Post-harvest coating with Arabic gum, paraffin liquid and jojoba oil to prolong the storage period and maintain the quality of "Kensington Pride" mango fruits.

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ABSTRACT:

The mango fruit (*Mangifera indica* L.) is one of the most popular fruits in the world. Producers and traders face losses of about 30-50% after harvest. Therefore, proper storage becomes crucial to maintain the quality, freshness, and delay spoilage of mangoes. This investigation was conducted to assess the influence of Arabic gum (10% and 15%), paraffin liquid (75% and 100%), and jojoba oil (75% and 100%) on the quality of "Kensington Pride" mango fruits, under cold storage (13°C ± 1 and 80% RH). The physicochemical properties were determined at zero storage time and until the fifth week of the storage period. All treatments resulted in decreased fruit decay and weight loss percentage, while maintaining fruit firmness, acidity, and ascorbic acid levels. These positive outcomes were observed in relation to the different concentrations So, post-harvest coating "Kensington Pride" mangoes with 100% jojoba oil or 100% paraffin liquid for an extended storage period with minimal loss in fruit quality. Therefore, these coatings could be promising safe materials for extending the postharvest life and marketing period of mango fruit.

Keywords: Kensington Pride; mango; cold storage; edible coating; paraffin liquid; Arabic Gum; jojoba oil; fruit quality.

INTRODUCTION:

The mango (*Mangifera indica*) is a tropical fruit that originated in South Asia, it's consumed both in its fresh form and as processed products such as juices, jams, and dried mango slices. Today, mangoes are widely enjoyed across the globe in around 80 countries in various cultures and cuisines, because of their, exquisite Taste and flavor, appealing color, nutritional value, and versatility (Gupta & Jain 2014 and Tiwary *et al*., 2018)

Mango is characterized as climacteric fruits and rapid increase in metabolic changes, prolonging the shelf life of fruits during the harvesting season is crucial to minimize losses for farmers, producers, and traders, while ensuring a consistent supply of fresh produce to consumers (Abdel-Salam *et al*., 2022). About 30 to 50% of the crop is lost because of fungi diseases and fruit bioactivity as a result of poor postharvest handling practices, poor Cold chain infrastructure, want of post-harvest treatments, and a lack of technical post-harvest knowledge (Hasan *et al*., 2020 and Moss, 2002). The mango has a narrow shelf life because a climacteric fruit it is rapidly degraded, the ripe fruits reach the max respiration rate a few days after harvesting at room conditions (Narayana *et al*., 1996). Proper storage is crucial to maintain the quality and freshness of mangoes.

Mango fruits often undergo several treatments such as sorting and grading, washing, disinfection, and submerging in chemical fungicide solutions during preparation for export in the pack house to ensure their quality, extend their shelf life, and meet the phytosanitary requirements of importing countries. These treatments may vary depending on the specific regulations and practices in different regions. The growing consumer demand for a healthy diet has encouraged research into novel, risk-free methods of preserving fruits and vegetables as a safe alternative to chemical fungicides (Kumar *et al*., 2021 and Hasan *et al*., 2020).

The edible coating is used for the prevention of food products from physiological disorders and microbial contamination, during the 12th and 13th centuries, the Chinese developed a wax coating for application on lemons and oranges to protect them from microbial spoilage (Kumar and Neeraj, 2019).

The application of an edible coating on fresh fruit offers a potential alternative to fungicides. This coating serves to modify and control the internal atmosphere of individual fruits, reducing changes in quality and quantity. By limiting oxygen penetration, the coating inhibits metabolic activity and softening, thereby controlling ripeness (Kahramanoglu *et al*., 2020). To achieve a thin protective layer, the coating materials can be applied through spraying or coating methods. The edible coating acts as a barrier against gas diffusion, water migration, aroma changes,

solute exchange, and respiration rate reduction. It also prevents weight loss, controls ethylene biosynthesis, maintains fruit firmness, and prevents color changes by regulating anthocyanin and carotenoid synthesis. Additionally, it delays the breakdown of soluble solids, minimizes the loss of TA, phenolic compounds, and ascorbic acid, and preserves antioxidant activity. Furthermore, it helps delay or control chilling injury and reduces microbial decay (Arnon *et al*., 2014; Saberi *et al*., 2018; Korge *et al*., 2020). Recent studies have focused on the use of natural oils as edible coatings for fruit protection. These oils serve as alternatives to artificial fungicides when applied postharvest (Taheri *et al*., 2020). Essential oils possess various biological activities and exhibit different physical and chemical properties. Therefore, selecting the most suitable oil for each specific application is crucial (Chen *et al*., 2021).

