

AWIS MANGOES BEHAVIOUR DURING STORAGE AS AFFECTED BY SOME JOJOBA OIL TREATMENTS

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ABSTRACT

This experiment was carried out during the two successive seasons (2006 and 2007) on Awis mango fruits (*Mangifera indica L.*) harvested at mature stage. Experimental fruits were divided into five similar groups each of (3 boxes, eight fruits in each box about 2 kg). Fruits of each group were emulsified in one of the following jojoba oil concentrations (100, 75, 50, 25 and 0 %). Treated fruits were stored at $13 \pm 1^\circ\text{C}$ and 90% RH. Weight loss%, decayed fruits, changes in fruit firmness, flesh SSC, sugar, acid and V.C content were evaluated at 7 days intervals.

Jojoba oil emulsifying reduced weight loss, decayed fruit percent. This beneficial effect was connected to oil concentrations; the high oil concentration gave the lower weight loss and fruit decay%. Jojoba oil lowered the decrease in both fruit flesh firmness and flesh acid content. Fruits treated with 100 % concentration showed higher flesh firmness and flesh acid values than the lower tested oil concentrations. Fruits received the 100% concentration showed the highest total sugar content than those of the control and other tested oil concentrations. Flesh SSC and vitamin C content was not much affected by jojoba oil at 100% concentration. It could be concluded that jojoba oil is beneficial natural product for the conservation of Awis mangoes during cold storage.

Key words: Mango, Awis, Jojoba oil, Cold storage

INTRODUCTION

Mango (*Mangifera indica L.*) grown throughout the subtropics and tropics regions and considered one of the most highly prized fruits due to its delicious taste, attractive flavor and its highly nutrients value. It has been called the Apple of Orient (Sowdon, 1990).

In Egypt, the mango is one of the most economically important fruit crop ranged after dates, citrus and grapes. Recently an extensive increase in mango plantations were recorded, whereas between 1980 and 2005 the mango cultivated area has increased by about 500% (from 28.245 to 139.433 Fadden) according to the statistics of Ministry of Agriculture (Anon 2006). Total mango production amounted 545 thousand tons in 2006. However the exportation of fresh mango fruits to 20 countries in the Near East and Europe represented about 0.973% (5305 tons) of the total production (UPEHC, 2006). For all local

cultivars "Awis" found to be one of the most important to local consumption and to export to Kingdom of Saudia Arabia and Kuwait for several consideration i.e. its attractive appearance, fruit is yellow with a red-yellow blush, medium size skin is smooth its easily separating, the flesh is soft, tender melting and juicy with no fiber, yellow, very sweet, aroma is good quality, polyembrionic, with woody small stone. Degree of cultivar is Excellent

Export trade however is hindered by difficulties in the transport and storage (Pinto *et al.*, 2004). The quality of imported mangoes at arrival in the market and the ripening behavior after arrival vary widely between lots. For better service to their customers, the importers of mango should be better able to predict the influence of quality and ripening behavior of imported mangoes (Tefera *et al.*, 2007)

Storage is essential for extending the marketing period of fruits, regulating their supply to the market and for transportation to long distances. The marketing period could be extended by pre-cooling, storage under low temperature and some pre-storage treatments. In this respect, recent experiments were conducted to study the effect of jojoba oil to extend marketing life of some fruit kinds. Several attempts were conducted to prolong the marketing season of mango fruits. Among these attempts-besides cold storage are the use of jojoba oil as emulsifiable natural product.

There is a dispute need to study how the marketing period could be extended and how to reduce the loss of fruits and supply mango fruit frequently and over long period of time.

Jojoba oil (pronounced "ho-HO-bah") is the liquid wax produced in the seed of the jojoba (*Simmondsia chinensis*) plant. Unrefined jojoba oil appears as a clear golden liquid at room temperature with a slightly fatty odor. Refined jojoba oil is colorless and

odorless. The melting point of jojoba oil is approximately 10°C.

Benefits of Jojoba oil

- Provides all day moisturization – jojoba oil doesn't evaporate like water based moisturizers can.
- Very stable – jojoba oil does not become rancid or lose antioxidants even after long periods of storage.
- Spreads well and absorbs well.

