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Influence of some safety post-harvest treatments on fruit quality and storability of Guava fruits

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ABSTRACT

This study carried out during 2015 and 2016 seasons on Etmani guava fruits (*Psidium guajava* L.). The objective of this study was to study the effect of postharvest treatments with rice or cassava starch at levels 1, 3 %, Cinnamon oil at 0.1% and Clove oil at 0.1% on keeping fruit quality during cold storage at 8±1°C and 90% relative humidity (RH) for 3 weeks. Characteristics considered were weight loss%, fruit decay%, firmness, color parameters [lightness (L*) and hue angle (hº)], respiration rate, soluble solids content (SSC), titratable acidity (TA), vitamin C and total pectin content. The results showed that different treatments had significant effect on most characteristics. The results indicated that Clove oil at 0.1% and cassava starch at 1% fruit treatments before cold storage was the best concerning to maintain fruit quality (especially fruit weight loss, decay, and retard ripening) and storability.

Key words: Guava, Rice starch, Cassava starch, Cinnamon oil, Clove oil, Cold Storage

Introduction

Guava (*Psidium guajava* L.) is an important fruit crop of tropical and subtropical countries, fruits are an excellent source of vitamin C and have high levels of sugars and nutrients. Guava a climacteric fruit are highly perishable and have limited storage and shelf life. Fruits have the low of PH and this lowest makes them vulnerable to fungal decaying (Singh and Sharma, 2007).

Many storage techniques have been developed to extend the useful marketing distances and holding periods for fresh horticultural commodities after harvest. One method of extending postharvest shelf-life is the use of edible coatings, such as some essential oils (clove or Cinnamon), rice starch or cassava starch. These coatings are made of edible materials that are safe and used to enrobe fresh produce, providing a semipermeable barrier to gases and water vapor.

Edible coatings like essential oils have recently attracted a great deal of attention for use in post-harvest treatments because of their anti-bacterial, antifungal, antioxidant and bio-regulatory properties (Holley and Patel, 2005).

Also, clove oils presented inhibitory effects on the fungi, (Zeng *et al*., 2012) suggested that Clove extract might be a viable alternative to synthetic fungicides to extend the post-harvest storage period and maintain fruits quality.

The positive effects of starch (rice or cassava) on extending could storage and shelf-life .might be attributed to the forming of a thin film of starch surrounding the fruit and induced a modification of microclimatic of fruits.

Edible coatings and can provide an alternative for extending shelf life of fresh fruits and vegetables and result in the same effects as modified atmospheric storage where the internal gas composition is adjusted. The main components are generally recognized as safe substances (GRAS); different extracts such as lipids, proteins, cellulose derivatives, starch and other polysaccharides. Use of edible coating is a common issue that is beneficial to protect nutrients of food specially fruits and vegetables and provides a long durability. These are a thin layer of edible material which restrict water loss, oxygen and other soluble materials of food (Wijewardana *et al*., (2014).

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Biologically active essential oils represent a rich potential source of an alternative and perhaps environmentally more acceptable disease management compounds. With a broad range of natural fungicidal plant volatiles, numerous opportunities exist to explore their usefulness in controlling post-harvest diseases. The general antifungal activity of essential oils is well documented (Nabakishor, 2014).

The aim of the present work was to study the effect of postharvest treatments on maintaining fruit quality and storability in guava fruits.

Materials and Methods

This investigation was carried out during the two seasons 2015 and 2016 on Guava (*Psidium guajava L.*) CV. 'Etmani') obtained from a commercial orchard located in El Klubia Governorate, Egypt. Guava fruits were picked at yellowish green maturity stage according to (Mekhiel *et al*. 2015), uniform in size and free from visual symptoms of disease or mechanical damages were used for the experiment. Fruits were transported to the laboratory immediately after harvest; fruits were randomly selected for different groups, 3 replicates for each and were subjected to the following treatments:

1- Dipping in rice starch at 1% for three minutes.
2-Dipping in rice starch at 3% for three minutes.
3-Dipping in cassava starch at 1% for three minutes.
4-Dipping in cassava starch at 3% for three minutes.
5-Dipping in Cinnamon oil at 0.1% + surfactant* for three minutes.
6-Dipping in Clove oil at 0.1% + surfactant* for three minutes.
7-Control (untreated fruits).

