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# African elemi oil incorporated coating for quality improvement and shelf life extension of tomato fruit

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## Abstract

The potentials of African elemi oil coating was evaluated on post-harvest loss reduction and shelf-life extension of tomato fruits during 16 days of storage. Tomato at turning stage were grouped into oil-incorporated (treated), non-oil incorporated (treated control) starch coated fruits, and non-coated fruits (untreated control). Fatty acid profile, phenolic and flavonoid contents of the extracted oil were also assessed. Oleic and pentadecanoic acids were the most predominant fatty acids at 51.51 and 40.00% respectively, while the phenol (6.03 ± 0.001 mg/g) and flavonoid (4.59 ± 0.003 mg/g) were appreciably high. The moisture content (91.49%) of the untreated samples was significantly ($p<0.05$) higher than those of the treated groups. There were no significant differences in the average weight losses and ash contents of the tomato groups. The oil-coated and untreated control samples recorded gradual reduction in TTA which culminated at 0.20 and 0.32% respectively on day 16, while the treated control recorded significantly ($p<0.05$) higher values at days 13 and 16 (0.72 and 0.78% respectively). TSS content of the tomatoes increased significantly ($p<0.05$) with increase in storage duration with the untreated control having the highest value (5.30 $^{o}$Brix), and the oil-coated samples the least (4.6 $^{o}$Brix). The treated groups had significantly ($p<0.05$) higher pH values compared to the untreated control. The oil-treated tomatoes had significantly ($p<0.05$) higher sensory attributes than the other groups. Results of the study revealed that African elemi oil-incorporated starch impacted positively on the quality, aesthetic appeal and sensory properties of the stored fruits.

**Keywords:** Edible coating; Atili oil; Cassava starch; Tomato; Essential oil

## 1. Introduction

Postharvest loss of vegetables and fruits has remained a daunting challenge for farmers worldwide. It is estimated that the total postharvest loss of Horticultural crops, including fruits and vegetables, at various stages: harvesting, storage, transportation and marketing ranges from 15 to 70% [1]. The principal causes of postharvest losses in vegetable and fruits occur at harvest time (bruises), postharvest management and storage (decay), processing stages, transportation and consumption. [2].

Tomatoes are one of the most common vegetables in the world [3]. Tomato are climacteric fruits and continue to ripen and experience continuous change in quality after harvesting. It ranks next to Irish and sweet potatoes with respect to world vegetables. It is broadly cultivated in temperate, subtropical and tropical climates, and thus is ranked third globally in terms of vegetable production [4]. Tomato fruits production is high and harvest is in abundance during its season, but post-harvest processing and management are inefficient. Therefore, early and easy decay of fruits due to lack of appropriate systems of preservation and processing [5].

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Climacteric fruit ripening is an active process characterized by its sudden increase in respiration and ethylene production. The fruits are more vulnerable to post-harvest losses due to their speedy ripening rate, which is triggered by ethylene. If the rate of ethylene formation is reduced or prevented during ripening, then post-harvest storage life of fruits can be prolonged and extended. [6].

*Canarium schweinfurthii*, commonly known as African elemi or Canarium**,** is a specie of large tree native to tropical Africa. In Nigeria, the fruit is called "ube mgba" in Ibo and "atili" in Hausa. It is high in fatty acid content (44.5% and 61% in pulp and seed respectively.

Essential oils (EOs) are plant-derived volatiles with a hydrophobic character, also defined as intricate mixtures of volatile, odoriferous, lipophilic and liquid substances. They are products of secondary plants' metabolism and play crucial roles in plant protection such as antiviral, antibacterial, antifungal, insecticidal properties [7] Further, many essential oils are used for food preservation, analgesic, antimicrobial, anti-inflammatory, spasmolytic remedies and localized anaesthetic [8;9]. Despite the eminent potential of essential oils, their utilization in food preservation remains limited mostly because of their intense aroma, toxicity problems and possible changes in the organoleptic properties of the food [10]. The use of edible coatings incorporated with essential oils however, could limit doses requirement by the encapsulation effect in the polymer matrix, which minimizes their volatilization and controls the compound release, thus reducing the negative impact of these limitations [11].