Abd El-Moniem *et al.* (2006) studied the effect of different coating materials and concluded that coating Washington navel orange fruits with jojoba oil and orange oil were the best in reducing decay and weight loss and increasing fruits storage life. Hoa *et al.* (2002) reported that all coating treatments reduced the respiratory rate and loss of firmness except carnauba wax changes in acids were also delayed in all coated mangoes.

Mehaisen (2005 b.) found that olive oil coating treatment on pear significantly increases fruit firmness and decreased weight loss, but had no effect on total soluble solid and T.A. compared with un coated fruits

MATERIALS AND METHODS

This work was carried out during the two successive seasons (2006 and 2007) on "Awis" mangoes. Fruits were harvested at green mature stage from trees grown in a private orchard at Ismailia, Egypt according to indices reported by (Hassan *et al.*, 2004)

Harvested fruits were directly transferred to the laboratory at the Agricultural Development System (ADS) Project at Faculty of Agriculture, Cairo University.

Defective fruits including wounded and other disorders were excluded, the rest considered as sound fruits were washed with tap water and air dried. Experimental fruits were divided into five similar groups. Each group was subjected to one of the following treatment:

- 1-Jojoba oil at 100%
- 2-Jojoba oil at 75% (75 ml jojoba +25 ml water)
- 3-Jojoba oil at 50% (50 ml jojoba +50 ml water)

4-Jojoba oil at 25% (25 ml jojoba +75 ml water)

5-Control (tap water only)

Each treatment was represented by three replicates each of 3 carton boxes/ about 2 kg and measure (45 x 35 x 10 cm), in one layer inside the box. Experimental boxes were stored at 13±1°C and 90% relative humidity for 28 days.

Changes in same physical and chemical fruits properties were determined at 7 days intervals.

1. Physical properties

1.1. Fruit weight loss percentage

Each box was individually weighted before cold storage to get the initial weight, and then weighted after each period of cold storage. Fruits weight was recorded, then % of weight loss were calculated according to the following equation:

$$\text{Fruit weight loss \%} = \frac{W_i - W_s}{W_i} \times 100$$

Where:

W_i = initial fruit weight before cold storage

W_s = fruit weight at the end of sampling period

1.2. Decay Percentage:

The decayed fruits as percentage were calculated according to the following equation:

(Total number of decayed fruit / Initial number of stored fruit) x100

1.3. Fruit firmness

A very thin batch of skin was removed on the two opposite sides of each fruit and flesh firmness was determined by using a hand managess T pressure tester and the average fruit flesh firmness of two sides was measured in lb/ inch².

2. Chemical properties

2.1. Soluble Solids Content (SSC) %

A refractometer was used to determine the soluble solids percent in fruit flesh according to (A.O.A.C. 1990)

2.2. Titratable acidity %

It was determined according to the method described in (A.O.A.C. 1990). Results

were expressed as gm citric acid in 100 gm fruit flesh.

2.3. Ascorbic acid content (vitamin C)

It was determined according to (A.O.A.C. 1990). It was calculated as milligram vitamin C per 100 ml of fresh weight.

2.4. Total sugar %

Was determined by using the methods of (A.O.A.C. 1990) and the concentration were calculated as gm glucose per 100 gm. Fresh flesh weight.

Statistical analysis

Data were statistically analyzed using MSTAT-C software (MSTAT, Michigan University East Lansing). Analysis of variance (ANOVA) and Duncan multiple significant difference was performed to determine any significant difference among various treatments. $p < 0.05$ was selected as decision for significant differences according to (Sendecor and Cochran 1982).

Every sampling date was analyzed individually, means with different letters within each column are significant(S) at 5% level and means without letters are not significant (N.S.)

RESULTS AND DISCUSSION

Physical properties

Fruit weight loss percentage

Data in Table (1) cleared that jojoba oil treatments reduced the loss in fruit weight %. For instance in the first season after 7 days, the loss percent in fruit weight for the control fruits reached 2.44%, compared with 1.44,1.44,1.70 and 1.69 for the 100,75,50,25% jojoba oil concentration respectively. Similar results were obtained in the second season.