*The surfactant Tween 80 at 0.01% was added to obtain best dipping results.

Each replicate was packed in 3 carton boxes / 3 Kg. Then, guava boxes were stored at 8±1º C and 90% relative humidity for 3 weeks. Postharvest physical and chemical properties of guava were determined weekly from the beginning of cold storage (0 time) till the end of storage period (3 weeks) in both seasons of the study.

The following properties were estimated:-

Physical properties:

Fruit weight loss percentage:

Calculated as the difference between fruit weight at the beginning of storage and fruit weight at the inspection dates using the following equation:

Loss in fruit weight % = [(Initial weight – Weight at time of sampling) / The initial weight of fruit] x100.

Fruit decay percentage (FDP): -

The number of decayed fruits due to fungus or any micro organism infection was recorded periodically (every week) and calculated as a percentage from the total number of fruits using the following equation : -

$$FDP = \frac{\text{number of decayed fruits}}{\text{Total fruit number}} \times 100$$

Fruit firmness:

Was determined as (Lb/inch^2) by using fruit pressure tester mod. FT 327.

Fruit color:

Lightness and hue angle were estimated using Minolta Calorimeter (Minolta Co. Ltd.,Osaka, Japan) as described by (Mc Gire, 1992).

Respiration rate (CO_2 production):

Individual fruits from each treatment were weighed and placed in 1- liter jars at 8±1º C. The jars were sealed for 24 h with a cap and a rubber septum. The resulting O_2 and CO_2 samples of the head space were removed from the septum with a syringe and injected into Service Inst. Model 1450 C (Food Pack Gas Analyzer) to measure carbon dioxide production. Respiration rate was calculated as ml CO_2 /kg/hr. (Varit and Songsin, 2011).

Chemical properties:

Soluble solids content (SSC):

Was determined by digital refractometer of "Model Abbe Leica", according to A.O.A.C., (2005).

Titratable acidity percentage:

Was determined by titrating 5 ml of the extracted juice against 0.1 N of NaOH using phenolphethalin indicator. Titratable acidity was expressed as percentage of citric acid (g citric acid/100ml juice) according to A.O.A.C., (2005).

Vitamin C (mg/ 100 ml juice):-

It was determined by titration against 2, 6 dichlorophenolendophenol and using 2% oxalic acid solution as substrate described by (Lucass, 1944).

Total pectin percentage:-

Levels of pectic substances in guava fruits were determined colorimetrically by carbazole sulfuric acid method according to the method of Reitmier and Lore (1996). Results were expressed as g. anhydro galacturonic acid (A.G .A) per 100 gm on dry weight basis.

Statistical analysis:

The data were arranged as a randomized complete design with three replicates. All data were subjected to statistical analysis according to the procedures reported by Snedecor and Cochran (1990) and means were compared by Duncan's Multiple range test at the 5 % level of probability in the two seasons of experiment.

Results and Discussion

Physical properties:

Fruit weight loss percentage:

Results in Table (1) show the effect of post-harvest treatments on weight loss percentage of guava cv. 'Etmani' fruits under cold storage conditions during 2015 and 2016 seasons. Fruit weight loss percentage was increased gradually toward the end of storage period. All treatments decreased significantly weight loss% compared with untreated fruits during both seasons of this study. After 3 weeks of cold storage, fruits treated by clove oil recorded the lowest value of weight loss percentage (7.99 & 8.52%) in the two seasons, respectively. Whereas, the highest value of weight loss percentage was found in untreated fruit (14.81& 14.22 %) during 2015 and 2016 seasons, respectively. This result may be that respiration rate its high in control fruit than other treatments (Fig.1).

