International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-3, February 2020

Postharvest Application of Moringa Gum and Cinnamon Essential Oil as Edible Herbal Coating for Extending Shelf Life and Quality of Guava (*Psidium Guajava*)

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Abstract: ***In recent years, the use of various chemicals before and after harvest has become common to boost shelf life. However, the use of these chemicals has its own drawbacks, as some of them are considered to be harmful to the environment and also unfeasible. The main objective of this study is to use edible herbal coating formulations based on Moringa gum [MG] (Concentration: 1, 2 3, 4 and 5 %) and cinnamon essential oil (1 %) for the enhancement of quality and lifespan of guava kept at room temperature for 15 days by applying two methods of coating; dipping and brushing. The guava was dipped and brushed in MG solution for 2 minutes. Analyses of the guavas were done at every 3 days interval. The treatment C3D (Concentration 3 %; dipping) showed the minimum shrinkage index (13.34 %), Physiological Weight Loss [PWL] (27.09 %), fungal decay (70 %), pH (3.76), Total Soluble Solids (TSS) (11.14 °B), mesophilic microbial count (6.73 log CFU/g) as compared to the other samples. The maximum firmness (190.72 N), Titratable Acidity [TA] (0.28 g/L), antioxidant content (15.58 %) and phenolic content (15.93 mg GAE/g) were also observed in C3D coated guavas. These findings indicate that usage of C3D MG coating was successful in maintaining the physiochemical properties of guava and in preserving the fruit's sensory qualities. Future studies would benefit the industries on the utilization of MG for postharvest management of fruits and vegetables as a healthy alternative to chemical fungicides.***

Keywords **: *coating, dipping, brushing, quality***

Revised Manuscript Received on February 05, 2020.

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I. INTRODUCTION

In general, crops were cultivated for immediate use and sold on local markets. This evolved as communication facilities enhanced delivery technology, increased inventory storage and better transportation systems. Many developing countries in the tropical region are vulnerable to catastrophic consequences of elevated temperatures and relative humidity due to fruit processing and handling schemes. Subsequently, effective new production handling schemes were built to ship fruits to global consumers, as compared to national and local markets [1].

Consequently, it really is consequential to track postharvest diseases to tidy crop efficiency. This study deals with eco-friendly approach to control postharvest diseases. Edible coatings usually consist of one or more of four main substance: proteins, resins, polysaccharides and lipids. The optimal edible coating needs to develop a layer that can prevent the removal of appropriate volatile taste and water vapour while reducing CO_2 and O_2 transmission, producing a modified environment.

The fifth main fruit of India is Guava (*Psidium guajava*) and belongs to the genus of Myrtaceae. Guava is among the most widely known fruits appreciated by the poor and the rich, and also known as the "Apple of Tropics"[2]. Guava is cultivated throughout the subtropical and tropical area because of its immense nutritional importance and suitable taste. It is a pleasant fruit with rich vitamin C source and because it is a climatic fruit it matures soon after collection and has a very limited shelf life [3]. Guavas are therefore required to be treated properly in order to obtain a controlled and efficient availability to the market through postharvest treatments and improved storage life.

Plants like *Moringa oleifera* are in great demand for their nutritional and medicinal properties. All parts of moringa plants are used by humans as a rich source of vitamins B and C as well as amino acids. It has exceptionally high crude protein, low anti-nutritional elements and antimicrobial agents. In this study it's used as herbal edible coating to enhance stability and shelf life and to increase microbial safety of food.

Cinnamomum zeylanicum is a tropical tree that belongs to the family Lauraceae. Cinnamon leaves and barks are popularly used in food items and for various medical uses as a spice and flavoring agent.

Cinnamon is used mainly for therapeutic means, due to its specific attributes. The essential oil from its bark is high in transcinnamaldehyde with antimicrobial properties against microbes of food poisoning [4].

Keeping these viewpoints, this study was conducted with objectives to extend the marketable lifespan of guava and to evaluate the physiochemical developments of guava fruits throughout transportation and storage, to analyze the impact of variations on the consistency and lifespan of guava fruits treated with moringa gum herbal edible coating material enriched with cinnamon essential oil and to determine the efficiency of two methods of coating; dipping and brushing.

