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# Effect of edible coating made from plantain peel waste on the quality of African elemi (*Canarium schweinfurthii*) fruit

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**ABSTRACT:** Edible coating was developed from plantain peel waste and applied to improve the quality and postharvest storage of African elemi (*Canarium Schweinfurthii*). Application of edible coating on the African elemi (*Canarium Schweinfurthii*) fruit improved the nutritional composition. The protein content of the coated fruit was (17.94%), crude fibre (3.91%) and ash content (3.64%). The proximate composition of the coated African elemi fruit was higher when compared to the uncoated fruit sample which had a protein content of (11.47%), crude fibre content (1.84%) and ash content (1.42%). Fruit with edible coating after 20 days, was still generally acceptable. The uncoated and coated African elemi fruits showed varying physicochemical properties across the storage period as firmness was (46.93 – 53.30N/m) for uncoated and (47.78 -53.3- N/m) for coated. Decay Incidence was (60%) for uncoated and (10% for coated). Weight loss was (1.37 – 2.49%) for uncoated and 0.61 – 1.92% for (coated) while the total soluble solids (12.55 – 13.32°Brix) for uncoated) and (12.55 – 14.29°Brix) for coated. The study showed that application of edible coating on the African elemi fruit will help reduce the postharvest loss of the fruit which is mostly as a result of hardening and rotting.

**Keywords:** Edible coating, Storage, Postharvest losses, plantain peel, plantain peel, African elemi fruit
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## INTRODUCTION

African Elemi (*Canarium schweinfurthii*) fruit similar to smaller species of African pear is an abundant perennial plant in the burseracae family. The plant can be found in Nigeria's South East, Middle Belt, and South West areas (Tchiegang *et al*., 1998) and also in East, Central, and West Africa. In the South East Nigeria, it's one of the abundant and rich wild fruits, which is neglected and underutilized despite having high nutritional content. According to reports, wild seeds and fruits provide a practical but affordable way of giving tropical residents appropriate supply of minerals, fat, protein, and carbohydrates (Ayoade *et al.,* 2015). African Elemi fruit is known as "*ubemgba*" in Igbo, *ako* in Yoruba and "*atili"* in Hausa. It is a sizable forest tree plant about 4.5 meter diameter and has a crown that reaches the forest's upper canopy. The seeds are enclosed in a delicious, oily, purple greenish pulp that tastes sweet just like the African pear. It tastes better after it is softened in warm water. The fruit is primarily eaten by people in the eastern part of Nigeria after being blanched in lukewarm water. African elemi pulp is rich in proteins, carbohydrates, oils and vitamins (Onimawo and Adukwu, 2003; Kiin-Kabari *et al.,* 2020). African Elemi whole seeds and pulp have been employed as food additives, vitamin C sources and for medicinal use (Maduelosi and Angaye, 2015). Despite being high in nutrients, African elemi deteriorates quickly. According to Ehiem *et al. (*2018), rotting and hardening cause roughly 40% of the fruit to be wasted annually. Postharvest losses recorded for the fruit is often as a result of its nature to harden after a few days

of harvest. In some other cases the fruit decays easily. Edible coating has in recent times been applied for various fruit preservation. Although edible coatings are being developed from starch based peels such as potatoes and cassava, little work has been done on the use of plantain peel waste for edible film. Plantain peels which are considered a waste but can be adopted for food formulations in the food industry (Okolo et al., 2022). The study was therefore aimed at evaluating the effect of plantain peel edible coating on the quality and postharvest storage of African elemi fruit.

## MATERIALS AND METHODS

Fresh African elemi (*Canarium Schweinfurthii*) was sourced from a farm in Ebonyi State of Nigeria. The seeds were sorted to get the wholesome (uniform size, shape, and color and that are free from any blemish or defects), after which it was washed and allowed to dry at room temperature. The fruits were then weighed and grouped into 2 parts (Samples A and B) respectively. Sample A was left uncoated while samples B was coated with plantain peel edible coating. The edible coating was prepared from plantain peel waste starch, glycerol and water according to the method prescribed by Al-Hashimi *et al.*(2020). About 5g of starch extracted from plantain peel was dissolved in 100 mL of distilled water, then 1.0% of glycerol was added to the solution as a plasticizer and then mixed with the solution. The suspension was then heated at 950C for 30 min with constant stirring at 360 rpm until the solution gelatinized. After the heating process was completed the edible coating formation was left to cool. After cooling, It was then applied to the African elemi fruit using the dipping method as prescribed in Mahardiani *et al*. (2021). Analysis for moisture, ash, fat and protein contents was done for the uncoated and coated samples using standard methods prescribed in Onwuka (2018). Physiochemical properties of the fruit (decay incidence, weight loss, fruit firmness) were determined using the method prescribed by Thakur *et al*. (2019). Sensory evaluation was conducted on both African elemi fruit samples using a five point hedonic scale.