The application of an edible coating on fresh fruit provides a potential alternative to fungicides. This coating helps modify and control the internal atmosphere of individual fruits, reducing changes in quality and quantity. It limits oxygen penetration, inhibits metabolic activity and softening, and controls ripeness. The coating can be applied through spraying or coating methods to create a thin protective layer that acts as a barrier against gas diffusion, water migration, aroma changes, solute exchange, and respiration rate reduction. It also prevents weight loss, controls ethylene biosynthesis, maintains fruit firmness, and regulates anthocyanin and carotenoid synthesis to prevent color changes. Additionally, it delays the breakdown of soluble solids, minimizes the loss of TA, phenolic compounds, and ascorbic acid, and preserves antioxidant activity. It helps delay or control chilling injury and reduces microbial decay. Recent studies have focused on using natural oils as edible coatings for fruit protection. These oils serve as alternatives to artificial fungicides when applied postharvest. Essential oils have various biological activities and different physical and chemical properties, so selecting the most suitable oil for each specific application is crucial (Hasan *et al*., 2020 and Abdel-Salam *et al*., 2022).

Paraffin oil is a notable edible coating due to its high safety, non-toxicity, biocompatibility, and affordability. It forms a thin, protective layer on the fruit's skin, reducing moisture loss during storage and inhibiting the growth of certain microorganisms like fungi and bacteria. This helps prevent spoilage and extends the fruit's shelf life. Paraffin oil also alters the atmosphere around the fruit's surface during storage by reducing available oxygen and increasing CO2 levels (Magashi and Bukar, 2006).

Arabic Gum, derived from the sap of the Acacia Senegal tree, has various applications in the food additive, beverage, pharmaceutical, and cosmetic industries. It can also be used as an edible coating for fruits (Ali *et al*., 2010). Arabic Gum forms a protective layer on the fruit's surface, preventing moisture loss and prolonging shelf life. It acts as a barrier against oxygen and microbial contamination, reducing spoilage. Additionally, Arabic Gum gives fruits a glossy appearance, provides a smooth surface, and helps preserve taste and aroma by preventing the loss of volatile compounds (Jiang *et al*., 2013, Khaliq *et al*., 2016 and Al Alawi *et al*., 2018).

Jojoba oil, derived from the *Simmondsia chinensis* plant, is another promising edible coating. It is odorless, colorless, nonvolatile, and free from rancidity (El-Emam *et al*., 2019). Jojoba oil has antibiotic activity and has been used in the cosmetic and pharmaceutical industries for years. It is not a triglyceride like other plant oils but a mixture of long-chain esters of fatty acids and fatty alcohols (Sturtevant *et al*., 2020). Jojoba oil improves the quality of citrus and mango fruits by retarding water loss, improving the external skin layer, and regulating gas permeability and transpiration rate (Abd El-Moniem *et al*., 2008 and Din *et al*., 2015). The purpose of this study was to evaluate the impact of paraffin liquid, Arabic Gum, jojoba oil edible coatings on physicochemical properties of "Kensington Pride" Mango fruits at 13°C ± 1 and 80% RH cold storage conditions.

MATERIALS AND METHODS

The experiment was conducted during 2022 season. Fresh fruits of "Kensington Pride" Mango trees, seven years old grown in a private orchard located in the Wady El Mulak EL Sharkia Governorate, Egypt, in sandy soil using a drip irrigation system. The mango fruits were carefully hand-harvested randomly at commercial maturity stage in the early morning during the second week of September. Mangoes were transported to the laboratory without signs of mechanical damage and deterioration were selected and standardized in fruits showing homogeneous size, color, form and free from any physiological or pathological disorders. After

harvesting, the mangoes were sorted based on their specific gravity using the water immersion method. Any fruits that floated, indicating insufficient development, were discarded. The remaining fruits were washed with running tap water and then dipped in a solution of 1% w/v borax acid and Twin-20 for 5 minutes.

To prepare the coating solutions, Tween-20 (0.1%) was added to each solution as a surfactant. The mango fruits were then dipped in these solutions for 5 minutes and allowed to air dry for 2 hours to ensure surface dryness. Seven treatment consisted of 9 boxes of fruit, with 3 boxes allocated to each replicate as box to determine decay, the second to determine weight loss and the third for determine fruit quality parameters, each box contained of (12 fruits) was replicated three times. The boxes were stored at 13°C ±1 and 80±1% relative humidity refrigeration was done in special refrigerators in Sadat City of Fruit quality parameters were assessed at intervals of 7 days throughout the storage period at zero storage time and then selected weekly

Fruit quality assessments:

Physical characteristics:

Decay Percentage: Fruits that showed any decay symptoms during storage were counted and eliminated from the experiment. Decay percentage was calculated using the following formula:

Decay % = Eliminated fruits/ Total number of the fruit×100

At the beginning of cold storage

Weight loss percentage: The difference between the initial weight of the clusters and that recorded at the date of sampling was translated as weight loss percentage according to the following equation**:**

Weight loss % = Initial weight (g)– weight of the fruit at each date(g)/ Initial weight at the beginning of cold storage(g) ×100

Fruit Firmness (kg/ cm^2)**:** was determined by hand firmness tester (8 mm diameter probe) on pared fruit surface, and the results were expressed in pound-force (kg/ cm^2)

Chemical characteristics:

Total soluble solids °Brix (TSS): were measured by using a digital refractometer (Digital Hand-held Model PAL-1, Atago, Japan).