II. MATERIALS AND METHODS

The current investigation was undertaken to evaluate the efficacy of cinnamon essential oil enriched moringa gum as an edible coating for the postharvest shelf life extension of guavas. The guava samples in the current study were divided into 11 groups [(Dipping (D), Brushing (B), Concentration (C); C1D, C1B, C2D, C2B, C3D, C3B, C4D, C4B, C5D, C5B (the numbers indicate the percentage of MG) and Control]. Cinnamon essential oil (1 %) was added to each treatment except the control to reduce the characteristic smell of moringa gum.

A. Procurement of raw materials

Freshly harvested guavas of uniform size, maturity and colour had been bought from a local market in Chennai, Tamil Nadu, India 24 hours before treatment application. Requirements for selecting were size, lack of skin damage, maturity and colour. Guavas were thoroughly washed and cleansed using distilled water and air dried.

B. Preparation of moringa gum herbal coating solution

Moringa gum powder (1, 2, 3, 4, and 5 g) were taken and dissolved in 100 mL distilled water. The sample was then magnetically heated to 60ºC for 20 minutes. Cinnamon essential oil (1%) was added after 20 minutes and heated at 60°C for 5 minutes using magnetic stirrer.

C. Coating of guava with moringa gum and cinnamon essential oil

Dipping and brushing techniques were employed to coat the guavas. The samples were immersed in individual coating solutions for 2 minutes and allowed to drip off and air dried for dipping method of coating. The samples were brushed with moringa gum herbal coating solution for 2 minutes and air dried for brushing method of coating. Control samples were immersed and brushed with sterilized distilled water and allowed to drip off and air dried. All the samples were stored in aseptic environment and analyzed at an interval of 3 days for a period of 15 days.

D. Shrinkage Index (SI)

Diameter of fruits was measured by using Vernier Caliper at the point on which fruits had maximum diameter. This observation was recorded initially and subsequently at 3 days interval of storage [5].

E. Physiological Weight Loss (PWL)

Weights of the guavas were recorded at regular intervals of the storage period by semi analytical scale with ± 0.01 g accuracy.

F. Determination of pH

For the measurement of pH, Systronics digital pH meter 335 was used. The fruit sample (5 g) was crushed and filtered with muslin cloth to obtain the juice. The pH probe was placed in the juice sample and pH value was recorded [7].

G. Titratable Acidity (TA)

The fruit sample (10 g) was grounded in a blender and filtered using a muslin cloth to obtain the juice. Volume was formed by distilled water up to 50 ml. Diluted sample (10 mL) was then titrated with 0.1N NaOH against a few drops of 1% phenolphthalein solution [8]. The measured titre value was used to measure the TA as percent anhydrous citric acid.

H. Total Soluble Solids (TSS)

For determination of TSS, 10 g of fruit sample was grounded in a blender to extract the juice. TSS is measured with Fisher Hand Refractometer (0 - 30 °B). The results were reported as degree of brix (°B).

I. Texture analysis

Texture analysis (firmness) of guavas was done using TA-XT Plus texture analyzer. Firmness of the fruit sample was determined using the skin puncture strength of the sample by penetrating with a 2 mm probe at 5 mm depth.

J. Antioxidant

The total antioxidant content of the guava was calculated using the method of DPPH scavenging activity [9]. Stock solution was prepared in 100 mL methanol by dissolving 1.9 mg of DPPH (0.1 mM) and kept at refrigeration condition until used. Guava juice (1 mL) was added to 3 ml of methanolic DPPH solution and allowed to scavenge in the dark for 30 minutes. The absorbance was taken at 516 nm.

K. Total phenolic content

The total phenolic content of the guava was calculated by using the reagent Folin-Ciocalteu [10]. Each treatment's juice (1mL) was thoroughly mixed with a Folin-Ciocalteu reagent of 5 mL. After 3 minutes of stirring, 5 mL of 7.5 % (w/v) sodium carbonate was added and kept in dark for 30 minutes. The absorbance was analyzed at 760 nm along with a blank. The findings were presented as gallic acid equivalent (GAE) milligrams (mg) per gram (g) of guava.

L. Spoilage (Fungal decay %)

After coating, the stored guavas were visually inspected at regular time periods for fungal decay for 15 days.
The percentage of fungal decay was defined as the percentage of number of affected fruits to the overall number of guavas [11].

M. Microbial analysis

Guava juice (10 mL) was serially diluted to enumerate different microbial groups [12]. The colonies were counted and microbial counts were determined using the formula as log CFU/ g (colony forming units per gram of sample).