The coated and uncoated sample was displayed for twenty semi-trained panellists who were conversant with eating the fruit. They evaluated the suitability of the plantain peel edible coating on the fruit in terms of appearance, firmness, texture/hand feel, and overall acceptability. Sensory evaluation was done on the day 5, 10, 15 and 20 using a 5-point hedonic scale where;
1- Dislike extremely, 2- Dislike, 3-Neither like nor dislike, 4- Like, 5-Like extremely. The statistical analysis was performed using analysis of variance (ANOVA) with SPSS (20. 0, version).

## RESULTS AND DISCUSSION

### Proximate composition of African elemi (*Canarium Schweinfurthii*) fruit

The proximate composition indicates that the fruit is a rich source of protein, fat and carbohydrate as seen in (Table 1). There was a significant difference recorded for the protein, fat, crude fibre, ash, moisture and carbohydrate content of both samples at ($p<0.05$). It was also observed that the protein content (17.94%), crude fibre (3.91%) and Ash content (3.64%) of the sample coated with edible coating developed from plantain peel than the uncoated sample. It was observed from (Table 1), that the protein content was between 11.47 % - 17.94% with the coated sample having higher protein content. In various studies, African elemi fruit has been reported to have a high protein content ranging from 19.28 % - 20.98% (Ehiem *et al*., 2015; Maduelosi and Angaye, 2015). The protein content of the African elemi fruit is higher than most indigenous fruits such as the African eggplant (10.16%) and African pear (4.16%) (Kamga *et al*., 2013; Omogbai and Ojeaburu, 2010). The result as seen in (Table 1) shows that the protein content for the coated fruit (17.94%) is higher than the uncoated fruit (11.47%). This can be attributed to the protein composition of the plantain peel which was used in the development of the edible coating. The properties of an edible coating help to improve the nutritional quality of the fruit (Carmo *et al*., 2022). The crude fat content of African elemi as seen in (Table 1) was between 31.02 % - 32.24 %. Other similar reports have shown the crude fat to be in the range of 24.42 % - 61.00 % (Mathew *et al*. 2020; Ehiem *et al*., 2015). The fruit has been reported to be rich in crude fat hence it often processed for its essential oil. The essential oil is rich in antioxidants and has been applied to edible coating formation (Akudo *et al*., 2023). African elemi fruit has a higher fat content when compared with most fruits (Maduelosi and Angaye, 2015). The fruit can serve a good source of energy as a result of the high fat content. The result from (Table 1) shows that the fibre content of the coated fruit (3.91%) was higher than that of the uncoated fruit (1.84 %). Crude fibre plays an important role in reducing constipation, rectum associated with colon cancer and appendicitis (Mathew *et al*., 2020).

The moisture content in the range of 26.05 % to 28 .52% was in the range of (26.09%) reported Maduelosi and Angaye (2015). Moisture content in the form of unbound water causes food spoilage when it is high. The moisture content of the coated sample was observed to have reduced as a result of coating. Some studies have shown that edible coating can reduce the moisture content of food by adsorbing water from the food surface or preventing water loss to the environment.

**Table 1:** Proximate composition of African elemi fruit.

| Proximate composition (%) | Uncoated African elemi | Coated African elemi |
|---|---|---|
| Moisture | 28.52*±0.01 | 26.05*±0.02 |
| Protein | 11.47*±0.12 | 17.94*±0.13 |
| Fat | 32.24*±0.02 | 31.02*±0.01 |
| Crude fibre | 1.84*±0.03 | 3.91*±0.04 |
| Ash | 1.42*±0.00 | 3.64*±0.03 |
| Carbohydrate | 24.51*±0.14 | 17.44*±0.01 |

Mean value ± standard deviation of duplicate determination.
*: Mean value on same row are significantly different at ($p<0.05$).

