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Variations in the physicochemical properties of guava var. Arka Kiran during storage

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Abstract
Guava (*Psidium guajava* L.) is a climacteric fruit crop, ripens quickly after harvest within a week during storage under atmospheric condition. Arka Kiran is a pink fleshed variety developed by Indian Institute of Horticultural Research (IIHR), Bengaluru enriched with lycopene and vitamin-C content, but has poor shelf life. The study has been conducted to delay the ripening and to evaluate the shelf life of guava stored under atmospheric (32 ºC) and refrigerated condition (8 ºC) packed in corrugated fibre boxes. The biochemical and engineering properties of fruits were investigated at regular intervals of 3, 6, 9 and 12 days after harvest to determine their shelf life. The results revealed that an increasing trend of physiological loss in weight, total sugar, reducing sugar and TSS was observed. Ascorbic acid, titratable acidity and firmness showed a declining trend during storage irrespective of storage temperature. Fruits stored at ambient temperature (32 °C) ripened more quickly and had a shelf life of 3 days. Fruits stored at 8 ºC showed the extension of shelf life up to 18 days with minimal quality deterioration with pleasing colour, flavour and quality.

Keywords: Guava, Arka Kiran, TSS, ascorbic acid, firmness, shelf life

Introduction

Guava (*Psidium guajava* L.) is the fourth most important fruit crop in India belongs to Myrtaceae family. India is the largest producer of guava in the world. It is considered as "the fruit of the poor man" or "the apple of the tropics" due to its very high nutritional content and delicious sweetness (Kosky *et al.*, 2005) [17]. It is regarded as a superfruit because of its high concentration of phenols and other antioxidant compounds (Da Silva Lima *et al.*, 2019) [8]. The guava fruit is valued for its "vitamin-C" content as well as minerals like calcium, iron and phosphorus that have a delicious aroma (Dhaliwal and Dhillon, 2003) [10].

Guava fruit is cultivated in an area of 3,04,000 ha. With the production of 4.43 million metric tonnes in India during the fiscal year 2021 (Statista, 2022). It is a climacteric fruit and the ripening of guava results in a typical rise in respiration and ethylene production (Brown and Wills, 1983) [5]. Due to its vulnerability to mechanical damage and chilling injury, shelf life of guava fruit is poor after the harvest. The cultivar, cropping season, maturation stage, materials used for packing during storage, temperature and humidity of the storage environment, physicochemical changes and loss due to microbial attack affect the quality and shelf-life of guava fruits (Ismail *et al.*, 2010) [14].

Arka Kiran is an ICAR-IIHR improved hybrid pink pulped guava variety with an average fruit weight of 200-220 g. The fruits are medium-sized round fruits with a deep red, firm pulp and a high lycopene level (7.14 mg/100 g). The fruits are flavourful, sweet (TSS content of 12 to 12.5 ºBrix), and have good vitamin C content (190-200 mg/100 g). It also has medium-soft seeds and good flavour, making them suitable for both eating fresh and value-added products namely Fruit bar, osmo-dried slices, RTS beverages and squash.

Up to 18-20% of fruits perish as post-harvest losses by various post-harvest techniques and short shelf life (Narayana *et al.*, 2014) [23]. When guava fruits are being harvested, their rapid respiration rate and ethylene production causes the fruits to perish during the storage period (Qiuping *et al.*, 2006) [25]. Reduction in post-harvest losses may contribute to guava's longer shelf life (Gojiya, 2017) [12]. It is generally known that storing produce at a low temperature from the time of harvest till consumption is an efficient way to maintain the quality and nutritional content (Concellón *et al.*, 2007) [7]. Low temperatures have the potential to slow or delay ripening and minimize spoilage (Wang, 1989) [38]. In the present study, shelf life of guava fruit variety Arka Kiran was evaluated by analysing the changes in physicochemical properties stored at ambient and refrigerated conditions.

Materials and Methods

Sample collection

Guava 'Arka Kiran' fruits was randomly harvested and procured from the farm located at Theethipalayam, Coimbatore district. The fruits were uniformly harvested at 80% maturity in the morning and packed in Corrugated Fibre Board (CFB) boxes. Fruits selected for the study was of uniform size, free from physical damage and devoid of diseases. The physicochemical analysis for the fruits were investigated on the day of harvest and at regular intervals of storage period in the Department of Food Process Engineering, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore.