Total titratable acidity: was measured by titrating 5 ml of the fruit juice against 0.1N of NaOH using Phenol phathalin indicator then acid per cent calculated from the following equation(A.O.A.C, 2005):

Total acidity %= mls NaOH used × M1 of NaOH x 0.0064/ M1 juice used×100

Ascorbic acid mg/100 mL juice: Vitamin C content was measured by the colorimetric method described in A.O.A.C (2005) based on the reduction of 2, 6-dichlorophenolindophenol-sodium (DCIP), standardized with ascorbic acid. The fruit ascorbic acid extracts was titrated with DCIP solution until a light rose pink hue persisted for 30 s. The amount of used DCIP solution in the titration stage were determined and used for the calculation of vitamin C (100 mg mL-1 juice) content.

Statistical analysis

The study was conducted using a factorial completely randomized design with three replications. The means of the treatments were compared using the least significant difference test (L.S.D.) at a significance level of 5%. All data were analyzed statistically following the methods described by Snedecor and Cochran (1989).

RESULTS:

Decay percentage:

The effects of different coating treatments on the decay percentage of "Kensington Pride" mango fruits during cold storage at 13±1°C were shown in Figure 1. The decay percentage increased continuously with a longer storage period in all treatments, with the highest decay percentage observed on the 35th day of storage for all treatments. All treatments significantly reduced the decay of "Kensington Pride" mango fruits, with treatments Arabic gum (T2), jojoba oil at 100% (T7), and paraffin liquid (T5) showing the lowest significant decay percentage. Similarly, all mango fruits treated with edible coatings exhibited a positive result in decreasing the decay percentage compared to control fruits, Uncoated fruits showed higher decay than coated fruits during cold storage. These findings are consistent with previous studies (Khaliq *et al*., 2016; Abdel-Salam *et al*., 2022) that demonstrated the inhibitory action of edible coatings on postharvest decay by restricting gas exchange and ethylene action (Hassan *et al*., 2014). The use of plant oils as alternatives to synthetic fungicides has also been reported (Shehata *et*

al., 2017; Taheri *et al*., 2020). On the other hand, treatments control (T1) and jojoba oil at 75 (T6) showed high significant decay percentages. The combination of postharvest treatments and storage periods resulted in the lowest decay values in mango fruits when coated with Arabic gum (T2), jojoba oil at 100% (T7), and paraffin liquid at 100% (T5) compared to the control treatment (T1) at various sampling times ranging from 7 to 35 days of storage.

Weight loss percentage:

Figure 2 illustrates the impact of different coating treatments on the weight loss percentage of "Kensington Pride" mango fruits during cold storage at 13±1°C. The data clearly indicates that the weight loss percentage gradually increased as the storage period extended. However, all treatments exhibited a significant reduction in the weight loss percentage compared to untreated fruits. This can be attributed to the thick peel of "Kensington Pride" mango fruits, which slows down the evaporation of water during cold storage. Notably, treatments Paraffin liquid100 % (T5) and Paraffin liquid75% (T4) demonstrated the lowest weight loss percentages, indicating their effectiveness in minimizing weight loss. Additionally, the interaction between these treatments and the storage periods had a positive effect on reducing weight loss (Nasrin *et al*., 2020). Conversely, treatments control (T1) and Jojoba oil75% (T6) recorded significantly higher weight loss percentages. Uncoated fruits showed higher weight loss than coated fruits .These findings align with a study conducted by Khaliq *et al*. (2016), which found that treated Choke Anan mango fruits with Arabic Gum and Chitosan exhibited significantly lower weight loss compared to untreated fruits throughout the storage period. The control fruits had the highest weight loss at the end of the storage period. The reduction in weight loss can be attributed to the coating acting as a semi-permeable barrier against oxygen, carbon dioxide, moisture, and solute movement. This barrier effectively reduces respiration rate, water loss, and oxidation reaction rates (Abdel-Salam, 2016).

Fruit firmness (kg/cm^2)

The firmness of "Kensington Pride" mango fruits during cold storage at 13±1°C was influenced by different coating treatments and storage periods. Figure 3 shows that the firmness of the fruits decreased linearly as the storage period increased. However, all treatments significantly increased the firmness of the fruits compared to the untreated fruits. Treatments Arabic gum 10% (T3) and Paraffin liquid75% (T5) demonstrated the highest firmness values, indicating their effectiveness in maintaining firmness. uncoated fruits showed less firmness than coated fruits Similar findings were observed in studies on other fruits, such as Persimmon, Choke Anan Mango, and Ashwina Mango, where treatments with jojoba, Arabic gum, and paraffin oil respectively, improved fruit firmness during storage (Abd-Allah *et al*., 2012, Khaliq *et al*., 2016 and Hasan *et al*., 2020)

The application of Arabic gum and chitosan has been found to reduce the activity of enzymes that degrade cell walls during ripening, leading to the deposition of solid silica in the cell membrane and maintenance of fruit firmness (Epstein, 2009, Ali *et al*., 2010 and Mshraky *et al*., 2016). Excessive water loss in fruits can increase ethylene biosynthesis and polygalacturonase activity, leading to a decrease in firmness during storage. The degradation of insoluble protopectin to more soluble pectic acid and pectin also contributes to the decrease in firmness in many fruits (Bisen and Pandey, 20012 and Liplap, 2013).

