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Effect of Some Post Harvest Treatments under Different Low Temperature on Two Mango Cultivars

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Abstract: The effect of different treatment; potassium permanganate, hot water treatment under 50-53° C for 10 min. and shrink film addition to control on storage life of mango cultivars Hindi Besennara (early ripe) and Alphonse(mid season) under three low temperature 8, 10 and 13°C and R.H. (80-85%) for 30 days was investigated. The quality characteristics such as decay, shelf life, firmness, weight loss, T.S.S., titratable acidity, ascorbic acid, reducing and total sugars were studied at an interval of 6 days during storage. However, the treatment shrink film at 8°C was the most effective in keeping storability of the two cultivars and this reflect on the mean performance physical and chemical parameters in the two seasons for the two cultivars. It was found that keeping quality in low temperature and decreased with increasing temperature degree. Whereas, hot water treatment take the same trend with control in the high contain of T.S.S., acidity, reducing and total sugars and low content in V.C.. All treatments and control had no shelf life in 24 and 30 days in 13◦C. Shrink film had no decay till the 24 days under three storage temperature.

Key words: mango, cultivars, storage temperature, post harvest treatment, fruit quality, storability.

INTRODUCTION

Mango (Mangifera *indica* L.) is an important tropical fruit having heavy demand in world market. It is consumed both as fresh and in 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 (Jha *et al*., 2006). Fruit is susceptible to chilling injury, which leads to a storage disorder manifested mainly as dark, scald-like discoloration and pitting or sunken lesions on the peel when fruit are stored at low temperature (below 13 °C)

For long periods, storage treatments, such as heat treatment, intermittent warming, modified atmosphere, and application of plant growth regulators have been developed to prevent or alleviate this storage disorder (McCollum, *et al* ., 1993; Wang, 1993; Pesis *et al*., 2000; Gonz´alez-Aguilar *et al*., 2001; Nair and Singh, 2003). Susceptibility of mango fruit to harvest diseases increases after harvest and prolonged storage as a result of physiological changes occurring in the fruits that enable pathogen development (Eckert and Ratnayake, 1983; Prusky *et al*., 1999).

The production, marketing and consumption of mango fruits are restricted due to improper handling, in a adequate transport and storage facility, disease problems, and sensitivity to low storage temperature (Mitra S.K. and E.Z. Baldwin, 1997).

Low temperature handling and storage are the most important methods of postharvest management (Johnson *et al*., 1997). Prolonged storage is difficult since temperatures low enough to delay ripening injury these fruits, some mango cultivars can be safely stored at 7- 8°C, others, require temperatures above 10°C or even 13°C (Mitra, S.K., 1997). Generally, green fruit should be stored at 10 or 15°C, while ripe fruit can tolerate lower temperatures (Medlicott *et al*., 1990).

Potassium permanganate was found to extend the shelf life of climacteric fruit (Nwufo *et al*., 1994). It is quite effective in reducing ethylene levels by oxidizing it to carbon dioxide and water and this retard the ripening of many fruits.

Hot water immersion has a number of advantages, which include short treatment time, (Mitcham and McDonald, 1993) measured an increase in ethylene production as a response to heat stress. Increases in ethylene production might stimulate ripening processes. However, this stimulus could be limited because of the effects of elevated temperatures on the enzymes of the ethylene biosynthetic pathway (Paull and Chen, 2000).

The atmosphere generated by modified atmosphere packaging (MAP) delays ripening of certain subtropical-tropical fruits, including mango (Kader, A.A., 1994). The main factors that maintain mango quality in various film packaging is increased Co2 and, which reduce respiration rate and prevent water loss (Chaplin *et al*., 1982; Miller *et al*., 1983; Yuen *et al*., 1993; Rodov *et al*., 1997) is still not a commercial technique.

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As induced above, mangoes are a climacteric fruit with a limited shelf life. The quality of the fruit rapidly decreases once fully ripe. For this, the relationship between methods to extend fresh fruit shelf life have included external coating, used potassium permanganate and hot water treatment and under three different storage temperatures (the susceptibility for low temperature under 13°C for two mango cultivars (early and mid season) for one month did not study before.