Storage

The freshly harvested fruits were graded based on size to maintain homogeneity throughout the storage period. The samples were packed in CFB boxes and stored in the atmospheric condition (32 °C) and refrigerated (8 °C, 90-95% RH) condition in the cold room. The physicochemical parameters was analysed at regular interval of 3 days.

Engineering properties

Weight, Size and sphericity

The weight of guava was measured by using digital weighing balance (AR2130, Ohaus corporation, USA) with an accuracy of ± 0.001 g. The size of guava was determined by the equivalent diameter (D_e). On the three major axes of the fruit, length (l), width (b) and thickness (t) were measured by using digital vernier calliper (Aerospace, ISC, 0-150 mm) with the least count of 0.01mm and the sphericity (Ø) was calculated by using the following relationship (Mohsenin, 2020) [22].

$$D_e = (l \times b \times t)^{1/3}$$

$$\text{Ø} = \frac{(l \times b \times t)^{1/3}}{l}$$

Where,
l – Length, mm.
b – Breadth, mm.
t – Thickness, mm.

Moisture content

The moisture content of the guava was determined by following the standard procedures (AOAC, 2005) [2]. Five grams of the guava were weighed and placed in a petri dish. The sample was oven-dried at 105 °C for 3 hours. The change in weight was noted until concordant values were obtained. The percentage of moisture content was expressed as follows;

$$\text{Moisture content w.b.} (\%) = \frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Initial weight (g)}}$$

Bulk density

Bulk density was determined by the mass-volume relationship (Mohsenin, 1986; Balakrishnan *et al.*, 2020) [21, 4]. The sample was filled in the known volume of the container without compactness in the container. Bulk density was calculated by using the following formula.

$$\text{Bulk density } (\text{kg.m}^{-3}) = \frac{\text{Mass of the grain (kg)}}{\text{Volume of the grain } (\text{m}^3)}$$

True density

The true density was calculated by the water displacement method adopted by Mohsenin, 1986 [21]. True density of fruit was estimated by the following formula.

$$\text{True density } (\text{kg.m}^{-3}) = \frac{\text{Weight of sample in air (kg)}}{\text{Volume of displaced fruit } (\text{m}^3)}$$

Porosity

The porosity is the ratio of the volume of internal pores in between the fruits to its bulk volume (Sahay and Singh, 1996; Balakrishnan *et al.*, 2020) [31, 4]. It was determined using the following formula;

$$\text{Porosity } (\%) = \frac{1 - \text{Bulk density}}{\text{True density}} \times 100$$

Fruit Firmness

Firmness was determined by hand-held digital penetrometer (Parisa technology, AGY-30, Mumbai). The sample was placed on the platform of the penetrometer. The meter has been set to zero error and push the handle down towards the fruit. The firmness of the fruit was measured in N.

Biochemical properties

Total Soluble Solids (TSS)

The TSS of the guava pulp was estimated by using Erma's hand-held refractometer in the range of 0 to 32% (AOAC, 2005) [2]. A drop of fruit pulp was placed over the screen of the refractometer and the values were observed from the scale of the refractometer. TSS of the fruit pulp was expressed in °Brix.

Physiological Loss in Weight (PLW)

The physiological loss in weight (PLW) of fruits was estimated based on the weight loss and expressed in percentage and calculated as suggested by Srivastava and Tandon, 1968 [35].

$$\text{PLW } (\%) = \frac{\text{Initial weight(g)} - \text{Final weight (g)}}{\text{Initial weight (g)}} \times 100$$

Titratable acidity

Titratable acidity was determined using the procedure reported by Ranganna, 1986 [26]. Five grams of guava pulp was macerated using pestle and mortar and made up to 100 ml with distilled water. A known quantity of the diluted juice was titrated against 0.1N NaOH with phenolphthalein. The results were expressed in terms of citric acid.

$$\text{Titratable acidity } (\%) = \frac{\text{Titre value} \times \text{Equivalent weight of acid} \times \text{Volume made up} \times 100}{\text{Volume of aliquot} \times \text{Weight of the sample} \times 1000}$$

Ascorbic acid

The ascorbic acid content was estimated by 2,6 Dichlorophenol indophenol dye method (Ranganna, 1986; AOAC, 2004) [26, 1]. Five grams of sample was macerated with 4% oxalic acid and the volume was made up to 100 ml. The diluted solution was filtered and 5 ml of supernatant was mixed with 10 ml of 4% oxalic acid and titrated against dye. The ascorbic acid was expressed as mg/100 g and calculated using the following formula.

$$\text{Ascorbic acid}\left(\frac{\text{mg}}{100\text{g}}\right) = \frac{0.5/V_1 \times V_2/5 \times 100}{\text{weight of the sample}} \times 100$$

Where,
V_1-Titre value of the standard.
V_2-Titre value of the sample.