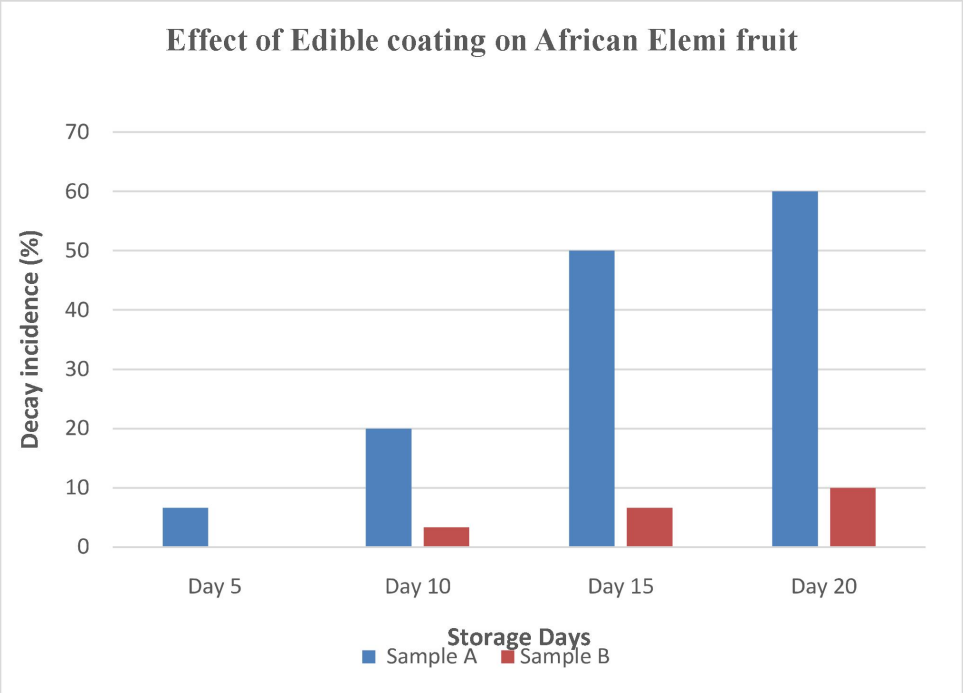


**Figure 1:** Effect of coating on the decay incidence of African elemi (*Canarium Schweinfurthii*) fruit.

Edible coating made from chitosan and gelatine were recorded to have reduced the moisture content of fruits, vegetables, meat and seafood (Aqila *et al*., 2020). In this study, it was observed that the coated fruit had a higher nutritional value than the uncoated fruit.

**Effect of coating on the decay incidence of African elemi (*Canarium Schweinfurthii*) fruit**

The decay incidence of the African elemi fruits during storage is depicted in (Figure 1). The graph shows that during the 20 days of storage the decay incidence of the uncoated fruit rose from 6.67% to 60%. It was observed that African elemi started deteriorating after a few days of storage. It has been reported that about 40% of the fruit is wasted through rotting and hardening (Ehiem *et al.,* 2018). On the other hand, the coated African elemi had a lower record for decay incidence (10%) at the Day 20 of the storage. The low decay rate is attributed to the edible coating applied to the fruit which helps to control loss of moisture in the fruit hence; there is lesser number of rotten fruits (Aqila *et al*., 2020). This study therefore shows that decay incidence and rot in Africa elemi fruit was significantly reduced by the plantain peel edible coating developed.

**Effect of coating on some selected physicochemical properties of African elemi fruit.**

The study on some selected physiochemical properties was done to evaluate the ability of the plantain peel edible coating to maintain the integrity of the African

**Table 2:** Effect of edible coating on some selected physicochemical properties of coated African elemi fruit at different storage periods.

