The Pharma Innovation Journal 2022; 11(9): 1812-1820

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 1812-1820

www.thepharmajournal.com
Received: 01-06-2022
Accepted: 03-07-2022

Archit Singh
Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

BK Singh
Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Kalyan Barman
Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Anand Kumar Singh
Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Corresponding Author:
Archit Singh
Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Effect of edible coating and packaging on ripening behaviour and keeping quality of guava fruits

Archit Singh, BK Singh, Kalyan Barman and Anand Kumar Singh

Abstract
Guava (*Psidium guajava* L.) is the most important fruit crop in India, which has a limited shelf life after harvest. This study investigated the use of some post-harvest treatments to increase shelf life, reduce decay incidence, and evaluate the physico-chemical changes of fruit during storage. Guava is grown extensively in Uttar Pradesh and sometimes causes a glut in the local market. The fruit growers have insufficient facilities to increase the shelf life of guava fruits. The processing and storage of fruits at the point of production is the only solution for the economical disposal of this marketable surplus to ensure reasonable returns for producers as well as reasonable prices for consumers. An experiment was conducted in the Post-harvest laboratory, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U. P.) in 2020–21 to investigate the combined effect of edible coating and packaging on ripening behaviour and keeping quality of guava fruits under ambient conditions. The experiment was designed in a factorial completely randomized design with three replicates for each treatment at 3-day intervals under ambient conditions. The results of the present studies revealed that the physiological mature fruits treated with CMC (1.5%) + Shrink film packaging were most effective in delaying physiological weight loss and reduction of total soluble solids, total chlorophyll, ascorbic acid, total antioxidant capacity, total phenolics, decay loss, and retained marketability of fruits up to a later stage of storage. Thus, the combination of edible coatings with packaging can be used to improve shelf life and maintain the post-harvest quality of guava fruits. The results of this study will be very helpful for farmers to minimize post-harvest losses and long-distance marketing of guava fruits. Furthermore, it will also be beneficial to consumers due to the extended storage life.

Keywords: CMC, postharvest quality, shelf life, packaging, guava

Introduction
The guava (*Psidium guajava* L.) fruit is a native of tropical America, belongs to the family Myrtaceae, and is the fifth most important tropical fruit crop. It is grown throughout the tropical and sub-tropical regions. Records indicate that it has been cultivated in India since the early 17th century and has gradually become a crop of commercial importance, considered the apple of the tropics. Guava is a rich source of vitamin-C (100 to 160 mg/100 g FW) and pectin. The fruit has a significant amount of minerals such as phosphorus (23 to 37 mg/l00 g FW), calcium (14-30 mg/100 g FW), iron (0.6 to 1.4 mg/l00 g FW) and vitamins such as niacin, pantithenic acid, thiamine, riboflavin and Vitamin-A (Paul and Goo, 1983). It is usually eaten fresh as table fruit or processed and formed into puree, juice, concentrate, jam, jelly, nectar, or syrup and does not lose Vitamin-C in the preserved form. Guava fruits are best relished when perfectly mature and freshly picked from the tree. It gives off a sweet aroma that is pleasantly sweet and refreshingly acidic in flavour. It is fully edible along with the skin, which is papery and almost melds with the pulp. The guava is considered one of the most delicious fruits. Guava fruits are climacteric with high respiration rates and usually ripen within 7 days at 20 °C (Campbell, 1994) [7].
Guava showed a typical increase in respiration and ethylene production during ripening. Guava, because of its high moisture content (83%), is inherently more, susceptible to deterioration. In order to extend the shelf life of guava, it is necessary to control the rate of respiration, transpiration, ripening, any undesirable physiological and biochemical changes, and disease infection. Post-harvest treatments are very important to avoid post-harvest losses by increasing the shelf-life and preserving the fruit quality. Various means, such as cold storage, skin coating with wax, growth regulator and chemical treatments, packaging materials, ethylene absorbent, are used to extend the shelf life of guava. Since the response of guava fruits to these treatments varies depending on the variety and storage conditions, it may

be necessary to find a suitable technology to extend the shelf life of guava fruits. Shrink film and CFB boxes are readily available packaging materials in local markets, along with edible coating, showed the best results for reducing shrinkage, protecting the produce from the incidence of fungal disease and reducing mechanical damage. The use of shrink wrap with polymer film has a major benefit in reducing moisture loss from the fruit and provides a good surface for adhesive labels. It also protects the fruit from some damage by abrasion during transport. Very little is known about the behaviour of guava fruits in real storage conditions. There is a need for more research into post-harvest treatments for extending the shelf-life of guava.

Materials and Methods

Fresh, fully mature, and uniform fruits of guava cv. Lalit were procured from a commercial orchard in Varanasi. All the dirt and other extraneous materials from the fruits were removed. The fruits were washed with tap water and allowed to dry. After discarding the diseased, spotted, and bruised fruits, the fruits were placed in different lots. The fruits were then disinfected with a 2% sodium hypochlorite solution for 2 minutes. They were then air-dried and treated with aqueous solutions of carboxymethyl cellulose and sodium alginate (1.5% w/v) by immersing the fruit in treatment solutions for 5 minutes. The control fruits were dipped in distilled water for the same time. After air-drying at room temperature, the fruits were packed in corrugated fiber board (CFB) boxes and shrink film, respectively, and stored at room temperature. The experiment was designed in a factorial completely randomized design with replicated thrice for each treatment at 3 day interval during storage at ambient conditions.

Analytical methods

Weight loss

The weight of guava fruits under each treatment was recorded at 3 days interval during storage and physiological loss in weight (PLW) of fruit was calculated with the help following of formula.

$$\text{Physiological loss in weight (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where,

W_1 = Initial weight of fruits

$_2$ = Weight of fruit at the sampling day

Decay loss

Decay loss was assessed on the basis of the appearance of symptoms of fungal growth or rotting, irrespective of the severity. The results were expressed in per cent (%) and calculated by using the given formula.

$$\text{Decay loss (\%)} = \frac{\text{Number of fruit decayed at 0, 3}^{rd}\text{, 6}^{th}\text{, 9}^{th}\text{ and 12}^{th}\text{ days of storage}}{\text{Total number of fruits under observation at the beginning of storage}} \times 100$$

Total soluble solids (TSS)

Total soluble solids (TSS) content of guava fruit during storage was determined using digital refractometer (Atago, Tokyo, Japan) and expressed as degree brix (ºBrix).

Titratable acidity

Titratable acidity was estimated following titration method (AOAC, 2000) [1]. For this, 2.0 g of fruit sample was homogenized in distilled water and the volume of the sample was adjusted to 10 ml. After homogenization, titration of the sample was done against 0.1 N sodium hydroxide solution after adding 2-3 drops of phenolphthalein solution till pink colour appeared. The titer value was then recorded and titratable acidity was calculated using the following formula. Finally, the results were expressed as per cent citric acid.

