Effect of some natural edible coating materials on mango fruit characteristics during cold storage

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ABSTRACT

Postharvest management of mangoes is important for their successful marketing. In this context edible coating has been used for prolonging the storage life and preserving the quality of fresh fruits. This investigation was carried out during two successive seasons 2012-2013. The main aim was to evaluate the effect of gelatine, lemon grass and Arabic gum as edible coatings on the storability and quality of Keitt mango, during cold storage at (13°C, 90% RH) for duration of 35 days. The design included T1 (control), T2 (gelatine at 8%), T3 (gelatine at 4%), T4 (gelatine at 2%), T5 (gelatine at 8% + lemon grass at 0.5%), T6 (lemon grass at 0.5%), T7 (Arabic gum at 10%). The evaluated quality parameters included weight loss, firmness, decay, external and internal colors, and chemical parameters such as titratable acidity, total soluble solids and ascorbic acid. Generally, the results indicated that coated Keitt mangoes showed a significant delay in the changes of weight loss, firmness, titratable acidity, total soluble solids, decay and color of the fruits, compared to uncoated ones. Application of the gelatine at different percentages solely or in combination with lemon grass is more effective than the lemongrass or Arabic gum individually. Further, Arabic gum and lemongrass were less efficient than the others edible coating materials.

Key words: Mango, edible coating materials, physico-chemical analysis.

INTRODUCTION

Mango (Mangifera indica L.) is a very delicious tropical fruit belongs to family Anacardiaceae, it is also considered as the queen of the fruits as it is very popular world-wide [25,28]. Mango fruit is an abundant source of vitamins, minerals and is famous for its excellent flavour, attractive fragrance and nutritional value. It is as an emerging tropical export crop and is produced in about 90 countries in the world with a production of over 820,877MT [2]. Keitt mango cultivar grown successfully under the Egyptian conditions and its production comes in the late season. Storage life extension accompanied with maintaining fruit quality could be an advantage to achieve continuous supply of mangoes for the market at that time when shortages of mangoes occur. Moreover, significant extension in post harvest life of mango is important to permit transport, distribution and percent loss in sample weight based on its initial commercialization to distant export markets [2].

A number of studies have been conducted demonstrating that edible coatings can be used as a less costly modified atmosphere package to provide some control of ripening and lengthening of storage life. Baldwin [7] has written a review on the use of edible coatings in fruits and vegetables for prolonging shelf life and managing other post harvest factors. In recent years, coatings of some edible materials like lipid based coatings, polysaccharide based coatings, protein based coatings, composite and bilayer coatings etc. have been applied on the skin of different fruits in order to reduce moisture loss, restrict oxygen entrance, lower respiration, retard ethylene production and seal in flavour volatiles [9]. These coatings are used to create modified atmosphere and to reduce weight loss during transport and storage by controlling the permeability and gaseous exchange [12]. Previously such coatings have long been used on citrus, apples, tomatoes and cucumbers with excellent results but are less studied for the use on mango [8]. The use of polysaccharides and protein based coating materials on several types of fruits has been developed in last few years. Particularly, sucrose fatty acid esters on bananas [1], cellulose on mango [8], edible coatings on strawberry [13] and corn protein in tomato [35]. The application of reported coating material has also significantly increased the shelf life of different varieties of citrus and mangoes [5,11,18,27,34]. Many coatings have the added advantage of providing a moisture barrier that reduces dehydration in the fruit during storage. The availability and regulatory status of food coatings varies by country. In this context, these materials classified as generally recognized as safe (GRAS) and considered ‘edible’ by the US Food and Drug Administration [7]. One advantage to the use of coatings in a fruit like mangoes, is that the skin is not normally consumed,

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possibly providing greater flexibility in the choice of coating materials. Alternative post harvest treatments for prolonging storage life and maintain the good quality of fruits are needed.

Increasing public concern over the level of pesticide residues in food, especially fresh produce has built up adequate pressure for scientists to look for less hazardous and environmentally safer compounds for post harvest treatments [28]. Essential oils as registered food grade materials have the potential to be applied as alternative treatments for fresh fruits and vegetables [20]. Gelatine is an important functional biopolymer widely used in foods to improve elasticity, consistency, and stability [29]. However, few numbers of researches till date have been conducted on using gelatine as an edible coating material for fresh fruits and vegetables. Thus, the aim of this study was to evaluate the potential use of selected edible coatings namely gelatine, lemon grass oil and Arabic gum, to extend the storage life of mango fruits cv. Keitt maintaining their quality under cold storage condition.