Reducing sugar

The reducing sugar of guava pulp was estimated by Dinitrosalicylic acid method using ethanol extraction of the pulp suggested by Sadasivam and Manickam (1992) [30]. 0.5 to 3 ml of the alcohol-free sample extracts were taken in a test tube and the volume was made up to 3 ml. Three ml of DNS reagent was added followed by heating for 5 minutes. One ml of 40% Rochelle salt was added after the development of colour. The absorbance was measured at 530 nm (Miller, 1972).

Total sugar

The total sugar was estimated by the anthrone method and analysed spectrophotometric ally (Sadasivam and Manickam, 1992) [30]. A known quantity of sample was extracted using hot ethanol and sugar was dissolved by adding a known quantity of water. The content was made up to 4 ml with anthrone reagent. The mixture was then heated for 8 minutes followed by rapid cooling. The reducing sugar was estimated using a spectrophotometer at 630 nm.

Statistical analysis

The statistical software Minitab (version 20.00) was used for all statistical computations. One-way ANOVA was used to compare the means of various levels of single factor. All the findings were analyzed at 5% level of significance.

Result and Discussion

Engineering properties of guava

The engineering properties of fresh guava are presented in the Table 1. The moisture content of guava at the time of harvest was 83.16% (w.b.). The average weight, length, width and diameter are 203 g, 73.47 mm, 73.97 mm and 74.56 mm, respectively. Various engineering properties of guava fruit namely size, sphericity, true density, bulk density and porosity were found to be 73.99, 1.007, 958 kg/cm^3, 446.5 kg/cm^3 and 53.3%, respectively. The findings were similar to the results of Matholiya *et al.* (2020) [20] and Athmaselvi *et al.* (2014) [3] for guava.

Table 1: Engineering properties of guava fruit

Sl. No.	Name of the Property	Min	Max	Average
1.	Length (mm)	72.39	74.55	73.47
	Width (mm)	72.43	75.52	73.97
	Diameter (mm)	73.73	75.40	74.56
2.	Size	72.84	75.15	73.99
3.	Sphericity	1.006	1.008	1.007
4.	Weight (g)	192	214	203
5.	True density (kg.m^{-3})	942	974	958
6.	Bulk density (kg.m^{-3})	439	454	446.5
7.	Porosity (%)	53.39	53.38	53.38

Effect of storage on physicochemical properties

Physiological Loss in Weight (PLW)

The percentage of PLW increases with an increase in storage period. PLW was fairly low (4.09%) on 3rd day of storage and increased up to 16.79% on 6th day of atmospheric storage. At 15th day of refrigerated storage, the PLW was 16.24% and increased up to 26.28% at 21st day of storage. The maximum physiological loss in weight was observed when guava was stored at room temperature. PLW of the guava was less in case of refrigerated storage. The loss in weight of guava fruit was increased irrespective of the storage conditions. Fruits stored at room and refrigerated temperature had a significant effect (p<0.05) on the PLW of guava fruit. Fig. 1 shows the increase in weight loss with storage period. Due to moisture loss through evapotranspiration and respiration of conserved food material, an increase in PLW was noticed in all conditions. Even after harvest, the process of transpiration from fruit surfaces continues. The PLW of fruits was due to respiration, transpiration and other degrading activities during storage (Haard and Salunkhe, 1975) [13]. Similar results were observed by Joshi and Roy, 1985 [15]; Kader, 1992 [16]; Venkatesha, 1992 [37] and Mahajan *et al.* (2017) [18] for guava fruits.

