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# Development of Edible Coating for Shelf Life Extension of Guava

## Edible Coating for Shelf Life Extension of Guava

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***Abstract***

Guava is economically important fruit which occupies a prominent position among fruit crops grown in Sri Lanka. Reported post harvest losses of guava were 46%. The study was carried out to find out suitable coating formula for shelf life extension of guava. The fruits were harvested the maturity at colour break change from green to scant yellow. Medium size fruits were selected while discarding disease and damaged fruits. Three different concentrations of cassava starch (1%, 2%, 3%) with 1% sunflower oil and Rice bran (1%, 2%, 3%) with 1% sunflower oil + 1% Bee wax were used for treatments and stored under ambient condition ($28^0$C-30 $^0$C, 55%-60% RH), and quality evaluation was done to find out suitable concentration of cassawa starch and rice bran along with other constituents. 2% cassava starch+1% sunflower oil; 2% Rice bran +1% sunflower oil + 1% Bee wax were selected as better performed treatments in retaining the overall quality as it caused minimum changes in fruit Firmness, Titratable acidity, Reducing sugars, Total soluble solids (TSS). Generally, all treatments caused significant ($P<0.05$) decrease in fruit firmness and pectin content.

***Keywords***

*Guava; Edible Coatings; Bee Wax; Cassawa Starch; Shelf Life*

### Introduction

Guava, one of popular fruit crops grown in most of the agro ecological zones in Sri Lanka, is highly perishable and every year large quantities of fruits are discarded due to spoilage. The major deteriorative changes due to those are wilting, shriveling, and loss in texture of fresh fruits, weight and their appearance. Owing to its characteristics shape, structure, and relative soft texture associated with their high moisture content, guava is much more susceptible to mechanical or physical injuries such as bruising, cracking, and splitting of external tissues. Mechanical or physical injuries can occur at almost any point in the post harvest system resulting from poor handling and packaging, inadequate transportation and storage conditions, and damage in the market places (Iran, 1999).These changes can however be minimized by adopting proper postharvest management practices.

Edible coatings and film can provide an alternative for extending shelf life of fresh fruits and vegetables and result in the same effects as modified atmospheric storage where the internal gas composition is adjusted (Park, 1999). Traditionally, films and coatings have been used to reduce water loss but film materials and edible coatings formulated with wider range of permeability characteristics facilitate achieving a modified atmosphere effect in the fresh fruits (Smith et al., 1987). The main components are generally recognized as safe substances (GRAS); different extracts such as lipids, proteins, cellulose derivatives, starch and other polysaccharides (Guilbert, 1986; Kester et al.,1986). Use of edible coating is a common issue that is beneficial to protect nutrients of food specially fruits and vegetables and provides a long durability. These are a thin layer of edible material which restrict water loss, oxygen and other soluble materials of food (Baldwin et al., 1995).

Studies have been carried out in the past to improve the shelf life of guava using wax emulsion (Hussain, 1973). Although wax emulsion extends the shelf life of guava, there is a need to develop an alternative low cost edible coating material for shelf life extension using GRAS substances. Therefore the study was carried out to improve the market value of guava fruits by using different coating formulation.

### Material and Methods

Fresh guava (variety Bangkok giant) fruits were harvested at commercial maturity stage (based on peel color break stage, when skin color changes from dark green to light green) from a commercial farm at Anuradhapura (North Central part of the country) and transported under ambient conditions to the laboratory at Institute of Postharvest Technology

(IPHT). Diseased, damaged and extremely large or small fruits were discarded to minimize biological variability.

### *Selection of Coating Material*

Experiment was carried out to find out the suitable concentrations of the ingredients for coating formulations. Cassava starch, rice bran, sun flower oil and bee wax were used in different concentrations. Two different sets of formulations based on principlr ingredients as cassava and rice bran were tested. Pure and clean cassava starch was obtained by using the method (Dziedzoave et al.,2003), and Casswa roots were peeled, washed and grated. The grated pulp was mixed with water and filtered to separate particles. Settled starch was collected after washing and ground after drying. Pure bee wax was purchased and melted before use.