Total soluble solids percentage "TSS":

The Total soluble solids (TSS) content is a crucial factor in determining the taste quality of mango fruits. The findings presented in Fig. 4 illustrate the impact of different coating treatments on the TSS percentage of "Kensington Pride" mango fruits during cold storage. Generally, there was a gradual increase in the TSS percentage with extended storage periods, and the maximum significant value was reached after 35 days at 13±1°C. However, all treatments mitigated the increase in TSS percentage compared to untreated fruits. The control treatment exhibited the highest significant values of TSS as uncoated fruits showed faster perishable behavior than coated fruits while the treatments using Jojoba oil (Arabic gum15% (T3) and Paraffin liquid100% (T5) recorded the lowest significant values. Similar results were observed by El-Baz *et al*. (2021), where the TSS values increased with the storage period, and untreated mango fruits had higher TSS values compared to fruits coated with Arabic gum. This increase in TSS may be attributed to the hydrolysis of insoluble polysaccharides into simple sugars. Additionally, fruits coated with Arabic gum were found to enhance the consumption of insoluble polysaccharides (Jatoi *et al*., 2017). Furthermore, treatments using Jojoba oil and Paraffin oil demonstrated

stability in the TSS content of mango fruits during storage compared to the control (Hasan *et al*., 2020 and Tiwary *et al*., 2018). The degradation of cell walls, which primarily consist of polysaccharides like pectin and cellulose, by cell wall degrading enzymes contributes to the increase in TSS content during storage (Nasrin *et al*., 2020).

Total acidity percentage:

The Total acidity percentage of "Kensington Pride" mango fruits decreased significantly during storage at a low temperature of 10°C±1 for all coating treatments, as shown in Fig. 5 The treatments using Jojoba oil Arabic gum15% (T3) and Paraffin liquid100% (T5) recorded the highest significant values of total acidity percentage, while the control treatment had the lowest values as uncoated fruits showed less total acidity than coated fruits. This is consistent with the findings of Hasan *et al*. (2020), who reported that paraffin and mustard oil coatings resulted in the highest titratable acidity in Ashwina mango fruits, while untreated fruits had the lowest acidity. The decrease in fruit acidity during storage may be attributed to the oxidation of organic acids and their utilization in metabolic processes (Obenland *et al*., 2011). The acidity of the fruit is a crucial factor in determining its quality and acceptability, with citric acid being the primary acid found in mango fruit. The reduction in acidity during storage is primarily due to respiration (Yaman and Bayoindirli, 2002).

Ascorbic acid (mg^{-1}/ 100 g. F.W.):

Figure (6) clearly demonstrates that the ascorbic acid values decreased significantly during the storage period for all treatments, reaching their lowest values after 35 days. However, all coating treatments were effective in reducing the loss of ascorbic acid in "Kensington Pride" mango fruits during cold storage at 10 ±1 °C. These findings are consistent with the research conducted by El-Baz *et al*. (2021), who also observed a reduction in ascorbic acid levels during cold storage. Although there were significant differences in ascorbic acid values between treatments, Arabic gum15% (T3) and Paraffin liquid100% (T5). had significantly higher values compared to control (T1). The retention of ascorbic acid in the coated fruits may be attributed to the decrease in respiration rate and reduction of oxidation, uncoated fruits showed faster loss in ascorbic acid than coated fruits as suggested by Abdel-Salam (2016) and Atrash *et al*. (2018). The loss of ascorbic acid during storage can generally be attributed to the rapid conversion of L-ascorbic acid into dehydroascorbic acid in the presence of L-ascorbic acid oxidase, as explained by Hussein *et al*. (2015).

CONCLUSION:

The coating materials operate as a semi-permeable barrier to retard metabolism changes. Coating "Kensington Pride" mango fruits with 100% jojoba oil or 100% paraffin liquid gave the lowest fruit decay and weight loss percentage, maintaining fruit quality. Therefore, it is recommended to use these coatings for an extended storage period of 35 days to maintain fruit quality. Post-harvest coating treatments are safe and could be used for long storage period and export of "Kensington Pride"mango fruits.