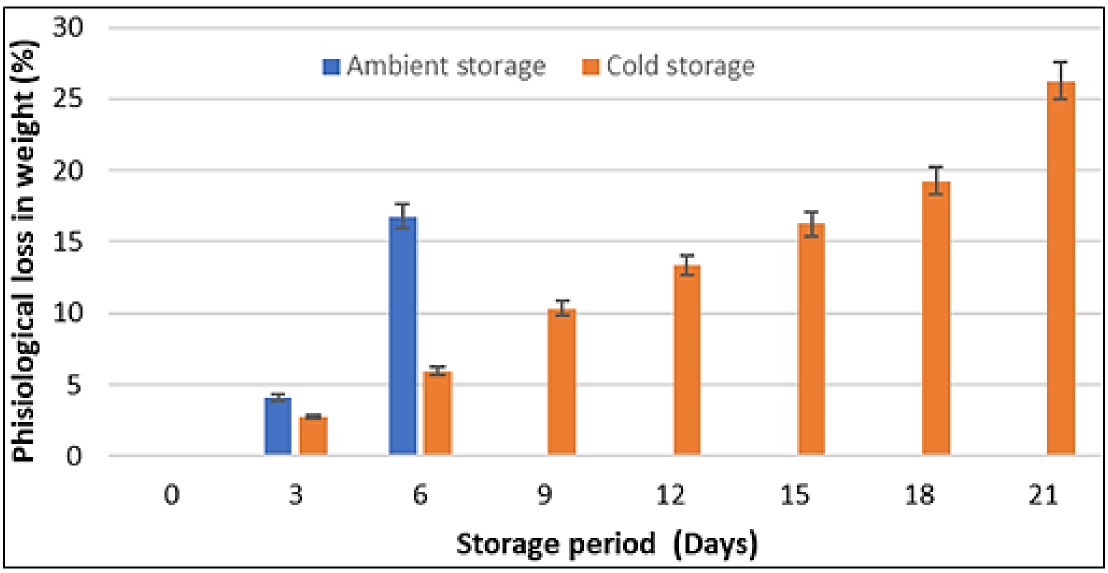

Fig 1: Effect of storage period on PLW of guava

Total Soluble Solids (TSS)

TSS of the fruits increases with an advancement of storage period as shown in Fig. 2. TSS increases up to a certain period and decreases until decay irrespective of the storage temperature. The TSS of guava was found to be 9.0 ºBrix at the time of harvest. At atmospheric storage, the maximum value of TSS was 11.25 ºBrix on the 6th day. TSS was 11.5 ºBrix at refrigerated storage on 18th day. A significant (p<0.05) impact in TSS was observed between atmospheric and refrigerated storage. The increase in TSS with storage time may be caused by an increase in organic solute content as a result of water loss in the fruit (Gojiya, 2017) [12]. TSS increases significantly during the ripening of climacteric fruits, primarily due to the hydrolysis of starch into simple sugars like glucose, fructose and sucrose that affect the flavour Rawan *et al.* (2017) [27] and further decreased in storage as they are the substrate for respiration (Mahajan *et al.*, 2009). The results showed a relevance with the work done by Mahajan *et al.* (2009) and Gojiya (2017) [12] for guava fruits.