Rice bran of white raw rice was taken and ground into fine particles before preparation of the coatings. Cassava starch used in three different concentrations (1%, 2%, 3%) with 1% sunflower oil and rice bran was used in three different concentrations (1%, 2%, 3%) with 1% sun flower oil and 1% bee wax. The fruits were coated with above treatments and kept for air drying before storage under ambient temperature (28-30$^0$C, 55%-60% RH). The storage qualities of treated fruits were evaluated at two day intervals.

### *Storage Quality Evaluation*

Percentage weight loss was taken after each storage interval and loss in weight during storage was expressed as % of initial weight. Fruit samples weighed on top lording balance (OHAUS, model ARA 520, New Jersey, 07058,USA) after each storage interval. The loss in weight of each sample was observed. Fruit firmness was measured with digital firmness tester (model TR 53205) and the values were expressed as force required (1 kg) to complete penetration (1cm).Colour changes during postharvest storage were observed by an increase in the a/b ratio with increase in yellowness (b) and decrease in greenness (a) orange external colour was evaluated with colour difference meter (Konica Minolta TR 400) which provided L*, a* and b* values; in which L* is lightness and a* (-greenness to + redness) and b* (-blueness to + yellowness) being the chromaticity coordinates measurements were done in triplicate. The content of total soluble solids (TSS) is defined as the sugar content expressed in grams for 100g of juice. This parameter has been determined by direct reading on a refractometer {ATAGO, Model: HR-5 (9-90%), Japan}. Reading was reported as $^0$Brix. Titratable acidity was determined by the following volumetric method. The juice was neutralized by a NaOH solution (0.1 mol $L^{-1}$) added by some drops of phenolphthalein as indicator solution. Indeed, under neutral conditions, the NaOH solution turned the juice pink. A known sample of fruits was measured and crushed, taken in 250 ml volumetric flask and the volume was made up after filtration, in addition, 10 ml of filtration were titrated with 0.1 N NaOH by using phenolphthalein as indicator to the end point of faint pink color (Horwitz,1980). Reducing sugar content was estimated by Lane and Eynon's volumetric methods(Horwitz,1980) by titrating prepared samples, against known quantity of Fehling's solution, using methelene blue as indicator, till the appearance of brick red precipitates as the end point. The results were expressed as percent of total sugar content. Pectin content was determined by carre and hayne's method as described by (Ranganna,1986) and expressed as percentage of Calcium pectate.

### *Statistical Analysis*

Three replicates were used in each treatments and the results were assessed by completely randomized design. Each replicate consisted of 20 fruits and mean separation was done by using Least Significant Difference (LSD) at $\alpha$= 0.05.

## Results and Discussion

### *Fruit Firmness*

A gradual decrease in fruit firmness of guava fruits was observed during storage (Table 1). 2% cassava starch +1% sun flower oil was the most effective treatment in retaining higher mean value of fruit firmness (58.59 N) and control sample exhibited higher reduction of fruit firmness from 70.89N to 37.00N.

TABLE 1 EFFECT OF CASSAVA STARCH BASED COATINGS ON FIRMNESS (N) OF GUAVA

| Cassava starch based coatings | | | | | | |
|---|---|---|---|---|---|---|
| | **Storage Intervals (SI)** | | | | | |
| Treatments | 2 | 4 | 6 | 8 | 10 | **Mean** |
| $T_1$ | 70.47 | 69.32 | 67.59 | 65.57 | 43.75 | 63.34$^a$ |
| $T_2$ | 55.67 | 54.14 | 53.04 | 52.94 | 50.43 | 58.59$^a$ |
| $T_3$ | 65.41 | 62.90 | 61.42 | 56.44 | 46.77 | 58.37$^a$ |
| $T_4$ | 69.06 | 40.23 | 40.14 | 39.63 | 37.00 | 40.94$^b$ |

