

Effect of Storage Temperature on Fruit Quality and Marketability of Some Mango Cultivars

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Abstract: This study was carried out during two successive seasons 2016 & 2017 to detect the effect of storage temperatures on selected high quality mango cultivars i.e. Alphonso, Sediek and Keitt. Mature fruits from a private orchard at Al-Salehia region, Ismailia governorate in order to evaluate the effects of storage temperature. The fruit cultivars were stored at 5°C, 10°C and 25°C. Changes in fruit characters, storability and marketing were evaluated. Fruits held at 10°C and 85-90% relative humidity were the superior to those held at 5°C or 25°C. No chilling injury appeared for fruits stored at 5°C and 10°C till the end of the storage period (21 days). The storage period was four weeks at 5°C, 10°C and twelve days at room temperature for the three cultivars. Generally, weight loss in fruits stored at 5°C showed lower values than fruits stored at 10°C. Sediek fruits had the highest values of weight loss compared to the other cultivars. Fruits stored at 10°C were at 5 days after being taken out of storage at a very good appearance: fresh, hard and with superior color. However, at 5°C, of storage fruits did not ripen and remained green till the end of storage. Fruits had a shelf life of 7 days at 25°C after two weeks of storage and 5 days after three weeks of storage at 25°C without any symptoms of chilling injury for the three cultivars.

Key words: Mango • Storage temperatures • Fruit quality • Marketability

INTRODUCTION

The limiting conditions for mango storage are bounded at the upper end by steady ripening in storage and relatively short shelf life. Hatton *et al.* [1] described temperature above 15.5°C as ripening temperature for mango, while temperatures below 12.7°C were considered as suitable for storage. At the lower temperature end, and various low temperatures for mango storage have been reported, the limiting condition is set by low-temperature injury to the fruit, collectively known as chilling injury (CI). Couey [2] and Nastasi [3] demonstrated that chilling symptoms may not be evident during cool storage, but may become obvious during post storage handling. Fornaris *et al.* [4] stored Keitt mango fruit at 10°C and 13°C for 1, 2, 3 and 4 weeks. They found that higher storage temperature shortened the storage life of the fruit. Also, Medlicott *et al.* [5] stored mango fruit cvs Amelie, Alphonso and Keitt at 8°C, 10°C or 12°C. Ripening changes during storage for 21 days were less at 8°C and 10°C than 12°C. They demonstrated that mature green mango fruits should be stored at 10- 12°C. Rullan *et al.* [6]

stored Keitt mango fruits at 10.6°C and 13°C for 1, 2, 3 and 4 weeks. They found that higher storage temperature shortened the storage life of the fruit. Pesis *et al.* [7] stored mango fruits cvs Alphonso and Keitt at different cold storage temperatures to improve fruit quality and to avoid chilling injury, they found that at 10°C chilling injury symptoms appeared as red spots and pitting on the peel, but black spots appeared at lower temperatures.

However, El-Khoreiby *et al.* [8] stored Pairi mango fruits at 25°C, 7°C or 4°C and revealed that the percentage of decayed fruits was 13% in the first week and 37% in the second week of storage at 25°C. They added that cold storage delayed decay initiation until the second week.

Salles and Travares [9] stored Alphonso mango at 10°C and 85% RH for 15 or 30 days. Another batch of fruits was kept at 30°C and 60% RH. They found that refrigeration extended the storage life of the fruit up to 35 days. The storage life of fruits stored at room temperature was about 8 days. Kesta *et al.* [10] kept mango fruits cv Nam dok mai for 21 days at 4°C. They found that fruits at 4°C were firmer than non-chilled fruits during subsequent ripening at 25°C. El-Oraby *et al.* [11] Stated that peel color

Mabrouka fruits stored at 13°C had the highest a/b ratio about (-0.55) at the beginning of storage and changed to (0.15, 0.25, 0.14) at 13°C, 10°C and 8°C, respectively. Regarding pulp color determined by a/b ratio changed from light yellow (0.07) at the beginning of storage to (0.14 and 0.19). Generality, at was higher than other two storage temperatures.

The objective of this study is to evaluate some promising cultivars for exportation under cold storage and marketing.

MATERIALS AND METHODS

This study was carried out during two seasons 2016&2017 on three mango cultivars. Alphonso, Sediek and Keitt. Mature medium fruits of the three cultivars were harvested according to Hassan *et al.* [12] from mature fruits from a private orchard at Al-Salehia region, Ismailia governorate to assess fruit quality during storage at room temperature and cold storage at 5°C and 10°C.