MATERIAL AND METHODS

This investigation was carried out during two consecutive seasons (2009 and 2010) on two mango cultivars; i.e., Hindi-Besennara(early ripe) and Alphonse(mid season). Trees were budded on Balady mango rootstock, spaced at 7 meters apart, in private orchard in Behera Governorate.

Uniform fruit samples were picked at mature stage for Hindi - Besennara cultivar on July 15 and 18 (10± 1% T.S.S) and on August 29 and September 4 for Alphonse cultivar(9± 1% T.S.S) in 2009 and 2010, in respectively from each experimental tree. Fruit samples were immediately transported to the laboratory of the Plant Production Department, Faculty of Agriculture, Saba Basha, Alexandria University, and were washed with tap water, treated with 10% Clorox (52 gram chlorine/ litre) and air dried, sample (four fruits) was taken for determined the initial fruit quality, the remained fruits for the two cultivars were divided into four groups: 1) potassium permanganate (ethylene absorbent) in sachets at 2.5 gram/ Kg fruit then cardboxes wrapped in low- density polyethylene films (28 µm thick) 2) hot water treatment at 50- 53˚ C for 10 min. After dipping, fruit were dried by electric fan 3) individual fruit was wrapped in low- density polyethylene films (28 µm thick) 4) control. Other fruits for each treatment were stored at Shelf life conditions (20˚ C and 56% R.H) and the decay was recorded. As for storage experiment, each treatment was replicated four times, each consisting of 2 open cardboxes (60x40x18 cm) each containing 24 mature fruits in a single layer. All boxes of the above mentioned treatments were stored at (8, 10, 13˚C) and relative humidity of 85-90% in a cold storage room and kept as long as they were marketable. In all treatments, including the control, it was noticed that, in both seasons for both mango cultivars, the experiments were terminated after thirty days.

During storage, samples of four fruits were taken from each replicate at, 6, 12, 18, 24 and 30 days from storage. Fruit firmness was determined by (Magness and Taylor, 1925) pressure tester using a 5/16 plunger. Two readings were taken at two opposite sides on the flesh of each fruit after peeling. T.S.S (%) was determined in fruit juice by a hand refractometer. Fruit juice acidity was determined according to the (A.O.A.C., 1980) by titration with 0.1N sodium hydroxide using phenolphthalein as an indicator and expressed as citric acid percentage. Vitamin C content was determined in fruit juice using 2, 6 -dichlorophenol-indo-phenol blue dye as mg ascorbic acid per 100 ml juice (A.O.A.C., 1980).The total sugars were determined colorimetrically using phenol and sulphuric acid according to (Malik and Singh, 1980). The reducing sugars were determined by the Nelson arsenate-molybdate colorimetric method (Dubois *et al*., 1956). For calculating the percentage of physiological fruit weight loss, 10 fruits from each replicate were labeled and were periodically weighed every 7 days. Weight loss was calculated according to the following equation:

$$\text{Weight loss (\%)} = \frac{\text{Average loss in fruit weight}}{\text{Average initial fruit weight}} \times 100$$

The experimental design was randomized complete block design, and all data obtained throughout the course of this study were statistically analyzed by the analysis of variance as described by [51].

RESULTS AND DISCUSSION

Physical Properties:

a) ***Shelf Life:***

The data listed in (Table 1) indicated that mango fruits stored at high temperature had shorter shelf life than those stored at low temperature, where fruits stored at 13°C for 24 or 30 days had no shelf life in Hindi - Besennara and Alphonse, except potassium permanganate and shrink film in 24 days in Alphonse. Whereas those stored at 8°C remained in cold storage room for 30 days with a suitable shelf life period.

The results, also, showed that shelf life of mango fruits treated with shrink film or potassium permanganate (ethylene absorbent) was longer than those treated with hot water and than those of the control. Hot water treatment markedly reduced shelf life of mango fruits (Table 1).

It was also noticed that fruit shelf life decreased with increasing storage period.

b) ***Fruit Decay:***

The present results indicated that mean fruit decay percentage markedly increased with increasing storage temperature (Table 2). In the meantime, the lowest fruit decay percentage was found on fruits wrapped with shrink film followed by those treated with potassium permanganate, then by those subjected to hot water treatment, whereas those of the control showed the highest fruit decay percentage. In both seasons for two cultivars.