Initial value: 70.89N

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row (n=3). cassava starch based coatings: $T_1$ -1% Cassava starch +1% Sunflower oil, $T_2$-2% Cassava

starch +1% Sunflower oil, $T_3$ -3% Cassava starch + 1%Sunflower oil,$T_4$ -Control

Firmness of guava fruits decreased with storage (Table 2). 2% rice bran + 1% sunflower oil + 1% bee wax and 3% Rice bran + 1% Sunflowers oil + 1% Bee wax, treatment was given the highest mean value of fruit firmness (52.92N) and control sample exhibited higher reduction of fruit firmness throughout storage. Generally, fruit firmness reduces due to softening of fruits by dissolving middle lamella of the cell wall (Wills et al.,1980). When fruits ripen, hemicelluloses become more soluble and therefore the cell wall is disrupted and loosened (Arvanitoyannis et al.,2005). Higher firmness was shown by treatments due to delaying of ripening. Nevertheless, the interaction between treatment and storage intervals was statistically significant.

TABLE 2 EFFECT RICE BRAN BASED COATINGS ON FIRMNESS (N) OF GUAVA

| Rice bran based coatings | | | | | | |
|---|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | | |
| Treatments | 2 | 4 | 6 | 8 | 10 | **Mean** |
| $T_1$ | 53.72 | 51.05 | 47.98 | 44.47 | 42.86 | 43.93$^a$ |
| $T_2$ | 46.24 | 45.62 | 46.17 | 43.74 | 37.91 | 52.92$^a$ |
| $T_3$ | 54.19 | 54.24 | 43.72 | 40.47 | 39.00 | 52.92$^a$ |
| $T_4$ | 59.95 | 43.04 | 40.23 | 40.13 | 37.13 | 40.94$^b$ |

Initial value: 70.89N

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row (n=3). $T_1$-1% Rice bran + 1% Sunflowers oil +1% Bee wax, $T_2$-2% Rice bran + 1% Sunflowers oil + 1% Bee wax ,$T_3$-3% Rice bran + 1% Sunflowers oil + 1% Bee wax, $T_4$ - Control.

TABLE 3 EFFECT OF CASSAVA STARCH BASED COATINGS ON TITRATABLE ACIDITY (citric acid %) OF GUAVA

| Cassava starch based coatings | | | | | | |
|---|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | | |
| Treatments | 2 | 4 | 6 | 8 | 10 | **Mean** |
| $T_1$ | 0.28 | 0.27 | 0.27 | 0.26 | 0.26 | 0.28$^a$ |
| $T_2$ | 0.25 | 0.23 | 0.23 | 0.22 | 0.22 | 0.23$^b$ |
| $T_3$ | 0.27 | 0.25 | 0.25 | 0.24 | 0.21 | 0.25$^b$ |
| $T_4$ | 0.23 | 0.21 | 0.21 | 0.21 | 0.20 | 0.22$^c$ |

Initial value: 0.28%

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row (n=3). cassava starch based coatings:$T_1$ -1% Cassava starch +1% Sunflower oil, $T_2$-2% Cassava starch +1%

Sunflower oil, $T_3$ -3% Cassava starch + 1%Sunflower oil,$T_4$ -Control

### *Titratable Acidity*

Variation of acidity in guava fruits under different coating treatments at storage showed a gradual decrease in TA during ambient storage (Table 2). At the end of storage, minimum mean acidity content (0.22%) was shown by control treatment and minimum change in acidity having 0.28% mean value was shown 1% cassava starch + 1% sunflower oil. Titrtable acidity content of fruits coated with rice bran based edible coatings was decreased slightly under ambient temperature (Table 4). Minimum changes identified in the treatment 2% rice bran + 1% sunflower oil + 1% bee wax having acidity mean value of 0.28% and the lowest acidity content (0.20%) was exhibited in the control treatment having 0.22% mean acidity content. The decrease in acidity and increase in pH during storage may be due to the use of organic acid as respiratory substrates during storage and conversion of acid into sugars (Keditsu, et al ,2003) and the acidity reduction appears to be a result of ripening process (Rodriguez and Mabery,2006).

