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EFFECT OF EDIBLE COATING ON THE SHELF-LIFE AND QUALITY OF KEITT MANGO PULP FRUITS DURING COLD STORAGE

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ABSTRACT: Mango is considered as a rich source of carotenoids, ascorbic acid, and phenolic compounds. In this study, fresh-cut mango samples (*Mangifera indica Cv.Keitt*) were coated with ascorbic acid (1%), calcium lactate (1%) and arabic gum (15%) solutions. They were then placed into plastic plates and stored at 4±2˚C for 14 days. Fresh-cut mango samples were evaluated by measuring the weight loss, pH, total soluble solids, texture, colour and sensory attributes. It was found that coating solutions could preserve fresh-cut mango quality by reducing weight loss, delaying the increase in total soluble solids, change in colour, and maintaining the sensory attributes (colour, flavour, taste, texture, and overall acceptability). The findings of this study revealed that ascorbic acid, calcium lactate, and arabic gum treatments could increase the shelf-life of mango for 14 days and could be used as an effective farm-based post-harvest treatment to increase the shelf-life, while keeping the physical and chemical characteristics of mango throughout storing at 4± 2℃.

Key words: *Mangifera indica*, edible films, ascorbic acid, calcium lactate, arabic gum.

INTRODUTION

Mango (*Mangifera indica*) is a prominent subtropical fruit farmed for its high economic value in subtropical climates (**Sellamuthu *et al*., 2013**). Mango is grown commercially in over 80 countries. India produces roughly 12.75 million tons of mango, accounting for 52 percent of global production (**NHB, 2009**). China, Mexico, Pakistan, Indonesia, Thailand, Nigeria, Brazil, the Philippines, and Haiti are the world's other largest mango producers. Mango exports account for less than 10% of global production. Mango demand is increasing in temperate countries as a result of social changes, the promotion of fruit trade in developing countries, and the availability of international air cargo space. The expansion of the mango trade has been made possible by successful post-harvest management strategies for disease and insect control. Products made from both ripe and green mangoes are very popular in India and abroad. Despite the fact that only about 1% of India's total mango production is processed, India dominates the world trade in processed mango products. The export of processed mango products is steadily increasing. The most important mango processed product exported is canned mangoes pulp, which has increased threefold in volume and fivefold in value over the last decade. Mangoes are processed into a variety of products such as slices, pulp, jam, squash, nectar, juice, mango leather, and so on (**Rajendrakumar *et al*., 2001**). Mango is a rich source of carotenoids, ascorbic acid, and phenolic compounds, and is known for its appealing colour, pleasant taste, rich aroma, exotic flavour, and high nutritional value (**Liu *et al*., 2013**). Because of its key components, mango fruit has a high nutritional value and health benefits. Macronutrients (carbohydrates, proteins, amino acids, lipids, fats, and organic acids), micronutrients (vitamins and minerals), and phytochemicals are the different types of mango components (phenolic, polyphenol, pigments, and volatile constituents).

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Ripe mango fruit is high in sugars (glucose, fructose, and sucrose) as well as other carbohydrates like starch and pectins (**Bello-Pérez *et al*., 2007**). All of these are important compounds in terms of nutrition and flavour. The flesh of a ripe mango contains about 15% of the total sugars. During the preclimateric phase, fructose is the most abundant monosaccharide (**Bernardes *et al*., 2008**), whereas sucrose is the most abundant sugar in ripe mango fruit (**USDA, 2018**).

Direct immersion of the fruit pieces in an aqueous solution of antibrowning chemicals frequently inhibits enzymatic browning. However, the use of edible coatings with freshcut fruit as antibrowning agents carriers has been studied (**Rojas-Grau *et al*., 2008; Oms-Oliu *et al*., 2008a,b**). **Olivas *et al*., (2003)** also found that adding certain additives (ascorbic acid, calcium chloride, and sorbic acid) to methylcellulose and methylcellulose-stearic acid coatings improved browning control of fresh-cut pears. Polysaccharide-based coatings are typically applied initially, followed by the incorporation of anti-browning chemicals in a calcium-containing dipping solution for crosslinking and rapid gelation of the coating (**Lee *et al*., 2003**).

