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Research Article

Evaluation of the shelf life of guava (*psidium guajava*) stored in a modified scoria evaporative cooler with organic treatments

Abstract

Guava (*Psidium guajava*) is a tropical fruit that is highly nutritious but highly perishable. The high perishability rate of the fruit is a clear indication that this fruit requires good post-harvest handling and preservation techniques to prolonging its shelf life. Evaporative cooling technology has been widely adopted for proper storage of perishable products, especially fruits and vegetables. This research was conducted with an objective of evaluating the shelf life of guavas stored in a scoria evaporative cooler in combination with neem extract treatment and beeswax treatment. A portion of the guavas was treated and stored in both ambient and evaporative cooler conditions while the other portion was untreated and stored in both ambient and evaporative cooler conditions. The changes in quality of the guavas over time were evaluated based on the physical, chemical and organoleptic properties of the fruit. The microclimate of the evaporative cooler i.e the temperature and relative humidity, were recorded using a data logger. The shelf life of neem extract treated guavas stored in the evaporative cooler increased by an average of 2 days compared with ambient conditions. For the beeswax treated guava the shelf-life increase by an average of six days compared to the ambient. For untreated guavas the increase in shelf life was 6 days relative to the ambient. The beeswax coated gauvas stored in the evaporative cooler retained the recommended firmness for 5 days more than the ambient. These results show that evaporative cooling combined with beeswax treatment have enormous potential to prolong the shelf-life of guavas significantly. Thus scoria evaporative cooler could be a game changer in post-harvest handing of guavas in rural areas.

Keywords: guava, post-harvest technology, evaporative cooling, beeswax coating

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Introduction

Guava (*Psidium guajava*) is a fruit tree that is currently being grown throughout the world's tropics and subtropics, with its origin being the American tropics.[1] The fruit has a delicate skin, with the mesocarp being characterized by stone cells that are about 0.1mm.[2] When consumed fresh, it may be eaten when mature green or when fully ripe. At mature green stage, the flesh is white. At fully ripe stage, the flesh is creamy white, yellowish pink, deep pink, or salmon red.[3] Guava fruit is highly nutritious since it contains a high level of ascorbic acid at 50–300 mg/100g fresh weight, dietary fibre (about 50%), potassium and antioxidant compounds. The fruit is composed of moisture (85%), proteins (7%), total sugars (7.93 to 8.9%), reducing sugars (5.04 to 5.49%), non-reducing sugars (5.23%) and acid (2.45%).[4]

The high fibre content in guava makes it to be considered as having a low glycemic index which is useful for losing weight and managing diabetes.[5] Guava fruit is also known for treatment of various ailments including, gastrointestinal disturbances and its applications in the cosmetic and dermatological industry.[6] Guava fruits are highly perishable commodities that require specialized care and handling immediately after harvest in order to reduce losses that accompany this period before they are consumed. Storage of vegetables and fruits at low temperatures for a definite period is a common practice in the world. This is commonly achieved through the use of refrigerators although other techniques such as using evaporative coolers can be applied. This research aimed at evaluating the evaporative cooling technology, of a scoria evaporative cooler, in the storage of guava fruits. The evaporative cooler uses water as the cooling media, and a good flow of air to attain low temperatures.

Evaporative cooling is a technology that reduces the temperature of air while increasing the relative humidity level. Humidity is added to the incoming air by forcing air through wetted porous media that has high surface area per unit volume, in this case, scoria. As air comes into contact with the wet surface, water changes its state from liquid to vapour to overcome the latent heat of vaporization. When this happens, air exits the system with a lower temperature and a higher humidity. This causes removal of heat from the refrigerated space and the commodity present into the atmosphere. Scoria is used as the porous media since it has larger vesicles with thicker walls. The larger vesicles reduce the chances of clogging of the media which would mean constant replacement of the media, placing additional financial management and time burden to the owner. The large vesicles also allow for adequate air/wetted media contact time, hence better cooling efficiency. Treatment using plant-based extracts and edible coating has been adapted as one of the ways of preserving fresh produce post-harvest therefore prolonging their shelf-life. An increase in the interest for natural food products among the consumers has led to the need to reduce chemical-based preservatives or additives for post-harvest handling of fruits, therefore adapting organic preservation techniques.