| Test | Storage period (days) | Uncoated | Coated |
|---|---|---|---|
| Firmness (N/m) | | | |
| | 0 | 53.30±0.00 | 53.30±0.00 |
| | 5 | 51.74$^{NS}$±0.08 | 51.40$^{NS}$±0.48 |
| | 10 | 51.26$^{*}$±0.04 | 50.60*±0.49 |
| | 15 | 49.29$^{**}$±0.01 | 49.77$^{**}$±0.05 |
| | 20 | 46.93$^{*}$±0.15 | 47.78$^{*}$±0.04 |
| Weight loss (%) | | | |
| | 0 | - | - |
| | 5 | 1.37**±0.02 | 0.61**±0.04 |
| | 10 | 1.49*±0.03 | 1.18*±0.07 |
| | 15 | 2.35**±0.04 | 1.44**±0.07 |
| | 20 | 2.49**±0.06 | 1.92**±0.02 |
| Total soluble solids (°Brix) | | | |
| | 0 | 12.55**±0.00 | 12.55**±0.00 |
| | 5 | 13.16**±0.05 | 14.29**±0.04 |
| | 10 | 12.78**±0.06 | 14.05**±0.05 |
| | 15 | 13.32**±0.03 | 13.89**±0.03 |
| | 20 | 12.72**±0.4 | 13.51**±0.01 |

Values are mean ± standard deviation of triplicate determination.
**: Means in the same row are significantly ($p<0.01$) different.
*: Means in the same row are significantly ($p<0.05$) different.
NS: Means in the same row are not significantly ($p>0.05$) different.

elemi fruit. The effect of storage on the firmness (N/M), weight loss (%), and Total Soluble solids of African elemi fruit coated with edible coating from plantain peel is seen in (Table 2). The firmness ranged 47.78 – 53.30 N/m for coated African elemi fruit stored within 20 days while the uncoated fruit had firmness ranging from 46.93-53.30N/m. The total soluble solids for the uncoated African elemi ranged from 12.55 to 13.32 Brix while that of the coated sample ranged from 12.55-14.29 Brix.

**Firmness**

Firmness is one of the most important parameter that help determines the general consumer acceptability as fruits which are firmer are crispier, crunchy and juicer (Oliveira *et al*., 2019). It was observed in (Table 2) that there was no significant difference between the firmness of the coated and uncoated African elemi fruit sample in the first 5 days of storage. However, on Day 10, a significant difference ($p<0.05$). It was observed between the two samples on Day 15 and Day 20, while there was a significant difference at ($p<0.01$) among the samples on Day 15, the significant difference at ($p<0.05$ ) was observed on Day 20.

The degree of firmness decreased as the number of storage days increased. The firmness of the coated African elemi fruit was higher when compared to that of the uncoated sample on Day 20. This can be attributed to the probability that the edible coating controls moisture loss on fruit surface and prevent excessive transpiration and respiration (Thakur *et al*., 2019). When excessive transpiration and respiration is reduced, the activity breakdown of enzymes decreases hence impacting on the firmness of the fruit (Susmitha and Jatinder, 2020). Similar to this study, Using chitosan and soybean isolated protein edible coating, Zhang *et al.* (2018) found that edible coating prevented a reduction in firmness. Coating has been reported to directly affect the fruit firmness by decreasing the activity of cell wall degrading enzymes such as pectinases and cellulases that cause softening and loss of texture (Susmitha and Jatinder, 2020).

**Weight loss**

The uncoated sample and coated sample of the African elemi both shows that there was a significant difference in the weight loss observed irrespective of the coating applied (Table 2). Higher weight loss was recorded for the uncoated sample (2.49%) when compared to coat (1.92%) on the Day 20. There was a significant difference ($p<0.01$) on day 5, 15 and 20 while there was a significant difference ($p<0.05$) on the day 10 of the observation. Increase in weight loss was recorded as the number of storage days increased. In fruits, decrease in weight during storage happens due to the loss of water as a result transpiration (Todhanakasem *et al*., 2022). The lower weight loss observed in the coated sample

could also be due to the characteristics of edible coating formed on the fruit surface which controls the water vapour movement in the fruits. This result is similar to that reported by Socha *et al*. (2017) on weight loss reduction as a result of the uniform thin layer of edible coating formed around the fruit. In a similar study, the edible coating of peaches using aloe vera gel showed a positive significant effect in the reduction of weight loss. Zhang *et al.* (2018) also found that weight loss of the apricot was considerably decreased with the use of chitosan edible coating on fruit. Reduction in fruit weight loss is an important parameter for consumer acceptability. Weight loss has been reported to be caused by transpiration which occurs as a result of the change of water pressure between the atmosphere and and the fruit (Susmitha and Jatinder, 2020). Edible coating and coating serves as an additional barrier between the atmosphere and the fruit surface were transpiration takes place.