There are reports of the use of starches from distinct sources in film and coating preparations with different properties, and have indicated that these carbohydrate sources are encouraging materials in this regard [12; 13; 14]. Coatings developed from starch have been described as tasteless, odourless, colourless, isotropic, non-toxic, renewable and biologically degradable. Its use has been reported to prevent change of flavour, appearance and taste of edibles [15]. Different edible coatings of vegetables and fruits have been experimented with the main aim of improving the fruits shelf–life and quality. Thus, this study aims to evaluate the effect of edible coating from atili oil and starch on the quality and shelf-life of stored tomato fruits.

## 2. Material and methods

### 2.1. Collection of samples

African elemi was purchased from Eke Onunwa market, Owerri, Imo State. It was washed with distilled water, deseeded and sliced to small pieces and then oven dried at 50°C to a constant weight. The dried sample was pulverized using hammer mill and placed in a labeled air tight container.

### 2.2. Oil extraction

Oil was extracted from the dried sample by extraction using the Soxhlet extractor (Konte, USA) method as described by [16]. Fifty grams of the milled sample was placed into a porous thimble of the soxhlet extractor and extracted using n-hexane (150 mL) as the extracting solvent for 6 hours. The oil was obtained under reduced temperature and pressure, and refluxing at 70°C to remove the excess solvent from the extracted oil. The oil was placed in labeled bijou bottle and kept for further use.

### 2.3. Fatty acid profile of the extracted oil

Fatty acid profile of the oil was determined with the aid of a gas chromatograph (Agilent 6890 GC; California, USA), equipped with an on-column automatic injector, flame ionization detector, HP 88 capillary column (100m x 0.25µm film thickness). The gas flow was adjusted to the columns, the inlets, the detectors and the split ratio. In addition, the injector and detector temperatures were set at 220 and 250°C respectively. The detectors were held at the high end of the oven temperature range to minimize the risk of analyte precipitation. All the equipment parameters were double checked to ensure that the values were correct. Integrator chart speed was set at 2 cm/min. The oven temperature was set to 180°C and the GC was allowed to warm up. While it was warming, the initial and final temperature values were set at 180°C and 181°C, with initial and final time values set at 15 min and 1 min respectively and rate set at 0°C/min. When the instrument was ready, the "NOT READY" light automatically went off, and then 1µL of the analyte was injected into column A using proper injection technique. After the completion of the analysis, the result was automatically printed out.

### 2.4. Determination of phenolic content of extracted oil

The phenolic content of *Canarium schweinfurthii* oil was estimated following the spectrophotometric method described by Tambe and Bhambar [17]. The reaction mixture consisted of 1 ml of oil and 9 ml of distilled water in a volumetric flask (25 ml), to which 1ml of Folin-Ciocalteau phenol reagent was added and shaken well. After 5 minutes, 10 ml of 7 % $Na_2CO_3$ solution was added to the mixture, and the volume made up to 25 ml with distilled water. A set of standard solutions of gallic acid (20, 40, 40, 60, 80 and 100 µg/ml) were prepared and treated as the test. The test and standard solutions were incubated for 90 min at room temperature and their absorbance determined against the reagent blank at 550 nm with an UV/visible spectrophotometer. Total phenol content was expressed as mg of GAE/g of oil [17].

### 2.5. Determination of flavonoid content of extracted oil

Flavonoid content was determined using the aluminum chloride colorimetric method [18; 19]. The sample solution contained 1 ml oil and 1 ml of 2% $AlCl_3$ solution dissolved in methanol. The solution was allowed to incubate for 1 hr at room temperature and the absorbance was taken at 415 nm. A set of rutin as standard at varying concentration was prepared, treated as the test and the results were expressed in terms of rutin equivalent (mg of Ru/g of extract).