Materials and methods

Materials

Mature guava fruits that adhered to Codex Alimentarius CXS 215-1999 were picked from the farm and selected for use in this research.

The neem leaves used for the extracts were sourced from JKUAT farm. The beeswax was purchased from local vendors.

Preparation of the samples

Leaves from mature branches of neem plants were dried under shade and then ground into a fine powder. The extract was then be prepared by adding 500 ml of distilled water to 100 g of leaves powder and kept overnight. This solution was then sieved and the sampled fruits dipped in it for 10 minutes. Beeswax was prepared by heating it to about 70°C in a container and allowing it to cool before applying it on the fruits. Half of the collected fruit samples were stored in a modified scoria evaporative cooler, with and without the neem leaf plant extracts treatment and beeswax coating. These samples were loaded into the cooling chamber of the evaporative cooler placed on a wooden meshed tray to allow air circulation around the product. The other half was kept at ambient room conditions with both treatments and without.

Physiological loss of weight

The weight of the fruits was measured using a weighing balance (SF-400) after every 2 days. The percentage of physiological weight loss was calculated by taking the difference between the initial weight of the fruit before storage and the weight of the fruit after storage.

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

Firmness

The firmness of the fruits was measured using a handheld penetrometer (GY-3) after every 2 days.

Total soluble solids

The guava fruits were washed, peeled and cut into small pieces then crushed using a mortar and pestle. Total soluble solids was determined by using a hand refractomer (ATAGO PAL-1) and expressed in standard °Brix unit.

Organoleptic parameters

The organoleptic parameter evaluated was the overall acceptace. The sensory evaluation parameters was carried out using 1 to 4 rating scale in which

1 - Good

2 - Average

3 - Poor

4 – Spoiled

Environmental conditions

The microclimate conditions that is the air temperature and the relative humidity were measured inside the cooler, outside the cooler and in the control room which is at ambient temperature. These measurements were done using DHT22 sensors and the data relayed using a digital data logger. The DHT22 sensors are located:

- S_{1out} – outside the cooler
- $S_{2(0.3m)}$ – inside the cooler, 0.3 m from the bottom
- $S_{3(1m)}$ – inside the cooler 1 m from the bottom

From the data obtained, the saturation efficiency of the evaporative cooler was determined. The saturation efficiency, $\eta_{cooling}$, helps in evaluating the performance of the evaporative cooler since it indicates the amount of moisture the media can evaporate into the air.

$$\eta_{cooling} = \left[\frac{T_a + T_i}{T_a + T_{wb}}\right] \times 100\%$$

where:

T_a is the outside air temperature in °C (dry bulb air temperature).

T_i is the inside air temperature in °C.

T_{wb} is the wet bulb air temperature of the outside air (Figure 1).

Figure 1 A picture of guava fruits placed in the evaporative cooler.

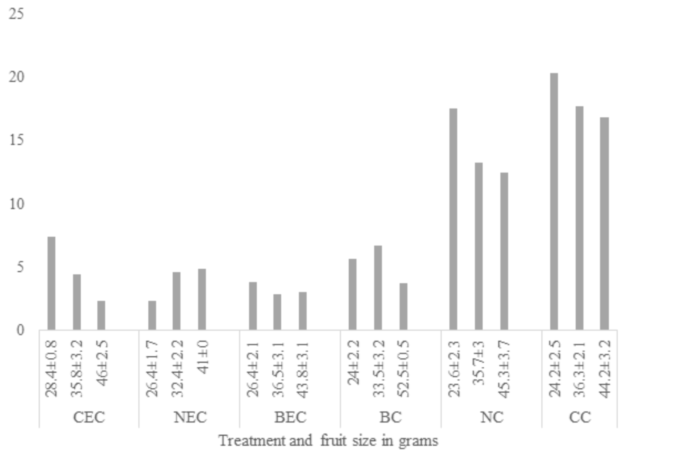
Shelf life

The shelf life was determined by counting the number of days from the start of storage to deterioration.

