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Prolonging the Shelf Life and Marketing Period of Mango Fruit by Using Edible Coating and Cold Storage

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Abstract:

Known, mango fruit is a climacteric and highly perishable fruit that requires specialized postharvest handling to extend its storage life. This research aimed to overcome these problems by demonstrating the impact of the edible coating such as *Aloe vera* and chitosan, used either separately or in combination form; in cold storage, on the; shelf life, and marketing period of mango fruit. Through two successive seasons 2019 & 2020, the influence of *Aloe vera* 75%, chitosan 2% was studied on; both physical and chemical properties; of mango fruit (cv. Langra) during cold storage (11 ± 1°C and 85% RH). All treatments prolonged the storage period reached to more than a month nearly 40 days in a good condition while the control reached 30 days only. On the fortieth day, all treatments gave positive effects on fruit storage but the best treatment was the combined *Aloe vera* with chitosan. This study recommended using the combination of chitosan and *Aloe vera* with cold storage to prolong the storage period of mango fruit until 40 days in good condition and to overcome the marketing and export abroad problems.

Keywords: *Chitosan, Aloe vera, Langra Mango and Cold storage.*

Introduction:

Mango (*Mangifera indica* L.) is commercially number one in the tropical and subtropical fruit crops that belong to the family Anacardiaceae. It is famous as the "King of fruits" due to its sweet taste and abundance in dietary fiber, proteins, vitamins as, A (beta carotene), B1, B2, and C (ascorbic acid) in addition, carbohydrates, fats, minerals, major alimentary like potassium, copper and 17 amino acids in high rates and also it is the richness of antioxidants which considered as a major source of reduction of the risk of certain forms of cancer, reduce complications associated with diabetes, improve lung function and slow the aging process (Talcott *et al*., 2005). Mango is a climacteric fruit that ripens quickly once picked. At ambient temperatures, it reaches its respiration peak on the third or fourth day after harvesting, so its shelf life is relatively short. It takes 6-10 days after harvesting for the fruit to ripen at ambient temperature, and it becomes overripe and spoiled within 15 days, but in cold storage at 13°C, shelf life can be until 2-3 weeks after harvesting. And researchers found there were differences among varieties in their shelf life such as Alphanso has almost 8-9 days extra compared with other varieties (Carrillo -Lopez *et al*., 2000; Srinivasa *et al*., 2002).

Mango ripening is a sequence of metabolic activities or biochemical reactions that cause increased respiration and ethylene production. Biochemical processes like, chlorophyll degradation which displays the other pigments like carotenoids synthesis, modification in structural polysaccharides causing softening, changing in both lipids, organic acids, phenolics, and volatile compounds, in addition to, carbohydrates or starch transfer into sugars. Therefore, the fruit reaches to ripening stage with a good appearance and high quality. Limited shelf-life and inexperience of post-harvest handling, make mango export to worldwide markets is very restrictive. Unknowing, the suitable harvest time (maturity) for mango fruits and the appropriate ambient conditions for ripening process besides, attacking microorganisms that cause damages to fruits and the lack of places which have capabilities are suitable for fruits storage with an abundance of the crop at the time of harvest. A big portion of the crop is either damaged or sold for a low price. Therefore, researchers are working seriously and suggest different techniques to overcome these problems and reduce yield loss (Jha *et al*., 2010).

The edible coating knows; as a very thin layer of substances that retardation to gaseous exchange and loss of water, reduce both respiration rates and ripening while retaining fruit quality, and can be used along with the coated product" in the form of fresh produce free of chemical residues. They are directly used to the food surface by various methods via spraying, immersing, or brush; using to create a modified atmosphere. So, the use of edible coating becomes a perfect method for sharing in market expansibility by increasing fruit shelf life, and then, fruit is transported to local and external markets. Several natural compounds have been investigated for their ability to slow fruit ripening and postharvest deterioration. Edible coatings, made of natural and biodegradable materials, are one of the most promising methods for extending the storage life of fruits after harvest. (Campos *et al*., 2011).

Chitosan is a carbohydrate polymer generated from chitin that can be found in several natural sources including crustaceans, insects, fungi, and algae. It is a natural and environmentally friendly compound and a bioactive substance in medical and industrial products, and for treating postharvest fruits and vegetables owing to its non-toxicity, this is a good alternative to synthetic fungicides because it’s biodegradable. Has a good substance and can create a semipermeable layer on fruit that can change the internal environment., reduce weight loss, withering because of transpiration, and progress fruit quality in general. Chitosan coating was successfully used with various fruits such as papaya, citrus, mango (Silva *et al*., 2017).

The contents of *Aloe vera* gel are; water; amino acids; vitamins; lipids; sterols; tannin, and enzymes, as well as other components such as phenol; saponin; and anthraquinones, which have anti-bacterial, antiviral, and antifungal properties that are responsible for food oxidation and spoiling. The usage of *Aloe vera* gel in the food industry has gotten a lot of attention, and its edible coatings have been shown to control each respiration rate, as well as development and maturation, inhibit loss of humidity and firmness, delays fruit senescence, retards oxidative browning, and reduces the microorganism proliferation in fruit.