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Post-harvest Treatments:

Dipping solutions	Concentration	Symbol
Tap water (control)	0.0	T1
Arabic gum	10 %	T2
Arabic gum	15 %	T3
Paraffin liquid	75 %	T4
Paraffin liquid	100 %	T5
Jojoba oil	75%	T6
Jojoba oil	100%	T7

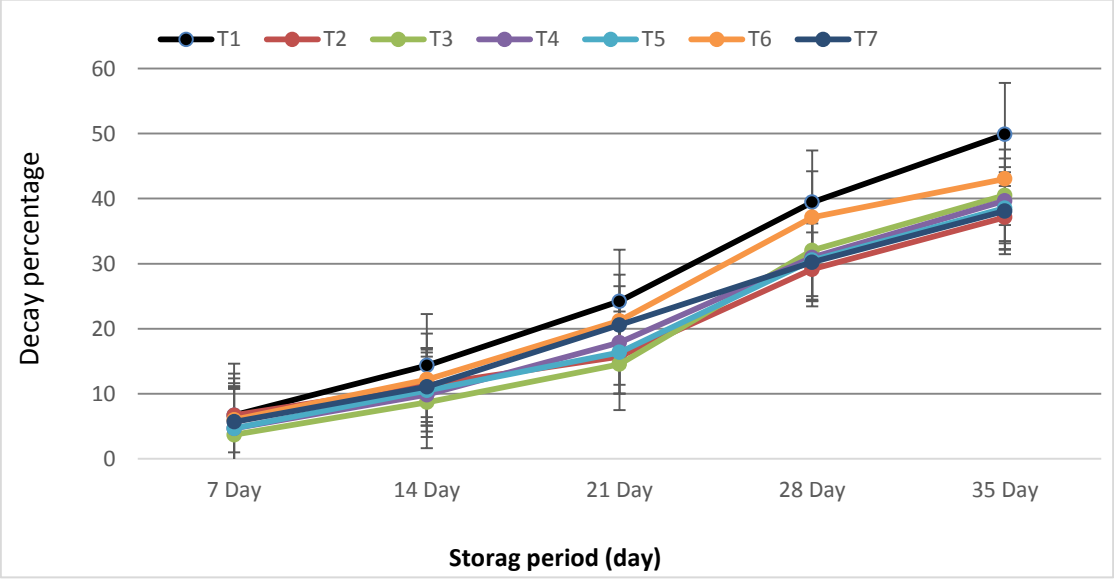

Figure 1: Effect of on Paraffin oil, Jojoba oil and Arabic gum on decay percentage of " Kensington Pride " mango fruit under cold storage conditions (13°C ± 1 and 80% RH). T1 : control,T2: Arabic gum 10%T3: Arabic gum15% ,T4: Paraffin liquid75% ,T5: Paraffin liquid100%, T6: Jojoba oil75%, T7 : Jojoba oil100%