Calcium has a significant impact on tissue integrity, and its role as a firming agent is well established. In a nutshell, this involves the complexing of calcium ions with cell wall and middle lamellar pectin, which influences cell wall strength and cell turgor pressure (**Fry, 2004**). Several techniques were developed for increasing calcium in the cell wall of fresh fruit after harvest, vacuum and pressure infiltration (**Chardonnet *et al*., 2003**). The application of calcium after harvesting improves cell wall pectins physiological and physicochemical characteristics by reducing uronic acids solubilization without significantly affecting the quality features of several fresh fruits in the pectin network (**Tsantili *et al*., 2002**).

Arabic gum, a neutral or slightly acidic salt of a complex polysaccharide containing calcium, magnesium, and potassium ions, is widely employed as a common food additive in the industrial sector (**Maqbool *et al*., 2011**). Because of its strong emulsification characteristics, the gum produced from *Acacia senegal* is the principal gum that is commonly utilised for commercial purposes (**Elmanan *et al*., 2008**). **Ali *et al*. (2010)** discovered that tomato fruit coated with arabic gum remained disease free even after 20 days of storage. Arabic gum has been shown to have antioxidant and antibacterial properties (**Boiero *et al*., 2014**), owing to its polyphenol components (**Alawi *et al*., 2018**). In recent years, various researches showed that edible coatings based on arabic gum might decrease spoiling and so enhance the shelf-life of some fruits, such as tomato, banana, sweet cherry, and mango (**Xu *et al*., 2018**). As a result, arabic gum can be considered a suitable natural edible coating ingredient to improve the postharvest quality of fruits.

The aim of this study was assessing the effect of edible coatings on the shelf-life and quality attributes of fresh mango, pretreated with ascorbic acid, calicium lactate and arabic gum during cold storage at 4±2 ºC.

MATERIALS AND METHODS

Materials

Mango (Keitt variety) fruits used in this study was obtained from Alopour market, Egypt. Mango was harvested in the year 2019, and were bought about 20 kilogram from mango. Chemicals used in this study: ascorbic acid, calcium lactate and arabic gum were obtained from Al-Gomhouria Company, Egypt.

Methods

Preparation of mango cubes

Mango was washed under tap water, dried with cloth, peeled, then cut into cubes approximately 2 cm ×1.5 cm×1 cm and ready to be used for the experiments.The amount of the peels and seeds from mango were about 6 kilogram from mango.

Preparation of ascorbic acid, calcium lactate, and arabic gum solutions

Finely ground ascorbic acid and calcium lactate were made into solution at aconcentration of 1% (w/v) in distilled water. In addition, finely ground arabic gum powder was made into solution at aconcentration of 15% (w/v) in distilled water at (40˚C) for 15 min. The solutions were then left to cool to 20˚C (**Daisy *et al*., 2020**).

Preparation of coated mango cubes

Fruits were divided into 7 groups and acontrol. Each group was treated by different treatments including:

(C) control samples without any treatments.

(T1) fruits were dipped in asolution of 1% ascorbic acid for 5 min. (Asc)

(T2) fruits were dipped in asolution of 1% calcium lactate for 5 min. (Ca la)

(T3) fruits were coated with 15% Arabic gum for 1 h. (AG)

(T4) fruits were dipped in asolutions of 1% ascorbic acid and 1% calcium lactate.

(T5) fruits were dipped in asolutions of 1% ascorbic acid and coated with 15% arabic gum.

(T6) fruits were dipped in asolutions of 1% calcium lactate and coated with 15% arabic gum.

(T7) fruits were dipped in asolutions of 1% ascorbic acid, 1% calcium lactate and coated with 15% arabic gum.

All treatments were then placed into plastic plates and stored at 4±2°C. The experiments were undertaken in three replications. The treated fruits were sampled at a certain period of time (0, 7 and 14 days) and analyzed for some quality characteristics.

Weight loss percentage

The weight of fruits was determined using an electronic balance. The difference between the initial and final weight of the fruit was considered as total weight loss and the results were expressed as the percentage of weight loss, as per the standard method of **AOAC (2003)**.

pH value

The pH of the sample solutions was measured using an electric pH meter. Twenty (20) millilitres of freshly prepared sample, was placed in a beaker. The electrode end of the pH meter was used to agitate the solution until a stable reading was obtained. This was done on the three replicated samples of the same solutions respectively. Between readings the electrode was rinsed with distilled water to eliminate cross-contamination (**Daisy *et al*., 2020**).

