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# Effect of Polyethylene Film lining and Potassium Permanganate on Quality and Shelf-life of Mango Fruits

## Research Article

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**Abstract**

The aim of this experiment was to investigate the effect of polyethylene film lining and potassium permanganate (KMnO4) on quality and shelf-life of 'Kitchener' and 'Abu-Samaka' mango fruits. The perforated polyethylene film lining significantly delayed fruit ripening in both mango cultivars. KMnO4 in addition resulted in more delay in fruit ripening and better quality of the fruits. Polyethylene film lining with 0.0, 1.0 and 2.0 g $KMnO_4$, delayed fruit ripening in both cultivars by one, three and four days, respectively, compared with the control. Weight loss reduced by 29.1%, 38.1% and 46.0% in fruits packed in carton boxes lined with perforated polyethylene film with 0.0, 1.0 and 2.0 g KMnO4, respectively, compared with the control.

## Introduction

Mango (*Mangifera indica L.*) is one of the most important tropical fruit of the world and is popular both in the fresh and the processed forms. It is famous for its excellent flavor, attractive fragrance, beautiful color, delicious taste and nutritional value. Mango plays an important role in balancing diet of human being by providing about 46-86 calories energy per 100 g of ripe fruit, and it is a good source of vital vitamins and minerals [1]. In Sudan mango is the second most important fruit crop, after banana, and it is commercially grown in every state. Its annual production is about 651 thousand tons and leading export fruit crop, representing about 60% of total exports of horticultural commodities in Sudan [2].

'Abugebeha' in Southern Kordofan is considered as one of the most important area in Sudan for producing low cost fruit crops, especially mango, guava and citruses, since they are produced under rain-fed conditions. Although more than 100 thousand tons of good quality mangoes are produced, only about 15% of the produce is marketed due to poor harvesting techniques, unsatisfactory handling practices and inadequate transportation and storage facilities [3].

Mangoes are usually harvested at the mature green stage and transported to distant markets and ripened afterwards. During transit, they should remain green and firm. The shelf life of mangoes can be extended by transporting them under optimum conditions of temperature, relative humidity and composition of the atmosphere and use of ripening retardants [4].

Polyethylene films, sealed or perforated are commonly used to minimize weight loss, reduce abrasion damage, delay fruit ripening and extend shelf-life [5]. Polyethylene box liners have been used for several years in storage of apples and pears and now extending to other commodities [6]. It has been shown that fruits packed in polyethylene lined boxes have a longer shelf-life than control fruits [5].


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Potassium permanganate ($KMnO_4$) is quite effective in reducing ethylene levels by oxidizing it to carbon dioxide and water. It is a chemical which has long been used to remove ethylene from the storage atmosphere [7]. It was demonstrated that $KMnO_4$ retarded the ripening of many fruits [6,8]. The use of $KMnO_4$ in conjunction with modified atmosphere in polyethylene films delayed fruit ripening, maintained quality and extended shelf life in mango and banana [5,9]. It has been shown that bananas packed in polyethylene-lined boxes could be transported at higher ambient temperatures in the presence of $KMnO_4$ [4].

This study was carried out to investigate the effect of polyethylene film lining and potassium permanganate on quality and shelf life of 'Kitchener' and 'Abu-Samaka' mango fruits.

## Materials and Methods

### Experimental material

Two of the most important mango cultivars grown in Sudan: an early 'Kitchener' and late maturing 'Abu-Samaka' were selected for this study. Mature green fruits were harvested from an orchard at Abugebeha area in South-East Kordofan (11˚ 27´ N, 31° 14´ E), they picked by a hook attached to a long bamboo pole equipped with a long cloth bag held open by a ring. About 900 fruits of each cultivar were selected for uniformity size, color and freedom from blemishes, then washed with tap water to remove latex and dust and then washed by distilled water, treated with 200 ppm sodium hypochlorite (Clorox, 5%) as disinfectant and air dried.

### Fruit treatment

The fruits were distributed among the six treatments in a completely randomized design with four replicates. The fruits were packed in carton boxes lined with perforated polyethylene films (0.0015 mm) or left without lining as control. Potassium permanganate ($KMnO_4$) was used in a granular form and packed as one and two grams in small mesh bags. The treatments were: (1) Fruits packed in unlined boxes (control), (2) Fruits packed in boxes lined with perforated polyethylene films, (3) Fruits packed in boxes lined with perforated polyethylene films with 1 g $KMnO_4$, and (4) Fruits packed in boxes lined with perforated polyethylene films with 2.0 g $KMnO_4$. All the boxes with fruits were stored at 18+ 1 °C and 85-90% relative humidity.