N. Sensory analysis

Sensory evaluation was conducted after each storage interval for its overall acceptability using a 9-point hedonic scale by semi and untrained board of 10 people after determining the acceptability of the fruit sample for human consumption with respect to physiochemical and microbial analysis. [13].

O. Statistical analysis

All data obtained from the trials were analyzed by SPSS, version 19.0 for Windows. The data were tested for one-way ANOVA by Duncan's multiple range analysis and shown as mean values ± standard deviation (SD). The probability value of statistical significance was $p \leq 0.05$.

III. RESULTS AND DISCUSSION

A. Shrinkage Index (SI)

The data regarding the shrinkage index of guava during storage as influenced by various treatment concentration and methods are depicted in Table I. The treatments were found to significantly influence the shrinkage index of fruits throughout the storage period. Regardless of storage period, it was observed that C3D (13.34 %) showed lower mean shrinkage index on the 15th day of storage followed by C4D (14.07 %) and C3B (15.16 %). Irrespective of the treatments, the mean shrinkage index (%) gradually increased with an expansion of the 15 day storing duration.

B. Physiological Weight Loss (PWL)

In the present study there was a significant difference in the weight loss of herbal edible coated and uncoated guavas during storage period. The weight loss in guavas increased significantly in all the coated and uncoated guavas as the progress of storage time as shown in Table I. While comparing the physiological weight loss of guavas coated with different concentrations of the herbal extract it was found that C3D (27.09 %) had a lower physiological weight loss followed by C3B (29.08 %) and C4D (29.38 %). The decrease in PWL was likely because of the efficacy of these edible herbal coating as a semi-permeable layer to O_2, CO_2, moisture and solvent transport, reducing respiration, water loss and oxidation reactions. [14].

C. pH variation

The herbal edible coated and uncoated guava pulp was analyzed for their pH value during storage period. The results revealed that the guavas stored at room temperature demonstrated a gradual significant increase in pH with increase in storage time for herbal edible coated and control guavas as depicted in Table II. Due to the edible coating that forms a semi-permeable layer on the surface of guavas, the pH raised, changing the internal CO_2 and O_2 content of the guavas, thereby slowing the maturing process. However, uncoated guavas had greater pH raise during storage as greater utilization of organic acids as aerobic substrate deposited throughout the vacuoles as compared to coated guavas because the herbal edible coating acted as a protective layer around the fresh produce which may result in less accumulation of acids inside the vacuoles [15].The guavas coated by the dipping method, in general, exhibited lower pH change when compared to those guavas coated by brushing method. While comparing the pH change of guavas coated with different concentrations of the herbal extract it was found that C3D (3.76) had the lowest pH change followed by C4D (3.78) and C3B (3.84).

D. Titratable Acidity (TA)

The values of titratable acidity of herbal edible coated and uncoated guavas reduced significantly with storage period as depicted in Table II. The maximum percentage of titratable acidity of guavas was found in C3D (0.28 g/L) followed by C4D (0.27 g/L) and C3B (0.27 g/L). Decreasing titrable acidity throughout ripening is an important concept as it makes the fruits less acidic. While organic acids such as citric acid, malic acid, are the essential substrate for breathing, respiring fruits and vegetables are supposed to decrease in acidity. A similar decrease in titratable acidity has been observed in mango during ripening [16]. Moringa gum and cinnamon essential oil based herbal edible coating applied on guavas hereupon decreased respiration intensity and restricted the use of organic acids that resulted in lower acid depletion in guavas.

E. Total Soluble Solids (TSS)

Taste and sweetness of the guavas depend on the concentration of total soluble solids. It was observed in Table III that there was a significant increase in TSS throughout the storage. Present study showed that TSS was increasing with the decrease of TA during ripening of guava. At the end of storage period TA was recorded as C3D (11.14 °B), C3B (11.2 °B) and C4D (11.5 °B). Increasing TSS during fruit maturation has been related to increased enzyme activity accountable for starch hydrolysis in soluble sugars [17]. Edible coating delays this process as coating slows down the metabolism by reducing internal respiration rate and thus, avoiding drastic reductions in the levels of soluble solids of coated fruits as compared to control which implies changes in TSS in coated fruit was slower than control.

F. Texture analysis

The firmness of the uncoated and coated samples significantly decreased with storage period as depicted in Table III. The results indicated that the moringa gum and cinnamon essential oil based herbal edible coating significantly kept guava firm and acted as a barrier against water and nutrient loss.