Results and discussion

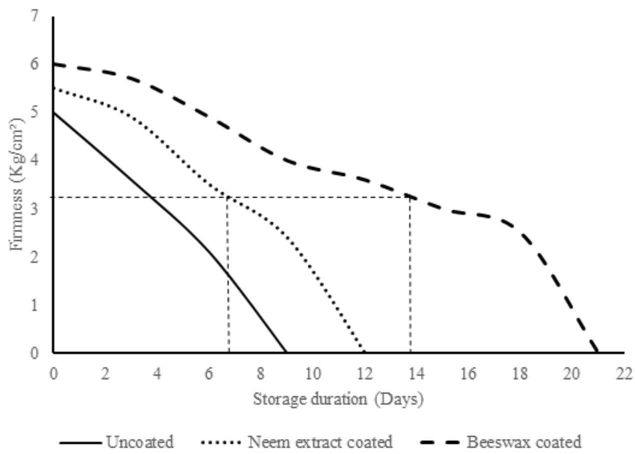
Physiological loss in weight (PLW)

The sampled fruits, for every treatment, were grouped into three categories based on their weights (20-30 grams, 31-40 grams, 41-50 grams). The fruits stored in the evaporative cooler had a lower PLW compared to those in the ambient. In both storage conditions, the uncoated fruits had a higher PLW as compared to the coated ones. Additionally, the fruits in the ambient conditions had a higher PLW than those in the evaporative cooler. The loss in weight in fresh guava fruits is mainly due to the loss of water caused by transpiration process. The loss of weight is a major indicator of the loss of visual quality of the fruits. The coatings on the fruits reduces the rate of desiccation of the fruits hence minimizing the weight loss. The fruits in the evaporative cooler lost moisture at a lower rate since the evaporative cooler's micro-climate had a higher relative humidity hence reducing the rate of moisture loss from the fruits (Graph 1).



Graph 1 Physiological loss in weight (PLW) of fruits with various treatments and storage conditions.

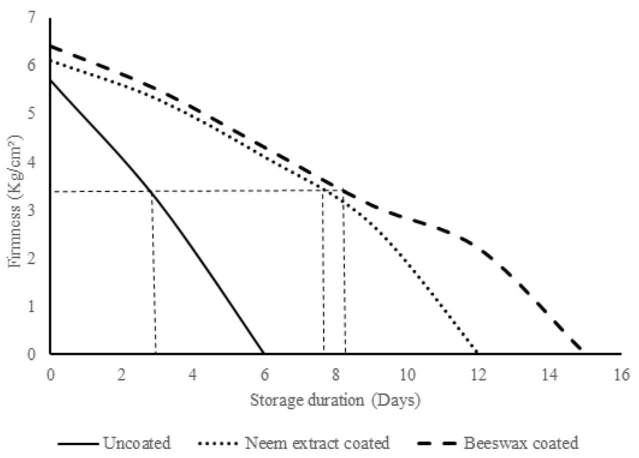
CEC, untreated fruits in the evaporative cooler; NEC, need coated in the EC; BEC, beeswax coated in the EC; BC, beeswax coated in the ambient; NC, neem extract coated in the ambient; CC, uncoated in the ambient.



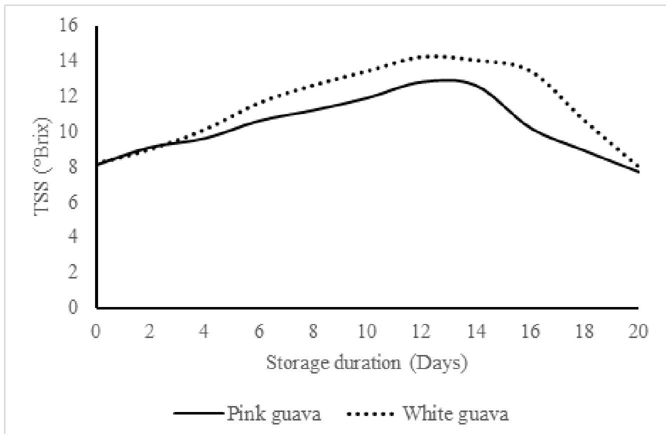
Graph 3 A graph showing variation of firmness with time of the fruits stored in the evaporative cooler.

Firmness

Firmness is an important attribute that is used by the consumers to assess the quality of the fruits. The firmness of the fruits decreased with advancing storage period as shown in Graph 2 & Graph 3 below. This is due to the softening of the fruit tissues resulting from senescence. The fruits stored in the evaporative cooler lost their firmness at a slower rate as compared to those stored in the ambient condition. Beeswax coating slowed the rate of respiration more compared to neem extract coating and the non-coated, by regulating the rate of gaseous exchange which minimized the ripening process of the fruits. The best consumption time for the guavas was at a firmness 3.2-3.5 Kg/cm² as shown in Graph 3 & Graph 4 since the fruits well-ripened and had the best flavour, texture and appearance.