Total soluble solids (˚Brix)

This was determined using a digital laboratory refractometer (range 0–32%). A drop of the specific solution was placed on the prism-plate of the refractometer (**Mazumdar and Majumder 2003**). The reading obtained after adjusting the refractometer to the mark was directly recorded as total soluble solids (˚Brix) (**Majidi *et al*., 2011**). This was done on three replicated sample solutions, and the refractometer was then calibrated using distilled water prior to use for the next sample.

Texture profile analysis

Texture profile of mango cubes was measured using Texture Analyzer (Texture Pro CT V1.6 at Food Industries Research Division, National Research Center, Dokki, Giza, Egypt.). Mangoes were cut into cubes of 2×1.5×1 cm, measured in the central zone. Firmness was measured as the maximum penetration force (N) reached during tissue breakage, and determined with a 5 mm diameter cylinder stainless probe. The equipment settings used were: preset speed, 5 mm/s; test speed, 1 mm/s; distance, 60% strain; time, 1 S. (**Rahman and Al-Farsi, 2005**).

Colour

According to **Siripatrawan and Noipha (2012)** the lightness (L*), redness to greenness (a*), and yellowness to blueness (b*) of mango samples were measured using a colour reader. All experiments were carried out in duplicate.

Sensory evalution

The sensory attribute was performed as described by **Navarro-Tarazaga *et al*. (2011)**. Mango fruit samples were presented as coded samples to a ten member panel from the Food Science Department, Faculty of Agriculture, Zagazig University, Egypt. The panelists were requested to assess the canned mango pulp fruits for the following attributes: colour, taste, texture, flavour and global acceptability. Scores were based on the nine- point hedonic scale where 1-3 represented a range of non-acceptable quality with the presence of off-flavour, 4-6 represented a range of acceptable quality, and 7-9 represented a range of excellent quality. The means of ten scores of each sample were taken.

Statistical analysis

The data of the present study were subjected to analysis of variance (ANOVA) using SAS software (**SAS Institute, 1990**). Differences between means were determined by the least significant difference test and significance was defined at $p<0.05$. All measurements were carried out in triplicate.

RESULTS AND DISCUSSION

Weight Loss

Fig. 1 illustrated the weight loss (%) of mango cubes treated with ascorbic acid, calcium lactate, arabic gum during cold storage at 4±2ºC for 0, 7 and 14 days. The weight loss percentage of all samples was decreased during storage period. Mango samples hadn't change weight at zero day. Mango control samples had the highest weight loss (22%) at the 14th day of storage while fruits coated with ascorbic acid + calcium lactate + arabic gum had the lowest weight loss (11.26%). Generally, coated samples had the lowest weight loss in all storage time. Previous studies have reported that the respiration process and movement of the water from fruit to the surrounding environment leads to greater weight loss in fruits (**Maqbool *et al*., 2011).** Similar result was observed when arabic gum alone used for strawberry coating (**Tahir *et al*., 2018**).

pH and Total soluble solids

As reported in Table 1, the pH values increased during the first week of storage period (4.8±0.2) in the control sample. The increase in the pH value was probably due to metabolic processes and reactions that occurred during postharvest storage, which continued to converting acids into the sugar (**Mannozzi *et al.*, 2017**). After 14 days of storage, the final pH values of all fruits showed no significant differences, and a similar result was also reported by **Mannozzi *et al.*, (2018)**. who used chitosan incorporated with procyanidins extract for improving the shelf-life of blueberries.

Regarding the TSS it was shown that the values of all treatments increased with storage time (Table 2). The increase in TSS may be due to the hydrolysis of insoluble polysaccharide into simple sugars. After 14 days of storage, the uncoated fruits presented significantly higher TSS (12.8 ± 0.2º Brix) compared with coated fruits. **Fan *et al*. (2019)** also reported that the use of composite coating enriched with lotus leaf extract increased the TSS content in fresh goji fruit, and a similar result was also observed by **Jatoi *et al*. (2017)**. The results exhibited that fruits coated with Arabic gum + white roselle extract and Arabic gum + red roselle extract could increase consumption of insoluble polysaccharide.