Researchers were intrigued by the combined effect of edible coatings on fruit postharvest diseases. They demonstrated a synergistic antifungal effect when chitosan coating was integrated into *Aloe vera* gel, while also maintaining natural features and reducing fruit decay. However, studies describing the use of chitosan coating paired with *Aloe vera* gel on mango fruit are uncommonly published. (Ahmed *et al*., 2009; Vieira *et al*., 2016).

It is known that the low temperature is one of the most effective methods to extend the postharvest life of fresh food products and reduce the loss of their quality during storage and export. This is due to the lowering of ethylene production and reduction of respiration rate. Whereas, Mango consider a tropical fruit so is sensitive to chilling injury at lower temperatures. Proved that, 13°C has been appropriate for mango storage to prolong its postharvest life. Where, storage under 10°C causes chilling injury and more than 15°C leads to a short life of postharvest storage (Ezz and Awad, 2011).

Materials and Methods

The experiment was carried out throughout two successive seasons; 2019 and 2020; using mango fruits of cv Langra; which were cultivated at the Pomology Department; Faculty of Agriculture; Assiut University. Uniform fruits as possible were harvested at the physiological maturity stage after 95 days of the fruit setting this is the best time which was recommended by Baloch and Bibi (2012) and they are free from pest infestation, bruises, and decay. Harvested fruit was transported directly to the laboratory. Fruits were washed with distilled water and their surface disinfected with a 1% sodium hypochlorite solution, then air-dried before use.

Preparation of coating solutions

Chitosan

To dissolve the chitosan, 5 g; of powder; was dissolved; in 850 ml; of distilled water; with 50 ml; of glacial acetic acid;1 mol/L NaOH was used to modify the pH; of the solution; to 5, and 1 ml; of Tween 80; was added to increase wettability. After making the chitosan solution, it was diluted to a 2% concentration according to Wongmetha *et al.,* (2015). The mango fruits were immersed in chitosan for five minutes and then; allowed to dry; at room temperature; to make a thin film coat on the fruits.

Aloe vera

Four-year-old *Aloe vera* plants were obtained; from the nurseries of; the Faculty of Agriculture; Assiut University. *Aloe vera* leaves with the same color, size, freshness, and maturity were taken; and washed in a 1percent (w/v) chlorine solution; then stored in plastic papers before being delivered to the laboratory on the same day. A sharp knife was used to separate the matrix of plant leaves from the outer cortex, and the colorless hydro parenchyma was uniformly blended in a blender. The extract was then strained to remove the fibers using Whatman filter paper number 100, and the liquid gel portion was recovered. Before use, the gel was pasteurized at 65°C for 30 minutes and kept at 4°C. The gel was quickly cooled to room temperature and 4.5 g of ascorbic acid was added to stabilize it; the pH was then adjusted to 4 with 4.5 g of citric acid and after being prepared, is used immediately (Hassanpour, 2015). To get 75% concentration off *Aloe vera* addition 75 ml *Aloe vera* gel to 25 ml distilled water. The mango fruits were dipped in the coating *Aloe vera* gel for 5min and were allowed to drain at ambient temperature to generate a thin film layer.

Chitosan solution and *Aloe vera* gel mixture

According to Vieira *et al.,* (2016) method with some modifications. Chitosan and *Aloe vera* gel solutions were mixed with glycerol and Tween 80. A mixture containing 2 percent (w/v) chitosan solution, 0.1 percent (w/v) Tween 80, 1 percent glycerol, and 75 percent *Aloe vera* gel was uniformly mixed for 3 hours at room temperature in a magnetic stirrer. To generate a thin film coating, the mango fruits were dipped in the solution for 5 minutes and then drained at room temperature.

The fruits were weighed afterward and the serial numbers were written on each of the mango fruits then all treatments were packed in plastic boxes and placed in the storage room at 11 ± 1°C and 85% RH for 40 days.

The fruits were randomly divided into four groups, each one was treated with the following treatments:

1. Fruits were immersed in distilled water as a control (**T_1**).
2. Fruits were immersed for 5 minutes in solutions of chitosan at 2% (**T_2**).
3. Fruits were immersed for 5 minutes in *Aloe vera* 75% (**T_3**).
4. Fruits were immersed for 5 minutes in a solution of combination between chitosan 2% and *Aloe vera* 75% (**T_4**).

Samples of fruits (3 replicate with 2 fruits of each) were taken every 10 days from cold storage until the end of storage to determine the following parameters:

Loss of weight %=

$$\frac{\text{Fresh fruit weight (g)} - \text{Weight after an interval (g)}}{\text{Fresh fruit weight (g)}} \times 100$$

Fruit firmness:

Magness-Taylor penetrometer (pressure tester) was used. Each tested fruit had two readings, which the average was recorded in lb/inch^2.

Fruit disorders (%):

The percentage of disordered fruits accounted for all ruined fruits caused by rots, fungus, bacteria, and pathogens, and the faults were calculated as follows:

Disorders % =

$$\frac{\text{No. of fruit disorders}}{\text{No. of fruits at the beginning of storage}} \times 100$$

Total soluble solid:

A hand refractometer was used to determine the soluble solids content in fruit juice.

Total acidity%:

10 g of pulp from each fruit was diluted to 50 ml with sterile distilled water to determine the fruit's titratable acidity. 10 ml of the dilution were titrated with 0.1 N NaOH. The results were calculated using the proportion of citric acid present in the samples (g citric acid/100 g fresh pulp weight) A.O.A.C (1999).