TABLE 4 EFFECT OF RICE BRAN BASED BASED COATINGS ON TITRATABLE ACIDITY (citric acid %) OF GUAVA

| Rice bran based coatings | | | | | | |
|---|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | | |
| Treatments | 2 | 4 | 6 | 8 | 10 | **Mean** |
| $T_1$ | 0.26 | 0.25 | 0.24 | 0.24 | 0.23 | 0.26$^a$ |
| $T_2$ | 0.27 | 0.26 | 0.26 | 0.25 | 0.25 | 0.28$^a$ |
| $T_3$ | 0.24 | 0.23 | 0.22 | 0.22 | 0.21 | 0.24$^b$ |
| $T_4$ | 0.24 | 0.22 | 0.22 | 0.21 | 0.20 | 0.22$^c$ |

Initial value: 0.28%

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row (n=3). $T_1$-1% Rice bran + 1% Sunflowers oil +1% Bee wax, $T_2$-2% Rice bran + 1% Sunflowers oil + 1% Bee wax ,$T_3$-3% Rice bran + 1% Sunflowers oil + 1% Bee wax, $T_4$ - Control.

### *Physiological Weight Loss*

1% cassava starch + 1% sunflower oil treatment showed the lowest mean weight loss (1.88%) with respect to cassava starch based edible coatings (Table 5) and 2% rice bran + 1% sunflower oil + 1% bee wax recorded the lowest mean weight loss (2.07%) with respect to rice bran based coatings (Table 6). The highest loss of weight was found in control with both coating materials having 2.92%. The highest moisture loss from control fruits might be due to the unrestricted transpiration, evaporation and respiratory losses.

TABLE 5 EFFECT OF CASSAVA STARCH BASED COATINGS ON PHYSIOLOGICAL WEIGHT LOSS (%) OF GUAVA

| Cassava starch based coatings | | | | | |
|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | |
| Treatments | 2 | 4 | 6 | 8 | Mean |
| $T_1$ | 2.06 | 1.95 | 1.82 | 1.60 | 1.88$^a$ |
| $T_2$ | 2.15 | 2.00 | 1.86 | 1.71 | 2.83$^a$ |
| $T_3$ | 1.45 | 1.41 | 1.38 | 1.17 | 1.95$^b$ |
| $T_4$ | 3.14 | 2.98 | 2.83 | 2.73 | 2.92$^c$ |

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row(n=3). cassava starch based coatings:$T_1$ -1% Cassava starch +1% Sunflower oil, $T_2$-2% Cassava starch +1% Sunflower oil, $T_3$ -3% Cassava starch + 1%Sunflower oil,$T_4$ -Control

TABLE 6 EFFECT OF RICE BRAN BASED COATINGS ON PHYSIOLOGICAL WEIGHT LOSS (%) OF GUAVA

| Rice bran based coatings | | | | | |
|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | |
| Treatments | 2 | 4 | 6 | 8 | **Mean** |
| $T_1$ | 2.00 | 1.90 | 1.85 | 1.63 | 2.87[a] |
| $T_2$ | 2.41 | 2.14 | 1.93 | 1.83 | 2.07[b] |
| $T_3$ | 1.80 | 1.71 | 1.70 | 1.65 | 2.66[a] |
| $T_4$ | 3.14 | 2.98 | 2.88 | 2.78 | 2.92[a] |

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row. (n=3).rice bran based coatings: $T_1$-1% Rice bran + 1% Sunflowers oil +1% Bee wax, $T_2$-2% Rice bran + 1% Sunflowers oil + 1% Bee wax ,$T_3$-3% Rice bran + 1% Sunflowers oil + 1% Bee wax, $T_4$ - Control.