As for storage period effect, it was found that fruits decay was, generally, observed after 18 days and increased with increasing storage period. At 8°C, fruit decay was observed after 30 days from storage, except fruits wrapped with shrink film found after 24 and 18 days when stored at 10 and 13°C, respectively, in both seasons for two cultivars.

The hot water immersion treatment was effective in decreasing the severity of many common physiological skin disorders, such as darkened lenticels (small black spots) and anthracnose, a fungus that is the most common postharvest disease affecting mango (Kim *et al*., 2007).

c) ***Weight Loss***

The results listed in (Table 3) indicated that weight loss of Hindi Besennara and Alphonse fruits was significantly higher when fruits were stored at 13°C, as compared with those at 10°C which, also, showed significantly higher weight loss than those stored at 8°C, except between10 and 13°C in the first season for Alphonse cultivar.

The data, also, revealed that mango fruits wrapped with shrink film showed the significantly lowest average weight loss than those of the other treatments in both seasons for the two cultivars. In Hindi Besennara, fruits treated with hot water showed significantly higher average, whereas those of potassium permanganate (T1) and control (T4) showed intermediate values. In Alphonse cultivar, control showed the highest significant value in both seasons, except to hot water treatment in the first season. As for the effect of storage period, it was found that the average weight loss of Hindi-Besennara fruits significantly increased with increasing storage period, except between third and fourth dates in the first season. In Alphonse cultivar, there were no significant differences were found till the third date in the first season and till the second period in the second season, also no significant difference were also found between fourth and fifth in the first season.

d) ***Fruit Firmness:***

The present results indicated that increasing storage temperatures from 8 to 13°C significantly decreased the firmness of mango fruits (Table 3), except between 10 and 13°C in Hindi-Besennara cultivar. This may be explained by the greater ripeness of the fruit. It was, also, noticed that fruits wrapped with shrink film had significantly higher firmness, as compared with other treatments. No significant differences were also found, except between fruits treated with potassium permanganate compared to those treated with hot water and those of the control in the first season of Alphonse.

It was, also, found that fruit firmness significantly decreased with increasing storage period. Significant differences were found among the different storage periods, except between the third and fourth period in the second season of Alphonse.

Chemical Analysis:

a) TSS:

It is clear in Table (4) that increasing the storage temperature increased the TSS, but differences between 8°C and 10°C were not big enough to be significant in both seasons for the two cultivars. Fruits treated with hot water and those of control had a significant value compared to those treated with potassium permanganate and those wrapped with shrink film. In the meantime, fruits treated with potassium permanganate showed a significant increase in TSS compared to those wrapped with shrink film in the second season for Hindi-Besennara and the first season of Alphonse cultivar.

It was, also, found that TSS significantly increased with storage time, except between the fifth and sixth dates in Hindi-Besennara, while the first date had a significant lowest value compared to other dates in Alphonse cultivar.

b) Acidity:

The present results showed that in general, fruit acidity higher in low temperature and decreased with increasing temperature degree. mango fruits stored at 8°C had significantly higher acidity than those stored at 10°C, which also had significantly higher juice acidity as compared with those stored at 13°C, except between 8 and 10°C in Hindi-Besennara (Table 4).

Fruits wrapped with shrink film had significantly highest juice acidity, followed by those of Potassium permanganate, then hot water treatment and control.

As for the effect of storage periods on juice acidity, it was found that its content significantly decreased with storage, while no significant difference was found between fourth and fifth period in the second season of Hindi-Besennara, while no significant difference was found between fifth and sixth period in the first season of Alphonse cultivar.

c) Vitamin C:

Concerning the effect of storage temperature on fruit vitamin *C* content, the present data in Table (4) showed that its values significantly decreased with increasing storage temperature. No significant difference was found between 8 and 10°C in the second season of Hindi-Besennara cultivar.

As for the effect of prestorage treatments, it was found that fruits wrapped with shrink film had significantly higher fruit vitamin C content than other treatments. On the contrary, control fruits and hot water treatment showed significantly lowest values, whereas for the potassium permanganate treatment showed intermediate values.

d) Reducing and Total Sugars:

It was found that increasing storage temperature significantly increased fruit reducing and total sugars content, no significant difference was found between10 and 13°C in the second season of Alphonse cultivar (Table 4). As for fruit treatments, the present results revealed that fruit treated with hot water and those of control had significantly higher reducing and total sugars content than the other treatments. In the meantime, fruits treated with Potassium permanganate had a significant value compared to shrink film in both seasons of the two cultivars.

