Effect of harvesting method and package type on quality and shelf-life of mango fruits

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ABSTRACT

The traditional method of harvest and package type were compared with an improved harvesting technique and packaging in standard export carton boxes and evaluated according to quality and shelf-life of 'Kitchner' and 'Abu-Samaka' mango fruits in 'Abu-Gebeha' area during 2012/2013 season. The fruits harvested by the traditional method were snapped by a hook attached to a long bamboo pole, the fruits dropped to the ground and then picked into carton boxes. In the improved method of harvest, the fruits were picked by a hook attached to a long bamboo pole equipped with a long cloth sleeve held open by a metal ring. When the pedicle was severed, the fruit dropped into the sleeve, moved smoothly downwards to be received from the open-end by the picker and packed into the carton boxes. Two types of packages were used. The traditional packages were carton boxes 27 x 27 x 42cm, and the improved packages were standard export boxes 43 x 33 x 15 cm. The treatments were (1) traditional harvest and traditional packages (control), (2) traditional harvest and improved packages, and (3) improved harvest and improved packages. The treatments were arranged in a completely randomized design with four replicates and stored at 18±1ºC and 85- 90% relative humidity. The improved method of harvest and improved packages significantly delayed the onset of the climacteric peak, reduced respiration rate, weight loss, fruit softening, peel color development, total soluble solids (TSS) accumulation and titratable acidity changes, retained ascorbic acid, maintained fruit quality and extended the shelf-life of mango fruits. Initial respiration rate was decreased by 14.9% and 24.6%, weight loss was reduced by 13.8% and 28.9% and ascorbic acid was more by 28.6% and 75.5% in the improved harvesting method and improved packages, compared with the control in 'Kitchner' and 'Abu-Samaka' mangoes,

respectively. At the end of the storage period, 48 % of the fruits were in the 'very good' quality grade and 22% in the 'good' grade in fruits harvested by the improved method and packed in improved packages, compared with 18.5% in the 'very good' quality grade and 20% in the 'good' grade in fruits harvested traditionally and packed in traditional packages. On the other hand, only 9.0% of the fruits were 'unmarketable' and 9.5% were 'poor' in quality in fruits harvested by the improved method and packed in improved packages, compared with 25%' unmarketable' and 20% in the 'poor' quality grade in the control fruits.

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important and popular fruit crop in the Sudan, and is commercially grown in every State. Its annual production is about 651 thousand tons (AOAD, 2009). It is the second most important fruit crop, representing 60% of total Sudan exports of horticultural commodities (AOAD, 2009).

South east Kordofan, especially Abu-Gebeha area, is considered as one of the most important areas in the Sudan for producing mangoes. More than a million mango trees are grown in South Eastern Kordofan with average annual production of more than 100 thousand tons of fruits (RMAFNK, 2008). Only about 15% of the produce is marketed, because of poor harvesting techniques, unsatisfactory post-harvest handling practices, and inadequate transportation and storage facilities. Mango is grown from seeds and produced under rain-fed conditions. Its production is early, which gives good opportunities for export that precedes the early mango season in India and Pakistan (RMAFNK, 2008). Picking of fruits is done by snapping the fruit by a hook attached to a long bamboo pole. The fruit will drop to the ground and later gathered and packed in carton boxes of different sizes (10-20 kg). The boxes are loaded on trucks, uncovered and exposed to sun and wind and transported long distances (690km) for markets. Large numbers of fruits are bruised and later show up as brown and black patches, making the fruits unattractive and with short a shelf-life. Post-harvest losses were estimated as 20-30% (Tahir *et al.*, 2002). These methods and practices need a lot of improvement for the development of a sound mango industry in the area.

Care in harvesting and handling is necessary to preserve subsequent quality of fruits. Faulty harvesting and rough handling at the farm, directly affect market quality and nutritive value of the fruit. Mechanical injuries such as bruising, surface abrasions and cuts can result in fungal infection, increased respiration rate, ethylene production, dehydration of tissues and water loss and accelerated loss of vitamin C (Kader, 2002; Abu-Goukh and Mohamed, 2004). The incidence and severity of such injuries are influenced by the method of harvest and handling operations (Kader, 2002).Abu-Goukh and Mohamed (2004) introduced an improved harvesting technique for mangoes. Fruits were snapped off the tree with a pole equipped with a long cloth sleeve held open by a metal ring. When the pedicle was severed, the fruit dropped into the bag and slided smoothly down to be received by the picker. They reported that the improved method greatly maintained fruit quality, reduced post-harvest losses and extended shelf-life.

Packages for horticultural commodities are sized to be convenient units for marketing and distributing horticultural products. They must protect fragile products against damage during distribution and must maintain their shape and strength, often for long periods at high relative humidity and sometimes after water contact (Kader, 2002).