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value} \times \text{Normality of alkali} \times \text{Vol. made up} \times \text{Equivalent wt. of citric acid} \times 100}{\text{The volume of sample taken for estimation} \times \text{Wt. or vol. of the sample taken} \times 1000}$$

Total Chlorophyll and total carotenoids content

The Quantitative estimation of total chlorophyll content was carried out by the method of Arnon (1949) [3], while total carotenoids content were determined by following method of Duxbury and Yentsch (1956). The quantitative determination of chlorophyll and carotenoids in certain whole pigment extract depends mostly on solvent system. Herein, samples (1.0 g) were extracted with 10 ml of 80% acetone until pellets were colourless. Sample was then centrifuged at 10,000 rpm for 10 minutes. After centrifugation, the absorbance (O.D.) of this extracted solution was measured at 480, 510, 645 and 663 nm. From these readings concentrations of chlorophyll and carotenoid pigment was determined using the following formula/equation:

$$\text{Total chlorophyll content (mg/g FW)} = \frac{\{20.2\ (A_{645}) + 8.02\ (A_{663})\} \text{ x V}}{1000} \text{ x W}$$

$$\text{Total carotenoids content (mg/g FW)} = \frac{\{7.6\ (A_{480}) - 1.49\ (A_{510})\} \text{ x V}}{1000} \text{ x W}$$

Where,

A = Absorbance at specific wavelengths

V = Final volume of chlorophyll extract in 80% acetone

W = Fresh weight of samples.

Lycopene content

Lycopene content was measured by spectrophotometric method (Ravelo-Perez *et al*., 2008) [33]. For determining the lycopene content, 1.0 g of pulp was ground with 50 mL of hexane-ethanol-acetone (2:1:1, v/v). The extract was taken in separating funnel in which 10 mL of distilled water was added. Upon separation of phases after 5 min, lower phase was discarded. After filtration, the absorbance of upper phase was recorded at 503 nm with hexane as blank and using a UV–vis spectrophotometer and result was expressed in µg/g. The final equation derived and used was:

Lycopene (µg/g FW) = (A_{503} x 31.2)/mass of sample (g)

Where,

A_{503} is the absorbance at 503nm and 3.12 is the extinction coefficient.

Ascorbic acid content

The method of Jones and Hughes (1983) [21] was used to

estimate the ascorbic acid content in guava fruit. For this, 10 g of fruit sample was crushed with 3% metaphosphoric acid (HPO_3) solution and then the volume of the sample was made up to 100 ml with 3% metaphosphoric acid solution. 10 ml of sample was taken from this and titrated against the 2, 6-dichlorophenol indophenol dye till pink colour appeared which persisted for 15 seconds. The titre value was then recorded and the ascorbic acid content of fruit was calculated using the following formula. Finally, the results of ascorbic acid content were expressed as mg/100 g FW.

$$\text{Ascorbic acid content (mg/100 g FW)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up x 100}}{\text{Aliquot of extract taken for estimation} \times \text{Weight or volume of sample for estimation}}$$

Total phenolics content

The total phenolics content of guava fruit was estimated by the method of Singleton *et al.* (1999) [39]. To do this, 2.0 g of fruit sample was mixed with 10 ml of 80% ethanol. Then, the homogenate was centrifuged at 10,000 rpm for 10 minutes and the supernatant was used for estimating the total phenolics content. After that, 100 µl of sample extract was added to 2.9 ml of distilled water and 0.5 ml of 1 N Folin-ciocalteau reagent. After 3 minutes, 2 ml of 20% of sodium carbonate solution was added into it. The solution was then kept for 90 minutes and after that absorbance was recorded at 760 nm in a spectrophotometer. Gallic acid was used to produce a standard calibration curve. The total phenolics content of guava fruit was expressed as milligram of gallic acid equivalent per 100 gram of fresh weight (mg GAE/100 g FW).

$$\text{Total phenols content (mg GAE/100 g FW)} = \frac{OD_{760} \times \text{Volume made up (with 80\% ethanol)} \times 100}{\text{Aliquot taken} \times \text{weight of sample} \times 1000}$$

Total antioxidant capacity (CUPRAC assay)

Total antioxidant capacity was determined following CUPRAC (Cupric ion reducing antioxidant capacity) assay (Apak *et al.*, 2008) [2]. In this, 0.1 ml of sample extract (in 80% ethanol) was added to 1 ml each of copper (II) chloride solution, neocuproine solution, ammonium acetate buffer solution and distilled water in a test tube. The mixture was then allowed to stand for 30 minutes and the absorbance was recorded at 450 nm in a Spectrophotometer (Model BGS – 305, make Biogen Scientific). The results were expressed as µmol trolox equivalent/ g FW.

$$\text{Total antioxidant capacity (µmol TE/ g FW)} = \frac{OD_{450} \times 4.1 \times \text{Volume made up}}{\text{Weight of sample} \times 1.67 \times 1000 \times 0.1}$$

Statistical design and analysis of data

The experiment was laid out in factorial CRD design with three replications per treatment. In this study, the data obtained from the experiment under different treatments in respect to various parameters during storage were subjected to analysis of variance (ANOVA) with treatments and storage duration as sources of variation. Values of different parameters were expressed as the mean ± standard error. Mean comparison among treatments were performed using the HSD Tukey's test. A difference was considered statistically significant when the p-value was less than 0.05 ($p \leq 0.05$). All analyses were performed with IBM SPSS Statistics 26.

Result and Discussion

The results obtained from the present investigation as well as the relevant discussion were presented under the following headings:

Weight loss

In all treatments, the percentage of weight lost increased significantly as the storage period was extended. However, from 3 days onwards, a significant difference in weight loss was recorded between control and treated fruits with CMC and SA, in combination with shrink film and CFB box packaging. After 12 days of storage, the fruits treated with CMC (1.5%) + shrink film packaging found a minimum weight loss (10.87%), followed by in SA (1.5%) + shrink film packaging (15.86%), which was statistically at par with CMC (1.5%) + CFB box packaging, followed by SA (1.5%) + CFB box packaging (20.68%), whereas the maximum weight loss (31.68%) was observed in control (without treatment and packaging). The weight loss in fresh fruit is mostly due to water loss caused by transpiration and respiration processes. The rate at which water is lost depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere and the storage temperature. Edible coatings, along with packaging, act as a protective barrier to reduce respiration and transpiration rates through fruit surfaces (Kester and Fennema, 1986) [22], and protect the fruit skin from mechanical injuries, as well as close small wounds and thus delay dehydration. The results have been reported by Pandey *et al.* (2010) [31] and Dutta *et al.* (2017) [10] in guava fruits, Bhadra *et al.* (1999) [5] in ber fruits, Nair *et al.* (2017) [29] in pomegranates, and Nasrin *et al.* (2018) [30] in Mandarin fruits.