Fruits of each cultivar were washed with running water, air-dried, labeled and their weights were determined. Fruits were distributed into three groups, one was held at 5°C and RH 85%, the second at 10°C and RH 85% and the third was held at room temperature 25°C. Every group contained 3 boxes as (replicate) and replicated 3 times. Every box contained 12 fruits. Fruit samples were taken from each replicate weekly until the end of storage period to determine fruit quality, weight loss, flesh firmness, TSS, acidity and color of peel and pulp (using Hunter colorimeter model DP 9000), color was represented by a (green-red) and b (blue-yellow) scale and a/b ratio was calculated to represent color development [13]. At the end of the storage period, various sugars were estimated by HPLC.

At weekly intervals, fruits removed from storage and allowed to ripen under room conditions (25°C) to compare the differently stored but eating ripe fruits on the basis of external parameters (shriveling, skin color, texture) and internal flesh appearance (pulp color. TSS, acidity, percentage of decay and chilling injury were determined.

Data obtained were statistically analyzed according to Snedecor and Cochran [14].

RESULTS AND DISCUSSION

Fruit Quality During Storage at Room Temperature and Cold Storage at 5°C and 10°C: Weight Loss: Weight loss increased significantly with the prolonged storage period and this of increase varied among the mango studied cultivars and storage temperature. Concerning weight loss at room temperature (25°C), the percentage reached 7.23, 11.41 and 9.95% during one week in Alphonso, Sediek and Keitt respectively in the first season and 7.82, 11.25, 8.54% respectively in the second one. Alphonso could be stored for 9 days at room temperature with weight loss 10.45, 11.22% in both seasons.

Comparing cold storage temperatures 5°C and 10°C, it is clear from Table (1) that the lowest percentage occurred with 5°C while 10°C was significantly higher for the three mango cultivars. At the end of storage 28 days, the highest weight loss was evident in Sediek 12.18 and 11.62% for both seasons at 10°C and 7.98 and 7.49% for both seasons at 5°C. No significant differences occurred between the other two mango cultivars in the two seasons. These results are in agreement with Ward law and Leonard [15] who noted that mango commercial grades of maturity started to show signs of shriveling when water loss has amounted to 12-15%.

Table 1: The effect of different storage temperatures on fruit weight loss % of three mango cultivars.

Temp.°C	Cv	First season				Second season			
		Storage period (days)				Storage period (days)			
		7	14	21	28	7	14	21	28
5°C	Alphonso	1.34 b	2.12 c	2.65 c	4.32 c	1.32 b	2.13 b	2.66 c	4.31 b
	Sediek	2.27 a	4.32 a	5.81 a	7.97 a	2.23 a	4.29 a	5.76 a	7.46 a
	Keitt	1.22 b	2.79 b	4.63 b	5.42 b	0.86 c	2.12 b	3.72 b	4.37 b
10°C	Alphonso	2.08 b	3.08 c	4.61 c	7.55 b	2.14 b	4.09 b	4.91 c	6.73 c
	Sediek	3.67 a	5.58 a	9.23 a	12.17 a	3.89 a	5.61 a	9.27 a	11.63 a
	Keitt	1.93 c	3.45 b	5.26 b	6.87 c	1.68 c	3.78 c	6.18 b	7.21 b
25°C	Alphonso	3.48 c	7.22 c	10.44 c	15.9 c	4.92 b	7.81 c	11.22 c	15.82 b
	Sediek	7.73 a	11.40 a	14.94 a	18.36 a	7.52 a	11.24 a	14.60 a	19.51 a
	Keitt	6.66 b	9.26 b	13.18 b	17.25 b	2.46 c	8.56 b	11.78 b	14.82 c
Te.	CV	3 days	6 days	9 days	12 days	3 days	6 days	9 days	12 days

Values followed by same letter in each column are not significantly at 5% level

Table 2: The effect of different storage temperatures on flesh firmness (lb/ inch²) of three mango cultivars.