This study compared the traditional method of harvest and package type with an improved harvesting technique and packaging in standard export carton boxes (43×33×15 cm) on quality and shelf-life of 'Kitchner' and 'Abu-Samaka' mango fruits in 'Abu-Gebeha' area.

MATERIALS AND METHODS

Experimental material

Two of the most important mango cultivars grown in the Sudan: an early 'Kitchner' and late maturing 'Abu-Samaka' were selected for this study. Fruits of the two cultivars were harvested at the mature-green stage from an orchard at Abu-Gebeha area in south-east Kordofan (11º27´ N, 31º 14´ E) during 2012/2013 season. Two harvesting methods were used. The traditional method, where the fruits were snapped by a hook attached to a long bamboo pole. The fruits dropped to the ground and then picked into carton boxes. In the improved method, the fruits were picked by a hook attached to a long bamboo pole equipped with a long cloth sleeve held open

by a metal ring. When the pedicle was severed, the fruit dropped into the sleeve, moved smoothly downwards to be received from the open-end by the picker and packed into the carton boxes. About 600 fruits of each cultivar were harvested at the mature-green stage and selected for uniformity in size, color and freedom from blemishes and defects.

Two types of carton boxes were used. The traditional carton boxes were 27cm long, 27cm wide and 42cm deep. The standard export carton boxes were 43cm long, 33cm wide and 15cm deep. The treatments were: (1) Traditional harvest and traditional carton boxes (control), (2) Traditional harvest and standard export boxes, and (3) Improved harvest and standard export boxes. The treatments were arranged in a completely randomized design with four replicates. The boxes were covered with tarpaulin and transported by truck to the laboratory at the Faculty of Agriculture, University of Khartoum for further investigations. All cartons were kept at 18 ± 1ºC and 85% - 90% relative humidity.

Parameters studied

Respiration rate (mg CO_2/ kg-hr) was determined daily during the storage period in 12 fruits from each replicate using the total absorption method (Mohamed-Nour and Abu-Goukh, 2010). Peel color was determined daily during the storage period on the same 12 fruits used for determination of respiration rate. The color score used was: mature green (=0), trace yellow on skin (=1), 20% yellow (=2), 40% yellow (=3), 60% yellow (=4), 80% yellow (=5), and 100% yellow (=6). Weight loss percentage was determined daily on the same fruits used for respiration and peel color determinations. Weight loss percentage was calculated according to the formula: $w_1 = [(w_o - w_t)/ w_o] \times 100\%$; where w_1 is the percentage weight loss, w_o is the initial weight of fruits at harvest and w_t is the weight of fruits at the designated time.

Flesh firmness, TSS, titratable acidity and ascorbic acid content were determined in three fruits picked randomly from each replication, other than those used for respiration rate, peel color and weight loss determinations, at 2- day intervals and later every day during the storage period. Flesh firmness was measured by Magness and Taylor firmness tester (D. Ballauf Meg. Co.), equipped with an 8 mm-diameter plunger tip. Two readings were taken from opposite sides of each fruit after the peel was removed, and expressed in kg/cm^2. Total soluble solids (TSS) were measured directly from the fruit juice extracted by pressing the fruit pulp in a garlic press,

using a Kruss hand refractometer (model HRN-32). Two readings were taken from opposite sides of each fruit and the mean values were calculated and corrected according to the refractometer chart.

Thirty grams of fruit pulp of the three fruits used for flesh firmness and TSS determinations, were homogenized in 100 ml of distilled water for one minute in a Sanyo Solid State blender (model SM 228P) and centrifuged at 10,000 rpm for 10 minutes using a Gallenkamp portable centrifuge (CF-400). The volume of supernatant, which constituted the pulp extract, was determined. Titratable acidity was measured according to the method described by Ranganna (1979) and expressed as percent citric acid.

Thirty grams of pulp from the three fruits used for flesh firmness and TSS determinations were homogenized in 100 ml of oxalic acid for one minute in a Sanyo Solid State blender (model SM 228P) and centrifuged at 10 000 rpm for 10 minutes by a Gallenkamp portable centrifuge (CF-400). The volume of supernatant was topped to 250 ml oxalic acid. Ascorbic acid was determined in the pulp extract using the 2,6-dichlorophenol-indophenol titration method of Ruck (1963) and expressed in mg /100 g fresh weight.

At the end of the storage period, the fruits in the different treatments were evaluated for general quality. The fruits were graded according to the general appearance into five categories: very good, good, fair, poor and unmarketable. The percentage of fruits in each category was calculated.