Citric acid (%) =

$$\frac{\text{Standard solution (N)} \times \text{base solution (ml)} \times 0.06404}{\text{Total juice volume (ml)}} \times 100$$

*The equivalent weight of citric acid =0.06404
*juice volume =5ml

Total sugars:

The concentration was computed as g glucose per 100 g juice and was determined calorimetrically using phenol and sulphuric acid. According to Malik and Singh (1980).

Reducing sugar content according to (Miller, 1972).

Vitamin C:

The amount of vitamin C in fruit juice was measured as mg ascorbic acid per 100 ml juice using the 2, 6-dichlorophenol-indo-phenol blue dye. (A.O.A.C., 1999).

Statistical analysis:

The results were examined statistically using ANOVA in a Randomized Complete Block Design (RCBD)., and the means of the three treatments were compared using the LSD test (least significant difference) based on Gomez and Gomez (1984) in Statistics 8.1. (Analytical Software, 2008).

This research aimed to study the impact of *Aloe vera*, chitosan individual form or combination between them on postharvest of mango fruit to:-

- Prolong the shelf life with keep fruit quality.
- Decrease the loss of productivity.
- Dissemination of the information that will help the farmers and sellers to select the appropriate coating to overcome the difficulties which face them for local marketing or export.
- Increase and improve yield for the local market and conformity with the export specifications of the international market.
- To solve the postharvest problems and improve the storage life of mango whether during marketing conditions and maintain the fruit quality during long-distance transport.
- Find out alternative methods of chemical materials and the scientific ways to decrease their applications and use of environmentally friendly technologies.

Mango cv. Langra is a mid-season cultivar indigenous to Uttar Pradesh. It is the choicest variety in the Indian market for its excellent quality having a medium shelf life and poor storage quality. Thus, to increase the shelf life and maintain the biochemical quality of harvested mango fruits during storage. The goal of this study was to see how different postharvest treatments affected the biochemical features of mangos. cv. Langra under ambient storage conditions.

Results:

In this study, the results illustrated that Mango fruits treated with chitosan and *Aloe vera* either separately or in combination form and stored in cold conditions were prolonged their storage life until 40 days with preservation of its properties as much as possible. Valuation of the storage period was based on the changes of physical and chemical mango characteristics during storage. Therefore, when data demonstrated the growing damage in properties of mango the storage was stopped. So, the storage was stopped after 30 days in uncoated fruits (control) in the two successive seasons.

Weight loss %:

In general, the increase of weight loss % is in parallel with the increased storage period. Data in Fig. 1 illustrated that the variations between all tested storage intervals were difference significantly compared with the start date of storage during

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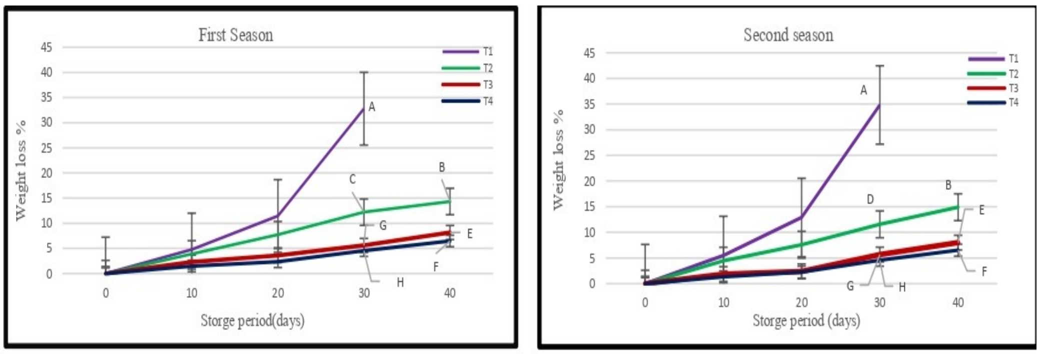
both seasons. And there were significant differences between treatments among them and compared with control.

The biggest percentage of weight loss was recorded in uncoated fruits **T_1** (32.8, 34.8%) after 30 days of storage compared with coated fruits, and the lowest value in the same period was found in fruits coated with chitosan and *Aloe vera* **T_4** (4.5, 4.6%). At the end of storage, **T_2** gave the greatest percentage of weight loss (14.3,14,9%) whereas **T_4** gave the lowest rate (6.48,6.54%) in two successive seasons, respectively.

Fig 1. The impact of chitosan 2% and *Aloe vera* gel 75% coating on weight loss % during cold storage (11 ± 1°C and 85% RH.) on "Langra" mango fruits in 2019 and 2020 seasons.



The same letters on curves are not significantly different. Descending order starts from (A) means the highest value until reaches the letter which has the lowest value
Vertical bars represent ± SE of means for three replicates.