The reducing sugars content in Hindi-Besennara and Alphonse mango fruits significantly increased with increasing storage period in the two seasons.

Table 1: : Effect of different low temperatures (8, 10 and 13°C), prestorage treatments (potassium permanganate, hot water and shrink film) and storage periods on shelf life fruit mean performance:

a) Hindi- Besennara cultivar.

Treatments	Date of sampling									
	6th		12th		18th		24th		30th	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
At 8°C										
Potassium permanganate (T1)	6	6	6	6	5	6	5•	5	5•	5•
Hot water (T2)	5	5	5	5	4	3	*	*	*	*
Shrink film(T3)	7	7	7	6	6	6	5	6	5	5
Control(T4)	5	5	5	4	4	4	4	4	3	2
At 10°C										
Potassium permanganate (T1)	6	5	6	5	5	5	5•	5•	5•	5•
Hot water (T2)	4	4	4	4	4	4	*	*	**	**
Shrink film(T3)	7	7	7	6	6	6	5	5	5	5
Control(T4)	4	4	4	4	4	4	4	3	3	3
At 13°C										
Potassium permanganate (T1)	5	5	5	4	3•	2	-	-	-	-
Hot water (T2)	4	4	4	5	***	***	-	-	-	-
Shrink film(T3)	6	5	6	5	5	5	-	-	-	-
Control(T4)	4	4	3	3	2	2	-	-	-	-

b) Alphonse cultivar

At 8°C										
Potassium permanganate (T1)	6	6	6	5	4	5	5•	5	5•	5•
Hot water (T2)	5	5	5	5	3	4	*	*	*	*
Shrink film(T3)	6	6	6	5	5	5	5	6	5	5
Control(T4)	5	5	5	5	3	4	4	4	3	2
At 10°C										
Potassium permanganate (T1)	5	5	5	5	4	4	5•	5•	5•	5•
Hot water (T2)	4	4	4	4	4	3	*	*	**	**
Shrink film(T3)	6	6	6	6	5	5	5	5	5	5
Control(T4)	4	4	4	4	4	4	4	3	3	3
At 13°C										
Potassium permanganate (T1)	5	5	4	4	4	4	2•	2•	-	-
Hot water (T2)	3	3	3	3	***	***	-	-	-	-
Shrink film(T3)	5	5	5	4	4	3	2	2	-	-
Control(T4)	3	3	3	3	3	2	-	-	-	-

* 25% of fruits were decayed on the 4th day, **35% of fruits were decayed on the 4th day, ***40% of fruits were decayed on the 3th day.. • Light green peel color .

Table 2: Effect of different low temperatures (8, 10 and 13°C), prestorage treatments (potassium permanganate, hot water and shrink film) and storage periods on decay(%) fruit mean performance of Hindi -Besennara and Alphonse mango cultivars.

	Decay (%)			
	Hindi-Besennara		Alphonse	
	2009	2010	2009	2010
Temperature(°C)				
8	0.34	0.32	0.38	0.40
10	1.14	1.16	0.93	0.95
13	2.24	2.20	1.53	1.48
Treatments	0.65	0.61	0.39	0.38
Potassium permanganate (T1)	1.57	1.55	1.18	1.20
Hot water (T2)	0.13	0.11	0	0
Shrink film(T3)	2.61	2.60	2.01	2.00
Control(T4)				
Storage period (6 days interval)				
S1	-	-	-	-
S2	0	0	0	0
S3	0	0	0	0
S4	0.78	0.76	0.33	0.31
S5	2.43	2.40	1.90	1.96
S6	4.23	4.26	3.14	3.18

Table 3: : Effect of different low temperatures (8, 10 and 13°C), prestorage treatments (potassium permanganate, hot water and shrink film) and storage periods on weight loss (%) and firmness (lb/in^2) fruit mean performance of Hindi -Besennara and Alphonse mango cultivars.