Materials and Methods

2.1. Fruit harvesting:

Mango fruits cv. Kieit were picked at mature stage from a private farm located in the desert road. The fruits were selected with the uniformity in shape, size and same physiological maturity stage, and free from defects, then, subjected to post harvest preparation to be stored. Peduncles were carefully trimmed up to 0.5 cm. Fruits were cleaned tenderly with clean soft tissues and divided into seven groups; each group consisted of 72 fruits and every four fruits constituted an experimental unit. Fruits then subjected to the coating treatments, and then replaced in the cartoon boxes. Treated and non-treated (control) fruits were then stored at 13°C ±1 and 90% RH (±2%) for 7, 14, 21, 28, and 35 days for further studies.

2.2. Coating preparation:

Gelatine was obtained as a commercial grade, and then dipping solution was prepared at the concentration of 2, 4 and 8% (w/v) using distilled water. The essential oil of lemongrass (Cymbopogon citratus Stapf) extract, extracted by steam distillation and emulated in water at 0.5 % as described by Abd El-Kader et al., [3]. The Arabic gum solution (10% w/v) was prepared by dissolving Arabic gum in distilled water and heated at 40°C with stirring, for 10 min by using magnetic stirrer.

2.3. Coating and storage of fruits:

Different treatments as various concentrations of coating materials were applied. The design included T1 (control), T2 (gelatine at 8%), T3 (gelatine at 4%), T4 (gelatine at 2%), T5 (gelatine at 8% + lemongrass at 0.5%), T6 (lemongrass at 0.5%) and T7 (Arabic gum at 10%). Fruits were dipped in different coating formulations for 1 min, immediately taken out and dried under blowing air. Fruits then were stored at the conditions previously mentioned.

The following variables were measured for fruit quality analysis at 0, 7, 14, 21, 28, and 35 days:

- Fruit weight loss due to active metabolic rate was determined by weighing the sample and report it as percent loss in sample weight based on its initial weight, fruit firmness (with removing the fruit skin) was measured at two points of the equatorial fruit zone (on the fruit’s surface area) using a stationary penetrometer, data are presented in lb in². Titratable acidity was measured in the juice of a composite sample of fruit flesh for each replicate by titration against diluted calibrated (Na OH) solution of known normality (0.1), data are reported as titratable acidity percentage. Total soluble solids (TSS) were recorded by Digital Refractometer, vitamin C (Ascorbic acid) was determined by using 2, 6 dichlorophenol indophenols’ dye as described by AOAC [4] method No. 967.21. Fruit skin and pulp color were determined using a Minolta colorimeter.

2.4. Statistical analysis:

Data were analyzed by analysis of variance (ANOVA), and means were compared using Duncan’s test at $p \leq 0.05$ to determine the significance of differences between the conducted treatments [16].

Results and Discussion

3.1. Physical characteristics:

3.1.1. Weight loss (%):

Percent weight loss during storage showed significant results (Fig. 1). The general trend was increasing weight loss by the time in all treatments and the maximum weight loss was recorded after 35 days of storage. The same trend has been recorded for coated or uncoated Haden mango in Mexico (Carrillo et al., 2000). In both seasons, the minimum weight loss occurred in fruits treated with gelatine at 4% (T3) and/or gelatine at 2% (T4) as compared with untreated fruit (T1). Statistically, there was no significant difference among the treatments after 28 days in both seasons, except for T5 (gelatine at 8% + lemongrass at 0.5%) and T3 (gelatine at 2%). However the rate of decrease in weight loss in coated fruit was slower than in control and followed the order of T3 < T4 < T2 < T5 < T6 ≤ T7 < T1 in first season and T3 = T2 < T5 < T4 < T6 < T7 < T1 in second season. According to Abbasi et al., [2], the weight loss is attributed to the loss of water during metabolic
processes like respiration and transpiration. In addition, moisture loss and gaseous exchange from the fruits is usually controlled by the epidermal layers provided with guard cells and stomata. Thus, the coating reduces this action because it forms a film on the top of the skin acting as an additional barrier to moisture loss [2]. These barrier properties also reduce the oxygen uptake by the fruit which in turn slowed down the rate of respiration and associated weight loss from the fruit surface [2,40].

![Graph A](image1)

**Fig. 1:** Weight loss of mango fruit stored at 13 °C during the first season (A) and second season (B). Bars with the same letter are not significantly different at P ≤ 0.05.