### Parameters studied

Respiration Rate (RR), Peel Color (PC), Weight Loss (WL) percentage were determined daily during the storage period on 12 fruits from each replication. The total absorption method was used and RR was expressed in mg $CO_2$ per kg/hr. 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) [10]. WL percentage is calculated according to the formula: $W1= [(W_o - W_t) / W_o] x100\%$; where W1 is the percentage WL, $W_o$ is the initial weight of fruits at harvest and Wt is the weight of fruits at the designated time. Flesh Firmness (FF), Total Soluble Solids (TSS), Titratable Acidity (TA) and Ascorbic Acid (AA) were determined in three fruits picked randomly from each replicate, other than those used for previous parameters in 2 days intervals and later every day during the storage period. FF was measured by Magness and Taylor firmness tester (D. Ballauf Meg. Co.), equipped with an 8 mm diameter plunger tip. Two reads were taken from opposite sides of each fruit after the peel was removed, and expressed in kilogram per square centimeter. TSS was 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 were homogenized in 100 ml of distilled water (oxalic acid for AA) 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 (was topped to 250 ml oxalic acid for AA). TA was measured according to the method described by Ranganna and expressed as percent citric acid [11]. AA was determined by using the 2,6-dichloro-phenolindophenol titration method of Ruck and expressed in mg per 100 g fresh weight [12].

### 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 [13].

## Results and Discussions

The use of perforated polyethylene film liners significantly delayed fruit ripening, maintained quality and extend shelf life of mango fruits of both cultivars. The use of $KMnO_4$ in conjunction with polyethylene film lining further retarded fruit ripening. The delay in fruit ripening and extension of shelf life of mango fruits due to polyethylene film liners and $KMnO_4$ were reflected in changes in respiration rate, weight loss, peel color, flesh firmness, total soluble solids, titratable acidity and ascorbic acid content.

### Effect on Respiration Rate (RR)

The respiration curves of the two mango cultivars exhibited a typical climacteric pattern. The untreated fruits reached the climacteric peak after 8 and 10 days in 'Kitchener' and 'Abu-Samaka' cultivars, respectively. Mango fruits packed in perforated film liners without $KMnO_4$ reached the climacteric peak one day later in 'Kitchener' and 'Abu-Samaka' mango fruits, compared with untreated fruits (Figures 1 and 2). Polyethylene film liners, with one and two grams $KMnO_4$ delayed the onset of the climacteric peak of respiration by three and four days, respectively, in both cultivars. These results agree with previous reports in banana, apricot and papaya [5,14-16]. Polyethylene film liners resulted in a Modified Atmosphere (MA) with lower $O_2$ and higher $CO_2$ concentrations. MA has been shown to decrease RR and delay the onset of the climacteric peak in mango and banana [6,9,14]. The use of $KMnO_4$ in conjunction with MA was found to delay the onset of the climacteric peak [5]. The addition of $KMnO_4$ decreases RR and delays ripening by maintaining ethylene at a low level for a long period [8].


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### Effect on Weight Loss (WL)

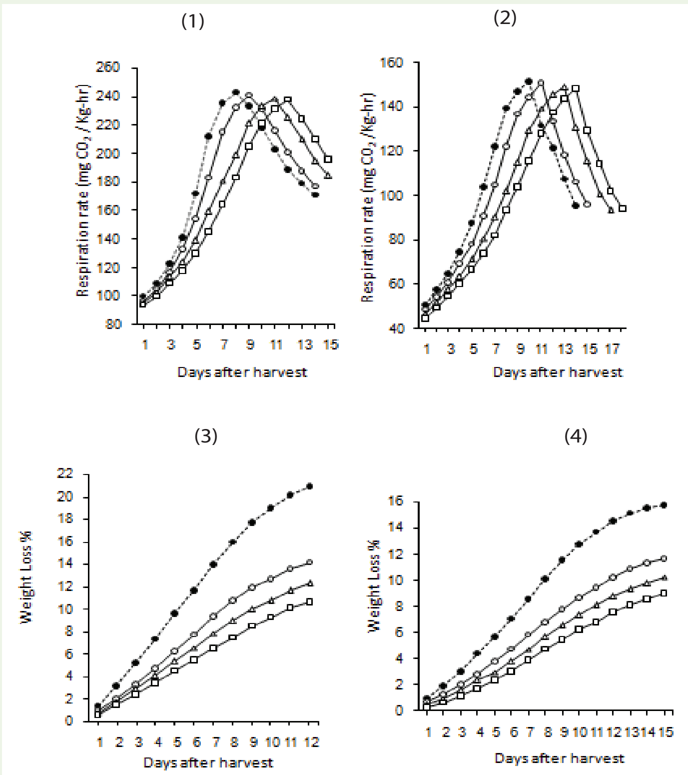
WL progressively increased with storage of mango fruits. Significantly lower percentages of WL were observed in the fruits packed in carton boxes lined with perforated polyethylene films (Figures 3 and 4). The fruits, packed in carton boxes unlined and without $KMnO_4$, reached the highest WL percentage of 20.86% in 'Kitchener' and 15.75% in 'Abu-Samaka' cultivar. Packing the fruits in carton boxes lined with polyethylene film with 0.0, 1.0 g or 2.0 g $KMnO_4$ reduced the WL by an average of 29.1%, 38.1% and 46.0%, respectively, compared with the control fruits. Elamin and Abu-Goukh reported that the bananas in intact polyethylene lined packages had the lowest WL, followed by those in perforated ones, whereas fruits in unlined packages had the highest WL [5]. Similar results were reported in banana, mango, grapefruit and papaya [6,17-19]. The use of $KMnO_4$ in conjunction with polyethylene liners resulted in more reduction of WL from the fruits. Similar results were reported in banana [5]. This could be due to delay in the fruit ripening in the presence of $KMnO_4$ as described earlier. Since ripening was delayed in the presence of $KMnO_4$ tissue permeability would be decreased and reduction in WL in the fruits would be obvious.