Decay loss

In this experiment, results revealed that decay loss in guava fruits showed an increasing trend with an increasing period of storage up to 12 days. After 3 days of storage, no symptoms of decay were observed in any of the treated or control fruits. Thereafter, control guava fruits exhibited a pronounced increase in decay loss as compared to other treatments. After 12 days of storage, the treatment combination of CMC (1.5%) + shrink film packaging (11.11%) was found most effective in reducing decay loss up to 12 days of storage, followed by SA (1.5%) + shrink film packaging (13.88%), which was statistically at par with CMC (1.5%) + CFB box packaging, followed by SA (1.5%) + CFB box packaging (22.22%), which was statistically at par with shrink film packaging without treatment. Whereas the highest decay loss (36.11%) was observed in control (without treatment and packaging), which was statistically at par with CFB box packaging without treatment. The decay percentage is very important for any perishable commodity. Guava fruits undergo rapid softening within a few days of storage due to ripening. They become susceptible to attack by various disease-causing microorganisms, which are responsible for rapid decay. The edible coating maintained a low concentration of oxygen and a high concentration of carbon dioxide in the atmosphere surrounding the fruit. Similarly, low-oxygen atmospheres also have a negative effect on germination and growth of phytopathogenic fungi (Wells and Uota, 1970; Barkai-Golan, 1990) [42, 4]. Additionally, coating prevented loss of integrity of the cell wall, reduced spoilage by reducing the leakage of electrolytes (Diaz-Sobac *et al.*, 1997) [9]. Fruit decay may be

caused by fungi. Rot turns fruits mushy, and affected fruits have foul odours as a result of their underlying biochemical changes. Similar outcome of results were recorded by Nasrin *et al*., (2018) [30], Farahi (2015) [12], Gad and Zagzog (2017) [13] and Singh *et al*., (2017) [38] in mandarin, grapes and guava fruits, respectively.

Total soluble solids: Results revealed that the total soluble solids of guava fruits increased slowly up to 9 days of storage and then decreased gradually up to the end of storage. The total soluble solids of the guava fruits significantly influence by various post-harvest treatments. After 9 days of storage, among the different treatments, the maximum total soluble solids (13.05 °Brix) was exhibited in CMC (1.5%) + Shrink film packaging, which was statistically at par with SA.

Table 1: Effect of edible coating and packaging on weight loss (%) of guava fruits during storage at ambient condition.

Treatments	Weight loss (%)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	0	5.29 ± 0.47 cd	10.02 ± 0.89 c	14.48 ± 0.48 de	18.52 ± 0.51 de
CMC (1.5%) + Shrink film packaging	0	2.83 ± 0.21 e	5.12 ± 0.30 d	7.49 ± 0.34 f	10.87 ± 0.76 f
SA (1.5%) + CFB box packaging	0	5.71 ± 0.22 cd	10.15 ± 0.36 c	15.14 ± 0.35 d	20.68 ± 0.32 cd
SA (1.5%)+ Shrink film packaging	0	4.84 ± 0.45 d	8.78 ± 0.53 c	12.73 ± 0.58 e	15.86 ± 0.32 e
CFB box packaging without treatment	0	8.51 ± 0.43 ab	14.83 ± 0.24 ab	20.91 ± 0.44 b	26.94 ± 0.47 b
Shrink film packaging without treatment	0	6.96 ± 0.37 bc	13.00 ± 0.26 b	18.13 ± 0.40 c	23.06 ± 0.38 c
Control (Without treatment and packaging)	0	9.52 ± 0.52 a	16.74 ± 0.73 a	23.59 ± 0.51 a	31.68 ± 1.45 a

Table 2: Effect of edible coating and packaging on decay loss (%) of guava fruits during storage at ambient condition.

Treatments	Decay loss (%)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	0	0	0	11.11 ± 2.78 bc	19.44 ± 2.78 bcd
CMC (1.5%) + Shrink film packaging	0	0	0	5.55 ± 2.78 c	11.11 ± 2.78 d
SA (1.5%) + CFB box packaging	0	0	0	13.88 ± 2.78 ab	22.22 ± 2.78 bc
SA (1.5%) + Shrink film packaging	0	0	0	5.55 ± 2.78 c	13.88 ± 2.78 cd
CFB box packaging without treatment	0	0	5.55 ± 2.78 b	19.44 ± 2.78 ab	30.55± 2.28 ab
Shrink film packaging without treatment	0	0	0	11.11 ± 5.55 bc	27.77 ± 5.56 abc
Control (Without treatment and packaging)	0	0	11.11 ± 5.55 a	27.77 ± 2.78 a	36.11 ± 2.78 a

Table 3: Effect of edible coating and packaging on total soluble solids (°Brix) of guava fruits during storage at ambient condition.

Treatments	Total soluble solids (°Brix)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	12.25 ± 0.62 a	12.61 ± 0.03 a	12.74 ± 0.19 a	12.83 ± 0.27 a	12.70 ± 0.09 a
CMC (1.5%) + Shrink film packaging	12.25 ± 0.62 a	12.71 ± 0.25 a	12.82 ± 0.14 a	13.05 ± 0.29 a	12.87 ± 0.20 a
SA (1.5%) + CFB box packaging	12.25 ± 0.62 a	12.56 ± 0.41 a	12.69 ± 0.09 a	12.76 ± 0.37 a	12.78 ± 0.10 a
SA (1.5%)+ Shrink film packaging	12.25 ± 0.62 a	12.68 ± 0.26 a	12.78 ± 0.12 a	12.98 ± 0.13 a	12.80 ± 0.12 a
CFB box packaging without treatment	12.25 ± 0.62 a	12.47 ± 0.34 a	12.62 ± 0.29 a	12.68 ± 0.27 a	12.52 ± 0.06 ab
Shrink film packaging without treatment	12.25 ± 0.62 a	12.49 ± 0.15 a	12.66 ± 0.18 a	12.71 ± 0.23 a	12.58 ± 0.12 ab
Control (Without treatment and packaging)	12.25 ± 0.62 a	12.41 ± 0.09 a	12.54 ± 0.31 a	12.59 ± 0.15 b	12.42 ± 0.22 b

Table 4: Effect of edible coating and packaging on titratable acidity (%) of guava fruits during storage at ambient condition.