### 2.6. Preparation of coating medium

Edible coating material was prepared from cassava starch using the method described by [20], where 5 g cassava starch was dissolved in 100 mL distilled water at 60℃ on a hotplate and stirred until the mixtures became clear. Two milliliter (2 mL) of glycerol monostearate was added as plasticizer to the solution mixture to enhance the potency and elasticity of the solution. The solution mixture was heated at 60℃ for 30 minutes followed by addition of the oil (50% v/v). Treatment control coating solution was prepared without the addition of oil.

### 2.7. Collection, preparation and coating of samples

Fresh tomatoes at turning stage were used in the experiment. The tomatoes were procured, sorted for the wholesome ones (free of infestation and mechanical injuries), washed and surface disinfected by immersing in 0.1% NaOCl (sodium hypochlorite) for 2 minutes and left to dry at room temperature. The tomato fruits were weighed and grouped into 3 as explained below:

- Group A: Treated with *Canarium schweinfurthii* oil coating.
- Group B: Treated control (coating without *Canarium schweinfurthii* oil)
- Group C: Non-treated control (with no coating)

Each group was coated as appropriate, allowed to dry and was kept at ambient condition (25 ± 5℃ and 70 ± 5%) monitored with a data logger installed in the storage environment. The stored tomatoes were observed for 16 days and analyses were carried out at days 0, 1, 4, 7, 10, 13 and 16.

### 2.8. Decay Incidence (%)

Decay incidence (%) was evaluated by recording the number of decayed fruits at different days during storage for all the treatments and divided by the total number of fruits initially packaged according to the method described by Lawal *et al*. [21].

$$\text{Decay incidence (\%)} = \frac{number\ of\ decayed\ fruits}{total\ number\ of\ fruits} x\ 100$$

### 2.9. Estimation of weight loss (%)

Weight or moisture loss (%) was determined by weighing the samples using a top-loading digital balance (CAMRY ACS-30-JE11) as reported by Maftoonazad and Ramaswamy [22] and reported as percentage loss in weight/moisture based on the original mass as follows:

$$Weight\ or\ Moisture\ Loss\ (\%) = \frac{W1 - W2}{W1} \times 100$$

Where; W1 = previous weight
W2 = current weight

### 2.10. Determination of moisture content

The moisture content was determined using the hot air oven drying method as described by [23]. A weighed portion (2 g) of the properly homogenized tomato samples was weighed and dried at 130°C for 1 hour, and the moisture content calculated as:

$$Moisture\ Content\ (\%) = \frac{(W2 + W1) - W3}{W2} X\ 100$$

Where:
W2 = weight of the sample
W1 = Weight of empty moisture dish
W3 = Weight of moisture dish plus dried sample

### 2.11. Determination of ash content

The ash content was determined using [23] method. A weighed portion (2 g) of the homogenized tomato sample was dried to a constant weight at 600°C (for 4 h) and the result recorded.

### 2.12. Measurement of pH, titratable acidity (%) and total soluble solid

The pH, titratable acidity and total soluble solid were determined using the method of Sharoba [24] with little modification. Ten grams (10 g) of sample was homogenized and centrifuged (5000 rpm for 20 min) at 4 °C. The supernatant was recovered for pH, titratable acidity, and soluble solid determination. The pH was measured with a pH meter (Searchtech PHS-3C, China). The titratable acidity was determined by titrating the supernatant with 0.1 N NaOH against phenolphthalein, until pH 8.1 was reached (rose pink color) and reported as gram citric acid/100 g fresh weight. The total soluble solids content was determined at 20°C with a refractometer (ABBE MARK II 10481; Cambridge Instrument Inc., NY) and reported as °Brix.