Graph 2 A graph showing variation of firmness with time of the fruits stored in the ambient conditions.



Graph 4 A graph of sugar content of the pink and white guava varieties against time.

Total soluble solids (TSS)

The TSS at the start of the storage period was low and increased as storage advanced until it reached an optimum after which it decreased. This was achieved faster in the fruits stored in the ambient than those stored in the evaporative cooler due to the higher ripening rates. The increase in TSS may be due to hydrolysis of starch into sugars by enzymes after whose completion the TSS does not increase further. The decline in TSS content thereafter is as a result of respiration where the sugars are the main substrates. The white variety was found to have a higher TSS content as compared to the pink guava as shown in Graph 5.

Organoleptic properties

Organoleptic ratings of the stored fruits were tabulated as shown in Table 1 below. It was observed that the rating remained higher for a longer period for the fruits stored in the evaporative cooler than those in the ambient conditions. The beeswax coated fruits maintained

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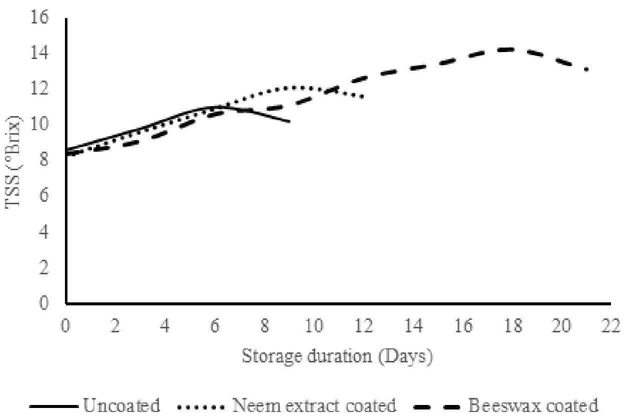
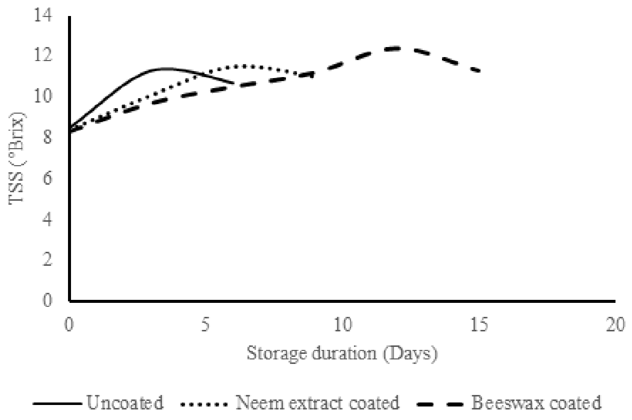
better quality for a longer period of time then followed by neem extract coated ones. The uncoated fruits maintained high organoleptic rating or the shortest time. This may be attributed to the different rates of post-harvest degradation as a result of senescence.



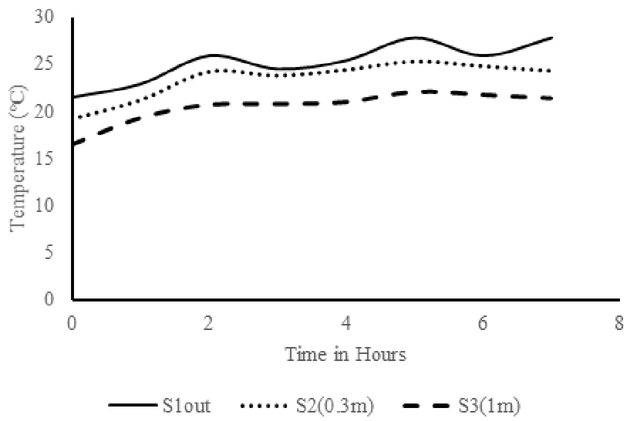
Graph 5 Variations in TSS with time for the fruits stored in the evaporative.