Temp. °C	Cv	First season					Second season				
		Storage period (days)					Storage period (days)				
		7	14	21	28	Initial	7	14	21	28	Initial
5°C	Alphonso	+28 a	26 a	18.3 b	18.0 a	+28 a	+28.0 a	27.0 a	18.69 a	18.0 a	+28 a
	Sediek	+28 a	24.7 c	16.1 c	17.0 b	+28 a	+28.0 a	24.0 c	16.70 b	16.0 b	+28 a
	Keitt	+28 a	25 b	18.7 a	18.0 c	+28 a	+28.0 a	26.0 b	16.30 b	15.3 c	+28 a
10°C	Alphonso	19.1 b	15.2 a	10.3 a	6.7 a	+28 a	19.3 b	16.6 a	9.30 b	5.7 b	+28 a
	Sediek	17.2 c	13.1 b	7.1 d	5.0 b	+28 a	18.4 c	12.8 c	6.00 c	4.7 c	+28 a
	Keitt	21.1 a	15.1 a	10.0 a	5.1 b	+28 a	20.0 a	15.0 b	11.20 a	7.3 a	+28 a
25°C	Alphonso	11.7 a	8.3 a	6.1 a	3.3 b	+28 a	13.0 b	8.1 a	6.00 b	3.3 a	+28 a
	Sediek	10.3 b	7.8 b	5.7 b	3.0 b	+28 a	10.7 c	6.8 c	5.30 c	3.0 a	+28 a
	Keitt	11.7 a	8.7 a	6.5 a	4.3 a	+28 a	14.0 a	7.4 b	7.70 a	3.0 a	+28 a

Values followed by same letter in each column are not significantly at 5% level

Kane *et al.* [16] stored mango fruit cv Francisque at 4°C or 12°C for up to 3 weeks. They revealed that fruits stored at 4°C showed chilling injury during subsequent ripening at 20°C. Water content decreased more with fruit placed at 4°C than with those placed at 12°C. also Hardenburg *et al.* [17] stated that the high storage temperature causes a high respiration rate which leads to a fruit weight loss. Sankat *et al.* [18] noted that weight losses of fruits at ambient storage and ripened fruits, as well as refrigerated stored and ambient, ripened fruits, increased significantly with time fruits ripened from periodically refrigerated stored at all temperature showed higher weight losses (shrinkage) compared to normality ripened fruits. Hussein *et al.* [19] showing that the percentage of weight loss in Mabrouka, Mesk and Keitt cultivars generally increased significantly with the increase in storage temperature.

Flesh Firmness: As the length of the storage period increased and as storage temperature raised, the firmness levels of fruits decreased. Data in Table (2) disclosed that room temperature resulted in fruit softens during one week recording 8.3, 7.8 and 8.7 for Alphonso, Sediek and Keitt respectively in the first season and 8.1, 6.8 and 7.3 lb./in², in the second season. Fruit firmness at 5°C during the first week in both seasons and tested mango cultivars, there was no difference from the initial value, then in the second week it showed a slight decrease and the fruit was still hard.

During the third and the fourth week, the decrease of firmness significantly increased especially when fruits were stored at 10°C. Storage at 5°C exhibited fully firm fruit at the end of storage while 10°C resulted in fairly firm fruits. This was obvious with the three cultivars in both seasons.

These results are in harmony with Baez-Sanudo *et al.* [20] who demonstrated that pulp firmness decreased from 17.0 or 22.0 kg, percentage force to 1.0 kg, when mango fruits cvs Alphonso, Haden, Keith and Kent were harvested at the mature green stage (30 days before normal harvesting) and placed under simulated market condition (20°C, 60-65 % RH). Also, Kesta *et al.* [10] stored mango fruits cv Nam doc mai for 21 days at 4°C; they found that fruits at 4°C were firmer than non-chilled fruits during subsequent ripening at 25°C.

El-Oraby *et al.* [11] revealed that fruits softened gradually with prolonging the storage period. The decrease in flesh firmness was obviously on the 3rd week of storage, this decrease in firmness was clear with the rise in storage temperature. They added that fruits stored at 10°C had the lowest value of firmness (3.6 lb/in²) while fruits stored at 8°C were much firmer (5.7 lb/in²). The fruits of Mabrouka, Mesk and Keitt stored at 10°C. Keitt mesocarp was firmer and also remained firm longer during ripening than those of stored at 20°C were consistently softer than Mabrouka and Mesk [19].

Peel and Pulp Color: Data in Table (3) indicated that peel color of mango fruits at 25°C (room temperature) recorded the values of a/b ratio (0.65 and 0.79), (- 0.26 and -0.24) and (0.30 and 0.33) for Alphonso, Sediek and Keitt for the two seasons, respectively.

Peel color developed slowly at low temperature in the three tested cultivars in the first and second seasons, the values of a/b ratio were higher at 10°C than those at 5°C. Pulp color of Alphonso, Sediek and Keitt recorded the values of a/b ratio (0.34 and 0.36), (0.26 and 0.24) and (0.38 and 0.39) for the first and second seasons, respectively using Hunter colorimeter.

It is clear that 10°C markedly helped to increase, pulp color in both seasons for all the tested cultivars.

Table 3: Peel and pulp color (a/b ratio) of the three mango cultivars at room temperature 25°C as read by hunter colorimeter.