These results are in agreement with Wijewardana *et al*. (2014) noted the cassava starch based edible coatings and 2% rice bran + 1% sunflower oil + 1% bee wax recorded the lowest mean weight loss with respect to rice bran based coatings. The highest loss of weight was found in control. The highest moisture loss from control guava fruits might be due to the unrestricted transpiration, evaporation and respiratory losses.

Table 1: Effect of some post-harvest treatments on weight loss % of guava fruit stored at 8±1ºC and 90%RH during 2015and 2016 seasons.

Treatments	Storage period per week			Storage period per week		
	2015			2016		
	1	2	3	1	2	3
Rice starch at 1%	4.43abc	5.71 abc	9.88ab	4.86abc	6.15 abc	11.91abc
Rice starch at 3%	3.92 bc	5.46abc	11.28ab	5.05abc	6.54 abc	12.15abc
Cassava starch at 1%	3.56 bc	5.13 bc	10.53ab	4.30abc	6.10 abc	10.87abc
Cassava starch at 3%	5.59 ab	7.53 ab	13.90a	5.23ab	7.01 ab	12.50 ab
Cinnamon oil at 0.1%	3.59 bc	4.62 c	8.12b	3.78bc	5.23bc	9.66 bc
Clove oil at 0.1%	3.34 c	4.42 c	7.99 b	3.46 c	4.62c	8.52c
control	6.37 a	8.23 a	14.81a	5.68a	7.95 a	14.22a

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

Fruit decay percentage (FDP): -

Tabulated data in Table (2) it shows that, fruit decay percentage was gradually increased with the elapse of the storage period in both seasons of study. All treatments reduced decay % compared with control treatment in the both seasons. At the end of storage, the highest decay percentage was obtained by control treatment, whereas the least percentage was recorded by fruits treated with clove oil at 0.1% in the both seasons.

Phothisuwan *et al*., 2013 noted that cinnamon oil and clove oil were strongest inhibitors decay fungi. Mango fruits treated by cinnamon essential oil was recorded the minimum disease incidence and severity after 25 days of storage (Gerefa *et al*. 2015).

Table 2: Effect of some post-harvest treatments on Decay % of guava fruit stored at 8±1º C and 90%RH during 2015and 2016 seasons .

Treatments	Storage period per week			Storage period per week		
	2015			2016		
	1	2	3	1	2	3
Rice starch at 1%	0.00a	0.00b	7.53 b	0.00a	0.00b	13.67 a
Rice starch at 3%	0.00a	5.67a	13.67 a	0.00a	0.00b	6.83 bc
Cassava starch at 1%	0.00a	0.00b	7.33 b	0.00a	0.00b	5.33 c
Cassava starch at 3%	0.00a	0.00b	8.00 b	0.00a	0.00b	7.90 b
Cinnamon oil at 0.1%	0.00a	0.00b	9.08 b	0.00a	0.00b	8.00 b
Clove oil at 0.1%	0.00a	0.00b	2.00 c	0.00a	0.00b	0.00d
Control	0.00a	6.00 a	16.33 a	0.00a	5.00a	15.67 a

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

Firmness (lb/inch^2) :

Data obtained regarding fruit firmness for seasons of 2015 and 2016 are presented in Table (3) it is clear that firmness decreased with progress of storage periods in the two seasons, Yaman and Bayoindirli (2002) noticed that, the retention of firmness which occurred during storage could be explained by retarded degradation of insoluble protopectins to the more soluble pectic acid and pectin. During fruit ripening depolymerization or shortening of chain length of pectin substances occurs with an increase in pectinesterase and polygalactronase activities.

All treatments maintaining the firmness than control fruits without significant differences among all treatments in both seasons. After 3 weeks of storage, fruits were treated with Cassava starch at 1% had significantly higher in firmness fruits. The results agree with those of with Wijewardana *et al*., (2014) on guava fruits.

Generally, fruit firmness reduces due to softening of fruits by dissolving middle lamella of the cell wall (Wills *et al*., 1980). When fruits ripen, hemicelluloses become more soluble and therefore the cell wall is disrupted and loosened (Arvanitoyannis *et al*., 2005). Higher firmness was shown by treatments due to delaying of ripening.