Table 1 Organoleptic rating of the stored guava fruits

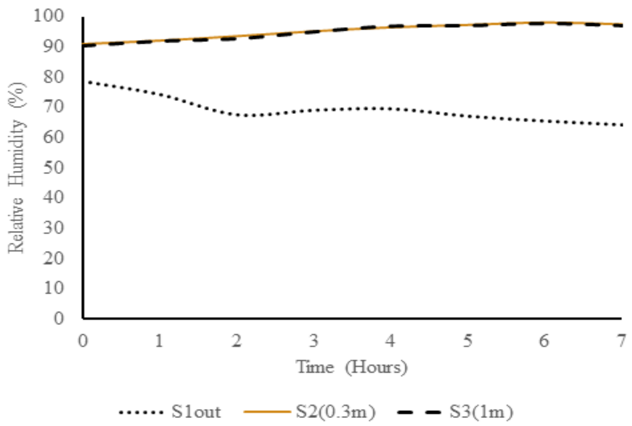
		Storage days							
Storage condition	Treatment	0	3	6	9	12	15	18	21
Evaporative cooler									
	Beeswax coating	1	1	1	1	1	2	3	4
	Neem extract coating	1	1	2	3	4	-	-	-
	Untreated	1	2	3	4	-	-	-	-
Ambient									
	Beeswax coating	1	1	1	2	3	4	-	-
	Neem extract coating	1	2	3	4	-	-	-	-
	Untreated	1	2	4	-	-	-	-	-



Graph 6 Variations in TSS with time for the fruits stored in the ambient conditions.



Graph 7 A graph of the average Temperature against Time throughout the day over the entire storage period.



Graph 8 A graph of the average relative humidity vs time throughout the day over the entire storage period.

Effects of storage conditions on the quality parameters of guava

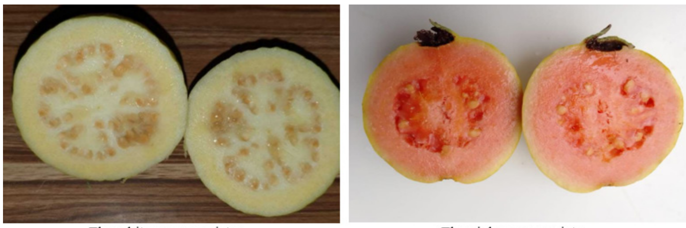
The micro-climate conditions within the cooler provided temperatures lower than the ambient and a higher relative humidity as shown in Graph 6–8 below. This was achieved through the evaporation of water by the incoming warm air thus achieving a cooling effect on the product. The products stored in the ambient conditions deteriorated in quality faster than those stored in the scoria evaporative cooler. The lower temperature in the cooler slowed down the rate of physiological and biochemical reactions which reduces the rate of ripening and deterioration of the product. The higher relative humidity reduces the rate of desiccation further prolonging the shelf-life of the products. The average saturation efficiency of the cooler obtained throughout the storage period was 84.2%.

Comparison of the quality of guava under different storage treatments

The guava fruits exhibited different rates of quality deterioration depending on the treatments and storage conditions, which affected their shelf-life as shown in Table 2 below. The products coated with beeswax maintained their quality for the longest time, followed by neem extract coated ones, and the uncoated ones had the least time. The micro-climate conditions in the cooler were suitable in prolonging the shelf life of guavas which increased by up to 12 days in the case of beeswax coated fruit (Figure 2).

Table 2 The shelf life of the sampled guava fruits

	Control (uncoated)	Neem extract coated	Beeswax coated
	Time (days)		
Evaporative cooler	4-7	7-9	16-20
Ambient	3-4	5-7	8-12



The white guava variety The pink guava variety

Figure 2 The two varieties used were the white and the pink varieties.

Conclusion

Storage of guava fruits in a scoria evaporative cooler was found to be an effective way of increasing their shelf-life, which is a desirable attribute in achieving food security. This is shown in Table 2, where the guava fruits stored in the evaporative cooler had a longer shelf life as compared to those stored in ambient conditions. This means that they maintained their quality for a longer period of time as compared to those in the ambient. The result was similar to that obtained by Vala et al.[7] On the hand, coating guava fruits with organic coatings, neem leaf extract and beeswax coating, prolonged the shelf-life by varying lengths of time. Beeswax coating on the fruits helped in attaining the longest shelf-life among the three sample groups, followed by neem leaves extract. These results were similar to those obtained by Shivani et al.[8]

Acknowledgments

None.

Conflicts of interest

The authors declare that there is no conflicts of interest.

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