Cv	First Season				Second season			
	a/b ratio of peel color		a/b ratio of pulp color		a/b ratio of peel color		a/b ratio of pulp color	
	Initial a/b ratio	End of storage	Initial a/b ratio	End of storage	Initial a/b ratio	End of storage	Initial a/b ratio	End of storage
Alphonso	+0.61 a	+0.064 b	+0.04 b	+0.34 a	+0.67 a	+0.79 a	+0.04 b	+0.36 a
Sediek	-0.42 c	-26 c	-0.04 c	+0.26 b	-0.40 b	-24 c	+0.04 b	+0.24 b
Keitt	+0.39 b	+0.31 a	+0.07 a	+0.38 a	-0.43 b	+0.33 b	+0.07 a	+0.39 a

Values followed by same letter in each column are not significantly at 5% level

Table 4: Peel and pulp color (a/b ratio) of the three mango cultivars at cold storage as read by hunter colorimeter.

Temp. °C	Cv	Peel color					Pulp color				
		Storage period (days)					Storage period (days)				
		-----First Season-----									
		Initial	7	14	21	28	Initial	7	14	21	28
5°C	Alphonso	+0.59 a	+0.58 b	+0.65 b	+0.71 b	+0.79 a	+0.04 a	+0.08 b	+0.13 b	+0.16 b	+0.16 b
	Sediek	-0.42 c	-0.39 c	-0.35 c	-0.35 c	-0.40 c	-0.04 b	+0.04 b	+0.11 b	+0.15 b	+0.15 b
	Keitt	-0.38 b	-0.35 c	-0.35 c	-0.20 e	-0.43 c	-0.07 b	+0.13 a	+0.13 b	+0.15 b	+0.16 b
10°C	Alphonso	+0.59 a	+0.71 a	+0.79 a	+1.06 a	+0.69 b	+0.04 a	+0.14 a	+0.23 a	+0.30 a	+0.30 a
	Sediek	-0.42 c	-0.35 c	-0.31 cd	-0.24 e	-0.40 c	-0.04 b	+0.11 a	+0.24 a	+0.29 a	+0.34 a
	Keitt	-0.39 b	-0.33 c	-0.26 d	+0.15 d	-0.42 c	-0.07 b	+0.10 a	+0.13 b	+0.26 a	+0.31 a
-----Second Season-----											
5°C	Alphonso	+0.59 a	+0.68 a	+0.73 b	+0.76b	+0.81 a	+0.04 a	+0.07 c	+0.14 b	+0.14 b	+0.18 b
	Sediek	-0.42 c	-0.39bc	-0.35 d	-0.35f	-0.33 d	-0.04 b	+0.04 d	+0.11 b	+0.13 b	+0.18 b
	Keitt	-0.38 b	-0.33 b	-0.35 d	+0.24c	-0.16 c	-0.07 b	+0.07 c	+0.12 b	+0.16 b	+0.17 b
10°C	Alphonso	+0.59 a	+0.79 a	+0.83 a	+0.90a	+0.71 b	+0.04 a	+0.11 b	+0.23 a	+0.27 a	+0.30 a
	Sediek	-0.42 c	-0.34 b	+0.31 c	-0.26e	-0.24 c	-0.04 b	+0.15 a	+0.25 a	+0.25 a	+0.35 a
	Keitt	-0.39 b	-0.35 b	+0.24 c	-0.13d	-0.21 c	-0.07 b	+0.10 b	+0.14 b	+0.24 a	+0.31 a

Values followed by same letter in each column are not significantly at 5% level

Table 5: The effect of different storage temperatures on total soluble solids (TSS%) of three mango cultivars.

Temp.°C	Cv	First season					Second season				
		Storage period (days)					Storage period (days)				
		Initial	7	14	21	28	Initial	7	14	21	28
5°C	Alphonso	7.41 a	9.52 a	11.73 a	13.77 a	15.01 a	7.90 a	9.91 a	11.98 a	13.74 a	14.74 b
	Sediek	6.50 b	7.34 b	8.67 c	9.90 c	10.60 c	6.62 b	7.30 b	8.21 b	9.51 c	12.00 c
	Keitt	7.57 a	9.27 a	11.03 b	12.33 b	13.57 b	7.70 a	9.53 a	11.83 a	13.07 b	15.11 a
10°C	Alphonso	7.41 a	13.60 a	14.27 a	15.01 a	17.53 a	7.90 a	11.03 b	14.07 a	14.40 b	17.41 b
	Sediek	6.50 b	12.37 b	12.70 c	13.40 c	13.82 c	6.63 b	9.47 c	12.23 b	12.67 c	13.84 c
	Keitt	7.57 a	12.30 b	13.67 b	14.40 b	16.27 b	7.70 a	11.90 a	12.43 b	17.70 a	18.27 a
25°C	Alphonso	7.41 a	10.40 b	14.30 b	16.18 a	18.06 a	7.90 a	11.33 b	14.77 b	15.43 b	18.05 b
	Sediek	6.50 b	10.25 b	14.01 c	15.80 b	16.27 b	6.63 b	10.23 c	13.90 c	15.98 b	18.01 b
	Keitt	7.57 a	11.08 a	14.60 a	16.33 a	18.07 a	7.70 a	14.56 a	15.10 a	17.44 a	19.49 a