	Weight loss (%)				Firmness (lb/in^2)			
	Hindi-Besennara		Alphonse		Hindi-Besennara		Alphonse	
	2009	2010	2009	2010	2009	2010	2009	2010
Temperature(°C)								
8	3.33^{c}	3.09^{c}	3.23^{b}	3.12^{c}	13.31^{a}	13.34^{a}	13.31^{a}	13.34^{a}
10	4.59^{b}	4.05^{b}	3.90^{a}	$3.51b^{b}$	12.57^{b}	12.27^{b}	12.57^{b}	12.27^{b}
13	5.48^{a}	5.42^{a}	4.19^{a}	3.88^{a}	12.10^{b}	11.91^{b}	12.10^{c}	11.91^{c}
Treatments								
Potassium permanganate (T1)	4.69^{c}	4.52^{c}	4.04^{b}	3.57^{c}	12.55^{b}	12.46^{b}	12.55^{b}	12.46^{b}
Hot water (T2)	6.19^{a}	5.76^{a}	5.05^{a}	5.21^{a}	12.41^{b}	12.37^{b}	12.41^{b}	12.37^{b}
Shrink film(T3)	1.55^{d}	1.22^{d}	1.13^{c}	0.86^{d}	13.30^{a}	13.15^{a}	13.30^{a}	13.15^{a}
Control(T4)	5.44^{b}	5.24^{b}	4.87^{a}	4.37^{b}	12.38^{b}	12.03^{b}	12.38^{b}	12.03^{b}
Storage period (6 days interval)								
S1	-	-	-	-	16.3^{a}		17.06^{a}	15.46^{a}
S2	3.27^{d}	2.77^{e}	3.44^{bc}	2.97^{d}	14.06^{b}	14.02^{b}	15.06^{b}	14.52^{b}
S3	4.23^{c}	3.62^{d}	3.00^{c}	3.38^{c}	13.18^{c}	13.20^{c}	$13. 81^{c}$	13.55^{c}
S4	4.32^{c}	4.16^{c}	3.99^{ab}	3.58^{b}	12.41^{d}	12.37^{d}	13.24^{d}	13.19^{c}
S5	4.91^{b}	4.92^{b}	3.99^{ab}	3.76^{a}	10.77^{e}	10.43^{e}	10.35^{e}	10.50^{d}
S6	5.59^{a}	5.44^{a}	4.44^{a}	3.83^{a}	9.25^{f}	9.23^{f}	9.31^{f}	8.67^{e}
Temp.X Treat.	n.s	***	n.s	***	n.s	n.s	n.s	n.s
Temp.X Stor.	n.s	***	n.s	***	n.s	n.s	***	n.s
Treat.X Stor.	***	***	***	**	***	***	***	***
Temp.X TreatX Stor.	n.s	***	n.s	***	n.s	n.s	**	n.s

Means followed by the same letter(s) within a separate column are not significantly different at 0.05 level of probability.
n.s not significant.* significant at 0.05 level of probability.** significant at 0.01 level of probability.*** significant at 0.001 level of probability.

Table 4: Effect of different low temperatures (8, 10 and 13°C) prestorage treatments (potassium permanganate, hot water and shrink film) and storage periods on chemical parameters mean performance of mango:

a) Cultivar Hindi-Besennara

	T.S.S. (%)		Acidity (%)		V.C (mg/100ml juice)		Reducing sugars (%)		Total sugars (%)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Temperature(°C)										
8	12.27^{b}	11.55^{b}	1.75^{a}	1.77^{a}	34.37^{a}	33.25^{a}	0.479^{c}	0.536^{c}	9.57^{c}	9.71^{c}
10	12.43^{b}	11.73^{b}	1.72^{a}	1.73^{a}	30.93^{b}	33.21^{a}	$0..531^{b}$	0.545^{b}	9.71^{b}	9.79^{b}
13	12.80^{a}	12.70^{a}	1.55^{b}	1.56^{b}	29.03^{c}	26.98^{b}	0.566^{a}	0.561^{a}	10.08^{a}	10.00^{a}
Treatments										
Potassium permanganate (T1)	12.26^{b}	11.72^{b}	1.71^{b}	1.69^{ab}	32.58^{b}	33.07^{ab}	0.509^{b}	0.543^{b}	9.70^{b}	9.78^{b}
Hot water (T2)	12.92^{a}	12.55^{a}	$1..59^{c}$	1.64^{b}	28.70^{d}	27.58^{b}	0.554^{a}	0.558^{a}	10.05^{a}	10.00^{a}
Shrink film(T3)	12.04^{b}	11.26^{c}	1.76^{a}	1.74^{a}	34.48^{a}	35.57^{a}	0.487^{c}	0.532^{c}	9.32^{c}	9.51^{c}
Control(T4)	12.77^{a}	12.44^{a}	1.63^{c}	1.68^{ab}	30.01^{c}	28.37^{b}	0.551^{a}	0.556^{a}	10.06^{a}	10.01^{a}
Storage period										
S1	10.80^{e}	10.26^{e}	$1..94^{a}$	2.00^{a}	50.00^{a}	48.40^{a}	0.395^{f}	0.463^{f}	8.82^{f}	8.92^{f}
S2	11.86^{d}	11.33^{d}	1.77^{b}	1.81^{b}	43.15^{b}	40.46^{b}	0.479^{e}	0.494^{e}	8.96^{e}	9.00^{e}
S3	12.41^{c}	11.78^{c}	$1. 72^{c}$	1.73^{c}	35.35^{c}	34.50^{bc}	0.515^{d}	0.525^{d}	9.86^{d}	9.93^{d}
S4	12.95^{b}	12.33^{b}	1.64^{d}	1.62^{d}	29.43^{d}	28.63^{cd}	0.566^{c}	0.568^{c}	10.02^{c}	10.00^{c}
S5	13.40^{a}	12.98^{a}	1.55^{e}	1.55^{d}	19.62^{e}	24.11^{d}	0.580^{b}	0.599^{b}	10.23^{b}	10.31^{b}
S6	13.53^{a}	13.28^{a}	1.43^{f}	1.42^{e}	11.10^{f}	10.79^{e}	0.618^{a}	0.635^{a}	10.82^{a}	10.89^{a}
Temp.X Treat.	n.s	n.s	***	n.s	n.s	n.s	***	*	***	*
Temp.X Stor.	n.s	n.s	**	***	***	n.s	***	*	***	*
Treat.X Stor.	**	n.s	***	n.s	***	n.s	***	**	***	**
Temp.XTreatXStor	n.s	n.s	n.s	n.s	n.s	n.s	***	n.s	***	n.s

Means followed by the same letter(s) within a separate column are not significantly different at 0.05 level of probability.
n.s not significant.* significant at 0.05 level of probability.** significant at 0.01 level of probability. *** significant at 0.001 level of probability.