Statistical analysis

Analysis of variance (ANOVA) followed by Fisher's protected LSD test with a significance level of $P \leq 0.05$ were performed on the data (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The improved method of harvest and packages significantly decreased mechanical injury, reduced post-harvest losses, delayed fruit ripening, maintained quality and extended the shelf-life of fruits. Proper harvesting methods and gentle handling are crucial factors in reducing post-harvest losses, maintaining quality and extending the shelf-life of the produce (Abu-Goukh, 1993). Mechanical injury is the major factor in providing pathways for infection by microorganisms. Moreover, it stimulates respiration rate, ethylene production, discoloration and hydration of the tissues (Abu-Goukh, 1993; Kader, 2002). These effects of harvesting method and type of package were reflected in changes in respiration rate, weight loss, peel color, flesh firmness, TSS, titratable acidity and ascorbic acid content.

Effect on respiration rate

The initial respiration rate (day 1) in fruits of the traditional harvest and packages was 101mg CO_2/kg-hr for 'Kitchner' and 57mg CO_2/kg-hr for 'Abu-Samaka' fruits (Fig.1). It decreased by 7.9% and 14.0% in the traditional harvest and improved packages and by 14.9% and 24.6% in the improved harvest and improved packages for 'Kitchner' and 'Abu-Samaka' fruits, respectively. The improved method of harvest and packages significantly decreased bruises on the fruits, which was reflected in higher respiration rate. Similar results were reported in mango (Abu-Goukh and Mohamed, 2004) and grapefruit (Elshiekh and Abu-Goukh, 2008). The decrease in respiration rate for the improved methods in 'Abu-Samaka' was higher than that in 'Kitchner' due to the larger size of 'Abu-Samaka' fruits, compared to 'Kitchner'. This is in line with the findings of Abu-Goukh and Mohamed (2004).

The respiration curves of the two cultivars exhibited a typical climacteric pattern, with climacteric peak at 240 and 156mg CO_2/kg-hr in the traditional methods, which was reached after 9 and 11 days in 'Kitchner' and 'Abu-Samaka', respectively (Fig.1). The climacteric peak was delayed by one and two days in the traditional harvest and improved packages and improved harvest and improved packages, respectively. The traditional method of harvest and packages resulted in bruises to the fruits, which was reflected in higher respiration rate and earlier climacteric peak of respiration. Kader (2002) reported that mechanical injuries stimulate respiration rate and ethylene production of fruits and vegetable

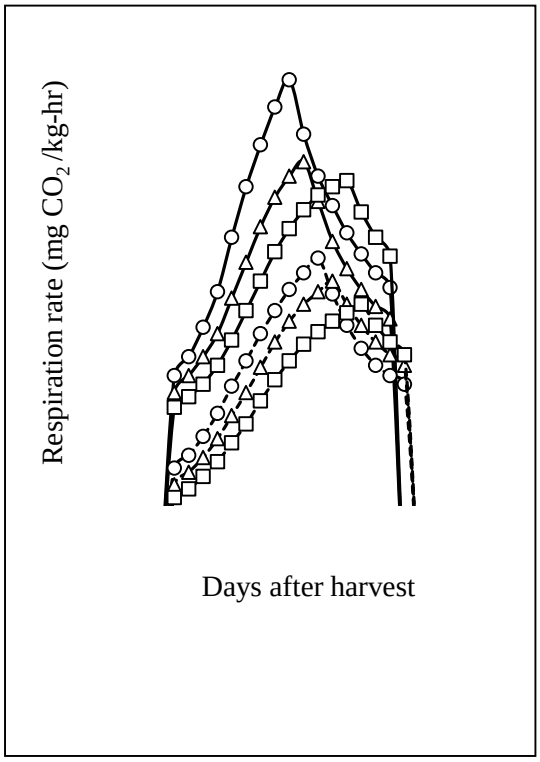

Fig. 1. Changes in respiration during storage of 'Kitchner' (——) and 'Abu-Samaka' (------) mango fruits harvested by the traditional method and packed in traditional cartons (o), harvested by the traditional method and packed in improved cartons (Δ) or harvested by the improved method and packed in improved cartons (□), at 18 ± 1 ºC and 85%-90% relative humidity.

Effect on weight loss

Weight loss progressively increased during storage of both cultivars regardless of the treatment (Fig. 2). Significantly higher percentages of weight loss were observed in the traditional harvesting method and packages. At the end of the storage period, weight loss was 27.6% and 9.7% in fruits harvested traditionally and packed in traditional packages, compared to 23.8% and 6.9% in fruits harvested by the improved method and packed in improved packages for 'Kitchner' and 'Abu-Samaka' fruits, respectively (Fig. 2). The higher percentage of weight loss in the traditional practices of harvesting and packaging was most probable due to bruises

from impact of fruits with the ground during harvesting and compression and abrasion of fruits in the large over-filled packages. Abu-Goukh and Mohamed (2004) reported that traditional method of harvest by snapping fruits by a hook attached to a long bamboo pole and fruits drop to the ground cause bruises and mechanical injuries to the fruits makes them unattractive, with poor quality and shorter shelf-life. Mechanical damage can greatly accelerate the rate of water loss from the produce. Bruising and abrasion damage the surface organization of the tissue, thereby allowing much greater flux of water vapor through the damaged area (Wills *et al.*, 1998).