**Total soluble sugars (TSS)**

The effect of edible coating on the total soluble solids (TSS) of fruit is a measure of how the coating affects the sugar content and the flavor of the fruit. TSS which is usually expressed in degrees Brix, which is the percentage of sucrose in a solution at 20°C. Higher TSS values indicate sweeter and more flavorful fruits (Deepika *et al*., 2018). The result (Table 2) showed that the TSS for African elemi was in the range of (12.55 - 13.32 $^{o}$Brix) for the uncoated while for the coated sample the TSS was in the range of (12.55 – 14.29 $^{o}$Brix). There was a significant difference at ($P<0.01$) observed in the TSS of the fruit. For the uncoated fruit, on Day 5 and Day 15 there was an observable increase whereas on Day 10 and Day 20, the TSS was reduced. For the coated fruit, TSS was increased for the first 10 days and after which there was a reduction from day 15 to day 20. This was similar to that reported by Carmo *et al.* (2022). In some studies, TSS values of coated fruits have been found to be marginally higher that the uncoated fruits (Thakur *et al.,* 2018; Akudo *et al*., 2023). In this study, an increase in TSS was observed for both samples although that for the coated was higher. This is similar to some studies which have shown that applying edible coating increases the TSS by concentrating the sugars in the fruit tissue and reducing water loss (Deepika et al., 2018; Abad Ullah *et al.,* 2017). Edible coating has been reported to have various effect on the fruits and vegetables, as in contrast to this study a decrease with no significant effect on the TSS was reported by Susmitha and Jatinder, (2020). The decrease was attributed to modification of the internal atmosphere of the fruit by reducing the oxygen and increasing the carbon dioxide concentrations, thus inhibiting the ethylene production and action, which are the main triggers of ripening and senescence, which can result in lower TSS values. In (Table 2), a decrease in the TSS of the uncoated African elemi fruit was observed on the Day 20. This can be attributed to the effect of edible coating on fruit firmness by decreasing the activity of cell wall degrading enzymes and delaying ripening, which can result in lower TSS values (Susmitha and Jatinder, 2020).

**Sensory evaluation of coated African Elemi**

The result of the sensory evaluation carried out on African Elemi fruit to determine the appearance, aroma, texture/handfeel and general acceptability during storage is depicted in the figures below.

**Sensory evaluation on the appearance of coated African elemi fruit**

The sensory evaluation on the appearance of the coated African elemi fruit is depicted in (Figure 2). There was a significant difference noticed on the sensory evaluation on the appearance of the coated and uncoated African elemi fruit.

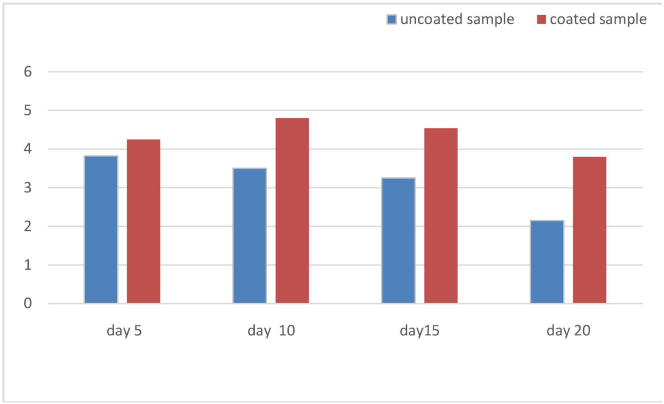


**Figure 2:** Sensory evaluation on the appearance of coated African elemi fruit.

The coated fruit had higher rating for appearance all through the storage period but showed the highest score of (4.80≈5.00)- Like extremely on the Day 10 of storage. This implies that edible coating enhances the appearance of the fruit. This is in agreement with the report of Bravin *et al.* (2006) that edible coating from Alginate gave the fruit a glossy appearance. Although it was noted that the value on the appearance dropped from 4.30 to 3.80, however the appearance still had a score of (3.80≈4.00) showing that it is liked by the panellists. For the uncoated sample, the scores for the appearance decreased from Day 5 to Day 20 with Day 5 having a score of 3.82 (3.82≈4.00)- Liked. On the Day 20, the score was recorded as 2.15 (2.15≈2.00) which showed that the

panellist disliked the fruit. This was due to the rot, weevil growth as well as hardening noticed on the African elemi fruit. Result from this study has showed that edible coating enhances and improves the appearance of the African elemi fruit hence increasing its shelf life.