These results are in line with those suggested by (Mehaisen, 2005 a) who found that coated guava fruits with olive oil coating reduced weight loss. Similar results obtained by (Panhwar, 2005) who revealed that edible coating films can delay ripening of climacteric fruit reduced water loss in mango fruits and thereby extended is shelf life.

Fruit decay %

Data in Table (2) clear that, fruits received the jojoba oil treatments seemed to have in general a longer life span than fruits of the control. For instance during the first season after two weeks the decay percentage was about 15.25 % for control fruits while it was 2.77, 4.16,4.16 and 6.94% for the 100,75,50,25% oil concentration respectively.

Also it is clear that % of fruits decay increased gradually till the end of storage period. After 28 days fruits treated with 100% jojoba oil and stored at $13 \pm 1^\circ\text{C}$ exhibited the lowest values of decay % while control fruits recorded the highest ones. In general, fruits treated with jojoba oil seemed to have a longer life span. The same trend was noticed during the second season

Table (1): Changes in weight loss % of Awis mangoes as affected by emulsions with jojoba oil during cold stored at 13±1°C and 90% RH in 2006 and 2007 seasons

Treatments	7 day	14 day	21 day	28 day	Main effect of treatments
Season 2006					
100% jojoba oil	1.44b	2.94c	4.41b	5.39b	3.54a
75% jojoba oil	1.44b	3.10bc	4.34b	5.31b	3.54a
50% jojoba oil	1.70b	3.41b	4.87a	5.84a	3.95a
25% jojoba oil	1.69b	3.38b	4.83a	5.81a	3.92a
Control	2.44a	4.89a	**	**	3.66a
Season 2007					
100% jojoba oil	1.49b	2.98c	4.48b	5.47b	3.60b
75% jojoba oil	1.51b	3.03c	4.55b	5.56b	3.66b
50% jojoba oil	1.73b	3.47b	4.96a	5.96a	4.03ab
25% jojoba oil	1.73b	3.47b	4.95a	5.94a	4.02ab
Control	2.73a	5.96a	**	**	4.34a

Table (2): Changes in decay % of Awis mangoes as affected by emulsions with jojoba oil during cold stored at 13±1°C and 90% RH in 2006 and 2007 seasons

Treatments	7 day	14 day	21 day	28 day	Main effect of treatments
Season 2006					
100% jojoba oil	2.77b	8.33c	12.50c	16.66c	10.06d
75% jojoba oil	4.16b	8.33c	13.89c	19.44b	11.45cd
50% jojoba oil	4.16b	11.11bc	16.66b	20.83b	13.19c
25% jojoba oil	6.94b	15.27b	20.83a	25.00a	17.01b
Control	15.25 a	44.44a	**	**	29.85a
Season 2007					
100% jojoba oil	2.77b	8.33d	12.50b	18.05c	10.41d
75% jojoba oil	4.16b	8.33d	18.05a	20.83bc	12.84d
50% jojoba oil	4.16b	11.11c	22.22a	25.00ab	15.62c
25% jojoba oil	5.55b	15.27b	22.22a	30.33a	18.40b
Control	16.66a	44.44a	**	**	30.55a

Means with different letters within each column are significant at 0.05% level.

** The treatment was terminated after 50% decay.

These results confirmed the findings obtained by (Hoa *et al.*, 2002 and Tripathi and Dubey 2004) they found that the biologically active natural products have the potential to replace synthetic fungicides

Fruit firmness

Data in Table (3) cleared that fruits of different treatments showed a sharp decrease in flesh firmness during the first week in storage which continued but at a lower rate, till the end of the storage period. The reduction in fruit firmness during storage is due to protopectin, starch and polysaccharides analysis which could lead to fruit ripening. The increment in flesh softening often lead to fruit deterioration. Jojoba treatments seemed to preserve fruit firmness during storage. Thus

fruit flesh firmness was higher in jojoba oil treated fruits than in the control at different sampling dates.

The control fruits showed the lowest flesh firmness values after 14 days in storage whereas for the jojoba oil treated fruits of the 25 % jojoba oil treatment showed the lowest one in all dates. This was the true in the two studied seasons.