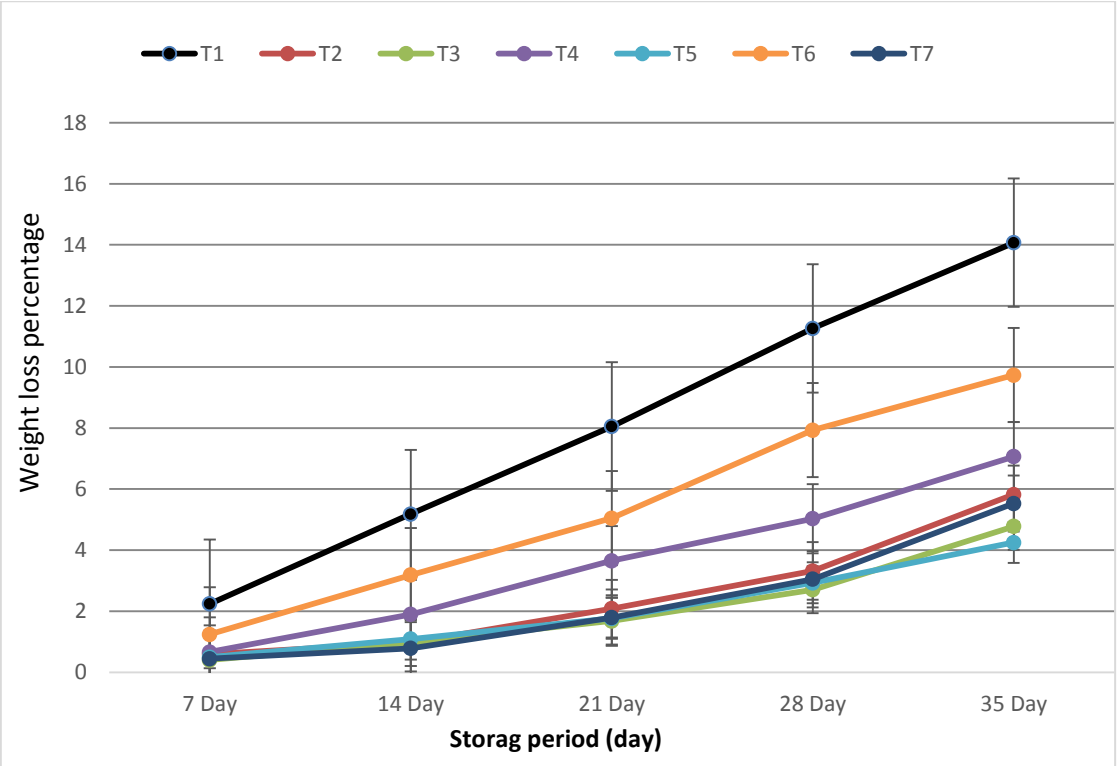

Figure 2: Effect of on Paraffin oil, Jojoba oil and Arabic gum on Weight loss percentage of " Kensington Pride " mango fruit under cold storage conditions (13˚C ± 1 and 80% RH). T1 : control,T2: Arabic gum 10%T3: Arabic gum15% ,T4: Paraffin liquid75% ,T5: Paraffin liquid100%, T6: Jojoba oil75%, T7 : Jojoba oil100%

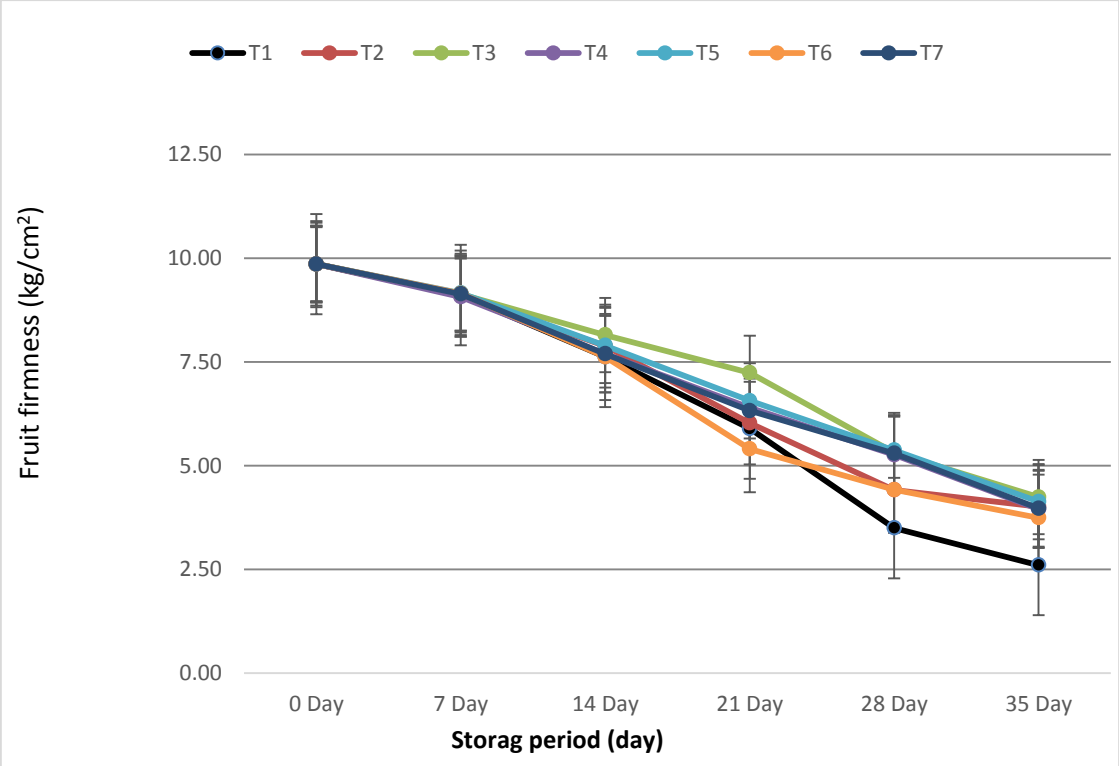

Figure 3: Effect of on Paraffin oil, Jojoba oil and Arabic gum on firmness (kg/cm²) of " Kensington Pride " mango fruit under cold storage conditions (13˚C ± 1 and 80% RH). T1 : control,T2: Arabic gum 10%T3: Arabic gum15% ,T4: Paraffin liquid75% ,T5: Paraffin liquid100%, T6: Jojoba oil75%, T7 : Jojoba oil100%