Treatments	Titratable acidity (%)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	0.54 ± 0.03 a	0.47 ± 0.05 a	0.41 ± 0.09 a	0.35 ± 0.04 a	0.32 ± 0.04 a
CMC (1.5%) + Shrink film packaging	0.54 ± 0.03 a	0.51 ± 0.04 a	0.45 ± 0.05 a	0.41 ± 0.04 a	0.38 ± 0.03 a
SA (1.5%) + CFB box packaging	0.54 ± 0.03 a	0.44 ± 0.03 a	0.38 ± 0.07 a	0.33 ± 0.05 a	0.29 ± 0.04 a
SA (1.5%)+ Shrink film packaging	0.54 ± 0.03 a	0.48 ± 0.03 a	0.42 ± 0.04 a	0.36 ± 0.04 a	0.34 ± 0.04 a
CFB box packaging without treatment	0.54 ± 0.03 a	0.41 ± 0.05 a	0.35 ± 0.05 a	0.29 ± 0.02 a	0.23 ± 0.04 a
Shrink film packaging without treatment	0.54 ± 0.03 a	0.42 ± 0.04 a	0.37 ± 0.06 a	0.30 ± 0.07 a	0.26 ± 0.05 a
Control (Without treatment and packaging)	0.54 ± 0.03 a	0.39 ± 0.02 a	0.33 ± 0.05 a	0.27 ± 0.03 a	0.22 ± 0.02 a

Values are mean ± standard error of three replicate determinations (n=3). According to HSD Tukey's test, values in the same column with different letters are significantly different (p<0.05).

Table 5: Effect of edible coating and packaging on total chlorophyll content (mg/100 g FW) of guava fruits during storage at ambient condition.

Treatments	Total Chlorophyll content (mg/100 g FW)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	7.72 ± 0.11 a	6.43 ± 0.43 a	5.43 ± 0.51 ab	4.61 ± 0.30 abc	3.50 ± 0.10 bc
CMC (1.5%) + Shrink film packaging	7.72 ± 0.11 a	6.91 ± 0.53 a	6.37 ± 0.38 a	5.25 ± 0.24 a	4.73 ± 0.30 a
SA (1.5%) + CFB box packaging	7.72 ± 0.11 a	6.20 ± 0.51 a	5.15 ± 0.47 ab	4.11 ± 0.29 abcd	3.28 ± 0.19 bc
SA (1.5%)+ Shrink film packaging	7.72 ± 0.11 a	6.72 ± 0.47 a	6.02 ± 0.37 ab	5.03 ± 0.23 ab	4.17 ± 0.21 ab
CFB box packaging without treatment	7.72 ± 0.11 a	5.75 ± 0.25 a	4.61 ± 0.21 ab	3.51 ± 0.33 cd	2.48 ± 0.15 cd
Shrink film packaging without treatment	7.72 ± 0.11 a	5.94 ± 0.38 a	4.93 ± 0.36 ab	3.93 ± 0.19 bcd	2.94 ± 0.11 cd
Control (Without treatment and packaging)	7.72 ± 0.11 a	5.58 ± 0.22 a	4.36 ± 0.19 b	3.30 ± 0.23 d	2.26 ± 0.38 d

Table 6: Effect of edible coating and packaging on total carotenoids content (mg/100 g FW) of guava fruits during storage at ambient condition.

Treatments	Total carotenoids content (mg/100 g FW)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	52.67 ± 5.61 a	78.41 ± 9.17 a	97.73 ± 6.01 ab	116.72 ± 5.75 ab	125.47 ± 04.74 ab
CMC (1.5%) + Shrink film packaging	52.67 ± 5.61 a	68.42 ± 7.51 a	86.86 ± 6.27 b	97.59 ± 2.82 b	109.05 ± 14.57 b
SA (1.5%) + CFB box packaging	52.67 ± 5.61 a	81.13 ± 5.56 a	99.57 ± 2.88 ab	119.15 ± 2.52 ab	128.46 ± 07.68 ab
SA (1.5%)+ Shrink film packaging	52.67 ± 5.61 a	73.32 ± 7.44 a	94.36 ± 3.49 ab	110.68 ± 5.16 b	117.87 ± 10.08 b
CFB box packaging without treatment	52.67 ± 5.61 a	87.47 ± 6.67 a	105.74 ± 6.83 ab	126.73 ± 5.12 ab	143.54 ± 03.98 a
Shrink film packaging without treatment	52.67 ± 5.61 a	83.42 ± 8.32 a	102.31 ± 5.57 ab	123.81 ± 3.50 ab	136.77 ± 05.15 ab
Control (Without treatment and packaging)	52.67 ± 5.61 a	92.06 ± 3.27 a	119.81 ± 4.64 a	136.29 ± 4.86 a	149.88 ± 08.79 a

Values are mean ± standard error of three replicate determinations (n=3). According to HSD Tukey's test, values in the same column with different letters are significantly different (p<0.05).

Table 7: Effect of edible coating and packaging on lycopene content (mg/100g FW) of guava fruits during storage at ambient condition.

Treatments	Lycopene content (mg/100 g FW)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	0.11 ± 0.01 a	0.20 ± 0.02 a	0.34 ± 0.02 ab	0.53 ± 0.03 ab	0.66 ± 0.07 ab
CMC (1.5%) + Shrink film packaging	0.11 ± 0.01 a	0.17 ± 0.01 a	0.29 ± 0.03 b	0.44 ± 0.02 b	0.59 ± 0.04 b
SA (1.5%) + CFB box packaging	0.11 ± 0.01 a	0.21 ± 0.01 a	0.38 ± 0.02 ab	0.56 ± 0.03 ab	0.68 ± 0.05 ab
SA (1.5%)+ Shrink film packaging	0.11 ± 0.01 a	0.19 ± 0.02 a	0.31 ± 0.02 ab	0.49 ± 0.02 ab	0.63 ± 0.02 ab
CFB box packaging without treatment	0.11 ± 0.01 a	0.24 ± 0.00 a	0.41 ± 0.03 ab	0.62 ± 0.03 a	0.76 ± 0.04 ab
Shrink film packaging without treatment	0.11 ± 0.01 a	0.22 ± 0.02 a	0.39 ± 0.01 ab	0.59 ± 0.04 ab	0.73 ± 0.03 ab
Control (Without treatment and packaging)	0.11 ± 0.01 a	0.25 ± 0.03 a	0.51 ± 0.05 a	0.65 ± 0.05 a	0.81 ± 0.03 a

Table 8: Effect of edible coating and packaging on ascorbic acid content (mg/100 g FW) of guava fruits during storage at ambient condition.