Texture Profile Analyses

The firmness of mango cubes treated with ascorbic acid, calcium lactate, arabic gum during cold storage at 4±2ºC is shown in Fig. 2. Firmness is one of the main quality parameters that specify the postharvest shelf-life and quality of fruit. During the whole storage period, all coated mango indicated higher firmness as compared to the control. Samples coated with ascorbic acid + calcium lactate + arabic gum had the highest firmness followed by those coated with calcium lactate + arabic gum. At the end of storage time, the firmness of the control sample recorded 0.38N, while those coated with calcium lactate + arabic gum or ascorbic acid + calcium lactate + arabic gum retained the highest firmness being 1.0, and 1.13N, respectively. Generally, it could be concluded that the presence of arabic gum in the coating gave structural rigidity to the fruit surface of mango. Furthermore, the retention of firmness could be elucidated by the delay of pectin and proto-pectin decomposition, which contributes to the conservation of the structural integrity of the fruit (**Duan *et al*., 2011**). These results agree with the result of arabic gum for tomato (**Ali *et al*., 2010**), guava (**Murmu and Mishra, 2018**) as well as in blueberry coated with various coatings, such as sodium alginate and pectin (**Mannozzi *et al*., 2017**).

Colour

Colour attributes (lightness, L*; redness to greenness, a* and yellowness to bluness, b*) of mango cubes treated with ascorbic acid, calcium lactate and arabic gum during cold storage at 4±2ºC are presented in Table 3. Directly after coating (zero day), all arabic gum -treated mango samples indicated higher L* values than other treatments, probably due to the influence of arabic gum coatings. The L*values of treated and control samples tend to decrease during the entire storage time, however, this change was more significant in the control sample. At zero time of storage the L*, a* and b* values of the control sample were 40.14 ± 0.02; -8.67 ± 0.1, and 25.18 ± 0.1, respectively. In addition, the L* and b* values increased in case of treated samples compared with the control sample, while a* value decreased. These variations may be due to the coating layer of the treated samples. Over storage time, the colour attributes of the control sample clearly decreased in value L* and increased in a* and b* values whereas