At the end of storage period the firmness obtained was C3D (190.72 N), C3B (187.15 N) and C4D (179.37 N). Reduced respiration rates caused by the herbal edible coated guavas may be accountable for postponing the softening that led to firmness retention throughout the storage time.

G. Antioxidant

The findings (Table IV) showed that there was a significant decrease in antioxidant activity throughout the storage period. The decrease in antioxidant activity has been confirmed to be correlated with a decrease in total phenolic content. Among the various extracts of coated and uncoated guava, extract from C3D treatment group exhibited the maximum activity (15.58 %). Amid the other coated guavas, greater antioxidant, scavenging activity was displayed by C3B (14.45 %), followed by C4D (12.05 %). Control samples exhibited the least antioxidant activity. Similar results were observed where the edible coating comprising cinnamon essential oil had the greatest antioxidant potential similar to other coatings in apples where cinnamon essential oil was used along with cassava starch [19].

H. Total phenolic content

Total phenolic content decreased significantly with the increase in storage period (Table IV). Polyphenolic compounds like flavonoids, tannins, and phenolic acids are responsible for many biological activities in which one of them is antioxidant activity. The highest value was observed in C3D (15.93 mg GAE/g), C3B (13.49 mg GAE/g) and C4D (12.35 mg GAE/g) on the last day of storage. During storage, coated guavas showed relatively slower reduction in total phenolic content than control guavas. These findings have coincided with the research carried out in sweet cherries coated with chitosan [18].

I. Spoilage (Fungal decay)

Table V indicates the decay percentage of uncoated and coated guavas during storage period under ambient conditions. The decay percentage in guavas increased significantly in all the coated and uncoated guavas. Decay percentage of control guavas were 100% from the 9^{th} day of storage period. C3D, C3B and C4D were found to be most effective and C1D, C1B, C2D, C2B, C4B, C5D and C5B proved to be less effective in reducing the decay percentage of guavas. In a similar study it was reported that the application of cinnamon oil to the cassava starch coating has apparently blocked the development of microorganisms such as *Staphylococcus aureus* and *Salmonella choleraesuis* [19].

J. Microbial analysis

Microbial counts for mesophilic microbes increased with longer storage duration significantly for all treatments (Table V). The highest mesophilic plate count was observed in control (6.78 log CFU/g) on the 6^{th} day. The minimum plate count was shown by the group C3D (6.73 log CFU/g) followed by C3B (6.79 log CFU/g) and C4D (6.87 log CFU/g). The protective effect of edible moringa gum layer aided in decreasing the growth of microbes that influence the performance of guavas, by acting as a boundary to gases as water and nutrients are necessary for the development of microbes [20].

K. Sensory analysis

Sensory evaluation of fruits and vegetables is an essential criterion for determining on the acceptance of customers. Human aspects play a major role in the evaluating organoleptic characters of the fruits. The sensory evaluation of uncoated and coated (C3D, C3B and C4D) guavas was carried out. Table VI summarizes the sensory evaluation results. The sensory data of the groups on day 12 and day 15 was more or less similar. In the scenario of the sensory assessment of the coated guavas' shelf life, it was observed that the moringa gum and cinnamon essential oil based herbal edible coating greatly improved the guavas' shelf-life, retaining the visual quality throughout the storage time in relation with uncoated guavas. The study findings imply that guava fruits coated (dipping method) with 3 % moringa gum displayed a considerable reduction in weight loss and delayed the change in firmness, titratable acidity and greater total soluble solids throughout storage at room temperature as compared to control guava. Furthermore, sensory testing revealed that 3% moringa gum coating (dipping method) kept the overall fruit consistency throughout storing better than the other treatment groups throughout the storage studies.