### 2.13. Carotenoids Determination

The tomato samples were homogenized using a mortar and pestle in a water bath containing squash ice. 16 ml of acetone-hexane (4:6) solvent was added to 1.0 g of homogenized sample and mixed in a test-tube to extract the carotenoids. An aliquot was taken from the upper solution of the two phases formed and its optical density (OD) measured at 663, 645, 505, and 453 nm in a UV-VIS spectrophotometer (Searchtech Instruments; UV1902PC, England). Lycopene and β-carotene contents were calculated according to the Nagata and Yamashita equations below as reported by Sharoba [24].

$$Lycopene\ (mg\ per\ 100\ mL) = -0.0458 \times OD\ 663 + 0.204 \times OD\ 645 + 0.372 \times OD\ 505 - 0.0806 \times OD453$$

$$Beta\ Carotene\ (mg\ per\ 100\ mL) = 0.216 \times OD\ 663 - 1.22 \times OD\ 645 - 0.304 \times OD\ 505 + 0.452 \times OD\ 453$$

Where OD=optical density

### 2.14. Determination of vitamin C content

Ascorbic acid content of the tomatoes was determined using the 2, 6-dichlorophenol indophenol titrimetric method described by [25]. This method was slightly modified and used as follows; 2 g of sample was homogenized in a mortar containing 10 mL of 0.5% oxalic acid as the extraction solution and the content transferred into 100 mL volumetric flask. More extraction solution was added and made up to the mark. The content was mixed thoroughly, filtered immediately (Whatman No. 4) and an aliquot (10 mL) of the mixture was titrated against standardized 2, 6-dichlorophenol indophenol solution. An equivalent amount of the extraction solution was titrated against standard 2, 6-dichlorophenol indophenol solution as blank.

### 2.15. Sensory evaluation

Evaluation of the sensory attributes was carried out using the method reported by [26]. At day 16, the stored tomato fruits were presented to a 20-member untrained panelists who are conversant with buying tomatoes to evaluate appearance, colour, odour, firmness and general acceptability using a five point hedonic scale.

### 2.16. Statistical analysis

Data obtained was subjected to analysis of variance (ANOVA) and tested for significant difference among treatments by New Duncan's Multiple Range F-Test (DMRT) at $p < 0.05$ using SPSS software package version 20.0 (IBM Statistics).

## 3. Results and discussion

### 3.1. Fatty Acid profile of *Canarium schweinfurthii* oil

The GC-MS spectra of the fatty acid profile of *Canarium schweinfurthii* oil is shown in Fig. 1. Four (4) fatty compounds were identified with their respective retention times expressed in Table 1. The most abundant compounds in the oil was the omega-9 fatty acid, oleic acid followed by pentadecanoic acid. The oil contained ethyl oleate, which is a compound formed from the condensation of oleic acid and alcohol. The fatty acid ethyl ester functions as a lubricant and a plasticizer, whose presence in *Canarium schweinfurthii* oil makes it useful in pharmaceutical as well as food industries [27]. Oleic acid is one of the most common monounsaturated fatty acids in the human diet [28]. The compound has the ability to lower cholesterol and low density lipoprotein levels, while increasing the level of high density lipoprotein in the human system. Its presence gives the oil great importance in human nutrition [29; 30]. Pentadecanoic acid is a saturated fatty acid found mainly in dairy fat and ruminant meat as well as some plants, of which *Canarium schweinfurthii* is one of them [31]. It is referred to as a macro fatty acid because of the numerous benefits it introduces into the human system through the diet [32]. The result of fatty acid profiling of *Canarium schweinfurthii* oil confirms the nutritional importance of both the fruit and its oil, as well as the potential use of the oil especially in food and pharmaceutical industries.


**Figure 1** GCMS Spectra of *Canarium schweinfurthii* oil

**Table 1** Fatty Acid profile of *Canarium schweinfurthii* oil

| S/N | Compounds | Retention time (min) | Abundance (%) |
|---|---|---|---|
| 1 | Palmitic acid | 37.652 | 4.02 |
| 2 | Pentadecanoic acid | 37.965 | 40.00 |
| 3 | Ethyl oleate | 38.759 | 4.46 |
| 4 | Oleic acid | 38.991 | 51.51 |

### 3.2. Total phenolic and flavonoid contents of *Canarium schweinfurthii* oil

As summarized in figure 2 the phenolic and flavonoid contents of the oil were estimated to be 6.03 ± 0.001 and 4.59 ± 0.003 mg/g respectively. A report made by [33] explained that essential oils are known to have low phenolic and flavonoid contents. This assertion was made in the authors' report on *Origanum*, in which they found the essential oil to have 3.81 and 12.74 mg/g of phenol and flavonoid contents respectively. Though a higher value for flavonoid was recorded for essential oil in the study, it was significantly ($p<0.05$) lowest of all the oils analyzed by the authors.