Treatments	Ascorbic acid content (mg/100 g FW)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	275.66 ± 4.18 a	265.26 ± 08.52 a	257.84 ± 07.70 a	250.45 ± 12.76 a	244.81 ± 12.86 a
CMC (1.5%) + Shrink film packaging	275.66 ± 4.18 a	270.25 ± 16.08 a	266.75 ± 14.87 a	260.67 ± 05.14 a	256.01 ± 05.80 a
SA (1.5%) + CFB box packaging	275.66 ± 4.18 a	262.32 ± 12.15 a	253.61 ± 13.16 a	245.12 ± 17.95 a	240.99 ± 11.49 a
SA (1.5%)+ Shrink film packaging	275.66 ± 4.18 a	268.47 ± 16.03 a	262.62 ± 14.13 a	255.49 ± 09.54 a	251.86 ± 18.30 a
CFB box packaging without treatment	275.66 ± 4.18 a	257.64 ± 11.13 a	246.33 ± 19.08 a	239.33 ± 06.32 a	227.46 ± 10.00 a
Shrink film packaging without treatment	275.66 ± 4.18 a	260.02 ± 14.52 a	251.88 ± 12.86 a	242.43 ± 23.97 a	235.86 ± 06.77 a
Control (Without treatment and packaging)	275.66 ± 4.18 a	254.97 ± 11.89 a	243.62 ± 17.60 a	234.68 ± 15.87 b	221.90 ± 08.83 b

Values are mean ± standard error of three replicate determinations (n=3). According to HSD Tukey's test, values in the same column with different letters are significantly different (p<0.05).

Table 9: Effect of edible coating and packaging on total phenolics content (mg GAE/100 g FW) of guava fruits during storage at ambient condition.

Treatments	Total phenolics content (mg GAE/100 g FW)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	384.36 ± 6.13 a	351.56 ± 05.52 ab	313.23 ± 04.63 a	286.68 ± 07.52 abc	266.21 ± 08.45 ab
CMC (1.5%) + Shrink film packaging	384.36 ± 6.13 a	366.69 ± 09.33 a	338.46 ± 08.06 a	313.09 ± 11.83 a	297.57 ± 11.56 a
SA (1.5%) + CFB box packaging	384.36 ± 6.13 a	343.98 ± 05.04 ab	308.38 ± 06.70 a	276.47 ± 06.17 abc	254.25 ± 13.47 ab
SA (1.5%)+ Shrink film packaging	384.36 ± 6.13 a	358.53 ± 08.94 a	329.22 ± 11.15 a	302.56 ± 14.30 ab	281.32 ± 07.95 a
CFB box packaging without treatment	384.36 ± 6.13 a	334.95 ± 11.01 ab	297.75 ± 02.65 a	259.44 ± 06.26 bc	225.57 ± 09.48 bc
Shrink film packaging without treatment	384.36 ± 6.13 a	338.84 ± 07.63 ab	305.21 ± 12.42 a	271.06 ± 08.47 abc	244.51 ± 09.20 abc
Control (Without treatment and packaging)	384.36 ± 6.13 a	315.75 ± 15.31 b	284.94 ± 13.89 a	239.37 ± 12.98 c	205.32 ± 11.49 c

Table 10: Effect of edible coating and packaging on total antioxidant capacity (µmol TE/g FW) of guava fruits during storage at ambient condition.

Treatments	Total antioxidant capacity (µmol TE/g FW)				
	Days after storage (DAS)				
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS
CMC (1.5%) + CFB box packaging	7.49 ± 0.57 a	6.67 ± 0.49 a	5.86 ± 0.15 a	4.91 ± 0.26 a	4.12 ± 0.10 abc
CMC (1.5%) + Shrink film packaging	7.49 ± 0.57 a	7.04 ± 0.32 a	6.21 ± 0.25 a	5.33 ± 0.21 a	4.54 ± 0.15 a
SA (1.5%) + CFB box packaging	7.49 ± 0.57 a	6.62 ± 0.40 a	5.72 ± 0.41 a	4.79 ± 0.22 a	3.96 ± 0.09 abc
SA (1.5%)+ Shrink film packaging	7.49 ± 0.57 a	6.74 ± 0.22 a	5.97 ± 0.20 a	5.15 ± 0.28 a	4.40 ± 0.15 ab
CFB box packaging without treatment	7.49 ± 0.57 a	6.39 ± 0.07 a	5.53 ± 0.19 a	4.54 ± 0.16 a	3.56 ± 0.05 c
Shrink film packaging without treatment	7.49 ± 0.57 a	6.54 ± 0.21 a	5.66 ± 0.26 a	4.74 ± 0.23 a	3.81 ± 0.24 bc
Control (Without treatment and packaging)	7.49 ± 0.57 a	6.33 ± 0.13 a	5.41 ± 0.32 a	4.42 ± 0.14 a	3.49 ± 0.09 c

Values are mean ± standard error of three replicate determinations (n=3). According to HSD Tukey's test, values in the same column with different letters are significantly different (p<0.05).

(1.5%) + Shrink film packaging, CMC (1.5%) + CFB box packaging, SA (1.5%) + CFB box packaging, CFB box and shrink film packaging without treatment, while the minimum total soluble solids (12.59°Brix) was observed in control (without treatment and packaging). After 12 days of storage, CMC (1.5%) + Shrink film packaging were found maximum total soluble solids (12.87°Brix) which was statistically similar with SA (1.5%) + Shrink film packaging, CMC (1.5%) + CFB box packaging and SA (1.5%) + CFB box packaging. Whereas, the minimum total soluble solids (12.42°Brix) was observed in control (without treatment and packaging), Shrink film and CFB box packaging without treatment. Total soluble solids play an important role to improve the quality of fruits and give a rough idea of the sweetness. The major sugars present in guava are fructose, glucose, sucrose, and inositol in descending order (Mowlah and Itoo, 1982) [28]. Depletion of total soluble solids in the fruit could be explained by a high metabolism of the fruits and senescence processes. There might be several reasons for variations in total soluble solids content including season, soil, and climatic conditions (Lakade *et al.*, 2011) [25].

Titratable acidity

Result showed that the guava fruits start decreasing its titratable acidity after the harvesting up to the end of storage period. However, control fruits showed a pronounced decreased in titratable acidity as compared to other treatments and the same pattern persisted until the end of the storage period. After 12 days of storage, among the treatments, the maximum value (0.38%) was found in CMC (1.5%) + Shrink film packaging, which was statistically at par with SA (1.5%) + Shrink film packaging, CMC (1.5%) + CFB box packaging and SA (1.5%) + CFB box packaging. Whereas, the minimum value (0.22%) of titratable acidity was recorded in control (without packaging and treatment), which was statistically similar with CFB box and shrink film packaging without treatment. The loss in acidity could be attributed to the activity of carboxylase and malic dehydrogenase, which are closely associated with the respiration rate, or might be due to the utilization of acid during respiration. Slower decline in acidity in treated fruits as compared to control might be due to delayed senescence and lower respiration rate in the fruits. This might be due to rapid utilization of acids in guava fruits during the respiration process as a substrate. Similar results have been reported by Kumar *et al.*, (2017) [23], Mahmoud *et al.*, (2019) [27] and Hazarika *et al.*, (2019) [15] in guava, pomegranate and strawberry fruits respectively. Titratable acidity indicates the presence of total organic acids in fruit and plays an important role in determining the flavour of fruit. The major organic acid presents in guava are citric acid (Javed *et al.*, 2016) [19].