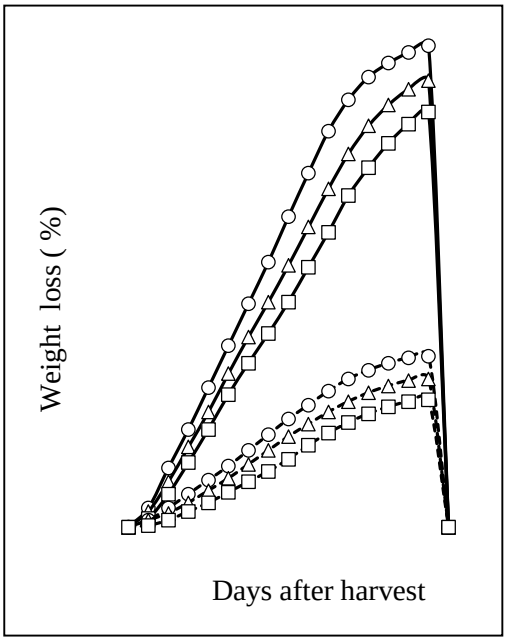

Fig. 2. Changes in weight loss during storage of 'Kitchner' (——) and 'Abu-Samaka' (-----) mango fruits harvested by the traditional method and packed in traditional cartons (o), harvested by the traditional method and packed in improved cartons (Δ) or harvested by the improved method and packed in improved cartons (□), at 18 ± 1 ºC and 85%-90% relative humidity.

Weight loss was reduced by 7.3% and 14.4% in the traditional harvest and improved packages and by 13.8% and 28.9% in the improved harvest and improved packages for 'Kitchner' and 'Abu-Samaka' cultivars, respectively (Fig.2). Method of harvest and type of package to minimize mechanical injury and bruises is a crucial factor in reducing postharvest losses, improving

quality and extending the shelf-life of the produce. Mechanical injury stimulates respiration rate, ethylene production, discoloration and dehydration of the tissue of the produce (Kader, 2002). Improved harvesting techniques minimized weight loss, reduced post-harvest losses, maintained quality and extended the shelf-life of mango (Abu-Goukh and Mohamed, 2004) and grapefruit (Elshiekh and Abu-Goukh, 2008).

Weight loss in 'Kitchner' was much higher than in 'Abu-Samaka' fruits (Fig. 2). This may be due to the smaller fruits of 'Kitchner' compared with 'Abu-Samaka'. On purely physical grounds, there is proportionally greater water loss from produce with a higher surface to unit volume ratio. A small fruit, root or tuber will lose water faster than a relatively larger one (Wills *et al.*, 1998).

Effect on peel color

Peel color score steadily increased during storage of 'Kitchner' and 'Abu-Samaka' mango fruits (Fig.3). The fruits harvested by the traditional method and packed in traditional packages reached the full yellow stage (color score 6) after 14 days in 'Kitchner' and 15 days in 'Abu-Samaka' cultivars. Peel color score was delayed by one and two days in the traditional harvest in improved packages and in the improved harvest and improved packages, respectively (Fig.3). The enhanced ripening in the traditional harvesting and packaging could be related to the bruises caused by impact of fruits with the ground during harvesting and compression and abrasion of fruits in the traditional packages. Mechanical damage stimulates respiration rate, ethylene production and dehydration of tissues (Kader, 2002), and accelerates fruit ripening (Macnish *et al.*, 1997). Abu-Goukh and Mohamed (2004) found that an improved harvesting technique that protected the fruit from falling to the ground, significantly delayed fruit ripening, maintained quality and extended shelf-life. Similar results were reported in grapefruits (Elshiekh and Abu-Goukh, 2008).