Values followed by same letter in each column are not significantly at 5% level

This results are in line with those of El-Oraby *et al.* [11] who stored Mabrouka mango at mature green at 13°C, 10°C and 8°C for up to 4 weeks, they stated that peel color showed a gradual change from green to yellowish-green or yellow at the end of stored period, fruits stored at 13°C had the highest a/b ratio about -0.55 at beginning of storage and changed to 0.15, 0.25, 0.14 at 13°C, 10°C and 8°C respectively. Regarding the pulp color, a/b ratio

changed from light yellow 0.07 at the beginning of storage to yellow 0.14, 0.19. Generally, at 13°C, a/b ratio was higher than the other two storage temperatures. Also, Serry (2003) reported the same results.

Total Soluble Solids: Data presented in Table (5) showed that TSS in fruits stored at room temperature reached its maximum at the end of storage 21 days, while after one

Table 6: The effect of different storage temperatures on the acidity (%) of three mango cultivars

Temp. °C	Cv	First season					Second season				
		Storage period (days)					Storage period (days)				
		Initial	7	14	21	28	Initial	7	14	21	28
5°C	Alphonso	1.31 b	1.17 b	0.93 b	0.69 b	0.36 b	1.24 b	1.09 b	0.97 b	0.64 b	0.43 b
	Sediek	2.70 a	2.39 a	1.96 a	1.09 a	0.92 a	2.71 a	2.65 a	1.28 a	1.09 a	0.79 a
	Keitt	0.91 c	0.86 c	0.64 c	0.41 c	0.26 c	1.09 c	1.04 b	0.74 c	0.45 c	0.24 c
10°C	Alphonso	1.30 b	1.09 b	0.71 b	0.45 b	0.26 b	1.23 b	0.91 b	0.47 c	0.31 b	0.19 b
	Sediek	2.70 a	1.43 a	0.96 a	0.71 a	0.63 a	2.71 a	1.48 a	1.18 a	0.73 a	0.61 a
	Keitt	0.91 c	0.68 c	0.47 c	0.24 c	0.13 c	1.09 c	0.89 c	0.67 b	0.32 b	0.21 b
25°C	Alphonso	1.31 b	1.01 b	0.81 a	0.41 a	0.15 b	1.23 b	1.03 b	0.83 a	0.38 b	0.13 b
	Sediek	2.71 a	1.73 a	0.75 b	0.41 a	0.38 a	2.71 a	1.75 a	0.83 a	0.48 a	0.38 a
	Keitt	0.91 c	0.5 c	0.33 c	0.24 b	0.17 b	1.09 c	0.81 c	0.64 b	0.47 a	0.19 b

Values followed by same letter in each column are not significantly at 5% level

Table 7: Sugars fractionation determined in three mango cultivars in relation to temperatures at the end of the storage period

Temp. °C	Cv	First season		Second season	
		Ribose	Fructose	Ribose	Fructose
5°C	Alphonso	9.91 e	4.94 d	9.72 e	4.89 e
	Sediek	6.96 f	3.31 e	6.71 f	3.14 f
	Keitt	11.56 d	9.98 a	14.58 d	9.68 a
10°C	Alphonso	16.94 c	8.90 a	16.30 d	8.70 a
	Sediek	21.66 b	5.85 c	23.85 b	7.64 b
	Keitt	16.60 c	7.80 b	15.90 d	8.05 b
25°C	Alphonso	21.30 b	6.61 c	23.11 b	6.71 d
	Sediek	31.92 a	7.31 b	37.51 a	5.51 e
	Keitt	15.66 c	7.63 b	18.36 c	7.51 b