Table 3: Effect of some post-harvest treatments on firmness (lb/inch^2) of guava fruit stored at 8±1º C and 90%RH during 2015and 2016 seasons.

Treatments	Storage period per week				Storage period per week			
	2015				2016			
	0	1	2	3	0	1	2	3
Rice starch at 1%	9.70 a	8.43 a	7.20 a	6.67 a	9.13 a	7.53a	7.03ab	6.80a
Rice starch at 3%	9.70 a	8.63 a	7.03 a	6.53 a	9.13 a	7.57a	6.93ab	6.37a
Cassava starch at 1%	9.70 a	8.77 a	7.57 a	6.70 a	9.13 a	9.07a	8.77a	7.70a
Cassava starch at 3%	9.70 a	7.70a	7.07 a	6.63 a	9.13 a	7.30a	6.50ab	6.17a
Cinnamon oil at 0.1%	9.70 a	8.47 a	8.23 a	6.37 a	9.13 a	6.93a	6.57ab	5.43a
Clove oil at 0.1%	9.70 a	6.60 a	6.37 a	5.17 a	9.13 a	7.47a	6.40ab	5.43a
Control	9.70 a	8.17 a	6.37 a	4.67 a	9.13 a	7.87a	5.50b	5.10a

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

Respiration rate (ml CO_2 /kg/hr.):-

Data in Fig. (1) indicated that respiration rate was increased gradually toward the end of storage period. All treatments decreased significantly respiration rate compared with untreated fruits during both seasons of this study. After 3 weeks of cold storage, fruits treated by Cassava starch at 1% recorded the lowest value of respiration rate in the two seasons. Whereas, the highest value of respiration rate was found in untreated fruit (21.80 & 17.21) during 2015 and 2016 seasons, respectively.

Higher respiration rate detected in control fruits could be due to post climacteric decline and skin dryness preventing the exchange of gases. Reduced respiration rate observed in polyethylene packed fruit, as per previous study could be consequence of O_2 depletion and CO_2 accumulation in pack as polyethylene prevented the moisture loss, maintained the turgidity and modified the atmosphere around the fruit (Seema *et al*., 2015).

Fruit color:

Lightness (L):*

Results in Table (4), show that lightness (L*) was gradually decreased towards at the end of the storage period (after 3 weeks). At the end of storage period, Cassava starch at 1% treatment gave the highest values of L* in the first and second seasons. On the other hand, control treatment exhibited the lowest value of L*, without significant differences in all treatments.

Hue angle (hº value):

Results in Table (5) show that hue angle (hº) was decreased (increase density of yellow color) with the advance in cold storage period. At the end of storage period, no significant differences between all treatments were observed in the two seasons. Fruits treated by Rice starch at 1% gave the lowest value of hº (high density of yellow color) in the two seasons. On the other hand, the highest values were recorded with fruits treated by Clove oil at 0.1% and Cinnamon oil at 0.1% in first and second seasons, respectively.

This result agrees with Vila *et al*. (2007) noted that the biofilm at the concentration of 3 and 4% of cassava starch was more effective in delaying the ripening of guavas. Also, Wijewardana *et al*., (2014) on guava fruits.