### Effect of Peel Color (PC)

PC score continuously increased during storage of the two mango cultivars. The untreated fruits reached the full yellow stage (color score 6) after 11 days in 'Kitchener' and 14 days in 'Abu-Samaka' cultivars (Figures 5 and 6). The fruits packed in box lined with polyethylene films with 0.0, 1.0 g and 2.0 g $KMnO_4$ reached the full yellow stage after one, three and four days in both cultivars, respectively, compared with control fruits. This is in line with the findings of Elamin and Abu-Goukh who reported that polyethylene film lining and $KMnO_4$ delayed PC development in bananas [5]. Polyethylene film liners resulted in a MA with lower $O_2$ concentration, which suppresses ethylene biosynthesis, and higher $CO_2$, which inhibit ethylene action [20]. $KMnO_4$ in conjunction with film lining further reduces ethylene levels by oxidizing it to $CO_2$ and water [4]. These conditions are conductive to delay fruit ripening and hence resulted in longer green-life of the fruits.

### Effect of fruit Flesh Firmness (FF)

FF decreased steadily during storage of both mango cultivars (Figures 7 and 8). The control fruits packed in carton boxes, unlined and without $KMnO_4$ reached the final soft stage (0.15 kg/cm$^2$) after 13 and 16 days in 'Kitchener' and 'Abu-Samaka' cultivars, respectively. The perforated polyethylene film lining delayed the drop in FF during storage. The fruits packed in polyethylene lined boxes with 0.0, 1.0 g and 2.0 g $KMnO_4$ reached the final soft stage after one, three and four days later, compared with the control fruits. These results agree with the finding of Elkashif et al. [5,6,21]. It has been shown that $KMnO_4$ combined with polyethylene film lining was more effective in delaying fruit flesh softening in avocado, mango and banana [5,22,23].




**Figures 1-4:** Changes in respiration rate of 'Kitchener' (1) and 'Abu-Samaka' (2), weight loss of 'Kitchener' (3) and 'Abu-Samaka' (4) mango fruits in carton boxes lined with perforated polyethylene films without $KMnO_4$ (o), with 1 g KMnO4 (Δ) or with 2 g KMnO4 (□) compared with control fruits in carton boxes unlined and without KMnO4 (•), during storage at 18 ± 1 °C and 85%-90% relative humidity.