TABLE 7 EFFECT OF CASSAVA STARCH BASED COATINGS ON TSS (0Brix) OF GUAVA

| Cassava starch based coatings | | | | | |
|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | |
| Treatments | 2 | 4 | 6 | 8 | Mean |
| $T_1$ | 7.66 | 7.74 | 7.79 | 7.80 | 7.85 |
| $T_2$ | 7.66 | 7.71 | 7.73 | 7.76 | 8.02 |
| $T_3$ | 7.10 | 7.21 | 7.30 | 7.30 | 7.94 |
| $T_4$ | 7.55 | 7.58 | 7.65 | 8.02 | 8.26 |

Initial value: $7^0$Brix

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row (n=3). cassava starch based coatings:$T_1$ -1% Cassava starch +1% Sunflower oil, $T_2$-2% Cassava starch +1% Sunflower oil, $T_3$ -3% Cassava starch + 1%Sunflower oil,$T_4$ –Control

TABLE 8 EFFECT OF RICE BRAN BASED COATINGS ON TSS (0Brix) OF GUAVA

| Rice bran based coatings | | | | | |
|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | |
| Treatments | 2 | 4 | 6 | 8 | **Mean** |
| $T_1$ | 7.66 | 7.73 | 7.79 | 7.80 | 7.85 |
| $T_2$ | 7.21 | 7.42 | 7.45 | 7.46 | 7.85 |
| $T_3$ | 7.57 | 7.59 | 7.60 | 7.63 | 7.74 |
| $T_4$ | 7.42 | 7.96 | 7.96 | 8.02 | 8.02 |

Initial value $7^0$Brix

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row (n=3).rice bran based coatings: $T_1$-1% Rice bran + 1% Sunflowers oil +1% Bee wax, $T_2$-2% Rice bran + 1% Sunflowers oil + 1% Bee wax ,$T_3$-3% Rice bran + 1% Sunflowers oil + 1% Bee wax, $T_4$ - Control.

### *Total Soluble Solids*

Slower changes of TSS was observed in 1% cassava starch + 1% sunflower oil and 2% cassava starch + 1% sunflower oil while they have shown a slower increase in TSS at the end of storage. In all treatments TSS has increased with the time (Table 7,8), which is due to the hydrolysis of starch to simple (soluble) sugars higher during fruit ripening. When conversion is lower than the utilization, decrease of TSS can be seen (Gupta and metha,1987). Rate of increase in TSS under coating treatment may be due to delaying of ripening, however, the interaction between treatments and storage intervals was significant at $\propto$ = 0.05 level.

### *Reducing Sugar Content*

Reducing sugar content of fruits increased with the advancement in storage period (Table 9, 10). Slower changes of reducing sugar content was observed in 3% cassava starch + 1% sunflower oil treatment having (2.05%) at the end of the storage. Control treatment has shown the maximum changes of reducing sugar having 2.35% mean reducing sugar content. Rice bran based coatings also showed an increase in the reducing sugar content during the storage. Minimum changes in reducing sugar content was exhibited in treatment T1-2% rice bran + 1% sunflower oil + 1% bee wax having 1.94% at the end of the storage. Interaction between treatment and storage intervals was significant at $\propto$ = 0.05 level (n=3).

TABLE 9 EFFECT OF CASSAVA STARCH BASED COATINGS ON REDUCING SUGAR CONTENT OF GUAVA

| Cassava starch based coatings | | | | | |
|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | |
| Treatments | 2 | 4 | 6 | 8 | **Mean** |
| $T_1$ | 2.06 | 2.07 | 2.10 | 2.25 | 2.12 |
| $T_2$ | 2.00 | 2.00 | 2.11 | 2.20 | 2.20 |
| $T_3$ | 1.80 | 1.85 | 1.86 | 1.99 | 2.05 |
| $T_4$ | 1.84 | 1.91 | 2.65 | 2.98 | 2.35 |