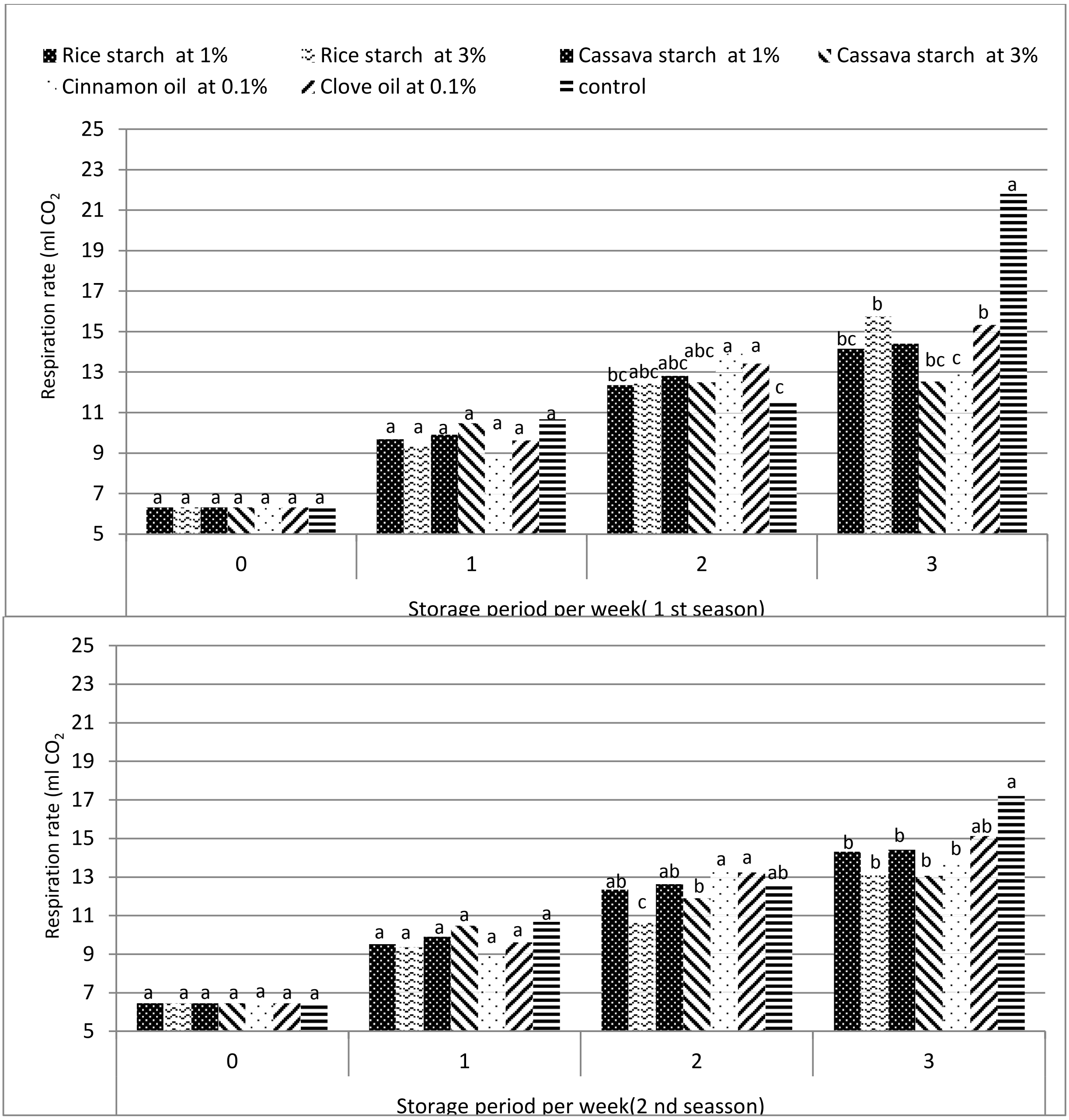

Fig.1: Effect of some post-harvest treatments on Respiration rate (ml CO_2 /kg/hr.) of guava fruit stored at 8±1º C and 90%RH during 2015and 2016 seasons .

Table 4: Effect of some post-harvest treatments on Lightness (L*) of guava fruit stored at 8±1º C and 90%RH during 2015and 2016 seasons.