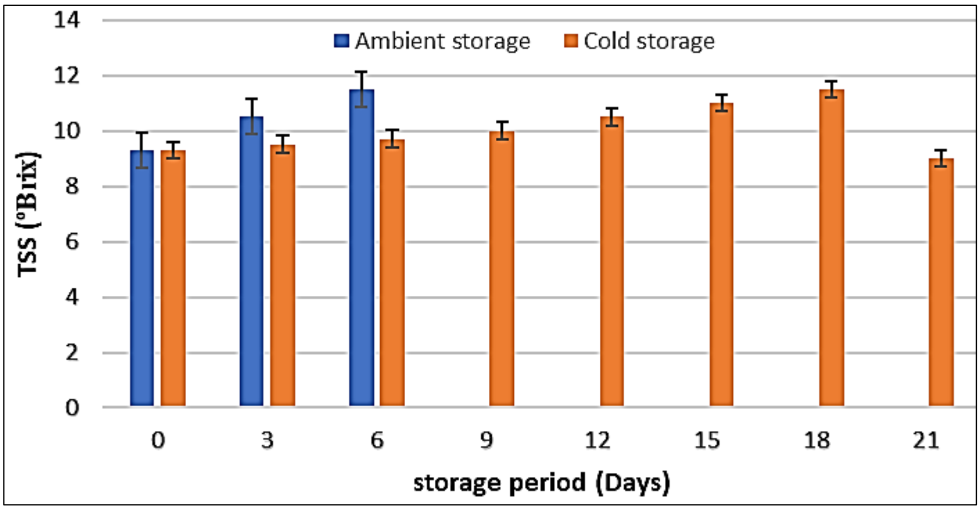

Fig 2: Effect of storage period on TSS of guava

Titratable acidity

Titratable acidity expresses a declining trend during storage as shown in Fig. 3. Titratable acidity was 0.45% at the time of harvest and 0.25% on the 6th day of storage at atmospheric conditions. At refrigerated condition the titratable acidity was 0.38% on the 15th day of storage and 0.26% on the 21st day of storage. The results showed a significant (p<0.05) decrease in titratable acidity during storage Due to the action of the enzyme invertase, which converts acid into sugar, the acidity has decreased. The utilization of organic acid as a substrate for respiration leads to the decline in acidity (Roth *et al.*, 2007) [29]. Similar trend was reported by Damodaran *et al.* (2001) [9] for sapota, Yadav *et al.* (2010) [39] in kinnow and Nunes *et al.* (2006) [24] for strawberry.

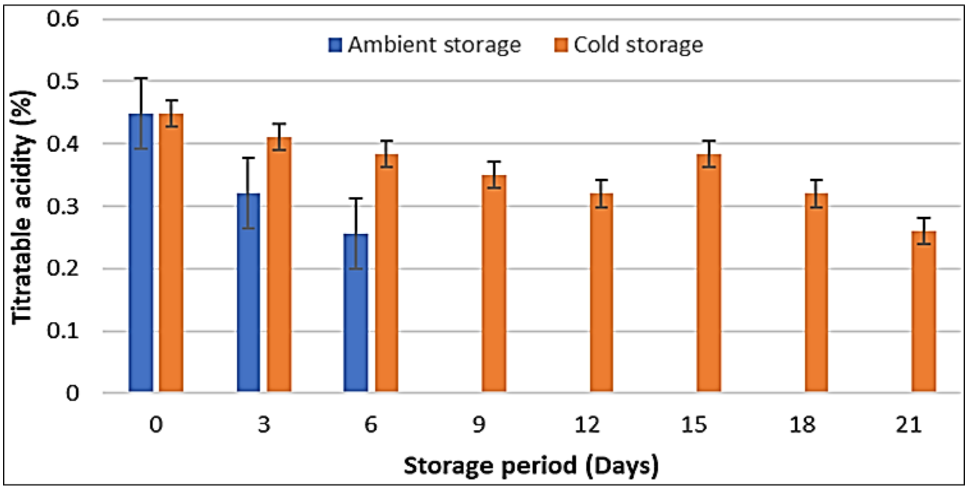

Fig 3: Effect of storage period on titratable acidity of guava

Ascorbic acid

Fig. 4 depicts the changes in ascorbic acid content during the storage of guava. Generally, ascorbic acid content decreases with the advancement of storage period. The ascorbic acid content was 198.3 mg/100 g at the time of harvest. A linear decline in ascorbic acid content was found to be 133 mg/100 g at the end of 21 days. The ascorbic acid content was 121 mg/100 g on the 6th day of storage under atmospheric condition. A significant difference (p<0.05) was observed in ascorbic acid content during the atmospheric and refrigerated storage. Ascorbic acid is converted to dehydro-ascorbic acid by the action of the enzyme ascorbic (Mapson, 1970) [19] which may lower the vitamin C content of fruits. Similar findings were reported by Ismail *et al.* (2010) [14] for guava.