Values followed by same letter in each column are not significantly at 5% level

week of storage recorded 14% approximately in both seasons for different mango cultivars. Cold storage at 5°C for Sediek fruits showed the least values of TSS. As for 10°C data show that TSS of stored fruits gave the highest values. Generally, TSS increased in fruits during cold storage and varied slightly at 5°C than at 10°C. Results are in harmony with Bhuyan and Islam [21] they stated that soluble solids content of 13 cvs. ranged from 15.00 to 21.44 %. Also, Medlicott *et al.* [5] mentioned that the development of soluble solids concentration in Amelie, Alphonso and Keitt mangoes increased progressively during storage for up to 21 days at 12°C based on the level of ripening changes that occurred during 12°C. Also, El-Oraby *et al.* [11] they stated that a gradual increase in TSS content in Mabrouka fruits occurred during storage. This increase was more significant in the 3rd and 4th weeks of storage.

Acidity: Data presented in Table (6) indicated that storage at room temperature resulted in a rapid decrease in acidity in all tested cultivars. The highest acidity value was

observed with Sediek mango Acidity showed a gradual decrease during the storage period. Fruits stored at 5°C gave the highest percentages at the end of storage. Highest acidity was measured in Sediek (0.92 and 0.79 %) for both seasons at 5°C while at 10°C it was (0.63 and 0.61 %) in the two seasons. These results agree with Salles and Tavares [9] who stated that acidity decreased in all treatments during the storage of Alphonso fruits, at 10°C and 60 %RH for 15 or 30 days and at room temperature. Also, El-Ansary [22] who demonstrated that acidity percentage in Mabrouka. Mesk and Keitt mangoes generally decreased with increasing of storage temperature and with the progress of storage period, especially at higher temperatures when the three cultivars are stored at 10°C and 20°C (90 % RH).

Also, El-Oraby *et al.* [11] have stated that acidity in cv Mabrouka decreased during storage at 8°C, 10°C and 13°C for 1, 2, 3.or 4 weeks. They added that fruits stored at 13°C had the lowest value of total acidity.

Sugars Fractionation: At the beginning of storage polysaccharides are the main content of fruits. At the end of storage polysaccharides were completely hydrolyzed with formation of other kinds of sugar during storage and ripening.

It is evident from (Table 7) that at the end of storage period, the major sugars were found in the juice of mango fruits, are ribose and fructose. There were significantly differences between cultivars at different temperature degree. The highest percentage of sugars was ribose; it recorded the maximum values at room temperature for two seasons, followed by 10°C had been converted to both glucose and fructose at cold storage at apricot fruits, while Roberld [23] detected that the principal sugars in Huden mango fruits have been identified as fructose 20.6%. glucose 5.3% and sucrose 74.1 %.

Table 8: Weight loss % of the three mango cultivars as affected by marketing temperature (25-30°C) after cold storage (shelf life).

Temp °C	Cv	First season				Second season			
		Storage period (days)				Storage period (days)			
		7	14	21	28	7	14	21	28
5°C	Alphonso	6.89 c	7.37 c	8.78 c	10.97 b	6.07 b	7.05 b	8.37 c	9.58 c
	Sediek	9.78 a	9.80 a	10.20 a	12.20 a	8.70 a	9.22 a	9.98 a	11.41 a
	Keitt	7.20 c	8.46 b	9.01 b	11.46 a	6.90 b	7.82 b	9.11 b	11.03 a
10°C	Alphonso	5.79 d	6.35 d	7.37 d	9.53 c	5.59 c	6.56 c	7.31 d	8.71 d
	Sediek	8.21 b	9.01 a	9.50 b	11.91 a	8.01 a	8.79 a	9.01 b	10.41 b
	Keitt	6.01 d	7.53 c	9.12 b	10.33 b	6.12 b	7.01 b	8.12 c	9.97 c

Values followed by same letter in each column are not significantly at 5% level

Table 9: Flesh firmness (lb/inch²) of the three mango cultivars as affected by marketing temperature (25-30°C) after cold storage (shelf life)

Temp.°C	Cv	First season				Second season			
		Storage period (days)				Storage period (days)			
		7	14	21	28	7	14	21	28
5°C	Alphonso	11.66 a	10.34 a	5.01 a	3.31 a	12.01 a	10.01 a	5.32 a	3.34 a
	Sediek	11.01 b	9.01 b	4.00 b	3.01 b	11.00 c	9.33 b	3.67 c	2.01 b
	Keitt	11.50 a	10.00 a	4.01 b	3.30 a	11.50 b	10.0 a	4.33 b	3.34 a
10°C	Alphonso	10.50 c	8.50 c	3.0 c	2.4 c	10.67 d	8.33 c	3.33 d	2.01 b
	Sediek	10.00 c	8.00 d	2.00 d	2.01 d	10.00 e	7.67 d	1.99 e	2.00 b
	Keitt	11.00 b	8.33 c	3.50 c	2.50 c	10.50d	8.33 c	3.33 d	2.00 b