Table I: Effect of different treatments on Shrinkage Index [SI] (%) and Physiological Weight Loss [PWL] (%)

Period	Day 3		Day 6		Day 9		Day 12		Day 15	
Treatment	SI	PWL	SI	PWL	SI	PWL	SI	PWL	SI	PLW
Control	2.18±0.81^{bc}	8.24±0.89^{e}	4.00±1.50^{d}	17.14±1.31^{d}	-	-	-	-	-	-
C1D	2.18±0.81^{bc}	7.13±1.44^{c}	3.27±0.81^{c}	14.66±1.34^{c}	10.54±1.52^{d}	26.34±1.08^{f}	-	-	-	-
C1B	2.18±0.81^{bc}	7.72±0.51^{c}	4.00±0.81^{d}	16.41±0.45^{c}	-	-	-	-	-	-
C2D	1.81±0.01^{b}	6.57±0.83^{c}	2.90±0.99^{c}	14.11±1.80^{c}	10.18±1.62^{d}	25.84±1.72^{f}	12.36±0.81^{d}	27.19±0.92^{e}	-	-
C2B	1.81±0.01^{b}	6.76±0.72^{bc}	3.67±0.81^{d}	15.24±3.48^{b}	10.54±1.52^{d}	26.39±1.92^{g}	13.01±0.65^{e}	28.03±1.04^{f}	-	-
C3D	1.45±0.81^{a}	5.18±0.90^{a}	1.81±0.01^{a}	12.05±3.37^{a}	6.18±3.77^{a}	19.12±4.75^{a}	9.45±1.52^{a}	22.11±4.82^{a}	13.34±1.11^{a}	27.09±4.86^{a}
C3B	1.79±0.81^{b}	6.07±1.17^{b}	2.32±1.25^{b}	14.14±4.29^{b}	6.90±2.37^{bc}	20.12±3.93^{a}	11.27±1.52^{c}	23.10±4.03^{b}	15.16±3.16^{c}	29.08±2.39^{b}
C4D	1.49±1.10^{a}	6.17±0.25^{b}	2.10±1.08^{b}	13.44±2.93^{b}	6.54±2.75^{a}	22.01±3.48^{c}	10.36±1.37^{b}	24.90±4.46^{c}	14.07±2.10^{b}	29.38±1.31^{b}
C4B	2.00±0.40^{bc}	6.47±1.17^{c}	4.00±0.81^{d}	16.73±2.95^{c}	7.27±2.22^{c}	23.70±2.56^{d}	12.36±1.37^{d}	25.69±4.06^{d}	-	-
C5D	2.14±0.99^{bc}	7.07±1.71^{cd}	4.00±2.69^{d}	15.11±2.28^{c}	10.54±2.69^{d}	25.05±3.16^{e}	-	-	-	-
C5B	2.00±0.40^{bc}	8.05±1.48^{e}	4.30±2.69^{e}	16.16±2.04^{d}	-	-	-	-	-	-

Results are expressed as mean ± SD by Duncan multiple range test. Means with the same letters (superscripts) are not significantly different and means with different letters (superscripts) are significantly different.

Table II: Effect of different treatments on variations in pH and Titratable Acidity [TA] (g/L)

Period	Day 3		Day 6		Day 9		Day 12		Day 15	
Treatment	TSS	Firmness	TSS	Firmness	TSS	Firmness	TSS	Firmness	TSS	Firmness
Control	9.06±0.05^{d}	263.22±0.04^{a}	10.16±0.1^{d}	239.57±0.03^{a}	-	-	-	-	-	-
C1D	8.84±0.05^{bc}	264.17±0.02^{c}	9.88±0.04^{c}	242.27±0.05^{c}	10.10±0.1^{b}	200.85±0.03^{a}	-	-	-	-
C1B	8.92±0.04^{c}	264.00±0.0^{b}	9.96±0.11^{c}	242.36±0.02^{d}	-	-	-	-	-	-
C2D	8.62±0.04^{b}	266.47±0.04^{f}	9.42±0.04^{b}	245.75±0.05^{g}	9.90±0.15^{a}	208.44±0.01^{d}	10.82±0.1^{bc}	189.56±0.05^{b}	-	-
C2B	8.90±0.07^{c}	266.54±0.1^{g}	9.48±0.08^{b}	244.39±0.05^{f}	10.18±0.1^{b}	207.48±0.05^{c}	10.92±0.1^{b}	188.35±0.02^{a}	-	-
C3D	8.26±0.05^{a}	268.94±0.1^{k}	8.92±0.08^{a}	253.89±0.05^{k}	9.70±0.15^{a}	220.70±0.04^{h}	10.60±01^{a}	196.85±0.03^{f}	11.14±0.1^{a}	190.72±0.02^{c}
C3B	8.64±0.05^{b}	268.35±0.04^{j}	9.70±0.10^{b}	251.71±0.04^{j}	9.80±0.10^{a}	217.84±0.04^{g}	10.80±0.1^{bc}	193.44±0.05^{e}	11.20±0.1^{a}	187.15±0.04^{b}
C4D	8.50±0.07^{b}	267.89±0.05^{i}	9.24±0.11^{a}	247.55±0.04^{i}	10.00±0.1^{b}	213.33±0.04^{f}	11.06±0.1^{d}	191.36±0.04^{d}	11.50±0.1^{b}	179.37±0.05^{a}
C4B	8.58±0.08^{b}	267.18±0.1^{h}	9.70±0.10^{b}	246.34±0.03^{h}	10.30±0.2^{c}	211.43±0.05^{e}	11.22±0.1^{d}	186.42±0.04^{c}	-	-
C5D	8.86±0.05^{bc}	265.87±0.01^{e}	10.10±0.1^{d}	243.90±0.05^{e}	10.22±0.1^{c}	206.53±0.05^{b}	-	-	-	-
C5B	8.88±0.04^{bc}	265.07±0.1^{d}	10.16±0.1^{d}	241.84±0.03^{b}	-	-	-	-	-	-