**Sensory evaluation on the aroma of coated African elemi fruit**

The sensory evaluation on the aroma of the coated African elemi fruit is depicted in (Figure 3).

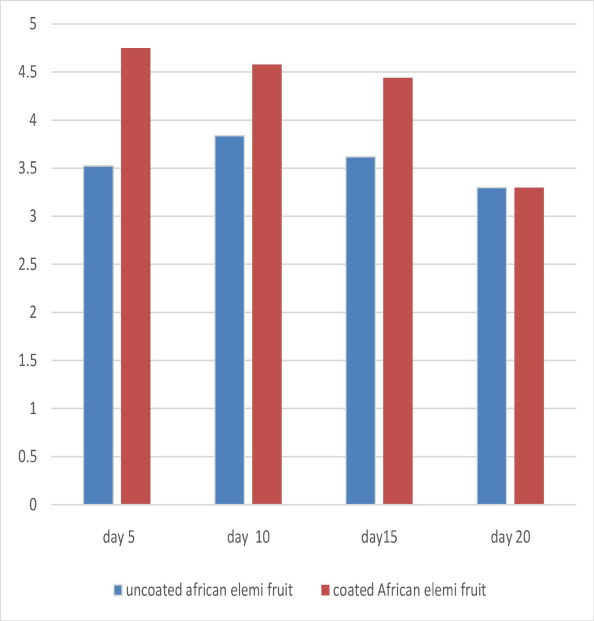


**Figure 3**: Sensory evaluation on the aroma of coated African elemi fruit.

African elemi fruit showed a significant difference in the sensory score for aroma except for the last day which had no significant difference in both the coated and uncoated fruits. The coated fruit had higher rating for aroma all through the storage period except for the Day 20. It was observed that the highest score of (4.75≈5.00)- Like extremely was recorded on the Day 5 of storage. This implies that edible coating enhanced the aroma of the coated fruit. Edible coating from plantain peel has a flavoured aroma like that of date nuts. It was observed that the aroma was infused into the fruit hence making its aroma more appealing. This confirms various reports that shows that edible coating and coating can be used as carriers of flavours, antioxidants and colour to the food product (Gotnard *et al.,* 2011; Himani *et al*., 2022). Although it was noted that the score value of the aroma the dropped from 4.75 to 3.30, however the appearance still had a score in the range of 4.44- 4.75 on the day 15 of storage showing that it was liked by the panellists. For the uncoated sample, the scores for the aroma decreased from Day 5 to Day 20 with Day 5 having a score of 3.50 (3.50≈4.00)- Liked. On the Day 20, the score was recorded as 3.30 (3.30≈3.00) which showed that the panellist neither liked nor disliked the aroma of the fruit.

**Sensory Evaluation on the Texture/ Hand feel of coated African Elemi Fruit**

The sensory evaluation on the Texture/ Hand feel of the coated African elemi fruit is depicted in (Figure 4).