Initial value: 1.2%

Figures with same superscripts are not significantly different ($\propto$ = 0.05) (n=3). along same column and row. cassava starch based coatings:$T_1$ -1% Cassava starch +1% Sunflower oil, $T_2$-2% Cassava starch +1% Sunflower oil, $T_3$ -3% Cassava starch + 1%Sunflower oil,$T_4$ –Control

TABLE 10 EFFECT OF RICE BRAN BASED COATINGS ON REDUCING SUGAR CONTENT OF GUAVA

| Rice bran based coatings | | | | | |
|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | |
| Treatments | 2 | 4 | 6 | 8 | **Mean** |
| $T_1$ | 2.06 | 2.08 | 1.92 | 2.25 | 2.30 |
| $T_2$ | 1.24 | 1.25 | 1.33 | 1.64 | 1.94 |
| $T_3$ | 1.56 | 1.56 | 1.68 | 1.94 | 1.95 |
| $T_4$ | 1.66 | 1.66 | 1.69 | 1.72 | 2.54 |

Initial value: 1.2%

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row. (n=3).rice bran based coatings: $T_1$-1% Rice bran + 1% Sunflowers oil +1% Bee wax, $T_2$-2% Rice bran + 1% Sunflowers oil + 1% Bee wax ,$T_3$-3% Rice bran + 1% Sunflowers oil + 1% Bee wax, $T_4$ - Control.

### *Pectine Content*

Pectin content of guava fruits decreased with the storage (Table 11) and highest mean pectin content was reported by 1% cassava starch + 1% sun flower oil (1.76 %). Pectin content decreased under rice bran

based coatings. Maximum mean pectin content (1.76%) was recorded by 1% rice bran + 1% sun flower oil + 1% bee wax (Table 12). Interaction between treatment and storage intervals was significant at $\propto = 0.05$ level.

TABLE 11 EFFECT OF CASSAVA STARCH BASED COATINGS ON PECTIN CONTENT OF GUAVA

| Cassava starch based coatings | | | | | | |
|---|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | | |
| Treatments | 2 | 4 | 6 | 8 | Mean | **Mean** |
| $T_1$ | 1.93 | 1.81 | 1.80 | 1.80 | 1.76 | |
| $T_2$ | 1.89 | 1.80 | 1.76 | 1.72 | 1.65 | |
| $T_3$ | 1.83 | 1.71 | 1.74 | 1.71 | 1.70 | |
| $T_4$ | 1.77 | 1.75 | 1.71 | 1.68 | 1.67 | |

Initial value: 1.98%

Figures with same superscripts are not significantly different ($\propto$ = 0.05) along same column and row (n=3). cassava starch based coatings:$T_1$ -1% Cassava starch +1% Sunflower oil, $T_2$-2% Cassava starch +1% Sunflower oil, $T_3$ -3% Cassava starch + 1%Sunflower oil,$T_4$ –Control

TABLE 12 EFFECT OF RICE BRAN BASED COATINGS ON PECTIN CONTENT OF GUAVA

| Rice bran based coatings | | | | | |
|---|---|---|---|---|---|
| **Storage Intervals (SI)** | | | | | |
| Treatments | 2 | 4 | 6 | 8 | **Mean** |
| $T_1$ | 1.74 | 1.71 | 1.68 | 1.70 | 1.62 |
| $T_2$ | 1.83 | 1.71 | 1.74 | 1.71 | 1.71 |
| $T_3$ | 1.74 | 1.71 | 1.70 | 1.70 | 1.69 |
| $T_4$ | 1.80 | 1.68 | 1.67 | 1.72 | 1.60 |

Initial value: 1.98%

Figures with same superscripts are not significantly different ($\propto$=0.05) along same column and row (n=3). rice bran based coatings: $T_1$-1% Rice bran + 1% Sunflowers oil +1% Bee wax, $T_2$-2% Rice bran + 1% Sunflowers oil + 1% Bee wax ,$T_3$-3% Rice bran + 1% Sunflowers oil + 1% Bee wax, $T_4$ - Control.