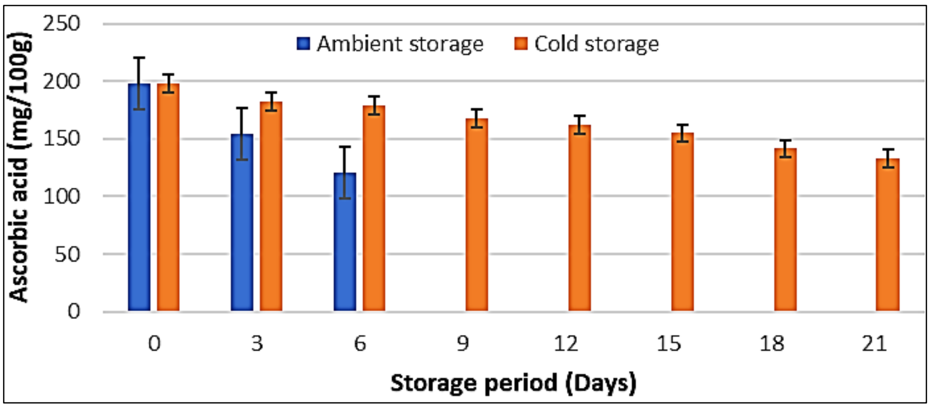

Fig 4: Effect of storage period on ascorbic acid of guava

Reducing sugar

During the storage of guava fruits the reducing sugar increases continuously up to certain extent and decreased thereafter as represented in Fig. 5. The maximum value of reducing sugar was 5.21% on the 3rd day and decreased to 3.75% on 6th day of atmospheric storage. In refrigerated storage, the maximum value was 6.31% on 15th day of storage. Storage conditions showed a significant ($p<0.05$) difference on reducing sugar of guava fruits. This is because of the accumulation of starch into sugars. Reducing sugars started to decline as they are the primary substrate for respiration (Smith *et al.*, 2005) [34]. The results were similar to Reddy *et al.* (2014) [28] and Singh *et al.* (2017) [33] for guava fruit.

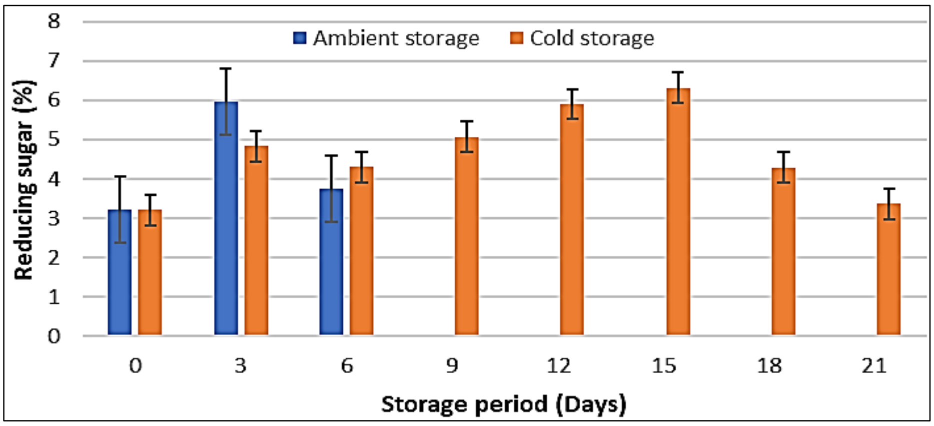

Fig 5: Effect of storage period on reducing sugar of guava

Total sugar

Fig. 6 showed the effect of storage on total sugar. The total sugars of guava were low at the time of harvest, but they increased during storage to their peak value and then continued to decline. The results showed a maximum value of 11.23% on the 3rd day of atmospheric storage and 12.52% on the 15th day of refrigerated storage. The results showed a significant ($p<0.05$) difference in total sugar in both the atmospheric and refrigerated condition. The increase in total sugar is because of the accumulation of starch into sugars. It was found that reducing sugars started to decline because of the degradative process. The findings of investigation are in confirmation with reports by Reddy *et al.* (2014) [28] and Dutta *et al.* (2017) [11] for guava fruits.