In this respect (Banks, 1984) found that the effect of coating material on delaying the ripening was due to the restriction in gas exchange between the fruit and its surrounding atmosphere. This caused a buildup of carbon dioxide and a depletion of oxygen, this causing an effect achieved in controlled atmosphere storage.

Table (3): Changes in firmness of Awis mangoes as affected by emulsions with jojoba oil during cold stored at 13±1°C and 90% RH in 2006 and 2007 seasons.

Treatments	0 day	7 day	14 day	21 day	28 day	Main effect of treatments
Season 2006						
100% jojoba oil	26.33a	18.47a	10.33a	7.17ab	4.47a	13.35ab
75% jojoba oil	26.53a	18.03a	9.93ab	6.37b	4.37a	13.05ab
50% jojoba oil	26.60a	18.03a	8.97b	6.17b	3.90b	12.73b
25% jojoba oil	26.50a	17.84ab	8.33b	6.07b	3.50b	12.46b
Control	26.53a	10.33c	5.97c	**	**	14.28a
Season 2007						
100% jojoba oil	26.10a	16.20a	11.07a	7.30a	4.93ab	13.12ab
75% jojoba oil	26.20a	16.20a	9.77b	6.40ab	4.23b	12.56ab
50% jojoba oil	26.40a	16.00a	9.20b	6.17ab	4.20b	12.39ab
25% jojoba oil	25.93ab	16.00a	8.80bc	5.75b	4.10b	12.12b
Control	26.07a	10.97b	4.93d	**	**	13.99a

Means with different letters within each column are significant at 0.05% level.

** The treatment was terminated after 50% decay.

Meanwhile, cell wall carbohydrates (pectin and hemicelluloses) are enzymatically hydrolyzed causing softening of mango pulp, the enzyme level increase simultaneously with pectin depolymerization (Ali *et al.*, 1995)

The obtained results agreed with those of (Ismail, 1997) who found that coating Le Conte pear with simper fresh significant increased firmness. Similar results were obtained by (Mehaisen, 2005 a) who reported that guava fruits coated with olive oil were firmer than uncoated ones. Based on these parameters (weight loss and firmness) Awis fruits coated with jojoba oil seemed to have in

general a long life span in cold storage compared with control.

Chemical properties

Soluble Solids Content (SSC) %

From Table (4) it is obvious that, the flesh SSC of the jojoba oil treated and untreated fruits, showed a gradual and continued increase till the end of storage period. The increase in SSC during the storage is achieved through, starch analysis into sugars or moisture loss from the fruit. Jojoba oil treatment caused very slight increases in fruit flesh SSC yet this increase was not pronounced.

Table (4): Changes in SSC % of Awis mangoes as affected by emulsions with jojoba oil during cold stored at 13±1°C and 90% RH in 2006 and 2007 seasons.

Treatments	0 day	7 day	14 day	21 day	28 day	Main effect of treatments
Season 2006						
100% jojoba oil	15.20b	15.77ab	16.43a	17.03a	17.70b	16.43a
75% jojoba oil	15.33b	16.00a	16.57a	17.30a	18.07a	16.65a
50% jojoba oil	15.33b	16.03a	16.63a	17.33a	18.30a	16.72a
25% jojoba oil	15.37b	16.07a	16.70a	17.37a	18.60a	16.82a
Control	15.60ab	16.13a	16.63a	**	**	16.12a
Season 2007						
100% jojoba oil	14.07b	14.63b	16.03b	16.47a	18.00a	15.84b
75% jojoba oil	14.50b	15.03ab	16.03b	16.57a	18.10a	16.05ab
50% jojoba oil	15.00ab	15.40ab	16.10b	16.57a	18.40a	16.29ab
25% jojoba oil	15.13ab	16.50a	16.70ab	17.00a	18.43a	16.75a
Control	15.30ab	16.57a	17.33ab	**	**	16.40a

Means with different letters within each column are significant at 0.05% level.

** The treatment was terminated after 50% decay.

Avery slight increased in SSC was noticed in the fruit of the 25% oil concentration after 28 days in storage, this was the same in the two seasons.