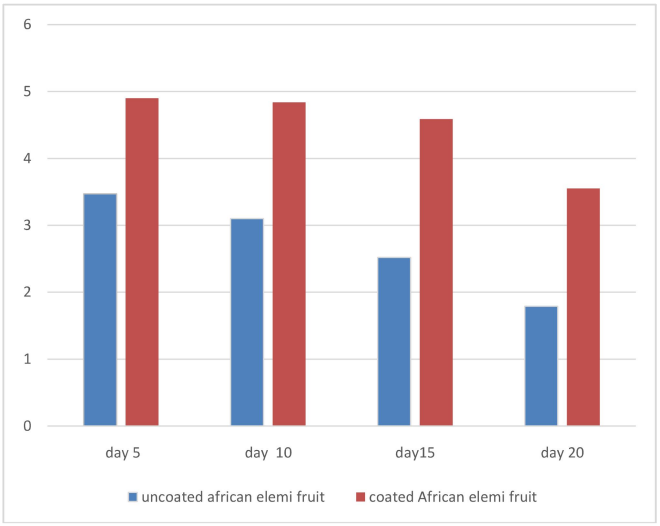


**Figure 4:** Sensory evaluation on the texture/ hand feel of coated African elemi fruit.

There was a significant difference on the sensory score for texture/hand feel of the coated and uncoated African elemi fruit on all the storage days. The coated African elemi fruit had higher rating for the texture/ hand feel all through the storage period except for the Day 20. It was observed that the highest score of (4.95≈5.00)- Like extremely was recorded on the Day 5 of storage. This implies that edible coating enhanced the texture/ hand feel of the coated fruit. The plantain peel edible coating improved the texture and hand feel of the fruit. As the coated fruit was observed to be glossy, smooth without showing the signs of hardening or rot which is a common postharvest problem of the fruit. Generally, the result showed a decrease in the score value of the texture/ hand feel as the storage days increased. The uncoated fruit score value reduced from 3.47 (3.47≈4.00)- neither like nor dislike to 1.70 (1.70≈ 2.00)- disliked. This is because the sample loosed is freshness which may be as

a result of moisture loss. The high score value for the texture/ hand feel of the coated fruit can be attributed to the property of the edible coating which helps regulate the moisture loss hence preserving the freshness of the fruit (Omogbai and Ojeabur, 2010).

### Sensory Evaluation on the General acceptance of coated African Elemi Fruit

The sensory evaluation on the appearance of the coated African elemi fruit is depicted in (Figure 5).

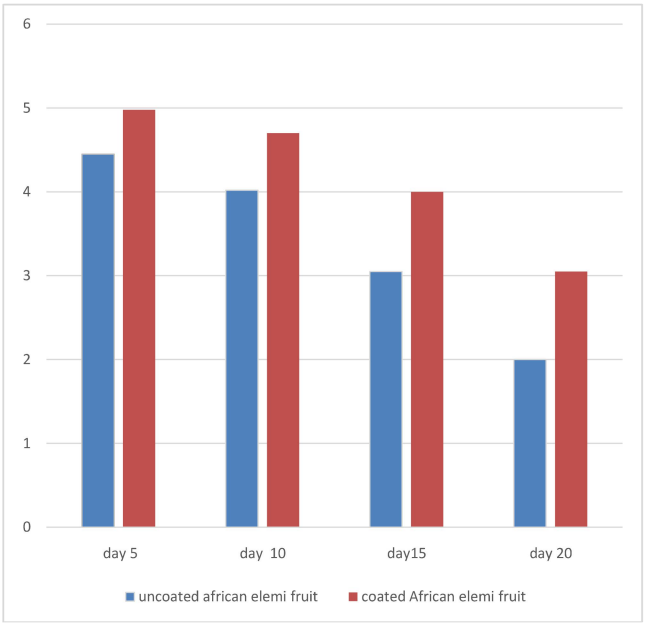


**Figure 5:** Sensory evaluation on the general acceptance of coated African elemi fruit.

The coated fruit had higher rating for general acceptance all through the storage period except for the Day 20. It was observed on the Day 5 of storage, the highest score was (4.98≈5.00) which indicates like extremely. The general acceptability score value ranged from 3.05 – 4.98 when compared to the uncoated sample having a range of scores from 2.00 – 4.45 during the storage days. The result showed a general reduction in the acceptability of the uncoated sample this was as a result of the loss of freshness observed in the uncoated sample. However the general acceptability of the coated African elemi (3.05) was due the better appearance even after 20 days of storage. The panellists indicated the willingness to pay more for coated African elemi fruits than for uncoated fruits. This is similar to the study by (Socha *et al*., 2017) that edible coating offers more aesthetic appearance in fruits.

## Conclusion

The use of the coating from the plantain peel waste for African elemi was beneficial for preserving the fruit as the moisture loss was reduced and while the nutritional properties of the fruits was improved which explains the benefits of applying edible coatings as an innovative packaging to fruits and vegetables. As an alternative packaging system to the current conventional and synthetic materials, edible coating from food waste is a prospective adoptable secondary packaging method because of their edibility. Plantain peels which are usually discarded have the potentials to be used as materials in food packaging.

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