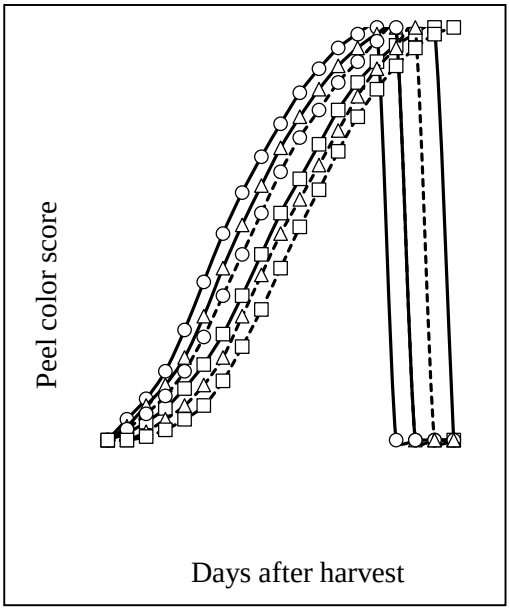

Fig. 3. Changes in peel color during storage of 'Kitchner' (———) and 'Abu-Samaka' (------) mango fruits harvested by the traditional method and packed in traditional cartons (o), harvested by the traditional method and packed in improved cartons (Δ) or harvested by the improved method and packed in improved cartons (□), at 18 ± 1 ºC and 85%-90% relative humidity.

Effect on fruit flesh firmness

Fruit flesh firmness showed a progressive decline during storage of both mango cultivars. Most of that decline occurred 3-4 days during the pre-climacteric rise of respiration (Fig. 4). Fruit softening is characterized by changes in flesh firmness and has long been associated with ripening (Dostal, 1970). These changes in fruit firmness determine shelf-life and quality of the commodity. Similar pattern were observed during the ripening of mango (Abu-Goukh and Abu-Sarra, 1993), guava (Bashir and Abu-Goukh, 2003), banana (Elamin and Abu-Goukh, 2009) and papaya (Shatir and Abu-Goukh, 2010). The fruits harvested by the traditional method and packed in traditional packages had less flesh firmness at harvest and softened more rapidly. In contrast, fruits harvested by the improved method and packed in improved packages retained a firmer texture for a longer period, and it would be more able to withstand long distant transportation.

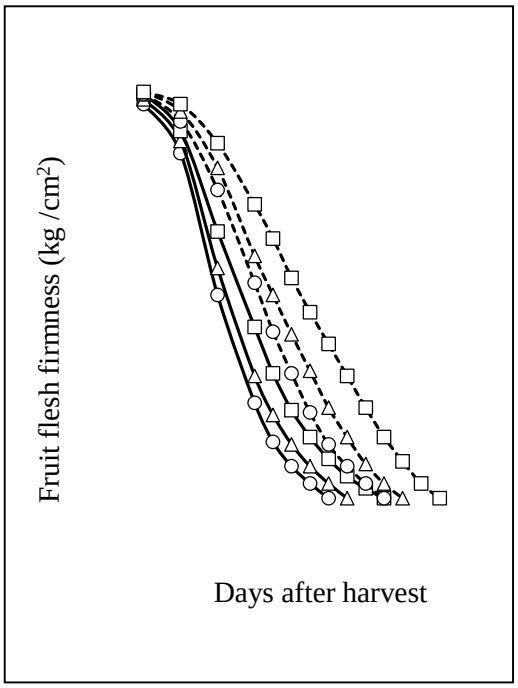

Fig. 4. Changes in fruit flesh firmness during storage of 'Kitchner' (———) and 'Abu-Samaka' (--------) mango fruits harvested by the traditional method and packed in traditional cartons (o), harvested by the traditional method and packed in improved cartons (Δ) or harvested by the improved method and packed in improved cartons (□), at 18 ± 1 ºC and 85%-90% relative humidity.

The control fruits, harvested by the traditional method and packed in traditional packages, reached the final soft stage (0.14 kg/cm^2) after 11 days in 'Kitchner' and 14 days in 'Abu-Samaka' fruits (Fig. 4). The fruits harvested traditionally and packed in improved packages reached that final soft stage one day later, while those harvested by the improved method and packed in improved packages reached the final soft stage three days later, compared to control fruits (Fig. 4). Bruising damages surface organization of the tissues (Wills *et al.*, 1998). This stimulates respiration rate, ethylene production and dehydration of the tissues (Kader, 2002) and accelerates fruit ripening (Macnish *et al.*, 1997; Abu-Goukh and Mohamed, 2004).

Effect on total soluble solids

Total soluble solids (TSS) steadily increased during storage in all fruits (Fig.5). TSS increased more quickly in fruits harvested by the traditional method and packed in traditional packages. The maximum TSS values reached were 19.6% in 'Kitchner' and 15.6% in 'Abu-Samaka' cultivars. Those maximum values were reached in the control fruits, harvested traditionally and packed in traditional packages, after 11 and 13 days in 'Kitchner' and 'Abu-Samaka' fruits, respectively (Fig. 5). The maximum TSS values reached were delayed by one and three days in fruits harvested by the traditional method and packed in improved packages and in those harvested by the improved method and packed in improved packages, respectively, in both cultivars. These results were in line with previous reports that traditional methods of harvest accelerates respiration rate, weight loss, fruit ripening and shortens shelf-life of mango (Abu-Goukh and Mohamed, 2004) and grapefruit (Elshiekh and Abu-Goukh, 2008). The higher TSS accumulation in the fruits during storage in the traditional practices of harvesting and packaging were most probable due to higher weight loss in fruits (Salih and Abdalla, 1982) and faster ripening rate due to impact bruises, high respiration rate and ethylene production (Kader, 2002).