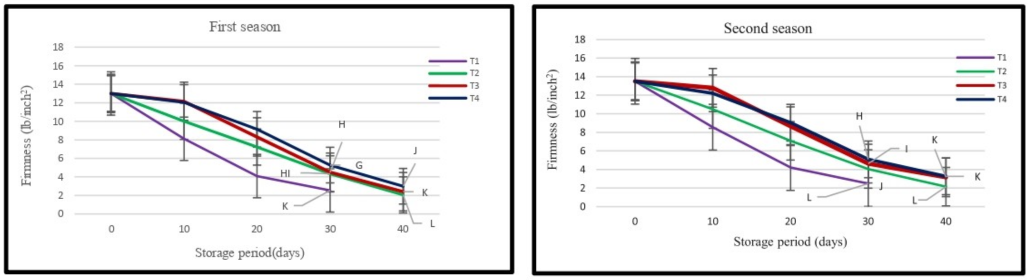
Fruit firmness:

It's known that there was found inverse relationship between fruit firmness and storage period. Whenever; the storage period increases fruit firmness decreases and data in Fig 2 proved that. All treatments gave a significant effect on firmness comparison with the control one. In the first season after 30 days, **T_4** gave the highest value (5.27 lb/inch^2) followed by **T_3** and **T_2** with an insignificant difference (4.5, 4,3 lb/inch^2), respectively while the lowest value was found in **T_1**(2,5 lb/inch^2). After 40 days of storage the highest was found in **T_4** (2.99 lb/inch^2) followed by **T_3** **(**2.4 lb/inch^2) then **T_2**(2.06 lb/inch^2**)** with a significant difference while control one couldn't continue to the end of storage.

In the second season at 30 days of storage, the best effect of firmness preservation was found in **T_4** and **T_3** with significant differences (5.09, 4.63 lb/inch^2), respectively and followed by **T_2** **(**4.05 lb/inch^2) while **T_1** (2.48 lb/inch^2) had the lower value. After 40 days the control did not reach the end but the highest values were found in both **T_4** and **T_3** **(**3.26,3.16 lb/inch^2) with trivial differences followed by T2 (2.15lb/inch^2).

Therefore, both **T_4** and **T_3** were considered the best treatments for the preservation of fruit firmness compared with others in two successive seasons.

Fig 2. The impact of chitosan 2% and *Aloe vera* gel 75% coating during cold storage (11 ± 1°C and 85% RH.) on firmness (lb/inch^2) of "Langra" mango fruits in 2019 and 2020 seasons.

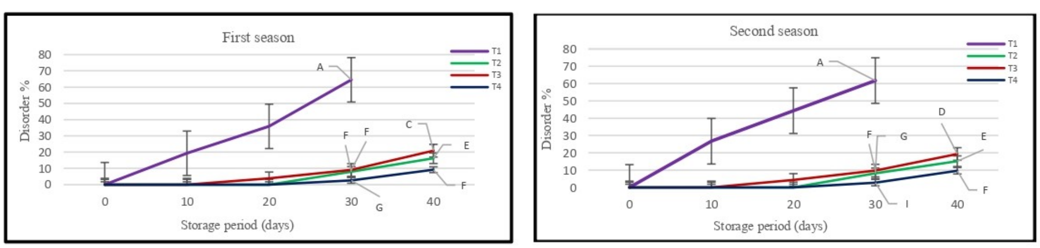


The same letters on curves are not significantly different. Descending order starts from (A) means the highest value until reaches the letter which has the lowest value. Vertical bars represent ± SE of means for three replicates.

Disorders%

As a rule, the percentage of disorder was increased whenever the storage period increased. Data in Fig 3 recorded that, all treatments gave a positive effect on disorder percentage in both seasons. In the first season, on the thirtieth day, the uncoated fruits (control) had the highest rate of disorder (64.5%), and there were insignificant differences between $\mathbf{T_2}$ and $\mathbf{T_3}$ **(**7.9, 9.1%), respectively; whenever $\mathbf{T_4}$ had a significant difference with others and gave the lowest rate of disorder (2.63%). After 40 days of the storage period, there were significant differences among treatments. The highest percentage was found in $\mathbf{T_3}$(20.9%) followed by $\mathbf{T_2}$ (16.2%) while $\mathbf{T_4}$ (9.2%) recorded the lowest percentage. In the second season, after a month of the storage period, there were significant differences among treatments and between the control. The highest percentage was found in $\mathbf{T_3}$(9.7%) followed by $\mathbf{T_2}$ (8.1%) and then $\mathbf{T_4}$ (2.8%) while the control gave the biggest percentage (61.7%). Whenever, on the fortieth day, there were significant differences between treatments the highest one was $\mathbf{T_3}$ **(**19.3%) followed by $\mathbf{T_2}$ (15.1%) while $\mathbf{T_4}$ (9.6%) gave the lowest percentage. So that the best treatment gave the lowest percentage on disorder was $\mathbf{T_4}$

Fig 3. The impact of chitosan 2% and *Aloe vera* gel 75% coating during cold storage (11 ± 1°C and 85% RH.) on disorders **%** of "Langra" mango fruits in 2019 and 2020 seasons.

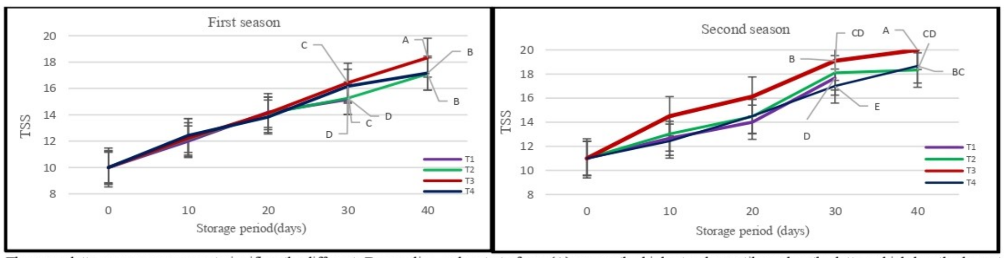


The same letters on curves are not significantly different. Descending order starts from (A) means the highest value until reaches the letter which has the lowest value. Vertical bars represent ± SE of means for three replicates.