B) Cultivar Alphonse

	T.S.S. (%)		Acidity (%)		V.C (mg/100 ml juice)		Reducing sugars (%)		Total sugars (%)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Temperature(°C)										
8	10.71^{b}	10.53^{b}	2.08^{a}	2.10^{a}	27.96^{a}	25.49^{a}	0.421^{c}	0.387^{b}	8.34^{c}	8.21^{b}
10	11.00^{b}	10.90^{b}	1.88^{b}	2.02^{b}	27.07^{b}	22.88^{b}	$0..445^{b}$	0.404^{a}	8.94^{b}	8.80^{a}
13	11.88^{a}	11.63^{a}	1.67^{c}	1.97^{c}	25.39^{c}	20.25^{c}	0.479^{a}	0.414^{a}	9.82^{a}	9.68^{a}
Treatments										
Potassium permanganate (T1)	$11. 04^{b}$	10.79^{b}	1.91^{ab}	2.05^{b}	27.55^{b}	23.67^{b}	0.439^{b}	0.395^{b}	8.71^{b}	8.51^{b}
Hot water (T2)	11.50^{a}	11.37^{a}	$1..82^{b}$	1.99^{c}	25.80^{c}	21.13^{c}	0.473^{a}	0.426^{a}	9.45^{a}	9.22^{a}
Shrink film(T3)	10.55^{c}	10.43^{b}	1.98^{a}	2.11^{a}	28.98^{a}	25.81^{a}	0.412^{c}	0.365^{c}	8.87^{c}	8.70^{c}
Control(T4)	11.69^{a}	11.49^{a}	1.80^{b}	1.96^{d}	24.89^{d}	20.89^{c}	0.469^{a}	0.421^{a}	9.51^{a}	9.33^{a}
Storage period										
S1	9.4^{d}	9.6^{e}	$2..4^{a}$	2.61^{a}	39.40^{a}	37.30^{a}	0.359^{f}	0.311^{f}	7.14^{f}	7.00^{f}
S2	10.5^{c}	$10..36^{d}$	2.07^{b}	2.22^{b}	33.26^{b}	29.46^{b}	0.402^{e}	0.337^{e}	7.81^{e}	7.63^{e}
S3	11.03^{c}	10.71^{cd}	1.88^{c}	2.08^{c}	28.63^{c}	25.82^{c}	0.440^{d}	0.389^{d}	8.83^{d}	8.67^{d}
S4	11.63^{b}	11.29^{bc}	1.73^{d}	1.87^{d}	25.63^{d}	21.43^{d}	0.455^{c}	0.426^{c}	9.11^{c}	9.01^{c}
S5	12.18^{ab}	$11..75^{b}$	1.65^{e}	1.79^{d}	20.83^{e}	13.81^{e}	0.528^{a}	0.448^{b}	10.36^{b}	10.25^{b}
S6	12.45^{a}	12.42^{a}	1.55^{f}	1.61^{e}	$13. 09^{f}$	9.43^{f}	0.546^{a}	0.500^{a}	10.94^{a}	10.90^{a}
Temp.X Treat.	n.s	n.s	n.s	n.s	n.s	n.s	**	n.s	**	**
Temp.X Stor.	n.s	n.s	n.s	***	***	***	***	*	***	*
Treat.X Stor.	n.s	n.s	**	***	***	***	***	***	***	***
Temp.XTreatXStor	n.s	n.s	n.s	**	n.s	n.s	***	n.s	***	n.s

Means followed by the same letter(s) within a separate column are not significantly different at 0.05 level of probability.
n.s not significant.* significant at 0.05 level of probability.** significant at 0.01 level of probability.*** significant at 0.001 level of probability.

Discussion:

Effect of Potassium Permanganate Treatment:

Potassium permanganate treatment (KMnO4) resulted in more delay of fruit ripening and extension of shelf life of mango fruits under the three low temperatures by removal of endogenous ethylene (Abu - Goukh, 1986; Scott *et* *al*., 1970). Mango is a typical climacteric fruit that exhibits characteristic rise in ethylene production and respiration rate. The high rate of respiration which is usually associated with short shelf life, soft texture and high moisture content makes mango a very perishable fruit that requires absolute care during handling and transportation. During ripening of fleshy fruits changes in tissue permeability and cellular compartmentation occur (Wills *et al*., 1989), since ripening was delayed in the presence of KMnO4, tissue permeability would be decreased and reduction in weight loss in the fruits would be observed. (Illeperuma and Jayasuriya, 2002; Joyce DCA, Shorter J and Jones, 1995) in mango found that KMnO4 was more effective in delaying fruit fresh softening. These results agree with previous reports that KMnO4 delayed the onset of the climacteric peak in banana (Abu- Goukh, 1986; Scott *et al*., 1970), papaya (Corrêa *et al*., 2005 and Silva *et al*., 2009), apricot (Palou and Crisosto, 2003) and kiwifruit (Bal and Celik, 2010). In addition, KMnO4 decreases respiration and delays ripening by maintaining ethylene at a low level for a long period (Wills *et al* ., 1989; Illeperuma and Jayasuriya, 2002). Reported that ethylene absorbents slow down the onset of ripening and sugar accumulation in mangoes.

Effect of Hot Water Treatment:

Hot water treatment at 50$^{\circ C}$ accelerated the ripening of mango fruits in both seasons for the two cultivars, as reflected in the increased weight loss within the fruits compared to control and other treatments, and the increased weight loss associated with conditioning could be due to either increased respiration associated with accelerated ripening or increased respiration, or both processes (Jacobi *et al*., 2000), and they added that the increase in mango fruit softness associated with hot water immersion, which leads to an increase in the activity of cell wall enzymes. In the meantime, the accelerated the ripening of the two cultivars as reflected in the increased weight loss, total soluble solids, reducing and total sugars and lower titratable acidity and vitamin C levels within the mesocarp of the fruit compared to other treatments and untreated fruits. Generally, the more ripe fruit had the lowest levels of injuries. Therefore, the advancement in ripening may play a key role in the protective mechanism established within fruit cells to heat stress (Jacobi *et al*., 2000). The probable role of soluble sugars in protecting cellular membranes from temperature extremes and desiccation has been studied by (Leprince, *et al*., 1992; Ingram and Bartels, 1996) and a mechanism for the action of sugars has been proposed by (Back *et al*., 1979). ˙It is proposed that sugars stabilize proteins from heat denaturation through effects on water structure and the degree of hydrophobic interactions exerted between molecules. An alternative theory is that sugars tend to form a metastable state characterized by high viscosity, which provides greater stability to chemical reactions, and biomembranes under stress (Roos, 1993). Therefore, from what is currently known about the probable roles of soluble sugars, it is possible that conditioning treatments applied to Hindi and Alphonse fruits, which accelerated sugar accumulation in fruit, may have caused cellular changes resulting in the protection of membrane integrity during the hot water treatment. This was measured as an increase the level of firmness and less of decay injuries.

Effect of Shrink Film Treatment:

(Kader *et al*., 1989) reported that the role of packaging was primarily to reduce the respiration rate of fruit and vegetables by retarding their metabolic activities. Reduced respiration also retards softening, and slows down various compositional changes such as TSS, which are associated with ripening. Plastic film was found to be advantageous in cutting down the respiration rates and increasing the shelf life of mango (Miller *et al*., 1986 and Boonsiri 2010) also reported that sealing individual climacteric fruit in low- density polyethylene bags delayed ripening and softening, and hence improved marketability

Effect of Low Temperature Treatment:

In general, the ripening rate of mangoes as indicated by a fall in firmness, acidity and ascorbic acid were found to be much slower using cold storage.

Reducing storage temperature improves the shelf ripe of perishable commodities mainly due to its effect on physiological activity leading to retarded senescence of fruit in storage (Pinto *et al*., 2004 and Aneja, 2009). Reducing the storage temperature (8 or 10°C) improved the maintenance of TSS, TA and AA when compared to (13°C).This could be due to the fact that low temperature retards aging through reduced respiration rate and other undesirable metabolic changes. High temperature is known to increase enzymatic catalysis and leads to a chemical and biochemical breakdown in fruits and vegetables (Yoshida *et al*., 1984). The relatively 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. The changes in TA is based on changes in citric acid, the concentration of this acid is 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. Similar observations were reported by (Seyoum, , 2002 and Aguayo *et* *al*., 2010).

Effect of Storage Period:

Regarding the effect of storage period on the changes in fruit weight loss, the data of both experimental seasons indicated that the average fruit weight loss was significantly increased with increasing storage period, In accordance with these results, are those previously reported by (Salins and Lakshminarayana, 1985) on different mango varieties.

Loss in fruit firmness with the progress of storage period is due mainly to decomposition, enzymatic degradation of insoluble protopectins to more simple soluble pectins, solubilization of cell and cell wall contents as a result of the increasing in pectin esterase activity and subsequent development of juiciness and the loss in peel and pulp hardness (Abd El-Migid, 1986).

As for the effect of storage period on fruit T.S.S content gradually increased with storage. This could be due to the losses in water through the respiration and evaporation during storage and hence the losses in fruit weight. (Ahmed Amin, K.I., 1982; Hussein *et al*., 2001) stated the formation of soluble pectinic acid from insoluble protopectin during senescence of fruit, (Cua, A.U., 1989) attributed such increase to the conversion of starch into sugar.

Citric acid is a respiratory substrate and its consumption in respiration increased with the progress of storage period, as it could be used as an organic substrate in the respiration process (Chandra *et al*., 1994).

The loss in ascorbic acid content with the progress of storage period could be attributed to rapid conversion of L-ascorbic acid into dihydro-ascorbic acid in the presence of L-ascorbic acid oxidase (Bashir and Abu-Goukh, 2002).

The reducing sugars content, gradually, increased in the fruits during the cold storage. From the above-mentioned results, such an increase in the percentages of fruit reducing sugars content could be due to the hydrolysis of sucrose during storage, yielding reducing sugars (glucose and fructose), (Hassan *et al*., 2004) working on some mango cultivars.

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