Treatments	Storage period per week				Storage period per week			
	2015				2016			
	0	1	2	3	0	1	2	3
Rice starch at 1%	73.11 a	70.6 a	66.3 b	65.4 a	72.36 a	70.7 a	68.2 a	68.0 a
Rice starch at 3%	73.11 a	72.2 a	67.9 ab	63.6 a	72.36 a	71.5 a	66.7 a	61.9 a
Cassava starch at 1%	73.11 a	72.8 a	71.6 a	70.4 a	72.36 a	71.8 a	71.1 a	70.3 a
Cassava starch at 3%	73.11 a	70.3 a	69.2 ab	68.2 a	72.36 a	70.7 a	70.3 a	69.9 a
Cinnamon oil at 0.1%	73.11 a	72.1 a	69.52 ab	67.0 a	72.36 a	72.4 a	69.2 a	66.1 a
Clove oil at 0.1%	73.11 a	70.3 a	66.8 ab	63.4 a	72.36 a	70.8 a	67.4 a	63.9 a
control	73.11 a	68.3 a	66.8 ab	62.0 a	72.36 a	68.4 a	65.9 a	61.2 a

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

Table 5: Effect of some post-harvest treatments on Hue angle (hº) of guava fruit stored at 8±1º C and 90%RH during 2015and 2016 seasons.

Treatments	Storage period per week				Storage period per week			
	2015				2016			
	0	1	2	3	0	1	2	3
Rice starch at 1%	95.18a	88.02 b	87.38b	86.75 a	94.31a	88.71b	86.82b	84.93a
Rice starch at 3%	95.18a	94.01a	91.31a	88.60a	94.31a	91.07ab	89.47ab	87.88a
Cassava starch at 1%	95.18a	90.16ab	89.04ab	87.92a	94.31a	89.34b	88.42ab	87.49a
Cassava starch at 3%	95.18a	87.53b	87.15b	86.77a	94.31a	90.56ab	89.74ab	88.91a
Cinnamon oil at 0.1%	95.18a	90.23ab	90.27ab	90.25 a	94.31a	90.35ab	90.69a	91.03a
Clove oil at 0.1%	95.18a	93.19a	91.88a	90.56a	94.31a	93.24 a	91.23a	89.20a
Control	95.18a	88.95b	88.94ab	88.94a	94.31a	90.90ab	89.91 ab	88.90a

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

Chemical characteristics:

Soluble solids content (SSC %):

It is clear from the results in Table (6) that, soluble solid content of fruits was gradually increased with the advance in cold storage. Fruits treated with cinnamon oil at 0.1% recorded the highest SSC% in the two seasons, while rice starch at 3% treatment exhibited the least percentage in the two seasons. There was a significant difference between the treatments during the storage periods in the two seasons of the study.

Our results are in line with Wijewardana *et al*., (2014) on guava fruits, they reported that TSS has increased with the time, which is due to the hydrolysis of starch to simple (soluble) sugars higher during fruit ripening. Rate of increase in TSS under coating treatment may be due to delaying of ripening. The coating treatments by starch had higher effect in maintaining of SSC% probably due to edible coating film that may have formed on the surface of the fruits and barrier to moisture loss, thus delaying dehydration and improves quality.

Excessive increase in TSS observed in control fruits indicates quality deterioration, may be attributed to the utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits or due to breakdown of complex polymer into simple sugars by hydrolytic enzymes which might be further metabolized during respiration and level decreased during subsequent storage. Combined effect of Packaging and low temperature regime reduced the respiration rate and retards compositional changes such as TSS and TA. Similarly delayed increase in TSS in individually packed 'Kinnow^ (HDPE of 0.1 μ thickness) and tomatoes (LDPE film) stored at ambient (12±1 °C, 90–95 % RH) condition was reported with minimum rotting, maximum palatability rating and maintained acidity without much deterioration in quality (Seema *et al*., 2015).

Table 6: Effect of some post -harvest treatments on SSC % of guava fruit stored at 8±1º C and 90%RH during 2015and 2016 seasons .