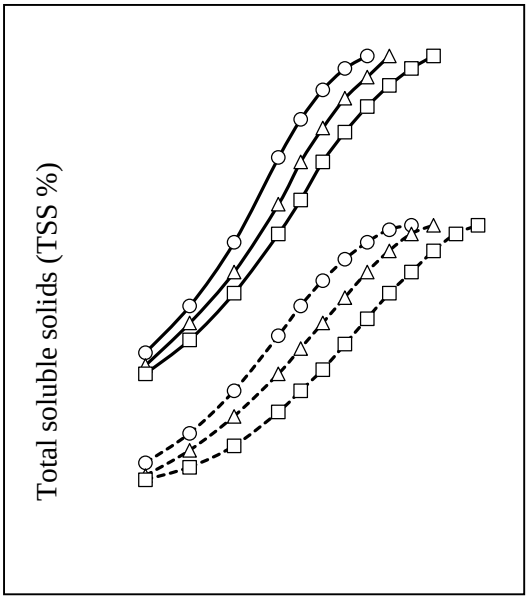

Fig. 5. Changes in total soluble solids (TSS) during storage of 'Kitchner' (———) and 'Abu-Samaka' (--------) mango fruits harvested by the traditional method and packed in traditional cartons (o), harvested by the traditional method and packed in improved cartons (Δ) or harvested by the improved method and packed in improved cartons (□), at 18 ± 1 ºC and 85%-90% relative humidity.

Effect on titratable acidity

Titratable acidity of the fruit pulp was progressively decreased during storage of both mango cultivars in all treatments (Fig. 6). This is in line with the findings of Srinivasia *et al.* (2002), who found that titratable acidity values of 'Alphonso' mango showed a decreasing trend from 2.17% to 0.08% in 12 days when stored at 27°C and 65% relative humidity. It decreased from 2.72% and 2.82% in the control fruits of

'Kitchner' and 'Abu-Samaka' to 0.26% in 13 and 16 days, respectively. The drop in titratable acidity was delayed by one day in fruits harvested traditionally and packed in improved packages and by three days in fruits harvested by the improved method and packed in improved packages in both

cultivars (Fig. 6). That was most probable due to the delay in the ripening process in the improved harvesting and packaging, which reduced bruises and mechanical injury (Abu-Goukh, 1993).

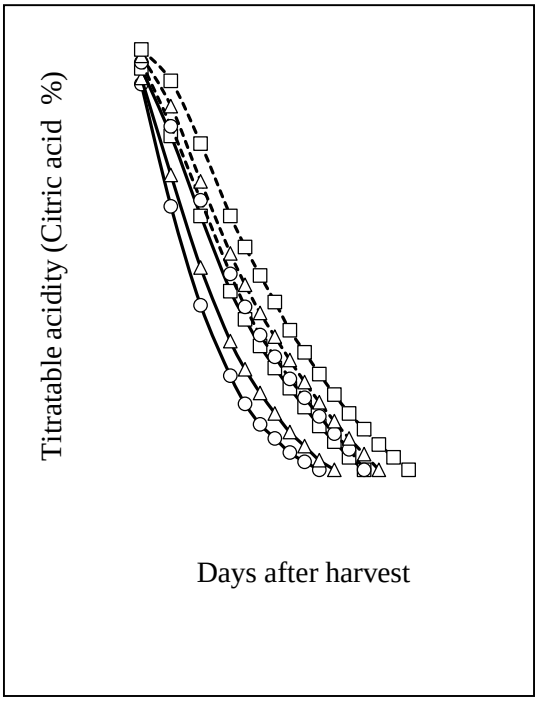

Fig. 6. Changes in titratable acidity during storage of 'Kitchner' (———) and 'Abu-Samaka' (--------) mango fruits harvested by the traditional method and packed in traditional cartons (o), harvested by the traditional method and packed in improved cartons (Δ) or harvested by the improved method and packed in improved cartons (□), at 18 ± 1 ºC and 85%-90% relative humidity.