TSS:

As a commonly, there is found a positive relationship between TSS and storage period. whenever the storage period increased, TSS increased. Results in Fig 4 illustrated, that in the first season; on the thirtieth day of storage, there was an insignificant difference between T_3 and T_4 (16.4, 16.1%), respectively and both of them gave the highest values of TSS and there were no differences between T_2 and T_1 (15.3, 15.1%), respectively which they gave the lowest values. After 40 days, the maximum rate was found in T_3(18.3%) while, minimum rates were found in T_2 and T_4 (17.1, 17.1%), respectively and there were trivial differences between them. In the second season, on day 30, the biggest value was found in T_3 (19.1%) followed by T_2 and T_1 (18.1, 17.6%), respectively which had not differentiated between them whereas, the lowest value was found in T_4(17%). on day 40, the biggest value was found in T_3(20%) followed by T_2 and T_4 (18.3, 18.6%) was no difference between them.

Fig 4. The impact of chitosan 2% and *Aloe vera* gel 75% coating during cold storage (11 ± 1°C and 85% RH.) on TSS% of "Langra" mango fruits in 2019 and 2020 seasons.

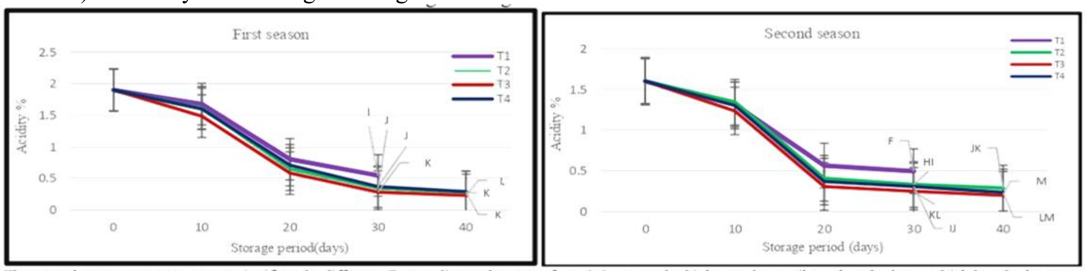


The same letters on curves are not significantly different. Descending order starts from (A) means the highest value until reaches the letter which has the lowest value. Vertical bars represent ± SE of means for three replicates.

Acidity:

Scientifically demonstrated that, if the storage period increases, the acidity decreases, and this proofing was found by results in Fig 5. In the first season, on day thirty of the storage period, data recorded the lowest value of acidity in T_3 (0.28%) followed by T_4 and T_2 (0.37, 0.34%), respectively with insignificant differences. Whereas, the control gave a high record of acidity (0.55%). After 40 days of the storage period, the control could not arrive at the last stage of storage reverse other treatments. The lowest value of acidity was found in T_3 and T_2 (0.23, 0.28%), respectively and there were significant differences between them while the biggest value was found in T_4(0.29%). In the second season, on day 30, the greatest value was found in T_1 (0.49%) followed by other T_2, T_4, and T_3 (0.33, 0.31and 0.25%), respectively and there were significant differences between them. On day 40 at the seam season, the highest rate was found in T_2(0.29%) followed by T_4 and T_3(0.24, 0.2%) there was a trivial difference between them.

Fig 5. The impact of chitosan 2% and *Aloe vera* gel 75% coating during cold storage (11 ± 1°C and 85% RH.) on acidity**%** of "Langra" mango fruits in 2019 and 2020 seasons.

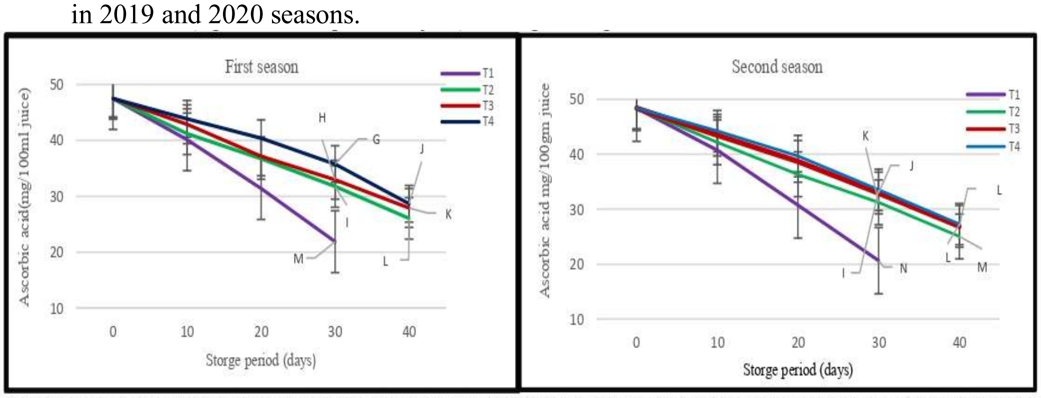


The same letters on curves are not significantly different. Descending order starts from (A) means the highest value until reaches the letter which has the lowest value. Vertical bars represent ± SE of means for three replicates.