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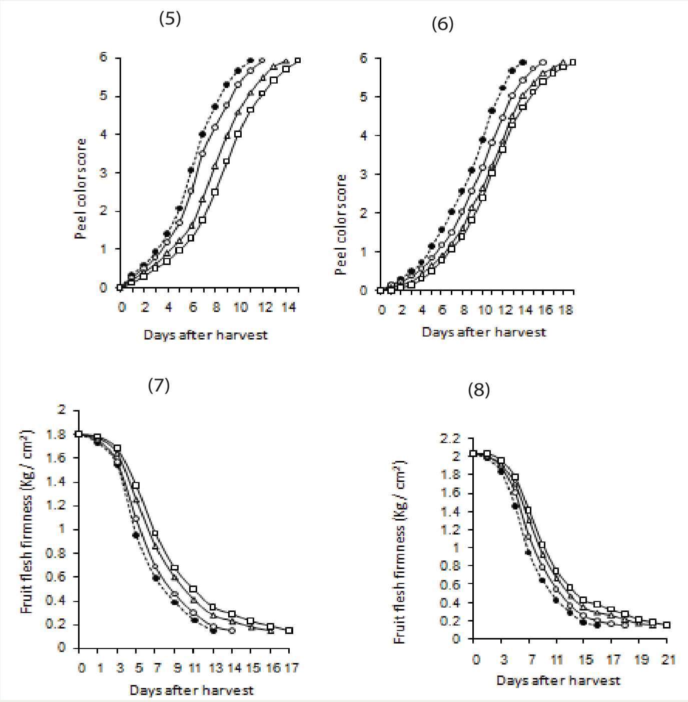
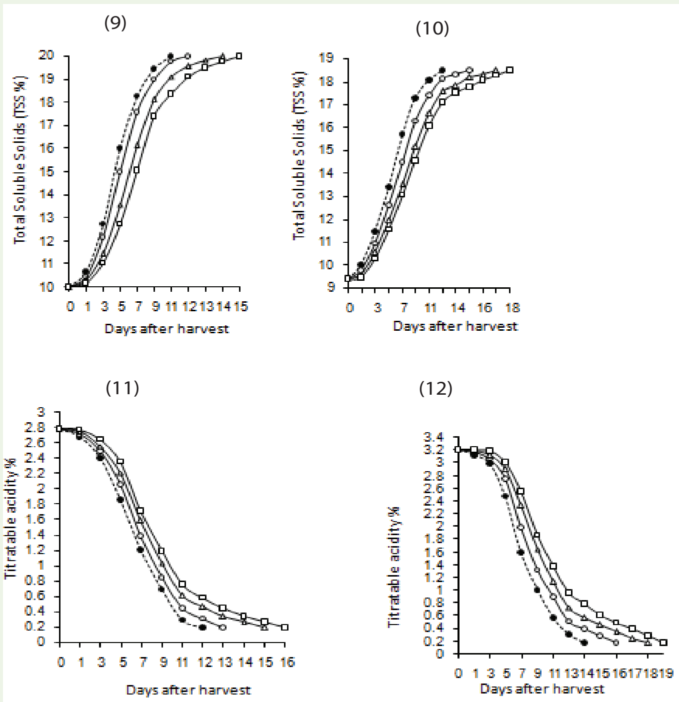



**Figures 5-8:** Changes in peel color of 'Kitchener' (5) and 'Abu-Samaka' (6), fruit flesh firmness of 'Kitchener' (7) and 'Abu-Samaka' (8) mango fruits in carton boxes lined with perforated polyethylene films without $KMnO_4$ (o), with 1 g KMnO4 (Δ) or with 2 g KMnO4 (□) compared with control fruits in carton boxes unlined and without KMnO4 (•), during storage at 18 ± 1 °C and 85% -90% relative humidity.




**Figures 9-12:** Changes in total soluble solids of 'Kitchner' (9) and 'Abu-Samaka' (10), titratable acidity of 'Kitchner' (11) and 'Abu-Samaka' (12) mango fruits in carton boxes lined with perforated polyethylene films without KMnO4 (o), with 1 g KMnO4 (Δ) or with 2 g KMnO4 (□) compared with control fruits in carton boxes unlined and without KMnO4 (•), during storage at 18 ± 1 °C and 85%-90% relative humidity.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### Effect on Total Soluble Solids (TSS)