Total chlorophyll content

It is evident from the data that total chlorophyll content decreased gradually with the increase in storage period up to 12 days of storage. After 12 days of storage, among the different treatments, the combination treatment of CMC (1.5%) + Shrink film packaging (4.73 mg/100 g FW) was retained higher total chlorophyll content, followed by SA (1.5%) + Shrink film packaging (4.17 mg/100 g FW), followed by CMC (1.5%) + CFB box packaging (3.50 mg/100 g FW), which was found statistically at par with SA (1.5%) + CFB box packaging, followed by Shrink film packaging without treatment (2.94 mg/100 g FW), which was found statistically similar with CFB box packaging without treatment, while the minimum total chlorophyll content (2.26 mg/100 g FW) was recorded in control (without treatment and packaging). peel colour of guava is an important criteria in determining the marketability of fruits, as most of the consumers select the fruit on the basis of fruit skin colour. The colour of skin changes from green to yellow in guava during ripening (Silva *et al.*, 2018) [37]. Loss of surface green colour might be associated with the natural ripening process triggered by ethylene, which occurs as the result of chlorophyll molecule breakdown parallel to an increase in carotenoids content (Yamauchi, 2008) [44s]. The loss of chlorophyll during storage is related to the change of chloroplasts into chromoplasts containing yellow and red carotenoid pigments. The changes in chlorophylls are probably due to varying activity of chlorophyll degrading enzymes such as chlorophyllase, chlorophyll oxidase, and peroxidase during ripening. Chlorophyll pigment is responsible for green colour which degrades with the onset of ripening and changes to pheophytin and pheophorbide (Heaton and Marangoni, 1996) [16].

Total carotenoids content

Results revealed that total carotenoids content of the guava fruits showed an increasing trend with increasing period of storage time up to the end of storage. However, control fruits exhibited much rapid increase in total carotenoids content than other treatments. However, after 12 days of storage, among the different treatments, the maximum total carotenoids content (149.88 mg/100 g FW) was noted in control, which was statistically at par with CFB box packaging without treatment, followed by Shrink film packaging without treatment (136.77 mg/100 g FW), which was statistically similar with CMC (1.5%) + CFB box

packaging and SA (1.5%) + CFB box packaging. Whereas, the minimum value of total carotenoids content (109.05 mg/100 g FW) was observed in CMC (1.5%) + Shrink film packaging, which was statistically similar with SA (1.5%) + Shrink film packaging, which was found more effective in delaying total carotenoids content during storage in guava fruits.

The lower amount of carotenoids might be associated with the delayed degradation of chlorophyll pigment. Thus, degradation of chlorophyll pigment was reduced, and synthesis of carotenoid pigments was inhibited (Siddiqui *et al*., 2011) [36]. Furthermore, the coating of fruit formed a thin layer on the surface surrounding the fruit, thus creating a barrier to gas exchange. This resulted in higher carbon dioxide and lower oxygen concentration around the fruit surface, suppressing the production and action of ethylene and inhibiting the synthesis of carotenoids due to delayed fruit ripening.

Lycopene content

It is revealed from data that the lycopene content of the guava fruits showed an increasing trend with increasing period of storage time up to the end of storage. However, different post-harvest treatments greatly influenced the lycopene content of guava fruits and the rate of lycopene content in guava was faster in control fruits as compared to other treatments during the storage period. After 12 days of storage, among various treatments, the maximum lycopene content (0.91 mg/100 g FW) was recorded in control (without treatment and packaging), followed by CFB box packaging without treatment (0.86 mg/100 g FW), which was statistically at par with shrink film packaging without treatment, SA (1.5%) + CFB box packaging, CMC (1.5%) + CFB box packaging and SA (1.5%) + Shrink film packaging. Whereas, the minimum value of lycopene content (0.68 mg/100 g FW) was noted in CMC (1.5%) + Shrink film packaging, which was found effective in delaying lycopene content during storage period in guava fruits. Lycopene is a powerful natural antioxidant, which imparts pink coloration to the fruit pulp in guava. The lycopene content of guava pulp was assessed in cv. Lalit, which was found to be 17.69 µg/100 g FW. This is in conformity with the findings of Lakade *et al.,* (2011) [25] and Chandrika *et al.,* (2009) [8]. The production of lycopene content is directly correlated with ripening (Javanmardi and Kubota, 2006) [18]. Similar results were also reported when tomato fruits were stored at 4 °C (Giovanelli *et al.,* 1999) [14]. It has also been reported that the formation of lycopene depends on the temperature range and rate of respiration during storage (Javanmardi and Kubota, 2006) [18].

Ascorbic acid content

In this experiment, it is evident from the data that ascorbic acid content of the guava fruits decreased in linear pattern with enhancement of storage time up to 12 days. However, different post- harvest treatments greatly influenced the ascorbic acid content of guava fruits. However, the rate of loss of ascorbic acid in guava was faster in control fruits as compared to other treatments during the storage period. After 12 days of storage, among the different treatments, CMC (1.5%) + Shrink film packaging was recorded maximum ascorbic acid

(256.01 mg/100 g FW), which was statistically at par with SA (1.5%) + Shrink film packaging, CMC (1.5%) + CFB box packaging, SA (1.05%) + CFB box packaging, shrink film and CFB box packaging without treatment, whereas the minimum value of ascorbic acid content (223.90 mg/100 g FW) was observed in control (without treatment and packaging). Storage days affected the ascorbic acid content significantly which decreased gradually irrespective of the treatments as the storage period progressed. The results are similar with the findings of Kumar *et al*., (2000) [24]; they found that ascorbic acid decreased with increasing period of storage in fruits of kinnow. Ascorbic acid contributes in protecting the plant against oxidative damage due to its antioxidant property. However, due to solubility in water, the vitamin undergoes rapid degradation due to oxidation during postharvest storage. The activities of the enzymes responsible for the oxidation of ascorbic acid *i.e.* ascorbic acid oxidase and phenol oxidase are influenced by the level of oxygen present in the storage environment (Yaman and Bayoindirli, 2002) [43].