Vitamin C:

Data in Fig 6 revealed that Ascorbic acid content in fruits reduced with a prolonged storage period. There were significant differences between treatments. The best treatment was **T_4** which preserved the highest value of ascorbic acid during the storage period in both seasons compared with other treatments. On the thirtieth day of storage, **T_4** gave the best value of ascorbic acid (35.7, 33.5%) however, **T_1** gave a little value of Ascorbic acid (21.8,20.6%) in two seasons, respectively. At the end of storage, the best treatment was **T_4** (28.6,27.3%) followed by **T_3**(27.8, 26.8%) then **T_2** (26, 25%) in two successive seasons.

Fig 6. The impact of chitosan 2% and *Aloe vera* gel 75% coating during cold storage (11 ± 1°C and 85% RH.) on vitamin C (mg ascorbic acid per 100 ml juice) of "Langra" mango fruits in 2019 and 2020 seasons.

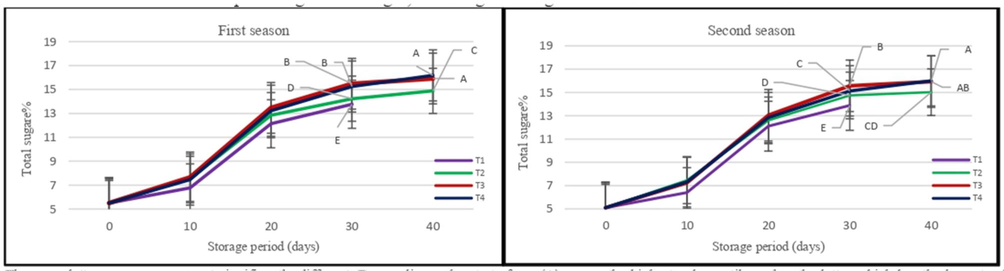


The same letters on curves are not significantly different. Descending order starts from (A) means the highest value until reaches the letter which has the lowest value. Vertical bars represent ± SE of means for three replicates.

Total sugars

The data in Fig 7 observed that total sugar gradually increased whenever prolonged the storage period. Recorded the greatest value of total sugar in **T_3**(15.5, 15.6g) & **T_4**(15.2, 15.1g) on the thirty and the forty days of storage **T_3(**15.9, 15.9g**)** & **T_4 (**16.2, 16g**)** and there were insignificant differences between them and followed by **T_2** and they compared with the control (13.7, 13.9g) which gave the lowest value on the thirtieth day of storage and could not reach to the end of the storage period in two successive seasons.

Fig 7. The impact of chitosan 2% and *Aloe vera* gel 75% coating during cold storage (11 ± 1°C and 85% RH.) on **total sugars** (glucose per 100 g. fresh weight) of "Langra" mango fruits in 2019 and 2020 seasons.

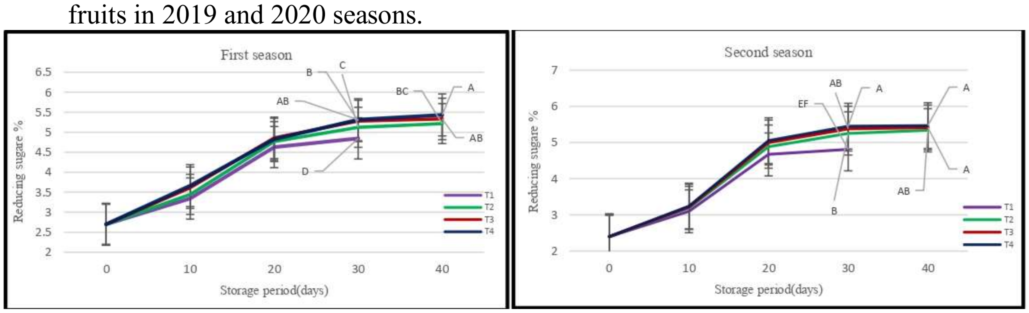


The same letters on curves are not significantly different. Descending order starts from (A) means the highest value until reaches the letter which has the lowest value. Vertical bars represent ± SE of means for three replicates.

Reducing sugars

The data in Fig 8 showed, that the content of reducing sugar increased with an elongated storage period. After 30 days of storage, $\mathbf{T_3}$ (5.3, 5.4g) & $\mathbf{T_4}$(5.3,5.45g) gave the maximum value of reducing sugar and there was an insignificant difference between them and followed by $\mathbf{T_2}$(5.1, 5.2g) then $\mathbf{T_1}$ (4.8, 4.8g) which had a minimum value of reducing sugar in both successive seasons. After 40 days, the control failed to reach the end of storage compared with other treatments which arrived at 40 days of storage with good condition to some extent. There were insignificant differences between treatments in both seasons, respectively.

Fig 8. The impact of chitosan 2% and *Aloe vera* gel 75% coating during cold storage (11 ± 1°C and 85% RH.) on reducing sugars (glucose per 100 g. fresh weight) of "Langra" mango fruits in 2019 and 2020 seasons.