3.1.2. **Firmness (lb in²):**

The results associated with fruit firmness as influenced by coatings treatments showed that minimum firmness was calculated after 35 days of storage while maximum, recorded at the beginning time of storage (Fig. 2). Maximum fruit firmness was retained in fruits treated with gelatine at 4% (T3) in both seasons, followed by the fruits treated with gelatine at 8% (T2) in first season and gelatine at 8% + lemongrass at 0.5% (T5) in second season. The lower fruit firmness value compared with T1 was noticed in fruits treated with lemongrass at 0.5% (T6) and Arabic gum at 10% (T7) without statistical difference between the two treatments (Fig. 2). However, the data presented revealed that there was a similar decreasing trend in fruit firmness in all treatments towards the end of storage. The ripening of mango fruits is characterized by a loss of firmness due to cell wall digestion by pectinesterase, polygalacturonase and other enzymes [33]. High fruit firmness value in coated fruits of T2 (gelatine at 8%), T3 (gelatine at 4%) and T5 (gelatine at 8% + lemongrass at 0.5%) could be attributed to the
permeability property of the coating and its effects on the fruits and provided better way to reduce the evaporation and avoided shrinkage [10,30]. While lower values in fruits of T1 (control), T6 (lemongrass at 0.5%) and T7 (gum Arabic at 10%) could be due loosening of cell wall, reduction of pectic enzymes which reduced the firmness of mango fruits [24,23].

![Graph A](#)

![Graph B](#)

**Fig. 2**: Firmness of mango fruit stored at 13 °C during the first season (A) and second season (B). Bars with the same letter are not significantly different at P ≤ 0.05.

### 3.1.3. Decay (%):

The decay monitoring indicated that the decay control of coated mango fruits was better as compared with uncoated fruits up to 28 days of storage. The first symptoms of decay were observed after 14 days at 13 °C in T1 (control) at both seasons, and in T2 (gelatine at 8%) in second season only (Fig. 3). At the end of the two seasons, coated fruit with gelatine at 8% (T2) and gelatine at 4% (T3) were comparatively less decay and having about 65-75% of fruits still not having disease attack (Fig. 3). Several studies indicated the importance of selected edible coating materials for inducing defensive enzymes, e.g., chitinase, which catalyse the hydrolysis of chitin, a common component of fungal cell walls [21], thus preventing the growth of fungi on the fruit.
Fig. 3: Decay of mango fruit stored at 13 °C during the first season (A) and second season (B). Bars with the same letter are not significantly different at P ≤ 0.05.

3.2. Chemical characteristics:

3.2.1. Total Soluble Solids (%):

The results of total soluble solids (TSS) in general showed an initial increase and then a decrease (Fig. 4). This trend was observed in all the fruits but the rate of increase in TSS in treated fruits was comparatively slower than in control. These results are also in agreement with those obtained by Carrillo et al., [11] on Haden mango in Mexico. Fruits treated with gelatine at 8% + lemongrass at 0.5% (T5) showed significantly highest amount of TSS in the two seasons (Fig. 4). Further, it was observed that fruits treated with only lemongrass at 0.5% (T6) had the lowest TSS content without significant difference in both seasons. The observed changes in TSS may be due to the hydrolytic conversion of polysaccharides into soluble sugar during the ripening process which resulted in an increase in TSS of the fruits [2]. On the contrary, the rate of conversion of soluble mono and disaccharides into organic acids, at end of storage stages, was faster than the conversion of insoluble polysaccharides into mono and disaccharides, thus, resulted in decreasing TSS in the fruits [27,23,2].
3.2.2. Titratable acidity (%): 

The acidity of the fruit is an important character to determine its quality and acceptability. The titratable acidity was decreased significantly along with increasing storage time in both coated and uncoated fruits (Fig. 5) in both seasons. It was found that coated fruits in T6 (lemongrass at 0.5%) and T7 (Arabic gum at 10%) had lowest values at the end of storage period. Higher values were recorded in T3 (gelatine at 4%) and T2 (gelatine at 8%) in first season, and T5 (gelatine at 8% + lemongrass at 0.5%), T3 (gelatine at 4%) and T4 (gelatine at 2%) in second season without significant differences among the three treatments (Fig. 5). Similar pattern in different varieties of mango fruits has been reported [17,19,15]. The obtained results showed that coatings slowed the changes on titratable acidity and effectively delaying fruit senescence. This was probably because the film formed by materials used on the surface of the fruit might have modified the internal atmosphere i.e., the endogenous CO₂ and O₂ concentration of the fruit, thus retarding ripening [6,26]. The higher levels of titratable acidity in coated fruit of T2, T3, T4 and T5 may be due to protective O₂ barrier or reduction of O₂ supply to the fruit surface which inhibited respiration rate [23,22,36].
3.2.3. Ascorbic acid (mg 100 g⁻¹):