Results are expressed as mean ± SD by Duncan multiple range test. Means with the same letters (superscripts) are not significantly different and means with different letters (superscripts) are significantly different.

Table III: Effect of different treatments on Total Soluble Solids [TSS] (°B) and Firmness (N)

Period	Day 3		Day 6		Day 9		Day 12		Day 15	
Treatment	DPPH	Phenol	DPPH	Phenol	DPPH	Phenol	DPPH	Phenol	DPPH	Phenol
Control	28.65±0.01^{a}	21.02±0.06^{a}	21.40±0.01^{a}	19.35±0.05^{a}	-	-	-	-	-	-
C1D	29.16±0.01^{bc}	22.37±0.04^{bc}	23.88±0.01^{d}	19.76±0.04^{a}	18.72±0.03^{a}	17.80±0.03^{bc}	-	-	-	-
C1B	29.65±0.01^{d}	23.02±0.03^{cd}	23.70±0.01^{d}	19.80±0.05^{a}	-	-	-	-	-	-
C2D	29.75±0.01^{d}	23.66±0.02^{d}	24.90±0.01^{g}	20.50±0.05^{ab}	19.87±0.04^{b}	18.86±0.05^{cd}	13.15±0.01^{a}	15.31±0.02^{b}	-	-
C2B	29.65±0.01^{d}	23.50±0.03^{d}	24.57±0.01^{f}	20.08±0.03^{a}	19.51±0.02^{b}	18.13±0.05^{bc}	12.95±0.01^{a}	15.06±0.02^{b}	-	-
C3D	30.37±0.01^{f}	25.85±0.01^{f}	28.04±0.01^{j}	23.90±0.05^{d}	25.46±0.01^{f}	21.10±0.03^{f}	17.08±0.02^{d}	18.02±0.05^{d}	15.58±0.04^{c}	15.93±0.05^{c}
C3B	29.83±0.04^{e}	25.75±0.01^{f}	27.12±0.05^{i}	23.06±0.05^{cd}	24.80±0.03^{e}	20.60±0.06^{ef}	15.86±0.06^{c}	17.38±0.05^{c}	14.45±0.07^{b}	13.49±0.06^{b}
C4D	29.54±0.04^{d}	24.77±0.03^{e}	26.01±0.07^{h}	22.10±0.06^{bc}	22.91±0.05^{d}	19.49±0.04^{de}	14.07±0.06^{b}	16.42±0.03^{c}	12.05±0.06^{a}	12.35±0.05^{a}
C4B	29.01±0.04^{b}	23.98±0.02^{de}	24.06±0.06^{e}	19.93±0.06^{a}	20.20±0.04^{c}	17.48±0.05^{b}	13.18±0.02^{a}	14.66±0.06^{a}	-	-
C5D	29.24±0.07^{c}	22.27±0.03^{bc}	23.57±0.05^{c}	19.49±0.06^{a}	20.07±0.05^{c}	16.05±0.06^{a}	-	-	-	-

C5B	29.16±0.06^{bc}	21.73±0.02^{ab}	23.06±0.05^{b}	18.99±0.06^{a}	-	-	-	-	-	-

Results are expressed as mean ± SD by Duncan multiple range test. Means with the same letters (superscripts) are not significantly different and means with different letters (superscripts) are significantly different.

