immediately after removal from storage temperatures and those that were stored at room temperature for seven days after removal. Fruits dipped in water at 25 ˚C and stored at 4 ˚C had the highest electrolyte leakage while those fruits treated with hot water at 50 and 55 ˚C and stored at 13 and 25 ˚C had the lowest electrolyte leakage, respectively. These results indicate the role of hot water treatment for up to 10 minutes in maintaining membrane integrity. As the duration in which mango fruit was held in hot water at 50 or 55 ˚C increased, the electrolyte leakage significantly ($P \leq 0.0001$) decreased in the current study. Junmatong *et al*. (2012) reported that the pulp and skin electrolyte leakage in 'Nam Dok Mai' mango cultivar commonly grown in Thailand, increased during storage at 5˚C and rapidly increased when fruits were transferred to room temperature. The increase in electrolyte leakage occurred before chilling injury symptoms (Junmatong *et al*., 2012). The results of the current study and those of Junmatong *et al*. (2012) suggests that oxidative stress is an early response of mango fruits to chilling injury as it initiates membrane degradation causing lipid peroxidation (Shewfelt and del Rosario, 2000). The results of the current study are in agreement to those reported by González-Aguilar *et al*. (2000), Zhao *et al*. (2006), Ding *et al*. (2007), Wang *et al*. (2008) and Junmatong *et al*. (2012) who reported that electrolyte leakage increased in Tommy Atkins, Wacheng, Zill, Tainong and Nam DOk Mai mango fruit cultivars during storage at 2-7˚C for 7-30 days. Zhao *et al*. (2009) reported that the electrolyte leakage intensity reflected chilling injury development phase and a degree in tomato fruit. Although the electrolyte leakage increased with decrease in storage temperature from 25 to 4˚C, electrolyte leakage decreased in mango fruits treated with hot water for a longer duration of 10 minutes. It is also suggested that the reduction in the electrolyte leakage and chilling injury induced by hot water treatment in the current study was attributed to the role of hot water at 50 or 55 ˚C for a maximum duration of 10 minutes in maintaining cell membrane integrity and reducing lipid peroxidation of cell membranes.

3.5 Fruit firmness

The interaction between the storage temperature and water temperature, as well as interaction between the water temperature and water treatment duration significantly ($P \leq 0.0001$) (Table 1 and 2) influenced the fruit firmness immediately after removal from storage and seven days after storage at room temperature. As the storage temperature and the water temperature increased, fruit firmness decreased significantly ($P \leq 0.0001$) immediately after cold storage and seven days later at room temperature. There was also a significant ($P \leq 0.0016$) interaction between storage temperature and water treatment duration on mango firmness seven days after storage at room temperature (Table 2). As the storage temperature and water treatment duration increased, the fruit firmness significantly ($P \leq 0.0001$) decreased. Water temperature and duration of hot water treatment interaction had a significant ($P \leq 0.0005$) effect on the mango fruit firmness (Table 1 and 2). As the water temperature and duration of hot water treatment increased, the fruit firmness decreased significantly ($P \leq 0.0001$) immediately after cold storage and seven days after storage at room temperature. The decrease in mango fruit firmness caused by the interactions of storage temperature and water temperature, storage temperature and duration in which mango fruit was dipped in hot water, and hot water temperature and duration in which mango fruit was dipped in hot water was attributed to the role of temperature in fruit texture changes during ripening. The ripening phenomenon in fruits is associated with loss of firmness. Yousef *et al*. (2012) reported that the firmness of mango fruits showed a gradual and significant reduction during storage at 8, 10, 13 ˚C for four weeks compared with untreated fruits (control). However, storage at 8 ˚C, was more effective in keeping the fruits firmer after 28 days (Yousef *et al*., 2012). They further reported a decline in mango fruit firmness in fruits stored at 10 ˚C after dipping in hot water at 48 and 52 ˚C for 10 minutes. In the current study, as the water temperature increased from 25 to 55 ˚C, the fruit firmness decreased significantly ($P \leq 0.0001$) from 46.5 N to 30.9 N after 28 days of storage. As storage temperature increased from 4˚C to 25˚C mango fruit firmness decreased from 45.9 N to 30.2 N. While fruit stored at 4°C but dipped in water at 25˚C or 55˚C had fruit firmness of 57.8 N and 38.1 N, respectively. Tian *et al*. (1996) reported that increasing storage temperatures from 8 to 13 ˚C significantly decreased the firmness of mango fruits. Heat air treatment of mangoes at 38 ˚C has been reported to accelerate the softening of fruits due to changes in pectic components and activities of polygalacturonase, pectin methylesterase, and β-galactosidase in 'Nam Dokmai' mango fruit during storage at 25˚C (Ketsa *et a*l., 1998). Zhang *et*

al. (2012) reported that the firmness in non-cold stored mango fruit declined rapidly from 74.8 n to 12.3 N after five days of storage at 20˚C. Jacobi and Gille (1997) suggested that the decrease in Kengston mango fruit firmness following heat treatment was attributed to an increase in activity of the enzymes pectin methylesterase, polygalacturonase, galactosidase and β-1, 4-gluconase.

4.0 CONCLUSION

This study showed that a combination of low-temperature storage in the range of 7-10˚C and hot water treatment of mango fruits at 50 or 55˚C for 10 minutes was effective in maintaining the chemical and physical attributes of Keitt mango (vitamin C content, firmness, reduced electrolyte leakage and proline content, and reduced fruit weight loss) during storage and seven days after storage when fruit was kept at room temperature. The chemical and physical attributes of Keitt mango fruits were significantly improved by the interactions of storage temperature, hot water temperature and duration in which the fruit was held in hot water.

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5.0 TABLES AND FIGURES

TABLE 1: Effects of storage and hot water temperature and hot water duration on mango chemical and textural attributes immediately after removal from the storage regimes.

TABLE 2: Effects of storage and hot water temperature and hot water duration on mango chemical and textural attributes 7 days after storage at ambient temperature.