The same letters on curves are not significantly different. Descending order starts from (A) means the highest value until reaches the letter which has the lowest value. Vertical bars represent ± SE of means for three replicates.

Discussion

Fruit firmness and storage period had an inverse relationship. Fruit firmness decreased with storage period prolongation because of enzymatic dissolution of insoluble protopectin to a simple form of soluble pectin caused by pectin-esterase, polygalacturonase, and other enzyme activity, which resulted in insolubilization of cell and cell wall contents, then juiciness contracted and hardness loss in both of the peel and pulp. (Ezz and Awad 2011). Fruit coated with *Aloe vera* and chitosan were maintained fruit firmness as much possible than the other treatments (Mongkon, 2005). Both of them could change gas spread and therefore the exchange of O_2 and CO_2 between fruit cells and the outside atmosphere, reducing the normal metabolic activity and preserving fruit moisture consequently, retard textural changes and delay ripening process in mango (Wang *et al*., 2007 and Zhu *et al.*, 2008).

During fruit storage, Weight loss is a significant indicator for fruit quality which gives shriveled fruit with less sensory observation and the loss of water considers the major responsible for fruit wilted and weight reduction. It is proved that coating limits loss of water and preserves fruit weight during storage period in excellent form to some extent. Coating materials have specific properties which replace natural wax and close the opening pores thus they influence the transpiration of mango fruits and restrict on gases diffusion resulted in a decreased respiratory rate and decreased mango weight loss. Chitosan enhanced the shelf life of mango and conserved the fruit's weight, color, flavor, and texture by lowering the respiration rate without affecting the ripening process. Temperature management, in addition to chitosan coating, is one of the most essential strategies for increasing the shelf life of fruit and has the most significant environmental impact on fruit quality. It is known that chitosan reduces the weight loss of fruits compared to control, but it does not have an excellent effect. One of the major disadvantages of using chitosan on fresh fruits is that it has weak water vapor barrier characteristics, which can be enhanced by combining it with other materials such as *Aloe vera* gel coating increases water holding fruits capacity, and less fungal infestation (Sogvar *et al,* 2016; Camatari *et al.,* 2018).

Fungal invasion deactivates cuticle safety, leading to more evaporation and greater weight loss (Vieira *et al.,* 2016). The studies proved that the unripe fruits were more resistant to disease compared with the ripe fruits. After postharvest the fruits are more susceptible to decay due to fungi, the low acidity in fruits; is considered as the highest resistance to bacterial infection. Knownely, the coating is considered a slow ripening agent consequently slowing down the metabolism by inhibition of ethylene (Hagenmaier, 2005) and limits the exchange of O_2 and increase CO_2 causing in a delay of mangoes ripening and increase in resistance fruit to pathogens and prolonged the shelf life (Bai *et al.,* 2003).

So, all fruits coated with chitosan and *Aloe vera* had able to resist the decay and disease by bacteria, fungus, and other environmental effects (Kumpoun *et al.,* 2005).

Aloin and Aloe-emodin are two components of *Aloe vera* gel that have been identified as efficient against; Colletotrichum gloeosporides; one of the most common fungi that causes mango fruit damage. (Raksha *et al.,* 2014; Zhu *et al.,* 2008). The negatively charged phospholipids of the fungal plasma membrane interact with the positively charged amino chains of chitosan. As a result of this interaction, fungal cells become more permeable, allowing cellular components to escape (Kong *et al.,* 2010). Thus, by combining chitosan and *Aloe vera*, a synergistic action to prevent fungus physiology and proper germination may be accomplished. (Bill *et al.,* 2014).

It is known that the TSS increases whenever the storage period increases. The increment of TSS during fruit ripening is due to the decomposition of stored carbohydrates and converting them to simple sugars; through a complex mechanism; during the respiration process. In addition, water loss causes an increase in TSS concentration in fruits; which may be misinterpreted as an actual change in fruit TSS (Olivas and Barbosa-Cánovas 2005). The reduction of TSS in fruit is associated with a decrease in the quantities of pectin and carbohydrates, decomposition of glycosides, and partial hydrolysis; of protein into sub-units; during the respiration process (Saranwong *et al.,* 2003).

Coated fruit had higher levels of TSS compared with uncoated fruit, probably because the coating acts as a barrier around the fruit surface reduces the entrance of oxygen to it, and increases the rate of CO_2 in it, therefore, inhibiting both of activity of ethylene and the respiration rates of fruit. Furthermore, delay ripening and decelerate changes in the amount of TA in the vacuole (Du et *al.,* 1997; Yonemoto *et al.,* 2002).

The coating could delay the breakdown of starch to sugar (glucose, fructose, and sucrose), which is considered the main component of TSS. This was parallel with the report of (Chien *et al.,* 2007) that an increment in the amount of TSS in ripening fruit had a direct relationship with the decomposition of starch.

Besides all of the above, that fruits coated with *Aloe vera* or chitosan were had restricted water loss so resulting in low TSS of coated fruits during storage.

Acidity is the major parameter to determine quality fruit. The highest or lowest values of acidity, are not recommended for their quality and acceptability. (Jiang *et al.,* 2005).

The main acid of Mango is citric acid and it increases during fruit ripening then decreases during the storage period. This may be due to their conversion to sugars and subsequent use in the fruit's metabolic activities. (Doreyappa and Huddar, 2001; Bai *et al.,* 2003).