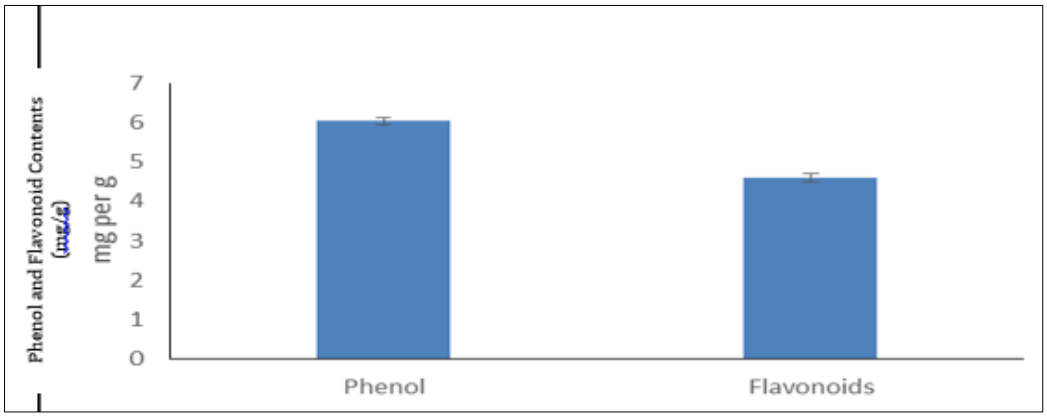



**Figure 2** Phenol and flavonoid contents of *Canarium schweinfurthii* oil

### 3.3. Decay Incidence and Weight/Moisture Loss

The effect of *Canarium schweinfurthii* oil coating on decay incidence of tomato fruits during storage is as summarized in Figure 3. It was observed that the coated fruits recorded lower decay incidences (66.67% each) compared to the untreated control with a decay incidence of 83.33%. This result revealed that the coating treatment was able to minimize the risk of decay in the fruits better than the untreated.