Table IV: Effect of different treatments on DPPH Radical Scavenging Activity (%) and Total Phenolic Content (mg GAE/g)

Period	**Day 3**		**Day 6**		**Day 9**		**Day 12**		**Day 15**	
Treatment	**pH**	**TA**	**pH**	**TA**	**pH**	**TA**	**pH**	**TA**	**pH**	**TA**
Control	3.30±0.07^{b}	0.40±0.01^{a}	3.54±0.05^{b}	0.35±0.01^{a}	-	-	-	-	-	-
C1D	3.24±0.05^{b}	0.41±0.01^{b}	3.38±0.08^{b}	0.36±0.01^{b}	3.64±0.05^{b}	0.31±0.01^{a}	-	-	-	-
C1B	3.28±0.04^{b}	0.41±0.01^{b}	3.44±0.05^{b}	0.35±0.01^{a}	-	-	-	-	-	-
C2D	3.14±0.11^{a}	0.41±0.01^{b}	3.36±0.05^{b}	0.36±0.01^{b}	3.56±0.05^{b}	0.32±0.01^{b}	3.75±0.07^{b}	0.29±0.01^{b}	-	-
C2B	3.24±0.05^{b}	0.41±0.01^{b}	3.44±0.05^{b}	0.35±0.01^{a}	3.66±0.05^{b}	0.31±0.01^{a}	3.92±0.04^{c}	0.26±0.01^{a}	-	-
C3D	3.06±0.08^{a}	0.42±0.01^{c}	3.16±0.08^{a}	0.41±0.01^{d}	3.32±0.08^{a}	0.38±0.01^{d}	3.50±0.07^{a}	0.32±0.01^{e}	3.76±0.05^{a}	0.28±0.01^{a}
C3B	3.10±0.12^{a}	0.41±0.01^{b}	3.22±0.08^{a}	0.40±0.01^{c}	3.44±0.08^{a}	0.37±0.01^{c}	3.68±0.10^{b}	0.31±0.05^{d}	3.84±0.05^{a}	0.27±0.01^{a}
C4D	3.08±0.13^{a}	0.41±0.01^{b}	3.18±0.08^{a}	0.40±0.01^{c}	3.38±0.08^{aa}	0.38±0.01^{d}	3.56±0.08^{a}	0.31±0.05^{d}	3.78±0.10^{a}	0.27±0.05^{a}
C4B	3.18±0.08^{a}	0.41±0.01^{b}	3.36±0.11^{b}	0.40±0.01^{c}	3.58±0.10^{b}	0.37±0.01^{c}	3.70±0.10^{b}	0.30±0.01^{c}	-	-
C5D	3.24±0.05^{b}	0.41±0.01^{b}	3.34±0.11^{b}	0.36±0.01^{b}	3.54±0.08^{b}	0.31±0.01^{a}	-	-	-	-
C5B	3.26±0.08^{b}	0.41±0.01^{b}	3.44±0.05^{b}	0.35±0.01^{a}	-	-	-	-	-	-

Results are expressed as mean ± SD by Duncan multiple range test. Means with the same letters (superscripts) are not significantly different and means with different letters (superscripts) are significantly different

Table V: Effect of different treatments on Fungal Decay (%) and Total Mesophilic Plate Count [TPC] (log CFU/g)

Period	**Day 3**		**Day 6**		**Day 9**		**Day 12**		**Day 15**	
Treatment	**Decay**	**TPC**	**Decay**	**TPC**	**Decay**	**TPC**	**Decay**	**TPC**	**Decay**	**TPC**
Control	0	6.25±0.02^{c}	50±5.47^{c}	6.78±0.03^{c}	-	-	-	-	-	-
C1D	0	5.98±0.02^{b}	40±5.47^{b}	6.54±0.01^{b}	60±4.47^{e}	6.82±0.02^{c}		-		-
C1B	0	6.02±0.02^{bc}	40±7.07^{b}	6.56±0.01^{b}	-	-	-	-	-	-
C2D	0	5.93±0.03^{b}	30±4.47^{a}	6.50±0.01^{b}	40±5.47^{b}	6.77±0.02^{bc}	60±4.47^{b}	6.96±0.01^{b}	-	-
C2B	0	5.98±0.01^{b}	40±4.47^{b}	6.52±0.01^{b}	50±5.47^{d}	6.79±0.04^{bc}	60±4.47^{b}	6.96±0.03^{b}	-	-
C3D	0	5.65±0.05^{a}	0	6.06±0.06^{a}	0	6.40±0.03^{a}	0	6.54±0.02^{a}	70±5.47^{a}	6.73±0.03^{a}
C3B	0	5.70±0.01^{a}	0	6.19±0.01^{a}	0	6.48±0.04^{a}	40±5.47^{a}	6.57±0.03^{a}	80±5.47^{b}	6.79±0.01^{a}
C4D	0	5.74±0.04^{a}	0	6.33±0.03^{b}	20±7.07^{a}	6.63±0.05^{a}	60±7.07^{c}	6.67±0.01^{a}	80±5.47^{b}	6.87±0.02^{a}
C4B	0	5.78±0.01^{a}	0	6.42±0.02^{b}	40±7.07^{c}	6.57±0.10^{a}	60±7.07^{c}	6.91±0.01^{b}	-	-
C5D	0	6.02±0.02^{bc}	40±5.47^{b}	6.56±0.02^{b}	50±5.47^{d}	6.79±0.01^{bc}	-	-	-	-
C5B	0	6.04±0.01^{bc}	40±7.07^{b}	6.57±0.01^{b}	0	-	0	-	-	-