Values followed by same letter in each column are not significantly at 5% level

Physical and Chemical Properties of the Three Mango Cultivars as Affected by Marketing Temperature (25-30°C) after Cold Storage

Weight Loss: Weight loss of three mango cultivars showed that at (25°C) weight loss slightly increased regardless of cold storage temperature. Weight loss of the cultivars showed that the highest losses were with fruits from 5°C storage. Among varieties of mango, Sediek showed the highest weight loss, recorded 12.2 % and 11.41 % for two seasons at 5°C and 11.91 % and 10.41 % for both seasons at 10°C. The lowest losses were for Alphonso, which recorded 10.97 % and 9.58 % for both seasons at 5°C and 9.53 %. 8.70 % at 10°C for both seasons respectively Table (8). Our findings are in line with Kane *et al.* [16] stored mango CV. Francisque at 4°C or 12°C for up to 3 weeks then placed them at room temperature. They revealed that fruits stored at 4°C. water content decreased more rapidly than those placed at 12°C.

Flesh Firmness: When ripened, fruit firmness was the most influenced quality factor influenced by storage time, temperatures and different mango cultivars. Firmness decreased with low temperature than the high with all of the tested cultivars and with a long storage period, after 7 and 14 days from cold storage then placed them at room temperature. No significant difference between varieties detected. At the third and fourth weeks of cold storage

and after transferred to room temperature fruits ripened after 5 days with low firmness recording (5.01 and 5.32 lb/inch² for Alphonso), (4.00 and 3.67 lb/inch² for Sediek) and (4.01 and 4.33 lb/inch² for Keitt) at 5°C. however, fruits which held at 10°C showed less firmness (Table 9). These results are in line with Ketsa *et al.* [10] who found that fruits cv. Nam dokmai at 4°C were firmer than non-chilled during ripening at 25°C.

Peel and Pulp Color: As for peel color, data in Table (10) was shown that good coloration was developed when fruits left at room temperature after cold storage. The change was to red color in Alphonso fruits and to yellow color in Keitt mango fruits but in Sediek mango fruits, the color remained green. Whilst pulp color was also more progressively developed in all the tested cultivars. after ripening fruits, for the first and the second seasons.

Total Soluble Solids: All the three mango cultivars showed an increase in TSS % values during ripening (shelf life) following the cold storage period. Fruits held at 10°C were higher in TSS values than those at 5°C (Table 11).

Our findings are in line with Serry [24] who found that SSC after ripening at 25°C progressively increased in Mabrouka fruits.

Table 10: Peel and pulp color (a/b ratio) of the three mango cultivars as affected by marketing temperature (25- 30°C) after cold storage (shelf life).

Temp. °C	Cv	Peel color				Pulp color			
		Storage period (days)				Storage period (days)			
		-----First Season-----							
		7	14	21	28	7	14	21	28
5°C	Alphonso	+0.92 b	+1.23 b	+1.52 b	+1.98 b	0.20 c	0.24 c	0.26 c	0.31 c
	Sediek	-0.35 d	-0.35 d	-0.34 e	-0.34 e	0.26 b	0.29 a	0.33 b	0.35 b
	Keitt	+0.18 c	+0.19 c	+0.22 c	+0.30 c	0.18 c	0.23 c	0.27 c	0.31 c
10°C	Alphonso	+1.26 a	+1.91 a	+2.26 a	+2.46 a	0.25 b	0.27 b	0.33 b	0.36 b
	Sediek	-0.30 d	-0.30 d	-0.25 d	-0.24 d	0.30 a	0.31 a	0.35 a	0.39 a
	Keitt	+0.19 c	+0.24 c	+0.28 c	+0.33 c	0.29 a	0.30 a	0.31 b	0.34 b
-----Second Season-----									
5°C	Alphonso	+1.06 b	+1.40 b	+1.57 b	+2.01 b	0.20 c	0.25 c	0.27 d	0.31 d
	Sediek	-0.34 d	-0.34 d	-0.33 d	-0.33 d	0.26 b	0.30 a	0.33 b	0.36 b
	Keitt	+0.19 c	+0.22 c	+0.25 c	+0.29 c	0.19 c	0.23 d	0.28 d	0.31 d
10°C	Alphonso	+1.39 a	+1.85 a	+2.20 a	+2.48 a	0.26 b	0.29 b	0.34 b	0.36 b
	Sediek	-0.30 d	-0.30 d	-0.27 d	-0.26 d	0.30 a	0.31 a	0.36 a	0.39 a
	Keitt	+0.20 c	+0.25 c	+0.29 c	+0.33 c	0.29 a	0.29 b	0.31 c	0.34 c

Values followed by same letter in each column are not significantly at 5% level

Table 11: Total soluble solids % of the three mango cultivars as affected by marketing temperature (25-30°C) after cold storage (shelf life).