Total phenolics content

In this study, results revealed that total phenolics content declined in fruits up to end of the storage. After 3 days of storage, control guava fruits showed to minimum total phenolics content as compared to other treatments. After 12 days of storage, among the different treatments the combination treatment of CMC (1.5%) + Shrink film (297.57 mg GAE/100 g) was recorded maximum in total phenolics content, which was statistically similar with SA (1.5%) + Shrink film, was found more effective in retaining higher phenolic compounds than other treatments. Whereas, the minimum value of total phenolics content (205.21 mg GAE/100g) was observed in control (without treatment and packaging), which was statistically at par with CFB box packaging without treatment. However, total phenolics content (266.21 mg GAE/100g) was found in CMC (1.5%) + CFB box packaging, which was statistically similar with SA (1.5%) + CFB box packaging and shrink film packaging without treatment. The decrease in phenolics content in fruit may be due to the cellular structure breakdown during the senescence. Edible coatings along with packaging protect the fruits by providing a barrier against the oxygen and moisture supply for enzymatic oxidation of phenolic compounds. This may be ascribed to higher activity of polyphenol oxidase and peroxidase enzymes in control fruits which caused rapid decrease in total phenolics in fruits (Serrano *et al*., 2009) [34]. The present finding is in accordance with the previous findings of Sogvar *et al*., (2016) [40] in strawberry and Kumar *et al*., (2017) [23] in guava who reported that application of edible coatings maintained higher phenolics content in fruits during storage by reducing polyphenol oxidase activity. Synthesis of phenolic compounds occurs as secondary metabolites in plants. The number of phenolic compounds reduced with the increase in storage period due to ripening of fruit (Sharma *et al*., 2008) [35]. The key phenolic compounds present in guava are gallic acid, ellagic acid and quercetin (Jiménez-Escrig *et al*., 2001) [20]. Both the pulp and peel contain large number of phenolic compounds (Mahattanatawee *et al*., 2006) [26].

Total antioxidant capacity

In this experiment, the data shows that the total antioxidant capacity decreases gradually with storage period increase up to 12 days at ambient condition. Among the different

treatments combination with packaging, the maximum value (4.54 µmol TE/g FW) of total antioxidant capacity was recorded in CMC (1.5%) + Shrink film packaging, which was statistically at par with SA (1.5%) + Shrink film packaging, followed by CMC (1.5%) + CFB box packaging (4.12 µmol TE/g FW), which was statistically at par with SA (1.5%) + CFB box packaging and shrink film packaging without treatment, whereas, the minimum value of total antioxidant capacity (3.49 µmol TE/g FW) was recorded in control (without treatment and packaging), which was statistically at par with CFB box packaging without treatment. Antioxidant capacity of fruit is contributed by several bioactive compounds like phenolics, flavonoids and ascorbic acid. Total antioxidant capacity is contributed by the bioactive compounds present in fruits particularly vitamins (ascorbic acid), polyphenols, flavonoids, etc. (Imahori *et al*., 2008; Song, 2015) [17]. In this study, two different methods (CUPRAC and DPPH assay) were used for determination of total antioxidant capacity. Furthermore, CMC coating formed a semi-permeable barrier over the surface of the fruit, thus modifying the atmosphere surrounding the surface of fruit and maintained higher ascorbic acid and total phenolics content. Since, it reduced loss of ascorbic acid and phenolic compounds; it preserved higher antioxidant capacity of the fruit as ascorbic acid and phenolic compounds contributed to antioxidant capacity of the fruit.

Conclusion

On the basis of result observed from this experiment, the freshly harvested mature green stage guava fruits treated with CMC (1.5%) in a combination with Shrink film was found effective to reducing physiological weight loss, decay loss and delaying reduction of total soluble solids, total chlorophyll content, ascorbic acid content, total phenolics content, total antioxidant capacity and retained marketability of fruits up to the end of storage. Hence, it was concluded that CMC (1.5%) in combination with shrink film packaging can be used for enhancing the shelf life and maintaining postharvest quality in guava fruits.

References

1. AOAC. Official methods of analysis. 17th ed. Association of Official Analytical Chemists, Gaithersburg, MD; c2000.
2. Apak R, Guclu K, Ozyurek M, Celik SE. Mechanism of antioxidant capacity assays and the CUPRAC (Cupric ion Reducing Antioxidant Capacity) assay. Microchimica Acta. 2008;160(4):413-419.
3. Arnon DI. Copper enzymes in isolated chloroplasts polyphenol oxidase in Beta vulgaris. Plant Physiol. 1949;24:1-15.
4. Barkai-Golan R. Postharvest disease suppression by atmospheric modifications. In: Calderon, M. and Barkai-Golan, R. (eds.), Food Preservation by Modified Atmospheres. CRC Press, Boca Raton, USA; c1990. p. 237-264.
5. Bhadra S, Chakraborti K, Sen SK. Physico-chemical changes during storage of ber var. Narikeli under different coatings and wrapping materials. J. Inter-academicia. 1999;3(3-4):269-274.
6. Brand-Williams W, Cuvelier ME, Berset CLWT. Use of a free radical method to evaluate antioxidant activity. LWT-Food Science and Technology. 1995;28(1):25-30.
7. Campbell CA. Handling of Florida guava and imported tropical fruits and vegetables. Hort. Sci. 1994;29:975-978.
8. Chandrika UG, Fernando KSSP, Ranaweera KKDS. Carotenoid content and *in vitro* bioaccessibility of lycopene from guava (*Psidium guajava*) and watermelon (Citrullus lanatus) by high-performance liquid chromatography diode array detection. International Journal Food Science and Nutrition. 2009;60(7):558-566.
9. Diaz-Sobac R, De La Cruz J, Vázquez Luna A, Beristain CI, Garcia HS. Evaluation of softening and associated enzyme activities during the ripening of coated 'Manila' mangoes. Journal of Horticultural Science. 1997;72(5):749-753.
10. Dutta P, Bhowmick N, Khalko S, Ghosh A, Ghosh KS. Post-harvest treatments on storage life of Guava (*Psidium guajava* L.) in Himalayan terai region of West Bengal India. Internation J. Curr. Microbiol. App. Sci. 2017;6(3):1831-1842.
11. Duxbury AC, Yentach CS. Plankton pigment monograph. J. Marine Res. 1956;15:190-191.
12. Farahi MH. The impact of aloe-vera gel as postharvest treatment on the quality and shelf life of table grape cv. 'Askari'. Agricultural Communications. 2015;3(1):30-36.
13. Gad MM, Zagzog OA. Mixing xanthan gum chitosan nano particles to form new coating for maintaining storage life and quality of elmamoura guava fruits. Int. J. Curr. Microbial. App. Sci. 2017;6(11):1582-1593.
14. Giovanelli G, Lavelli V, Peri C, Nobili S. Variation in antioxidant components of tomato during vine and post-harvest ripening. Journal of the Science of Food and Agriculture. 1999;79:1583-1588.
15. Hazarika TK, Lalrinfeli L, Lalchhanmawia J, Mandal D. Alteration of quality attributes and shelf-life in strawberry (Fragaria × Ananassa) fruits during storage as influenced by edible coatings. Indian J. Agric. Sci. 2019;89(1):28-34.
16. Heaton JW, Marangoni AG. Chlorophyll degradation in processed foods and senescent plant tissues. Trends in Food Science and Technology. 1996;7(1):8-15.
17. Imahori Y, Takemura M, Bai J. Chilling-induced oxidative stress and antioxidant responses in mume (Prunus mume) fruit during low temperature storage. Postharvest Biology and Technology. 2008;49(1):54-60.
18. Javanmardi J, Kubota C. Variation of lycopene, antioxidant activity, total soluble solids and weight loss of tomato during postharvest storage. Postharvest Biology and Technology. 2006;41:151–155.
19. Javed MS, Randhawa MA, Butt MS, Nawaz H. Effect of calcium lactate and modified atmosphere storage on biochemical characteristics of guava fruit. Journal of Food Processing and Preservation. 2016;40(4):657-666.
20. Jiménez-Escrig A, Rincón M, Pulido R, Saura-Calixto F. Guava fruit (*Psidium guajava* L.) as a new source of antioxidant dietary fiber. Journal of Agricultural and Food Chemistry. 2001;49(11):5489-5493.
21. Jones E, Hughes RE. Foliar ascorbic acid in some angiosperms. Phytochem. 1983;22(11): 2493–2499.
22. Kester JJ, Fennema OR. Edible films and coatings: a review. Food Technolology. 1986;60:47-59.
23. Kumar A, Singh O, Kohli K, Dubey MC. Effect of edible surface coatings on postharvest quality and shelf life of guava (*Psidium guajava* L. Cv. Pant Prabhat) Fruits. The