Effect on ascorbic acid content

Ascorbic acid content decreased steadily during storage of the two mango cultivars (Fig.7). This is in agreement with previous reports (Abu-Goukh and Abu-Sarra, 1993; Abu-Goukh and Mohamed, 2004). It was significantly higher in 'Kitchner' cultivar and in fruits harvested by the improved method and in the improved packages. It decreased in the control fruits (harvested by traditional method and packed in traditional packages) from 22.5 and 17.0 (mg/100g) to 10.5 and 3.6 mg/100g in 11 and 13 days in 'Kitchner' and 'Abu-Samaka' fruits, respectively (Fig.7). At that time, ascorbic acid content was 10.5% and 22.5% more in the fruits harvested traditionally and packed in improved packages and 28.6% and 75.5% more in the fruits harvested by the improved method and packed in improved packages, compared to the control fruits, in 'Kitchner' and 'Abu-Samaka' cultivars, respectively.

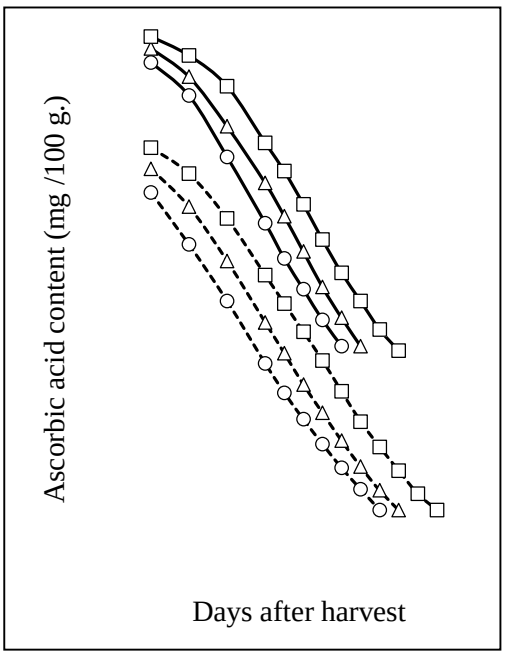

Fig. 7. Changes in ascorbic acid content during storage of 'Kitchner' (———) and 'Abu-Samaka' (--------) mango fruits harvested by the traditional method and packed in traditional cartons (o), harvested by the traditional method and packed in improved cartons (Δ) or harvested by the improved method and packed in improved cartons (□), at 18 ± 1 ºC and 85%-90% relative humidity.

The lower ascorbic acid content in the fruits harvested traditionally or packed in the traditional packages was most probable due to bruises and mechanical injuries. Lee and Kader (2000) reported that mechanical injuries such as bruising, surface abrasions and cuts result in accelerated loss of ascorbic acid. The incidence and severity of such injuries are influenced by method of harvest, type of package and handling operations. Abu-Goukh and Mohamed (2004) found that ascorbic acid was significantly higher in mango fruits harvested by an improved harvesting technique that protected the fruits from mechanical injuries. They reported that the amount of ascorbic acid retained at the end of the storage period was 44.3% more in the improved method, compared with the traditional one. Vitamin C content was about 15% lower in bruised tomato fruits than unbruised fruits (Moretti *et al.*, 1998). Mondy and Leja (1986) found a very large decrease in ascorbic acid content of the bruised tissue of potato tubers, while the unbruised halves appeared to show an increase in their ascorbic acid content.

Effect on general quality:

At the end of the storage period, the fruits were evaluated for general quality. Table 1 shows percentages of fruits in each quality grade. In the fruits harvested by the improved method and packed in improved packages, 48% on average were in the ‘very good’ quality grade and 22% on average were in the ‘good’ grade. In fruits harvested traditionally and packed in improved packages, 35.5% and 17.5% on average were in the ‘very good’ and ‘good’ quality grades. While in the fruits harvested by the traditional method and packed in traditional packages, only 18.5% were in the ‘very good’ quality grade and 20% in the ‘good’ grade, respectively (Table 1). On the other hand, only 9.0% on average were ‘unmarketable’ and 9.5% were in the ‘poor’ grade in fruits harvested by the improved technique and packed in improved packages. In fruits harvested traditionally and packed in improved packages, 19% were ‘unmarketable’ and 18.5% on average were ‘poor’ quality. While in fruits harvested by traditional method and packed in traditional packages, 25% on average were ‘unmarketable’ and 20% were in the ‘poor’ quality grade. Similar results were reported in mango (Abu-Goukh and Mohamed, 2004) and grapefruit (Elshiekh and Abu-Goukh, 2008).

Table 1. Effect of harvesting method and package type on general quality of mango fruits.