When fruit got ripen, pectin compounds were reduced and disassembled and also fruit softening took place. The gradual decline in pectin content with the advancement of storage period might be the results of pectin enzymes activity on natural pectin in the fruits (Nara and Motomura ,2001). Polygalacturonase (PG) enzyme involved solubilization of pectin resulting softening of fruits and act on deesterified pectin molecule by breaking the linkage between galacturonic acid group in the poly galacturonides as reported by Colvin and Lepard 1973. Coatings significantly decreased the rate of pectin degradation and therefore, enabling the fruit to retain higher pectine content during storage (Wijewardane and Gularia2009).

### *Fruit Peel Colour*

Slower changes in peel color of guava treated with $T_1$-2% cassava starch +1% sunflower oil and $T_1$-1% rice bran + 1% sunflower oil + 1% bee wax were observed and significantly different from other treatments (figure 1a, 1b). Development of yellow color was delayed in 2% cassava starch coatings after 10 days storage. Any significant change was not observed in treatments and the most effective treatment was 1% rice bran + 1% sunflower oil + 1% bee wax having slower changes in peel color.

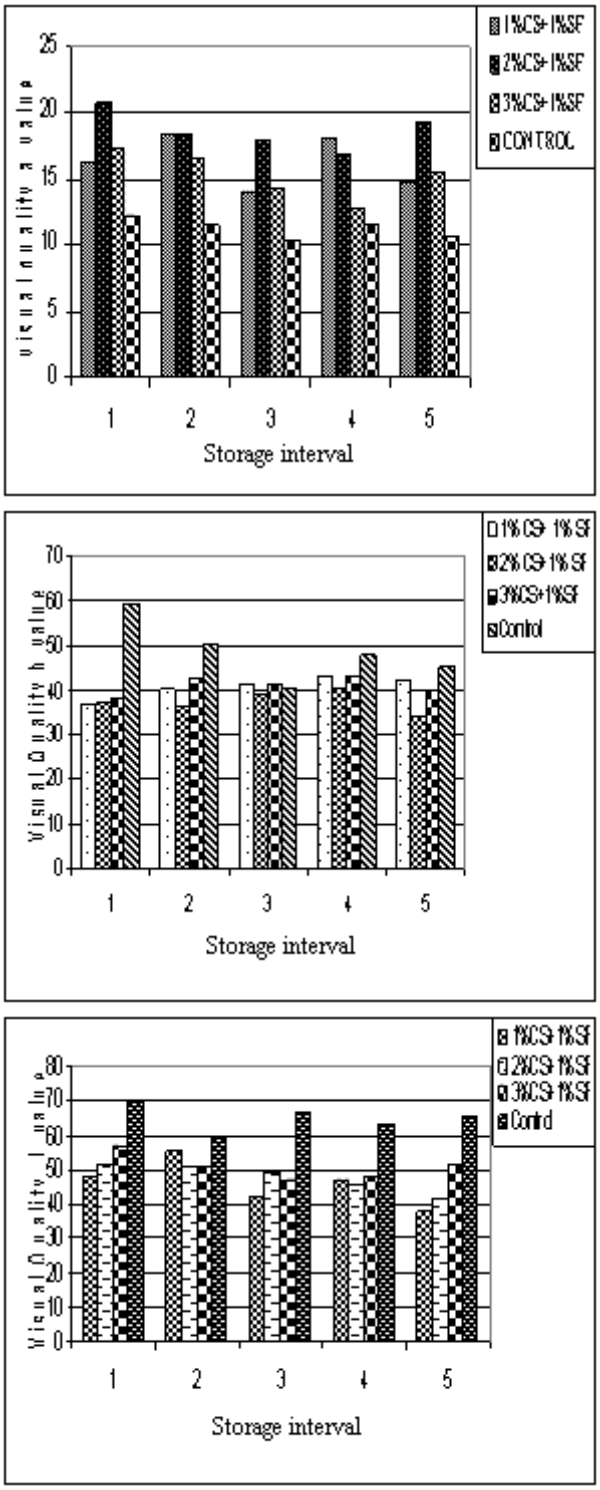


FIGURE 1 (a) EFFECT OF CASSAVA STARCH BASED COATINGS ON PEEL COLOR OF GUAVA ;CS-CORN STARCH, SF-SUNFLOWER OIL(n=3).

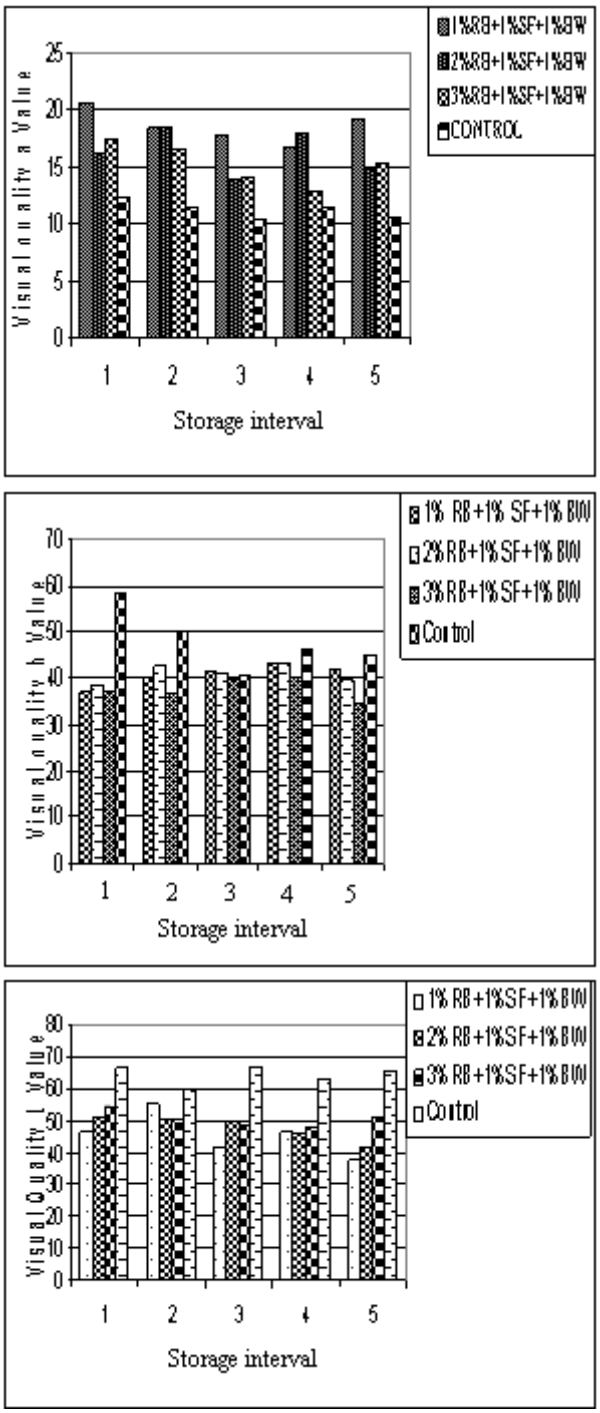


FIGURE 1 (b) EFFECT OF RICE BRAN BASED COATINGS ON PEEL COLOR OF GUAVA; RB-RICE BRAN,SF-ASAUNFLOWER OIL, BW-BEE WAX(n=3).

## Conclusions

Among 3 different concentrations, 2% cassava starch combined with 1% sunflower oil and 1% rice bran + 1% sunflower oil + 1% bee wax were the most suitable coating formulations for coating of guava fruits.

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