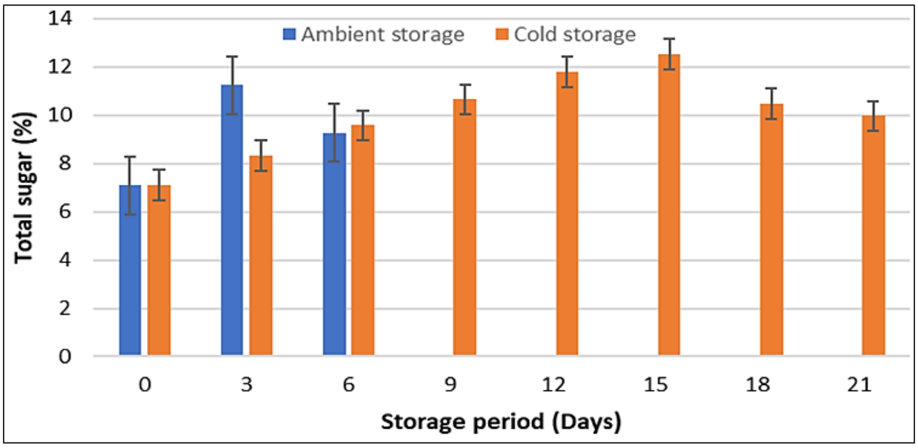

Fig 6: Effect of storage period on total sugar of guava

Fruit firmness

Fig. 7 depicts the decline in firmness during the storage of guava. The firmness of guava registered a declining trend throughout the storage period. Firmness at the time of harvest was 34.9 N and reduced to 8.13 N on the 6th day of atmospheric storage, whereas in refrigerated storage, firmness on 6th day was 32.8 N and 17.7 N on 21st day. The results showed significant (p<0.05) difference in fruit firmness. Fruit ripening causes insoluble protopectin to hydrolyze into water-soluble pectin and pectic acid, which leads to a decrease in fruit firmness. This resulted in weakening of the cell wall and a decrease in cell cohesiveness. Fruit ripening causes protopectin to transform into pectin, which makes the fruit softer (Setiasih *et al.*, 2017) [32].

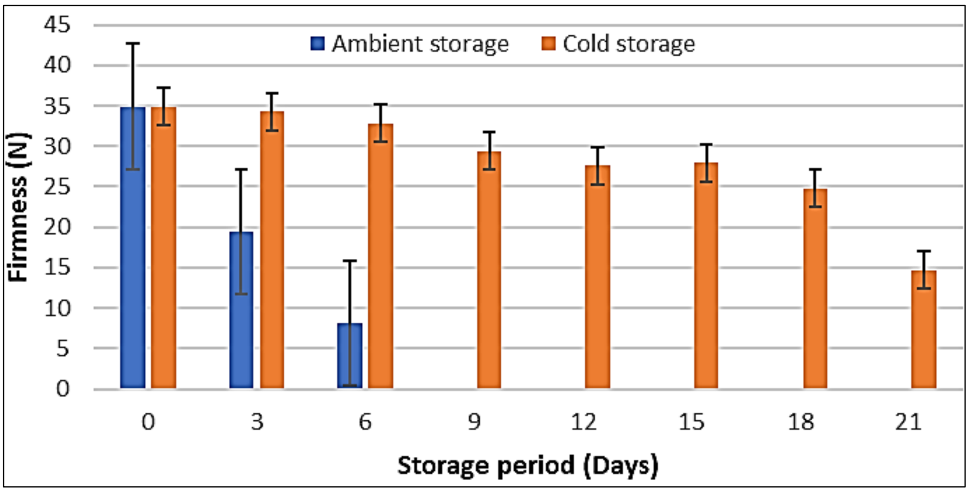

Fig 7: Effect of storage period on firmness of guava

Conclusion

Storage temperature is one of the important factors as it greatly influences the nutritional quality and shelf life of guava after harvest. In the present study, the effect of storage temperature on the physicochemical properties of guava was evaluated. The atmospheric storage of guava accelerates the ripening at a faster rate due to the rapid rise in respiration and ethylene emission. This in turn creates conditions of poor storage quality with maximum loss in nutritional content, whereas low temperature storage of guava slows down the metabolic process during storage that results in improvement of shelf life. The results revealed that the PLW, TSS, reducing sugar and total sugar increased and a decline in firmness, ascorbic acid and titratable acidity were observed during storage irrespective of storage conditions. The guava stored at ambient condition (32 ºC) had a shelf life of 3 days and the guava stored at refrigerated condition (8 ºC) extended the shelf life up to 18 days. Thus, storage at 8 ºC can be encouraged for shelf-life improvement with the absence of chilling injury by maintaining its pleasant flavour, texture, nutritional quality and reduction in microbial spoilage. Thus, the concept of low temperature storage is one of the best options for enhancing the of shelf life of guava.

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Conflict of interest

Authors declares that there is no conflict of interests that could possibly arise.

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