Scientifically proven that there was an inverse relationship between fruit acidity and storage period. Fruit acidity decreased with an increased storage period and a sharp drop of acidity indicates senescence (Ali *et al.,* 2011), but this increase was limited in cold storage.

Respiration is an enzymatic process and the organic acids are considered as a basic substrate of respiration (Yaman and Bayoindirli, 2002). The sudden drop in fruit acidity may be due to an overabundance of fungi, as fungi can utilize organic acids for growth (Vieira *et al.*, 2016). Edible coatings produce a thin layer on the surface of fruits, restricting gas exchange and so slowing the rate of fruit respiration (Silva *et al.,* 2017; Jiang and Li, 2000).

Total sugars are considered an important standard to estimate fruit ripening during fruit storage. Total sugars significantly increased; in all treatments except control; as all treatments decreased the respiration rate; transpiration; and other metabolic changes; and that led to a slow ripening process (Youssef *et al.,* 2002).

On the other hand; the maximum quantity of reducing sugars in uncoated fruits might be due to the rapid conversion of starch to sugars; as a result of loss of moisture and reduction in acidity; physiological changes; during storage (Wills and Rigney, 1979).

Ascorbic acid is; one of the most; abundant antioxidants in fruits, and it's a key indicator for assessing postharvest mango damage. Because it is rapidly oxidatively destroyed and its physiological activity declines with storage, the vitamin C in mango fruit is highly variable. When compared to uncoated fruit, data showed that chitosan and *Aloe vera* gel coating generated lower antioxidant losses at the end of storage. Application by *Aloe vera* gel and chitosan altered the internal atmosphere, resulting in a higher concentration of CO_2 and a lower concentration of O_2. As a result, the oxidation process was slowed, resulting in a lesser conversion of ascorbic acid; to dehydroascorbic acid (Lal and Mishra, 2007). The vitamin C level was likewise proportional to the extent of damage to the fruit's tissue structure. The loss of this structure increased the material's density, affecting the activity of; phenolic enzymes and; the rate of vitamin C breakdown (Brasil *et al.,* 2012).

Moreover, that fruit coated with chitosan or *Aloe vera* has a high rate of titratable acidity, TSS content, and ascorbic acid content during the storage period (Jiang and Li, 2000, Martinez-Romero *et al.,* 2006).

Starch breakdowns during fruit storage and transforms into sucrose, fructose, and glucose, which are characterized as the main sugars in mango fruit (Duan *et al.* 2011). Thus, coating by chitosan controls sugar accumulation; and starch degradation (Silva *et al.,* 2017).

Knowly, in the high temperature the enzymatic catalysis increases and results in a biochemical and chemical collapse in fruits and vegetables. Furthermore, low temperature retards ripening through decreased respiration levels and other unwanted metabolic changes. (Ezz and Award, 2011).

Conclusion

The current study demonstrated that postharvest coating with chitosan and Aloe vera gel treatments as applications is a promising strategy for managing postharvest fruit quality of mangoes cv. Langra during storage at 11°C and increased storage life by up to 40 days. As a result, some of the challenges that mangoes face after harvesting have been overcome, and their quality has been preserved to some extent during local marketing or sale overseas by using chitosan and aloe vera gel, either separately or in combination form, at low temperatures of not less than 10 degrees Celsius for no more than a month.

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دراسة تأثير تغطية ثمار المانجو صنف اللانجرا بالالوفيرا والشيتوزان اثناء التخزين البارد

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الملخص

تعتبر ثمار المانجو من الثمار الكلايمكتيرية وفترة صلاحيتها قصيرة وسريعة التدهور بعد حصادها وهذا يسبب مشاكل أثناء التسويق المحلي والتصدير للخارج ويتم التغلب على هذه المشاكل باستخدام التخزين المبرد وبعض المعاملات التي تقلل من سرعة التنفس. الهدف من هذه الدراسة هو استخدام المواد الالوفيرا والشيتوزان المستخدمة إما بشكل منفصل أو الدمج بينهما في تغطية الثمار وحفظها في التخزين البارد ودراسة تأثيرها على جوده الثمار ومدة صلاحيتها. تمت دراسة تأثير الصبار الألوفيرا ٧٥٪، الشيتوزان ٢٪ على الخواص الفيزيائية والكيميائية لثمار المانجو صنف اللنجرا أثناء التخزين البارد (١١ ± ١ درجة مئوية و٨٥٪ رطوبة نسبية) خلال موسمين متتاليين ٢٠١٩ و٢٠٢٠. جميع المعاملات أطالت فترة التخزين لأكثر من شهر قرابة ٤٠ يوم بحالة جيدة بينما وصلت معاملة الكنترول إلى ٣٠ يوم فقط. في اليوم الأربعين، أعطت جميع المعاملات تأثيرات إيجابية على تخزين الفاكهة ولكن أفضل معامله هي المعاملة التي تجمع بين الألوفيرا والشيتوزان. وهذة الدراسة بتنصح باستخدام مركب من الشيتوزان والالوفيرا في تغطية ثمار المانجو وحفظها في درجة حرارة ١١درجة مئويه لاطاله فترة صلاحيتها والتغلب على مشاكل التسويق والتصدير.