This results agreed with those of (Mehaisen, 2005 b, Abd EL-Moneim Eman 2006 and Abd El Migeed and Fatouh 2007)

Titrateable acidity %

Data in Table (5) showed that a sizable decrease in flesh acidity was occurred

after 7 days from storage. This pronounced decrease in acidity continued but at lower rate till the end of the storage period. Acidity is known to decrease as the ripening stage advances; this explains the decrease in flesh acidity during storage. The highest jojoba oil concentration showed the higher acidity value compared with the other tested concentrations. Contrarily the same concentration showed no significant difference than those of the other tested concentrations.

Table (5): Changes in flesh acid % of Awis mangoes as affected by emulsions with jojoba oil during cold stored at $13\pm 1^{\circ}\text{C}$ and 90% RH in 2006 and 2007 seasons

Treatments	0 day	7 day	14 day	21 day	28 day	Main effect of treatments
Season 2006						
100% jojoba oil	1.35a	0.96ab	0.88a	0.73a	0.42a	0.87a
75% jojoba oil	1.32a	0.95ab	0.82a	0.72a	0.38a	0.84a
50% jojoba oil	1.30a	0.93ab	0.82a	0.70a	0.36a	0.82a
25% jojoba oil	1.29a	0.92ab	0.80a	0.70a	0.34a	0.81a
Control	1.25a	0.81b	0.53b	**	**	0.86a
Season 2007						
100% jojoba oil	1.26a	0.89ab	0.73ab	0.62a	0.41a	0.78a
75% jojoba oil	1.25a	0.82ab	0.72ab	0.55ab	0.35b	0.74a
50% jojoba oil	1.22a	0.80ab	0.65b	0.52ab	0.31b	0.70a
25% jojoba oil	1.20a	0.77b	0.61b	0.50ab	0.31b	0.68a
Control	1.20a	0.67c	0.42c	**	**	0.76a

Means with different letters within each column are significant at 0.05% level.

** The treatment was terminated after 50% decay.

The reason for the higher acidity in the jojoba oil treated fruits than the control might be the effect of jojoba oil in delaying ripening. The lower acidity value was achieved in the control fruits after 14 day; this was the same in the two seasons.

This data are in line with those obtained by (Abd EL-Moneim Eman 2006 and Abd El Migeed and Fatouh 2007) on orange and mango fruits.

Ascorbic acid content (vitamin C)

Data from Table (6) cleared that the V.C content in treated and untreated fruits showed a sharp decrease during the two first weeks in storage. This decrease in flesh V.C content, while was sharp in the two first weeks it was gradual in the third and fourth sampling dates, but jojoba oil treatments in general increased this trend. Fruits coated by jojoba oil exhibited lower V.C value obtained with 25% jojoba oil after 28 days of storage. This was true in the two seasons. This results are in

accordance with what was obtained by (Mehaisen, 2005 a) who stated that ascorbic acid decreased in guava fruits with extended storage.

Total sugars %

It is clear from Table (7) that flesh sugar % increased gradually till the end of storage period. This gradual increase in total sugar is probably due to starch adverse; sugar content is known to increase as the ripening stage advances. Fruits coated with jojoba oil showed somewhat higher sugar content comparing with untreated fruits.

Differences between oil concentrations were rather slight in both seasons.

The fruits treated with jojoba oil at 100% concentration exhibited the highest flesh sugar content in the two experimental seasons; but differences were all insignificant between all jojoba treatments.

The positive effect of jojoba oil treatments on reducing of sugar during storage and consequently storage life of fruit was in line of (Joseph and Aworh,1991 and Bulk *et al.*, 1997) who concluded that fruit will reach high levels of sugar, ascorbic acid, soluble solids and their lowest level of acidity as they ripen. The present results provided supporting

evidence that coating Awis mango fruits with jojoba oil helped to delay ripening and preserve fruit quality.

It could be concluded that jojoba oil is benefit natural product to conserve Awis mangoes during cold storage.