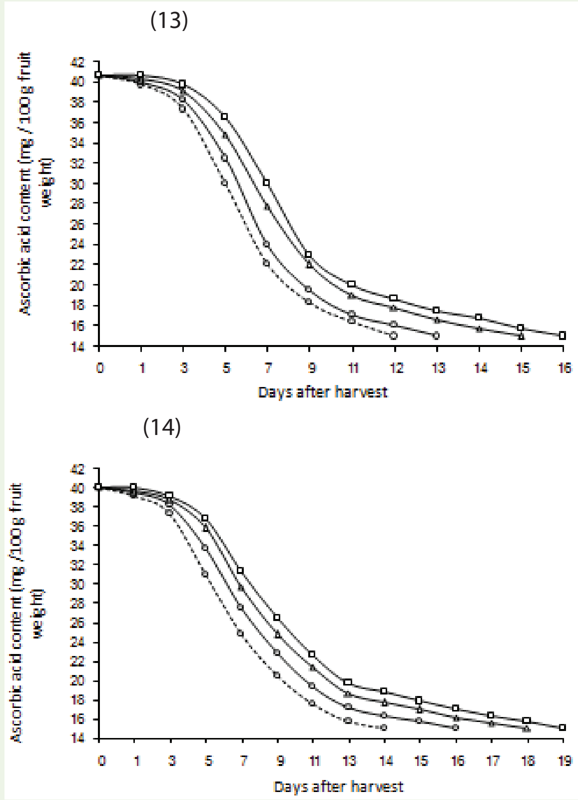
During storage period, TSS progressively increased in both mango cultivars. The maximum TSS value reached by the fruits packed unlined and without $KMnO_4$ was 20.0% in 'Kitchener' and 18.5% in 'Abu-Samaka' after 11 and 13 days, respectively, (Figures 9 and 10). TSS in fruits packed in boxes lined with polyethylene film, with 0.0, 1.0 g and 2.0 g $KMnO_4$ was reduced by an average of 1.9%, 4.7% and 7.0% compared to control fruits. The maximum TSS values reached by mango fruits kept in carton boxes lined with perforated films with 0.0, 1.0 g and 2.0 g $KMnO_4$ was delayed by one, three and four days, respectively, compared with the control fruits. This is in agreement with previous reports in mangoes and banana [5,9,21].

### Effect on Titratable Acidity (TA)

TA progressively decreased during storage in all fruits (Figures 11 and 12). It decreased in the control fruits from 2.67% in 'Kitchener' and 3.11% in 'Abu-Samaka' to 0.2% after 12 days and 15 days in the two cultivars, respectively. This is in agreement with the finding of Abu-Goukh et al. [24]. Polyethylene film lining and $KMnO_4$ treatment significantly delayed the drop in TA during storage in both cultivars. The fruits packed in boxes lined with polyethylene film with 0.0, 1.0 g and 2.0 g $KMnO_4$ reached the minimum TA (0.2%) after one, three and four days, respectively, compared with control fruits packed unlined and without $KMnO_4$. Polyethylene film liners and ethylene absorbents delay fruit ripening and hence the drop in TA during fruit ripening [4,5,25].

### Effect on Ascorbic Acid content (AA)

AA content sharply decreased during storage of both mango cultivars (Figures 13 and 14). In the control fruits, it decreased from 39.9 to 15.0 mg/100 g fr. wt. after 12 days and 37.6% of the initial amount was retained. This is in agreement with previous reports [24,26]. The minimum value of AA content of 15.0 mg/100 g fr. wt. reached after 12 days in control fruits, was delayed by one, three and four days in fruits packed in polyethylene films with 0.0, 1.0 and 2.0 g $KMnO_4$, respectively, compared with control fruits. AA was significantly higher in the fruits packed in polyethylene lined boxes, with or without $KMnO_4$, compared with control fruits. The amount of AA retained after 12 days in storage was 39.8%, 44.2% and 46.3% of the initial values in fruits packed in polyethylene lined boxes without $KMnO_4$, with 1.0 and 2.0 g $KMnO_4$, compared to 37.6% in the control fruits. MA packaging resulted in better maintenance of AA in broccoli [27].




**Figures 13,14:** Changes in ascorbic acid content of 'Kitchener' (13) and 'Abu-Samaka' (14) mango fruits in carton boxes lined with perforated polyethylene films without KMnO4 (o), with 1 g KMnO4 (Δ) or with 2 g KMnO4 (□) compared with control fruits in carton boxes unlined and without KMnO4 (•), during storage at 18 ± 1 °C and 85%-90% relative humidity.

## Conclusion

The objective of this experiment was to investigate the effect of coating linings by perforated polythene and potassium permanganate on the quality and marketing life of the mango cultivars 'Kitchener' and 'Abu-Samaka' in the Abujaheh area. The use of perforated polythene strips significantly delayed fruit maturity in mango varieties. The use of potassium permanganate, as well as perforated polythene, has led to more delay in ripening and maintaining quality. The effect of the treatment using perforated polythene with potassium permanganate was demonstrated by delaying the respiratory peak, delaying discoloration of the crust, concentration of total soluble solids, changes in acidity and softness reduction Fruits, reduced weight loss ratio, preserved ascorbic acid content, and preserved the quality of the fruits. The use of perforated polythene slices with potassium permanganate at 0.0, 1.0 and 2.0 g concentrations delayed fruit maturity for 1, 3 days and 4 days, respectively, compared to untreated fruit. The loss of weight loss was 29.1%, 38.1% and 46.0% in fruit coated with perforated polythene with potassium permanganate at a concentration of 0.0, 1.0 and 2.0 g, respectively, compared to untreated fruits.

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