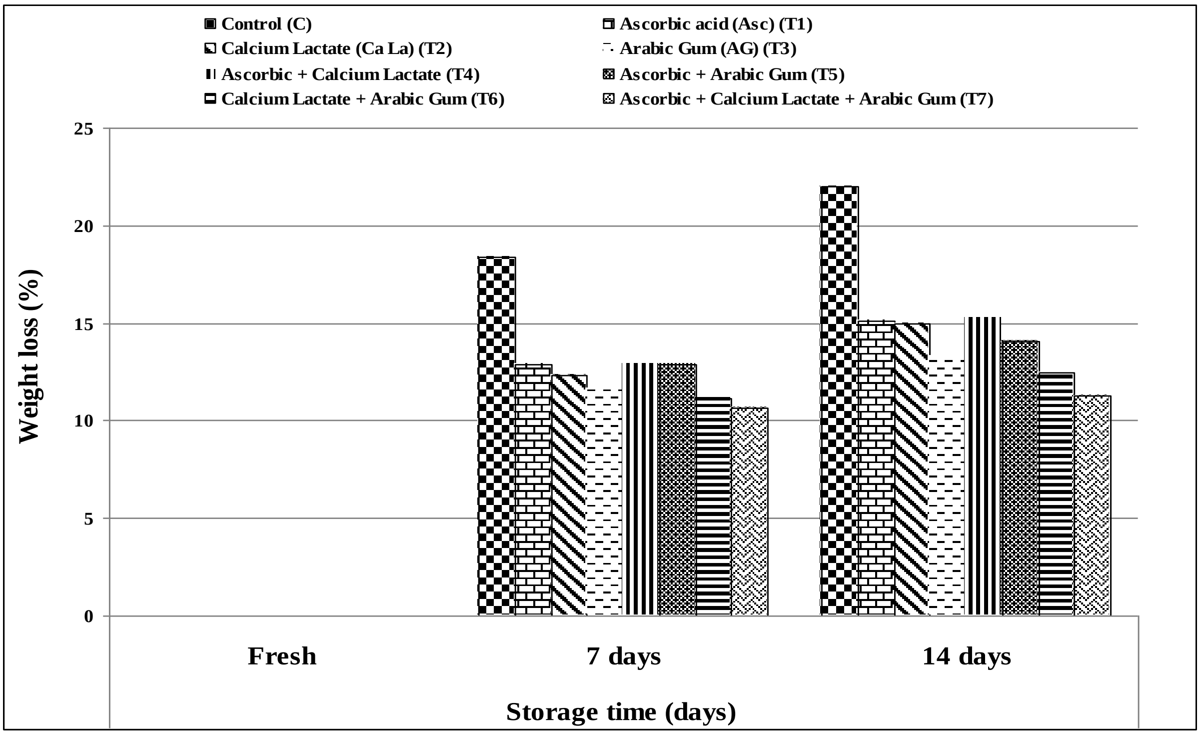

Fig. 1. Weight loss (%) of mango cubes treated with ascorbic acid (Asc), calcium lactate (Ca lact), arabic gum (AG) during cold storage at 4±2°C for 14 days

Table 1. pH of mango cubes treated with ascorbic acid (Asc), calcium lactate (Ca lact), arabic gum (AG) during cold storage at 4±2°C for 14 days

Treatment	Storage time (days)		
	Fresh	7 days	14 days
Control (C)	$4.2±0.2^{a}$	$4.8±0.2^{a}$	$3.7±0.2^{c}$
Ascorbic acid (T1)	$4.0±0.2^{a}$	$4.2±0.2^{b}$	$3.8±0.2^{bc}$
Calcium Lactate (T2)	$4.2±0.1^{a}$	$4.3±0.2^{b}$	$4.1±0.2^{ab}$
Arabic Gum (T3)	$4.2±0.2^{a}$	$4.3±0.1^{b}$	$4.2 ±0.1^{a}$
Ascorbic + Calcium Lactate (T4)	$4.0±0.1^{a}$	$4.3±0.2^{b}$	$4.0±0.1^{abc}$
Ascorbic + Arabic Gum (T5)	$4.1±0.3^{a}$	$4.3±0.2^{b}$	$4.1±0.2^{ab}$
Calcium Lactate + Arabic Gum (T6)	$4.2±0.1^{a}$	$4.3±0.1^{b}$	$4.0±0.2^{abc}$
Ascorbic + Calcium Lactate + Arabic Gum (T7)	$4.0±0.1^{a}$	$4.1±0.2^{b}$	$3.9±0.2^{abc}$

Each Value in a column followed by the same letter is not significantly different at P<0.05.

Table 2. Total soluble solids of mango cubes treated with ascorbic acid (Asc), calcium lactate (Ca lact), arabic gum (AG) during cold storage at 4±2ºC for 14 days

Treatment	Storage time (days)		
	Fresh	7 days	14 days
Control (C)	10±0.2^{a}	12.0±0.4^{a}	12.8±0.2^{a}
Ascorbic acid (T1)	10±0.2^{a}	10.8±0.2^{b}	11.0±0.2^{b}
Calcium Lactate (T2)	10±0.2^{a}	10.7±0.2^{bc}	10.9±0.1^{b}
Arabic Gum (T3)	10±0.2^{a}	10.3±0.2^{cd}	10.5±0.2^{cd}
Ascorbic + Calcium Lactate (T4)	10±0.2^{a}	10.7±0.2^{bc}	10.9±0.2^{b}
Ascorbic + Arabic Gum (T5)	10±0.2^{a}	10.4±0.2^{bcd}	10.8±0.2^{bc}
Calcium Lactate + Arabic Gum (T6)	10±0.2a	10.3±0.2^{cd}	10.5±0.1^{cd}
Ascorbic + Calcium Lactate + Arabic Gum (T7)	10±0.2^{a}	10.2±0.2^{d}	10.4±0.2^{d}

Each Value in a column followed by the same letter is not significantly different at P<0.05