Treatments	Storage period per week				Storage period per week			
	2015				2016			
	0	1	2	3	0	1	2	3
Rice starch at 1%	7.8 a	9.2a	9.6 a	10.3 b	8.6 a	9.9 a	10.1 a	11.3 abc
Rice starch at 3%	7.8 a	9.2 a	9.3 a	10.2 b	8.6 a	9.2 a	9.9 a	10.2 c
Cassava starch at 1%	7.8 a	8.9 a	9.1 a	11.2 ab	8.6 a	9.3 a	9.8 a	11.4abc
Cassava starch at 3%	7.8 a	10.3 a	10.3 a	10.7 ab	8.6 a	9.9 a	10.4 a	11.0 bc
Cinnamon oil at 0.1%	7.8 a	8.2 a	9.4 a	12.6 a	8.6 a	9.2 a	9.3 a	12.4 a
Clove oil at 0.1%	7.8 a	8.8 a	9.2 a	11.7 ab	8.6 a	8.9 a	9.5 a	11.7 ab
Control	7.8 a	8.7 a	9.3 a	11.3 ab	8.6 a	8.6 a	9.2 a	11.9ab

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

Titratable acidity percentage (TA):

Data in Table (7) revealed that titratable acidity% increased with the progress in storage period up to 2 weeks, then decreased. There were significant differences between the all used treatments in the most cases.

The obtained results agreed partially with those reported by Siddiqui *et al.* (1991) ,Korany *et al.* (2005) and Alana *et al.*(2015)., they noted that acidity increased progressively according to the length of storage period in all postures of guava fruits.

The decrease in acidity and increase in pH during storage may be due to the use of organic acid as respiratory substrates during storage and conversion of acid into sugars (Keditsu, *et al*., 2003). After 3 weeks, the highest values (0.181 and 0.170 %) were recorded by fruits treated with Rice starch at 1% in the two seasons, respectively. On the other hand clove oil at 0.1% and control treatments gave the least percentages in acidity in the both seasons.

The decrease of acidity during storage is due to the utilization of these compounds as respiratory substrates, and as carbon skeletons (from their carboxyl groups) for the synthesis of new compounds (e.g., flover compounds) (El-Anany and Hassan, 2012) .

Table 7: Effect of some post-harvest treatments on Titratable acidity of guava fruit stored at 8±1º C and 90%RH during 2015and 2016 seasons.

Treatments	Storage period per week				Storage period per week			
	2015				2016			
	0	1	2	3	0	1	2	3
Rice starch at 1%	0.096 a	0.128 ab	0.128 a	0.181 a	0.107 a	0.138 a	0.128 a	0.170 a
Rice starch at 3%	0.096 a	0.129 ab	0.139 a	0.117 b	0.107 a	0.149 a	0.128 a	0.106 b
Cassava starch at 1%	0.096 a	0.096 b	0.107 a	0.117 b	0.107 a	0.128 a	0.117 a	0.117 ab
Cassava starch at 3%	0.096 a	0.139 ab	0.139 a	0.117 b	0.107 a	0.117 a	0.128 a	0.096 b
Cinnamon oil at 0.1%	0.096 a	0.160 a	0.128 a	0.107 b	0.107 a	0.128 a	0.128 a	0.117 ab
Clove oil at 0.1%	0.096 a	0.128 ab	0.139 a	0.085 b	0.107 a	0.128 a	0.149 a	0.085 b
Control	0.096 a	0.107 ab	0.128 a	0.096 b	0.107 a	0.107 a	0.096 a	0.085 b

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

Vitamin C Content (mg/ 100 ml juice):

Data presented in Table (8) showed that vitamin c (mg/100ml) increased with the progress in storage period. The high contents of vitamin c was obtained by Rice starch and Cassava starch treatments at 1% with slight significant differences between them in the first season, but with no significant differences between them in the second season. On the other hand, control fruit treatment exhibited the least value of vitamin c (96.3 and 90.0 mg/100ml.juice) in the two seasons, respectively.

In this respect, El-Anany and Hassan (2012) noted that vitamin c content increased of guava fruits with progress in ripening might be due to the breakdown of starch to glucose which increases the biosynthesis of ascorbic acid (Lim *et al*., 2006).

Table 8: Effect of some post-harvest treatments on Vitamin C (mg/100ml) of guava fruit stored at 8±1º C and 90% RH during 2015and 2016 seasons.