Results are expressed as mean ± SD by Duncan multiple range test. Means with the same letters (superscripts) are not significantly different and means with different letters (superscripts) are significantly different

Table VI: Sensory analysis: mean score of panelists for overall acceptability of guava during storage. [They were scored on a scale of 1-9 (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5= neither like nor dislike, 6= like slightly, 7= like moderately, 8 = like very much and 9= like extremely)]

Quality Parameter	**Treatment**	**Storage period (days)**			
		3	**6**	**9**	**12**
Texture	**Control**	7	-	-	-
	C3D	8	6	5	5
	C3B	8	6	5	5
	C4D	8	6	4	3

	Control	8	-	-	-
	C3D	8	7	6	6
	C3B	8	7	4	6
Colour	**C4D**	8	5	5	3
	Control	8	-	-	-
	C3D	8	7	6	5
	C3B	8	6	5	3
Taste	**C4D**	7	4	4	2
	Control	7	-	-	-
	C3D	7	7	6	5
	C3B	7	6	5	4
Aroma	**C4D**	6	6	5	3
	Control	7	-	-	-
	C3D	7	7	6	5
	C3B	7	5	5	3
Overall acceptability	**C4D**	6	5	4	2

IV. CONCLUSION

Postharvest loss is a concern in most nations, particularly in tropical regions. Edible herbal coating is a convenient and safe measure for effectively extending the shelf life of postharvest fruits and vegetables. This study comprised of postharvest treatments with moringa gum and cinnamon essential oil herbal edible coating in which different concentrations were made by altering the composition of moringa gum concentration; 1, 2, 3, 4 and 5%.

The study also tested which coating method; dipping and brushing showed better efficacy. The observations on physiochemical parameters, texture analysis, microbial analysis, organoleptic characters and shelf life were recorded. This study concluded that the moringa gum and cinnamon essential oil herbal edible coating extended the usable life and quality of guava at room temperature. Herbal edible coated guavas were better for all quality parameters as compared to uncoated guavas. The MG herbal edible coating was most useful in minimizing weight loss, shrinkage index, decay percent, pH, TSS, mesophilic microbial count. It also maintained the visual appearance and showed the maximum firmness, TA, antioxidant content and phenolic content in comparison with other samples. Therefore herbal edible coating could be used effectively as it is an effective method for the enhancement of shelf life in guavas.

Among the two coating methods; dipping and brushing. Dipping seemed to be efficient in retaining all the physiochemical parameters, texture analysis, microbial analysis, sensory analysis and better shelf life. Among the different concentrations of moringa gum, C3D showed better results in all the parameters analyzed followed by C3B and C4D. Concentrations 1, 2 and 5% did not show any significant effect in protecting the characteristics of guava as compared to the 3% and 4% concentration. The lesser protective effect displayed by 1 and 2% may be due to their lower concentration whereas lesser protective effect of 5% could be attributed to its high concentration which made the coating solution more viscous. Thus CD3 showed better effect in all the aspects investigated in this study.

The moringa gum coating is environmentally friendly, easy to apply and cost effective. It can be widely used to extend guavas' shelf life. Experiments on moringa gum herbal edible coating was performed on an experimental lab scale only. More study is therefore required on an industrial level, for the preservation of fruits and vegetables on a large scale.

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