Treatment	Cultivar	Fruits in each quality grade (%)				
		Very Good	Good	Fair	Poor	Unmarketable
Traditional harvest and traditional package	Kitchner	25	15	13	18	29
	Abu-Samaka	12	25	20	22	21
Traditional harvest and improved package	Kitchner	29	18	14	16	23
	Abu-Samaka	42	17	5	21	15
Improved harvest and improved package	Kitchner	30	25	17	12	16
	Abu-Samaka	66	19	6	7	2

The traditional method of harvest and packages resulted in mechanical injury, which is the major factor in post-harvest losses of horticultural commodities. Mechanical injury causes loss of visual quality, characterized by unsightly abrasions, bruises and cuts. Such injuries lead to an increase in the general metabolic rate (wound response) as the produce tries to seal off the damaged tissues (Wills *et al*., 1998). Mechanical injuries stimulate

respiration, ethylene production and dehydration of tissues (Kader, 2002; Abu-Goukh and Mohamed 2004). Water loss of only 5% will cause many horticultural commodities to appear wilted and shriveled. Even in the absence of visible wilting, water loss can result in reduced quality (Abu-Goukh and Mohamed, 2004; Elshiekh and Abu-Goukh, 2008), and early ripening and senescence (Macnish *et al.*, 1997).

CONCLUSION

The improved methods of harvest and improved packages delayed the onset of the climacteric peak, reduced respiration rate, weight loss, fruit softening, peel color development, total soluble solids, and titratable acidity, retained ascorbic acid, maintained quality and extended the shelf-life of mango fruits.

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تأثير طرق الحصاد وأنواع العبوات على الجودة والعمر التسويقي لثمار المانجو

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الخلاصـــــة

تمت مقارنة طريقة الحصاد التقليدية ونوع العبوة المستخدمة مع طريقة محسنة للحصاد والتعبئة في صناديق الكرتون الخاصة بالصادر وتأثيرها على الجودة والعمر التسويقي لصنفي ثمار المانجو "كتشنر" و"أبو سمكة" في منطقة "أبو جبيهة". في طريقة الحصاد التقليدية، حصدت الثمار بنزعها بواسطة عصا طويلة في نهايتها خطاف مما يؤدى إلى سقوط الثمار على الأرض ويتم جمعها لاحقاً في حاويات الجمع. أما في الطريقة المحسنة، فقد أضيف إلى أداة القطف التقليدية كيس طويل من القماش مثبت على حلقة معدنية تحت الخطاف. عند فصل الثمرة من الغصن تسقط داخل الكيس وتنساب برفق إلى أسفل حيث يتم استلامها بواسطة عامل القطف من الفتحة السفلى للكيس وتوضع مباشرة في حاويات الجمع. كما أستخدم نوعان من العبوات: العبوات التقليدية كانت بأبعاد 42x27x27 سم، والعبوات المحسنة كانت صناديق الكرتون الخاصة بالصادر بأبعاد 15x33x43سم. وقد كانت المعاملات كما يلي: (1) حصاد تقليدي وعبوة تقليدية (الشاهد)، و(2) حصاد تقليدي وعبوة محسنة، و(3) حصاد محسن وعبوة محسنة. استخدم التصميم كامل العشوائية لإجراء التجربة بأربعة مكررات وخزنت الثمار تحت درجة حرارة 18±1°م ورطوبة نسبية 85 - 90 %. أدت طريقة الحصاد المحسنة والعبوات المحسنة إلى تأخير معنوي في حدوث ذروة التنفس وانخفاض معدل التنفس، وفقدان الوزن، وليونة الثمرة وتلون قشرتها، وتأخير تراكم المواد الصلبة الذائبة الكلية وخفض معدل الحموضة في الثمار. كما حافظت الثمار على محتواها من حمض الأسكوربيك (فايتامين ج)، وتحسين جودتها، و إطالة عمرها التسويقي. وقد انخفض معدل التنفس الابتدائي بنسبة 14.9% و24.6%، كما انخفض فقد الوزن بنسبة 13.8% و28.9%، وكان حمض الأسكوربيك أكثر بمقدار 28.6% و75.5% بطريقة الحصاد المحسنة والعبوات المحسنة في ثمار "كتشنر" و"أبوسمكة"، على التوالي، مقارنة مع الشاهد. بنهاية فترة التخزين، كانت48% من الثمار في درجة الجودة "جيد جداً" و22% في درجة "جيد" في الثمار التي حصدت بالطريقة المحسنة وتمت تعبئتها في العبوات المحسنة، مقارنة مع 18.5 % من الثمار في درجة "جيد جداً" و20% في درجة "جيد" في الثمار التي تم حصادها بالطريقة التقليدية وتعبئتها في عبوات تقليدية. من ناحية أخرى، لم يكن هناك سوى 9.0% من الثمار "غير القابلة للتسويق" و9.5% "فقيرة في الجودة" في الثمار التي حصدت بالطريقة المحسنة وتم تعبئتها في عبوات محسنة، مقارنة بنسبة 25% من الثمار "غير القابلة للتسويق" و20% من الثمار "فقيرة في الجودة" في ثمار الشاهد.