Bioscan. 2017;12(2):825-832.
24. Kumar J, Sharma RK, Singh R. Effect of different methods of packing on the shelf life of kinnow. J. Hort. Sci. 2000;29:202-203.
25. Lakade SK, Tambe TB, Dhomane PA, Gharge VR. Diversity studies in quality and biochemical attributes of guava genotypes Diversity studies in quality and biochemical attributes of guava genotypes. Asian Journal of Horticulture. 2011;6(1):77-80.
26. Mahattanatawee K, Manthey JA, Luzio G, Talcott ST, Goodner K, Baldwin EA. Total antioxidant activity and fiber content of select Florida-grown tropical fruits. Journal of Agricultural and Food Chemistry. 2006;54(19):7355-7363.
27. Mahmoud TSM, El-Moniem EAA, Yousef ARM, Saleh MMS. Enhancing storage efficiency of pomegranate fruits using aloe-vera gel and some natural oils. Plant Arch. 2019;19(2):188-193.
28. Mowlah G, Itoo S. Guava (*Psidium guajava* L.) sugar components and related enzymes at stages of fruit development and ripening. Nippon Shokuhin Kogyo Gakkaishi. 1982;29(8):472-476.
29. Nair MS, Saxena A, Kaur C. Effect of chitosan and alginate based coatings enriched with pomegranate peel extract to extend the postharvest quality of guava (*Psidium guajava* L.). Food chemistry. 2017;240:245-252.
30. Nasrin TAA, Islam MN, Rahman MA, Arfin MS, Ullah MA. Evaluation of postharvest quality of edible coated mandarin at ambient storage. Int. J Agric. Res. Innov. Technol. 2018;8(1):18-25.
31. Pandey SK, Jean EJ, Bisen A. Influence of gamma-irradiation, growth retardants and coatings on the shelf life of winter guava fruits (*Psidium guajava* L.). J Food Sci. Tech. 2010;47(1):124-127.
32. Paul RE, Goo T. Relationship of guava (Psidillm gllajava L.) fruit detachment force to the stage of fruit development and chemical composition. Hort. Sci. 1983;18:65-67.
33. Ravelo-Perez LM, Hernandez-Borges J, Rodriguez-Delgado MA, Borges-Miquel T. Spectrophotometric analysis of lycopene in tomatoes and watermelons. The Chemical Educator. 2008;13(1):11-13.
34. Serrano M, Diaz-Mula HM, Zapata PJ, Castillo S, Guillen F, Martínez-Romero D. Maturity stage at harvest determines the fruit quality and antioxidant potential after storage of sweet cherry cultivars. J Agric. Food Chem. 2009;57:3240–3246.
35. Sharma M, Sitbon C, Paliyath G, Subramanian J. Changes in nutritional quality of fruits and vegetables during storage. Post-harvest Biology and Technology of Fruits, Vegetables and Flowers. 2008;45:443-456.
36. Siddiqui MW, Chakraborty I, Ayala-Zavala JF, Dhua RS. Advances in minimal processing of fruit and vegetables: a review, Journal of Scientific and Industrial Research. 2011;70(9):823-834.
37. Silva WB, Silva GMC, Santana DB, Salvador AR, Medeiros DB, Misobutsi GP. Chitosan delays ripening and ROS production in guava (*Psidium guajava* L.) fruit. Food Chemistry. 2018;242:232-238.
38. Singh H, Kachway DS, Kuchi VS, Vikas G, Kaushal N, Singh A. Edible oil coatings prolong shelf life and improve quality of guava (*Psidium guajava* L.). Int. J. Pure App. Bio sci. 2017;5(3):837-843.
39. Singleton VL, Orthofer R, Lamuela-Raventós RM. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin- ciocalteu reagent. Methods in Enzymology. 1999;299:152-178.
40. Sogvar OB, Saba MK, Emamifar A. *Aloe vera* and ascorbic acid coatings maintain postharvest quality and reduce microbial load of strawberry fruit. Postharvest Biol. Technol. 2016;114:29-35.
41. Song J. Advances in postharvest maintenance of flavour and phytochemicals. In: Wills, R. B. H. and Golding, J. B. (eds.), Advances in postharvest fruit and vegetable technology. CRC Press, UK; c2015. p. 261-284.
42. Wells JM, Uota M. Germination and growth of five fungi in low-oxygen and high-carbon dioxide atmospheres. Phytopathology. 1970;60(1):50-53.
43. Yaman O, Bayoindirli L. Effects of an edible coating and cold storage on shelf-life and quality of cherries. LWT-Food Science and Technology. 2002;35(2):146-150.
44. Yamauchi N. Inhibitory effect of sucrose laurate ester on degreening in citrus nagato-yuzukichi fruit during storage. Postharvest Biol. Technol. 2008;47:333-337.