Temp. °C	Cv	First season				Second season			
		Storage period (days)				Storage period (days)			

		7	14	21	28	7	14	21	28
5°C	Alphonso	14.41 b	15.61 b	16.81 a	17.51 b	14.00 c	15.50 b	16.30 b	17.50 c
	Sediek	12.91 c	13.51 d	14.41 d	16.20 c	12.70 e	13.70 e	14.50 d	16.70 d
	Keitt	14.40 b	14.90 c	15.30 c	15.80 d	13.00 d	14.60 d	15.20 c	16.01 e
10°C	Alphonso	15.30 a	16.90 a	16.80 a	18.20 a	15.50 a	16.80 a	17.00 a	18.50 a
	Sediek	14.40 b	14.90 c	15.60 c	17.90 b	14.50 b	15.00 c	15.60 c	17.60 c
	Keitt	14.41 b	15.70 b	16.11 b	18.30 a	14.40 b	15.90 b	16.30 b	18.00 b

Values followed by same letter in each column are not significantly at 5% level

Table 12: Acidity % of the three mango cultivars as affected by marketing temperature (25-30°C) after cold storage (shelf life)

Temp. °C	Cv	First season				Second season			
		Storage period (days)				Storage period (days)			

		7	14	21	28	7	14	21	28
5°C	Alphonso	0.82 b	0.42 d	0.25 d	0.25 c	0.80 b	0.42 e	0.38 c	0.25 c
	Sediek	0.91 a	0.78 a	0.44 b	0.38 a	0.97 a	0.71 b	0.42 b	0.38 a
	Keitt	0.71 c	0.63 c	0.50 a	0.32 b	0.77 b	0.56 c	0.50 a	0.30 b
10°C	Alphonso	0.47 d	0.25 f	0.24 d	0.19 d	0.43 d	0.38 f	0.25 d	0.25 c
	Sediek	0.82 b	0.70 b	0.38 c	0.25 c	0.80 b	0.78 a	0.38 c	0.26 c
	Keitt	0.50 d	0.38 e	0.37 c	0.25 c	0.63 c	0.50 d	0.39 c	0.26 c

Values followed by same letter in each column are not significantly at 5% level

Acidity: The acidity decreased as the storage time was lengthened (Table 12) and after subsequent shelf life. Fruits stored at 10°C gave the least values of acidity.

These results are in line with Seery [24] who found that acidity showed a decrease after ripening in all stored fruits. Also, Medlicott *et al.* [5] showed that low-temperature storage and ripening tend to produce fruits that are more acid.

Decay: Considering the effect of temperature and duration of exposure on decay percentage of the three tested cultivars, it is obvious that the higher storage temperature 10°C gave the highest percentage of decay recording 6% and 8% in both seasons respectively. However, 5°C showed less decay percentage in both seasons 4% and 4.5% in the fourth week of storage. No significant difference between varieties detected. This result is in line with El-Khoreiby *et al.* [8].

Chilling Injury: Chilling symptoms were not evident during cold storage at 10°C or 5°C. but could be noticed during shelf life period (ripening) after the third week of storage at 5°C recorded 10 %, 15 % and 11% for Alphonso, Sediek and Keitt respectively (symptoms as red spots, pitting, failure to ripen, non-uniform ripening, poor flavor and failure color).

During the shelf-life period, after the fourth week of storage at 5°C, the fruits recorded 30%, 50% and 35% (Chilling injury symptoms) as black spots, pitting and increased susceptibility to post-harvest decay.

These results are in harmony with those of Couey [2]; Hidalgo *et al.* [26] and Pesis *et al.* [7].

Generally, it can be concluded that fruit ripened after 9 days at room temperature from harvesting were colored with yellow and bright red giving the fruit an attractive appearance for Alphonso. Sediek fruits remain light green and sometimes developed red color in the side of the fruit, however, Keitt mango fruits turn to yellow, pulp color turned to yellow in both Alphonso and Keitt and turned to orange for Sediek. Nevertheless, fruits held at 5°C showed less coloration and remained green. 10°C is suitable for ripening to alter 2 weeks of storage.

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