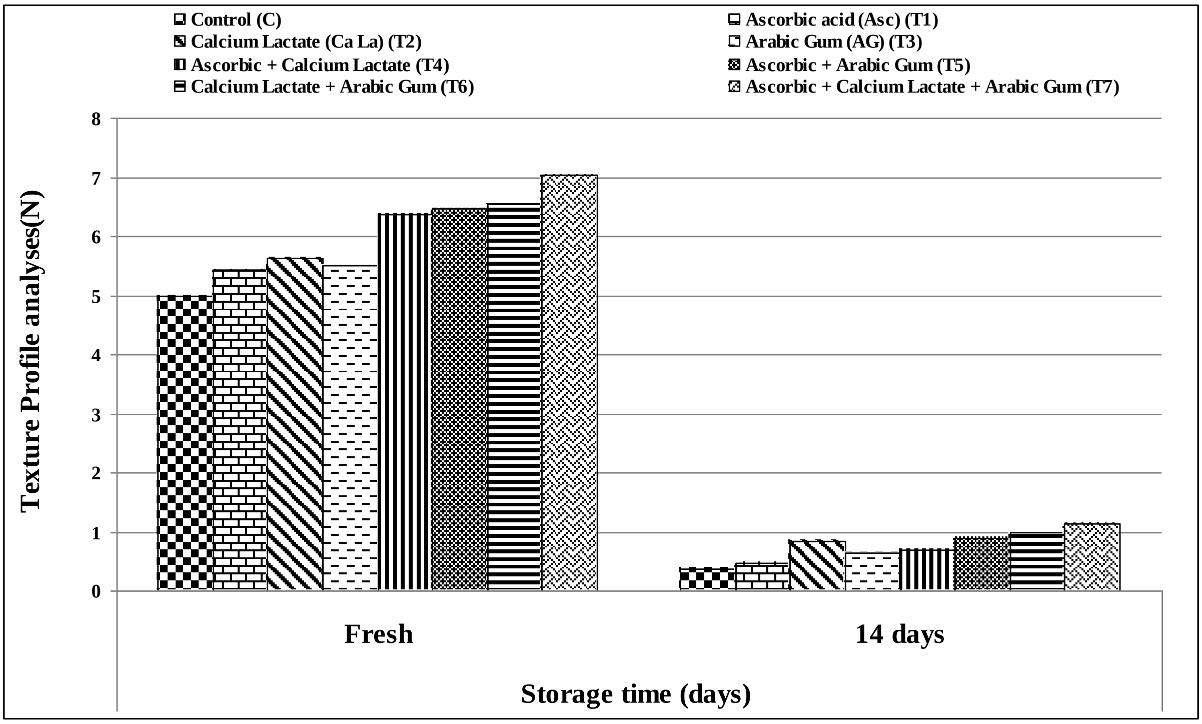

Fig. 2. Firmness (N) of mango cubes treated with ascorbic acid (Asc), calcium lactate (Ca lact), arabic gum (AG) during cold storage at 4±2ºC for 14 days

Table 3. Colour attributes (L*,a*and b*) of mango cubes treated with ascorbic acid(Asc), calcium lactate (Ca lact), arabic gum (AG) during cold storage at 4±2ºC for 14 days

Treatment	L*,a*and b* during storage time (day)								
	L*, lightness			a*, redness / greenness			b*,yellowness / blueness		
	Fresh	7 days	14days	Fresh	7days	14days	Fresh	7days	14days
Control (C)	40.14±0.02^{de}	31.55±0.1^{g}	31.36±0.1^{g}	-8.67±0.1^{e}	-8.71±0.1^{c}	-5.57±0.1^{e}	25.18±0.1^{d}	19.34±0.1^{f}	17.06±0.1^{g}
Ascorbic acid (T1)	43.71±0.2^{b}	37.89±0.1^{c}	34.18±0.1^{e}	-10.45±0.1^{c}	-8.49±0.2^{cd}	-8.74±0.2^{d}	27.23±0.1^{c}	20.37±0.1^{e}	22.17±0.1^{b}
Calcium Lactate (T2)	40.32±0.1^{d}	34.07±0.02^{f}	33.27±0.1^{f}	-9.69±0.1^{d}	-8.43±0.1^{d}	-8.6±0.1^{d}	28.89±0.1^{a}	17.87±0.1^{g}	19.88±0.1^{f}
Arabic Gum (T3)	43.62±0.2^{b}	36.34±0.1^{e}	35.75±0.2^{c}	-7.91±0.02^{f}	-10.17±0.1^{a}	-8.7±0.2^{d}	24.73±0.2^{f}	25.98±0.1^{a}	21.21±0.1^{d}
Ascorbic + Calcium Lactate (T4)	44.21±0.1^{a}	36.92±0.02^{d}	35.77±0.1^{c}	-11.35±0.1^{b}	-8.66±0.1^{c}	-9.66±0.1^{b}	28.62±0.1^{b}	21.86±0.1^{d}	23.01±0.1^{a}
Ascorbic + Arabic Gum (T5)	43.11±0.1^{c}	39.88±0.04^{b}	37.14±0.1^{b}	-6.78±0.1^{h}	-7.61±0.2^{e}	-5.5±0.1^{e}	24.95±0.04^{e}	22.43±0.1c	21.42±0.1^{c}
Calcium Lactate + Arabic Gum (T6)	40.04±0.02^{e}	37.82±0.1^{c}	34.61±0.2^{d}	-7.57±0.1^{g}	-9.90±0.1^{b}	-10.75±0.1^{a}	25.05±0.02^{de}	23.76±0.1^{b}	20.5±0.1^{e}
Ascorbic + Calcium Lactate + Arabic Gum (T7)	43.32c±0.1	40.26a±0.1	38.41a±0.1	-11.82a±0.1	-10.26a±0.1	-9.09c±0.04	27.15c±0.1	20.33e±0.2	20.42±0.2^{e}