The results illustrated in (Fig. 6) revealed that there was a significant decrease in ascorbic acid values of coated and uncoated fruits along with the storage period in both seasons. The obtained results are in accordance with Carrillo et al., [11] who observed a slower decreasing trend of ascorbic acid in Haden mangoes coated with different concentrations of Semperfresh as compared to non-coated fruit at 13°C during 32 days of storage. This decreasing trend of ascorbic acid during storage might be due to the presence of oxygen which resulted in the conversion of ascorbic acid into dehydroascorbic acid [2]. Oxidation of ascorbic acid may be caused by several factors including exposure to oxygen, metals, light, heat and alkaline pH [39]. Coatings served as a protective layer and control the permeability of O₂ and CO₂ [38]. However, the rate of decrease in vitamin C was significantly higher in T1 (control), T6 (lemongrass at 0.5%) and T7 (Arabic gum at 10%). Statistical analysis revealed that T2 (gelatine at 8%), T4 (gelatine at 2%), T3 (gelatine at 4%) and T5 (gelatine 8% + lemongrass at 0.5%) retained higher ascorbic acid values at the end of both seasons, without statically difference among them in first season (Fig. 6). Dhaka et al., [14] observed that the retention of ascorbic acid content of Totapuri mango depends on the concentrations of coating materials.
Fig 6: Ascorbic acid of mango fruit stored at 13 °C during the first season (A) and second season (B).

Bars with the same letter are not significantly different at P ≤ 0.05.

3.3. Color measurements:

Color is an important factor in the perception of mango fruit quality. Figures 7, 8 and 9 show the changes in surface and pulp color of mango fruit, as indicated by lightness (L*) and green color (a*). At the end of the storage period, the L* values of mango coated samples were significantly differed, except for T6 (lemongrass at 0.5%) in the second season (Fig. 7). The L* values had not significant differences between the fruit treated with gelatine at 2% (T4) and gelatine at 4% (T3). The values of green color (a*) of T1 (control), T6 (lemongrass at 0.5%) and T7 (Arabic gum at 10%) were not significantly differed at 14 and 35 days in first and second season, respectively. The statistical analysis revealed that T2 (gelatine at 8%), T4 (gelatine at 2%), T3 (gelatine at 4%) and T5 (gelatine at 8% + lemongrass at 0.5%) were significantly effective for retaining the green color of mango fruit in both seasons (Fig. 8). Minimum skin color constancy were observed in case of treatments T1, T6 and T7 due to the appearance of initial black spots on the fruit surface which extended on the whole with the progression in storage period. In parallel, the same trend has been observed for the fruit pulp color constancy (Fig 9). Whereas lower L* values of fruit pulp color was measured in fruits of T1 (control), T6 (lemongrass at 0.5%) and T7 (Arabic gum at 10%). However, the coated fruits in treatments T2 (gelatine at 8%), T4 (gelatine at 2%), T3 (gelatine at 4%) and T5 (gelatine at 8% + lemongrass at 0.5%) retained higher L*
values at end of both seasons, without significant differences among the T3, T4 and T5 treatments in second season (Fig. 9).

The general trend was an increase and than a decrease in skin color. The disappearance of green pigment chlorophyll is associated with the appearance of yellow pigment carotenoids [32]. These carotenoids are stable compounds which are synthesized during developmental stages but masked by the presence of chlorophyll. The results are in accordance with those of Doreyappy-Goda and Huddar [15] who reported that the concentration of carotenoids was increased due to a series of physico-chemical changes in green mature Alphanso and other varieties of mango stored at 18-34 °C. During ripening, skin color changes is due to the breakdown of chlorophyll leading to disappearance of green colour, whereas pulp color changes is attributed to the development of carotenoids [2].

![Skin color (L*) values of mango fruit stored at 13 °C during the first season (A) and second season (B). Bars with the same letter are not significantly different at P ≤ 0.05.](image)

**Fig. 7:** Skin color (L*) of mango fruit stored at 13 °C during the first season (A) and second season (B). Bars with the same letter are not significantly different at P ≤ 0.05.
Fig. 8: Skin color (a*) of mango fruit stored at 13 °C during the first season (A) and second season (B). Bars with the same letter are not significantly different at P ≤ 0.05.
Fig. 9: Pulp color (L*) of mango fruit stored at 13 °C during the first season (A) and second season (B). Bars with the same letter are not significantly different at \( P \leq 0.05 \).

4. Conclusion:

The results of the current research indicated that the Keitt mangoes coated with gelatine at 8%, gelatine at 4%, gelatine at 2%, gelatine at 8% + lemongrass at 0.5%, lemongrass at 0.5% and Arabic gum at 10% showed a significant delay in the changes of weight loss, firmness, titratable acidity, total soluble solids, decay and color of the fruits, compared with uncoated ones. Further, application of the gelatine separately and/or added to lemongrass at different percentages is more efficient than the lemongrass and Arabic gum individually. In this respect, the application of gelatine as edible coating material is recommended.

References