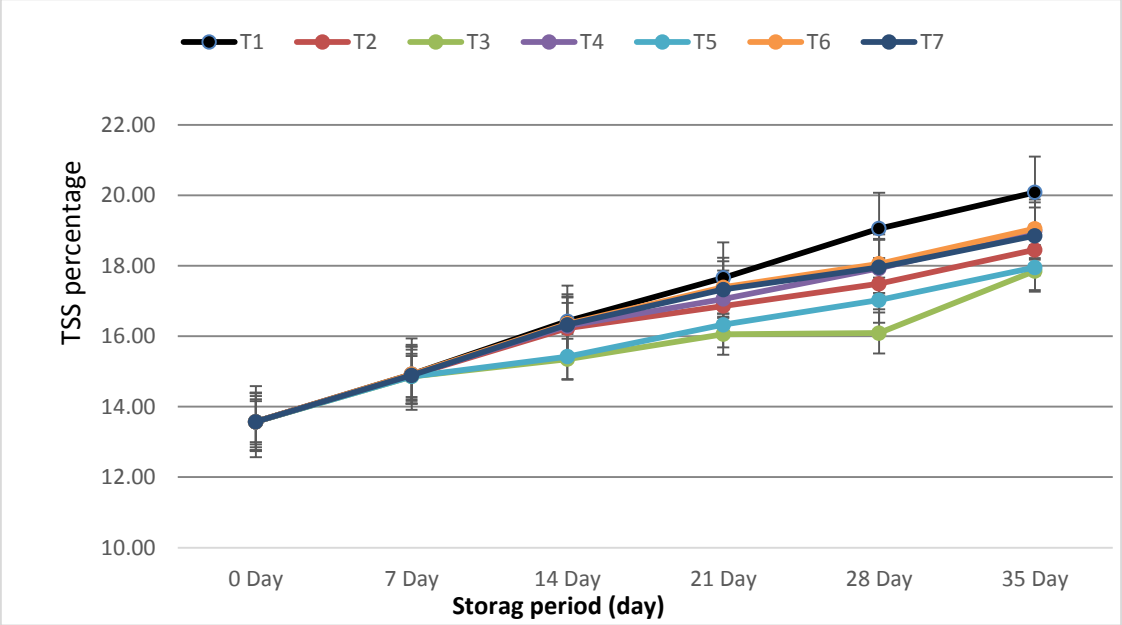

Figure 4: Effect of on Paraffin oil, Jojoba oil and Arabic gum on TSS of " Kensington Pride" mango fruit under cold storage conditions (13˚C ± 1 and 80% RH). T1 : control,T2: Arabic gum 10%T3: Arabic gum15% ,T4: Paraffin liquid75% ,T5: Paraffin liquid100%, T6: Jojoba oil75%, T7 : Jojoba oil100%

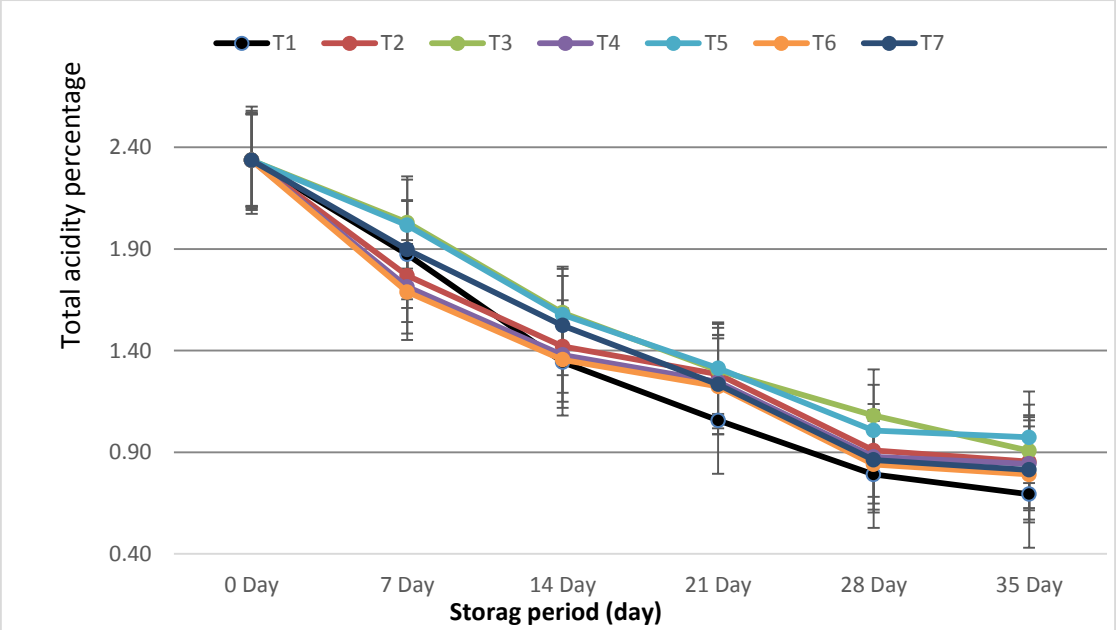

Figure 5: Effect of on Paraffin oil, Jojoba oil and Arabic gum on total acidity percentage of " Kensington Pride " mango fruit under cold storage conditions (13˚C ± 1 and 80% RH). T1: control, T2: Arabic gum 10%T3: Arabic gum15% ,T4: Paraffin liquid75% ,T5: Paraffin liquid100%, T6: Jojoba oil75%, T7 : Jojoba oil100%