Each Value in a column followed by the same letter is not significantly different at $P<0.05$

coated fruits retained the highest L*, a* and b* values at 7 and 14 days of cold storage. This treatment delay change for these colour attributes, which could attribute to the inhibition of the ripening process and senescence of mango fruits. Similar results behavior was observed when mango fruits were coated with arabic gum coatings (**Khaliq *et al*., 2016**).

Sensory Attributes

Colour, taste, texture, flavour and overall acceptability of cold stored mango cubes treated with ascorbic acid, calcium lactate and Arabic gum are shown in Fig. 3. At zero time, judges evaluated all samples as acceptable. Over storage time, control sample scores were greatly

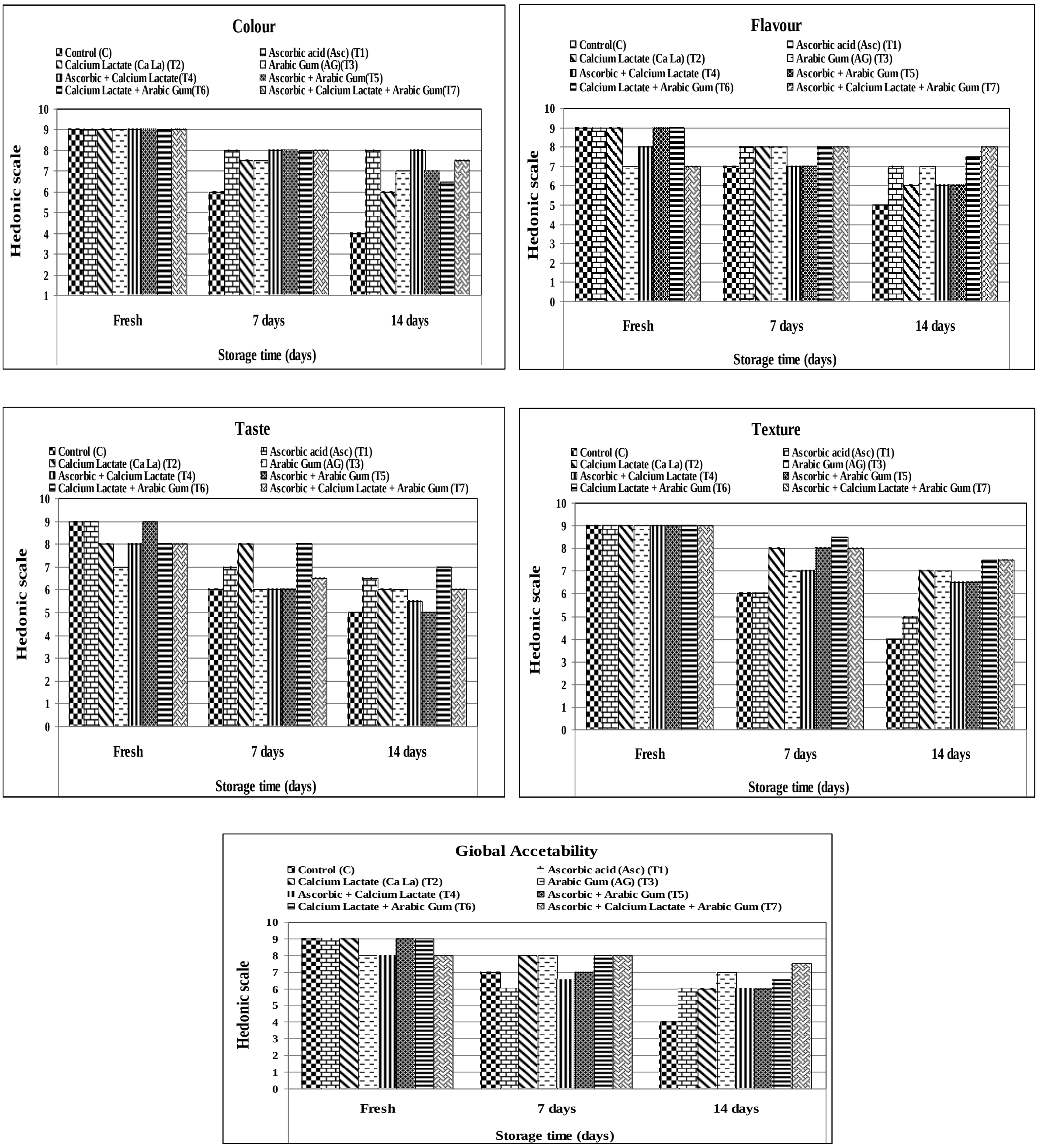

Fig. 3. Sensory attribute of mango cubes treated with ascorbic acid (Asc), calcium lactate (Ca lact), arabic gum (AG)during cold storage at 4±2ºC for 14 days

decreased at the 14th day of storage especially for colour, texture and the overall acceptability while, coated fruits were acceptable for all studied properties particularly those coated with ascorbic acid+ calcium lactate + arabic gum. Similar results were observed in tomato treated with arabic gum coatings (**Ali *et al*., 2010**) However, these data are more cute than those obtained for cold-stored strawberries by **Hernandez-Munoz *et al*. (2006) and Perdones *et al.* (2012)**.

Conclusion