Table (6): Changes in flesh V.C content of Awis mangoes as affected by emulsions with jojoba oil during cold stored at 13±1°C and 90% RH in 2006 and 2007 seasons (ml.gm/100 gm fresh flesh).

Treatments	0 day	7 day	14 day	21 day	28 day	Main effect of treatments
Season 2006						
100% jojoba oil	45.43a	36.60a	30.83a	28.33a	25.67ab	33.37b
75% jojoba oil	45.10a	36.33a	30.67a	28.10a	25.50ab	33.14b
50% jojoba oil	45.50a	36.10a	30.50a	27.53ab	25.40ab	32.01c
25% jojoba oil	45.03a	35.97a	30.07a	26.57b	24.23b	32.37c
Control	45.00a	35.07a	28.03b	**	**	36.03a
Season 2007						
100% jojoba oil	43.50a	35.87a	30.53ab	27.00ab	25.43ab	32.47b
75% jojoba oil	43.37a	35.07a	30.10ab	26.70ab	25.00ab	32.05b
50% jojoba oil	43.17a	35.03a	30.03ab	26.00ab	24.83ab	31.81bc
25% jojoba oil	43.07a	33.07ab	29.03b	25.70b	24.80b	31.13c
Control	43.03a	31.43b	25.80c	**	**	33.42a

Table (7): Changes in flesh total sugar % of Awis mangoes as affected by emulsions with jojoba oil during cold stored at 13±1°C and 90% RH in 2006 and 2007 seasons.

Treatments	0 day	7 day	14 day	21 day	28 day	Main effect of treatments
Season 2006						
100% jojoba oil	12.33ab	14.07b	14.43a	16.10ab	17.57a	14.90a
75% jojoba oil	12.50ab	14.00b	14.47a	16.20ab	16.57ab	14.75a
50% jojoba oil	12.47ab	14.07b	14.48a	15.13b	16.33ab	14.50a
25% jojoba oil	12.17b	14.33ab	14.50a	15.03b	16.43ab	14.49a
Control	12.50ab	14.00b	14.50a	**	**	13.67b
Season 2007						
100% jojoba oil	12.07a	13.37ab	14.07b	14.57a	16.50ab	14.12a
75% jojoba oil	12.03a	13.27ab	14.00b	14.53a	16.03b	13.97a
50% jojoba oil	12.00a	13.00b	14.47ab	14.53a	16.00b	14.00a
25% jojoba oil	12.00a	13.00b	14.33ab	14.90a	16.33ab	14.11a
Control	12.03a	13.33ab	14.43ab	**	**	13.26b

Means with different letters within each column are significant at 0.05% level.

** The treatment was terminated after 50% decay.

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تأثير بعض المعاملات بزيت الجوجوبا على سلوك ثمار المانجو العويس أثناء التخزين

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أجرى هذا البحث لدراسة تأثير تغطية ثمار المانجو صنف العويس المكتملة النمو بتركيزات من زيت الجوجوبا (صفر، ٢٥، ٥٠، ١٠٠، ٧٥%) وتخزينها على درجة حرارة ١٣±١م^١ ورطوبة نسبية ٩٠% وقد تم تقدير الفقد في وزن الثمار ونسبة التالف وصلابة اللحم ومحتواه من المواد الصلبة الذائبة والحموضة وفيتامين ج على فترات اسبوعية خلال فترة التخزين. أوضحت النتائج ان تغطية الثمار بزيت الجوجوبا قلل من نسبة الثمار التالفة ومن الفقد في الوزن الرطب لها وارتبط هذا التأثير طرديا مع التركيز المستخدم كما ادت المعاملة بزيت الجوجوبا الى تقليل الفقد في صلابة لحم الثمار ومحتواه من الاحماض العضوية وكانت افضل النتائج عند المعاملة بتركيز ١٠٠% كذلك أدى هذا التركيز الى اعلى نسبة من السكريات الكلية في لحم الثمار بينما لم يتأثر فيتامين ج كثيرا عند هذا التركيز ويمكن استنتاج ان معاملة ثمار المانجو صنف عويس بزيت الجوجوبا ذات تأثير مفيد في حفظ الثمار أثناء تخزينها.