Treatments	Storage period per week				Storage period per week			
	2015				2016			
	0	1	2	3	0	1	2	3
Rice starch at 1%	73.0 a	80.0 a	98.0 a	130.0a	70.7 a	90.0 a	89.3 ab	130.0 a
Rice starch at 3%	73.0 a	83.3 a	87.2 b	96.7 b	70.7 a	76.7 c	73.3 c	120.0 ab
Cassava starch at 1%	73.0 a	73.3 b	90.5 ab	120.0ab	70.7 a	95.0 a	94.3 a	130.0 a
Cassava starch at 3%	73.0 a	76.3 ab	88.0b	110.0b	70.7 a	80.7 b	81.0 bc	103.0 bc
Cinnamon oil at 0.1%	73.0 a	76.7 ab	88.0b	110.0 b	70.7 a	72.0 c	94.3 a	110.0 b
Clove oil at 0.1%	73.0 a	74.0 b	93.0ab	115.0 ab	70.7 a	74.7 c	74.3 c	91.2 c
control	73.0 a	85.0 a	87.3b	96.3 b	70.7 a	77.3 c	84.3 b	90.0 c

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

Shrink and cling wrapping retained 60–65%of original ascorbic acid as compared to 48 % retention in control fruits could be due to modified atmosphere (reduced O_2 concentration) around the fruits which slowed down the enzymatic oxidation of ascorbic acid and phenols to dehydroascorbic acid. More retention of ascorbic acid and polyphenols in wrapped fruits could be related to slow increase in PPO activity over control fruits (Seema *et al*., 2015).

Total pectin content (g/100 g fresh weight):-

Data tabulated in Table (9) declared the effect of some post-harvest treatments on total pectin% of guava fruits stored at 8±1ºC and 90 % RH, during 2015 and 2016 seasons.

It is clear that, all used treatments increased total pectin% than the control fruits. However, total pectin% increased with the advance in cold storage period. Increase in pectin content during fruit development might be due to conversion of other forms of pectin into water soluble form of pectin and in later stage the decrease in pectin could be due to enzymatic degradation of pectin with advanced ripening (Patel *et al*. 2013).

Data showed also that Cassava starch at 1% and Clove oil at 0.1% treatments gave higher pectin values in the first and second seasons, respectively with slight differences between them. On the other hand, control fruits treatment exhibited the least value in both seasons.Coatings significantly decreased the rate of pectin degradation and therefore, enabling the fruit to retain higher pectin content during storage (Wijewardane and Gularia2009).

These results agree with Wijewardana *et al*., (2014) noted that guava fruits coated by 1% cassava starch +1% sun flower oil gave the highest mean of pectin content.

Table 9: Effect of some post -harvest treatments on Total pectin% of guava fruit stored at 8±1º C and 90%RH during 2015and 2016 seasons.

Treatments	Storage period per week				Storage period per week			
	2015				2016			
	0	1	2	3	0	1	2	3
Rice starch at 1%	0.75a	0.82cd	1.12 a	1.15 ab	0.61a	0.95 a	0.98a	1.12 ab
Rice starch at 3%	0.75a	0.81d	0.85 d	1.06 cd	0.61a	0.81 b	0.90a	1.06 bc
Cassava starch at 1%	0.75a	0.93b	0.95 c	1.17 a	0.61a	0.92 a	1.01a	1.19 ab
Cassava starch at 3%	0.75a	1.03 a	1.03b	1.16 a	0.61a	0.97a	1.00a	1.16 ab
Cinnamon oil at 0.1%	0.75a	0.90 b	0.98 bc	1.06 cd	0.61a	0.86b	1.00a	1.15 ab
Clove oil at 0.1%	0.75a	0.89 b	0.96 c	1.10 bc	0.61a	0.71 c	0.82a	1.25 a
control	0.75a	0.87 bc	0.89 d	1.02 d	0.61a	0.73c	1.00a	0.92 c

Values followed by the same letter (s) in each period are not significantly different at 5 % level.

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