According to the findings of the current study, ascorbic acid, calcium lactate, and arabic gum treatments could increase the shelf-life of mango for 14 days, and could be considered as an in effect farm-based post-harvest treatment to increase the shelf-life while keeping the physical and chemical characteristics of mango throughout storing at 4± 2ºC.

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تأثير الطلاء الصالح للأكل على فترة صلاحية وجودة لب ثمار المانجو الكيت أثناء التخزين البارد

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يعتبر المانجو مصدر غنى بالكاروتينات، حمض الأسكوربيك والمركبات الفينولية. فى هذه الدراسة تم تغليف عينات المانجو الطازجة (*Mangifera indica Cv.Keitt*) فى محاليل حمض الأسكوربيك (1%)، لاكتات الكالسيوم (1%) والصمغ العربى (15%) ثم وضعت فى أطباق بلاستيكية وخزنت على درجة حرارة (4±2ºم) لمدة 14 يوم . تم تقييم التغير فى الوزن، الرقم الهيدروجينى، المواد الصلبة الذائبة الكلية، القوام، اللون والخواص الحسية. وقد تبين أن محاليل الطلاء يمكن أن تحافظ على جودة مكعبات المانجو الطازجة عن طريق تقليل الفقد فى الوزن، تأخير الزيادة فى المواد الصلبة الذائبة، التغير فى اللون والحفاظ على الخواص الحسية (اللون- النكهه- المذاق- القوام والقابلية العامة). أوضحت نتائج هذه الدراسة أن معاملات حمض الأسكوربيك ولاكتات الكالسيوم والصمغ العربى من الممكن أن تزيد من فترة صلاحية المانجو حتى 14 يوم، ومن الممكن أن تستخدم كمعاملة فعالة لما بعد الحصاد من أجل زيادة فترة الصلاحية، فى ظل الحفاظ على الخواص الطبيعية والكيميائية للمانجو خلال التخزين على 4±2ºم.

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