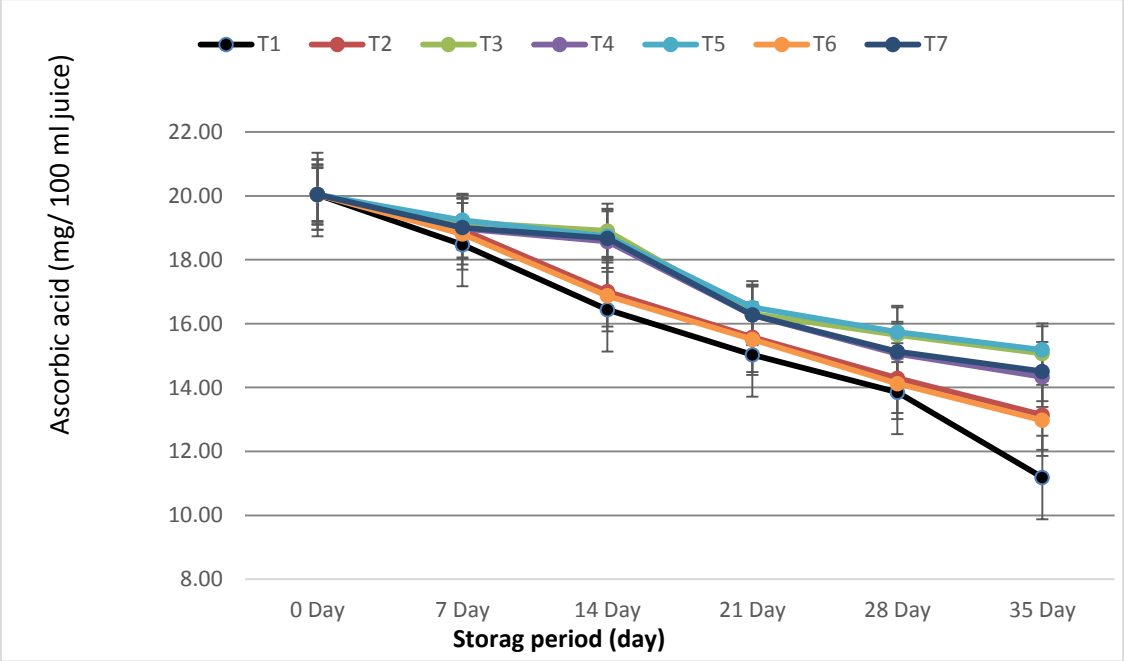

Figure 6: Effect of on Paraffin oil, Jojoba oil and Arabic gum on Ascorbic acid (mg^{-1}/ 100 g. F.W.) of " Kensington Pride " mango fruit under cold storage conditions (10˚C ± 1 and 80% RH). T1 : control,T2: Arabic gum 10%T3: Arabic gum15% ,T4: Paraffin liquid75% ,T5: Paraffin liquid100%, T6: Jojoba oil75%, T7 : Jojoba oil100%

تغطية ما بعد الحصاد بالصمغ العربي وسائل البارافين وزيت الجوجوبا لإطالة فترة التخزين والحفاظ على جودة ثمار المانجو "كنسينجتون برايد"

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الملخص العربي:

تعتبر فاكهة المانجو (Mangifera indica L.) واحدة من أكثر الفواكه شعبية في العالم. ويواجه المنتجون والتجار خسائر بعد الحصاد تصل إلى 30-50% لذلك، فيعتبر التخزين المناسب أمرًا بالغ الأهمية للحفاظ على جودة الثمار بجانب الحد من تلف الثمار. أجري هذا البحث لتقييم تأثير تغطية الثمار بالصمغ العربي (تركيز 10 و15%) وزيت البارافين (75 تركيز و100%) وزيت الجوجوبا (تركيز75 و100%) على الخصائص الفيزيائية والكيميائية لثمار المانجو "كنسينجتون برايد" تحت ظروف التخزين البارد (13 درجة مئوية ± 1 و 80% رطوبة نسبية). تم تحديد الخواص الفيزيائية والكيميائية عند بداية التخزين حتى الاسبوع الخامس من فترة التخزين. أدت جميع المعاملات إلى انخفاض نسبة تلف الثمار وفقدان الوزن والحفاظ على صلابة الثمار والحموضة وحمض الأسكوربيك، وكانت هذه النتيجة الإيجابية مرتبطة بزيادة تركيز مواد التغطية المستخدمه. لذا يفضل تغطية ثمار المانجو "كنسينجتون برايد" بعد الحصاد بزيت الجوجوبا بتركيز100% أو سائل البارافين بتركيز 100% لاطالة فترة التخزين وبأقل الخسائر فى جودة الثمار. لذلك، يمكن أن تكون التغطية مواد امنة واعدة لإطالة عمر ما بعد الحصاد وفترة تسويق ثمار المانجو.

الكلمات الاسترشادية : "كينجيستون برايد" مانجو ،التغطية، الصمغ العربي، زيت البارافين ، وزيت الجوجوبا ، التخزين المبرد، جودة الثمار