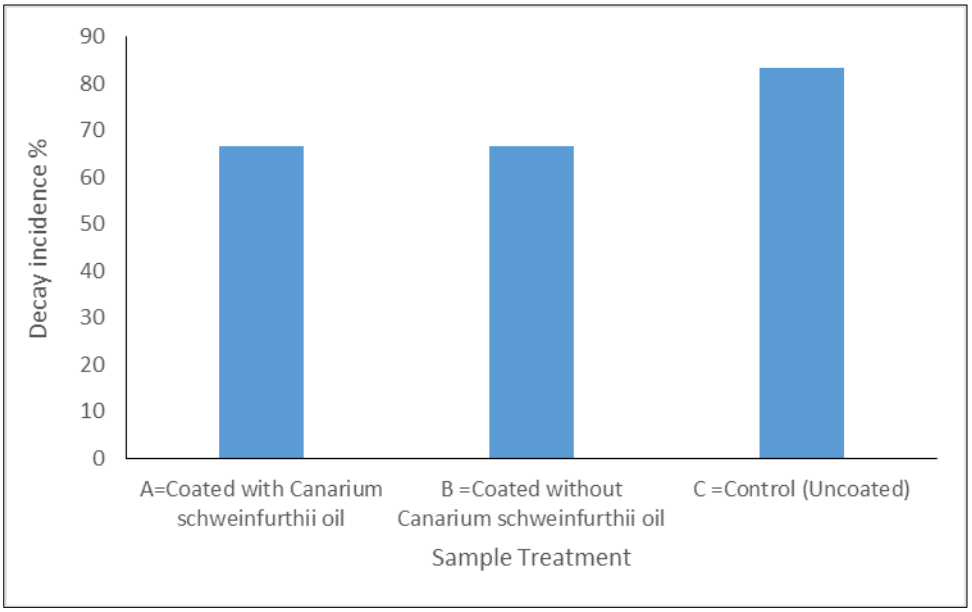



**Figure 3** Effect of *Canarium schweinfurthii* oil on decay incidence (%) of the stored tomatoes

Table 2 shows that the untreated control had the lowest average weight/moisture loss amongst all the treatments at 2.95%, followed by the non-oil treated control and the oil-coated sample with values of 3.03 and 3.86% respectively. This revealed that the coating treatments were unable to limit metabolic reactions involving respiration and transpiration which resulted in the loss of moisture from the coated fruits to the atmosphere

**Table 2** Effect of *Canarium schweinfurthii* oil coating on the weight/moisture changes of tomato fruits during storage

| Treatment | Average Weight Loss (%) |
|---|---|
| Coated with *C. schweinfurthii* oil | 3.86 |
| Coated without *C. schweinfurthii* oil | 3.03 |
| Uncoated (untreated) control | 2.95 |

### 3.4. Effect of coating on physicochemical properties of tomatoes

The effect of the storage treatment on the physicochemical properties of the tomato fruits over a period of 16 days is shown in Figures 4-8.

#### *3.4.1. Moisture Content*

It was observed over the storage period that the moisture content of the untreated control was significantly ($p<0.05$) preserved and recorded a higher value (91.49%) when compared with the oil-coated (87.92%) and non-oil coated (91.27%) treatment group. The coated samples recorded significantly ($p<0.05$) lower moisture contents at day 16. The reduced moisture content in the treatments corroborated the earlier observed higher average percentage weight loss and could be attributed to loss of water from the fruits to the atmosphere through transpiration [34].

#### *3.4.2. Ash content*

Over the storage period, the mineral content of the coated samples reduced non-significantly ($p<0.05$). At day 16, despite the reduced ash content, treated control, recorded an ash content of 0.22%, which shared no significant difference with the oil-coated group and the non-coated control at 0.20 and 0.23% respectively. The observed reduction in ash content could be attributed to some of the minerals being used up during metabolic reactions occuring in the fruits as they age/ripen [35].

#### *3.4.3. Total titratable acidity (TTA)*

The TTA of the stored tomatoes varied over time with treatments. The oil-coated samples recorded reduction in TTA varying from 0.38 – 0.20% at days 0 to 16 respectively. The treated control samples recorded significantly ($p<0.05$) highest values at days 13 and 16 (0.72 and 0.78% respectively). The reduction in TTA observed for the oil-coated and untreated control samples could be attributed to further ripening of the fruits, as the acidity of fruits tends to reduce with increased ripeing [26].

#### *3.4.4. pH*

According to Saltveit *et al*. [36], the pH of ripe tomato fruits ranges from 4.1–4.8. At day 16, an expected significant ($p<0.05$) increase in pH value was observed for oil-coated and non oil-coated samples, while the untreated control recorded a lower value for pH compared with day 0. The increase in pH values for the oil coated and non oil-coated control can be attributed to increasing maturity of the tomato fruits, causing the organic acids to be used for metabolic processes and thus converted into sugars [26; 21]. It could also be as a result of oxidation of the acids during storage [37].

#### *3.4.5. Total soluble solids (TSS)*

At the end of the storage days, it was observed that the TSS of the tomatoes increased significantly ($p<0.05$) with the untreated control having the highest value (5.30 $^{o}$Brix). The oil coated samples recorded the lowest (4.6 $^{o}$Brix), followed by 5.2 $^{o}$Brix recorded for the treated control samples. The TSS of fruits gives a representation (from 10-20%) of the fruits' fresh weight [37]. The result of TSS at day 16, when compared with day 0 agrees with Islam *et al*. [37] where the authors stated that the TSS of fruits increase as the fruit matures or ripens, giving rise to a less acidic sweeter fruit.

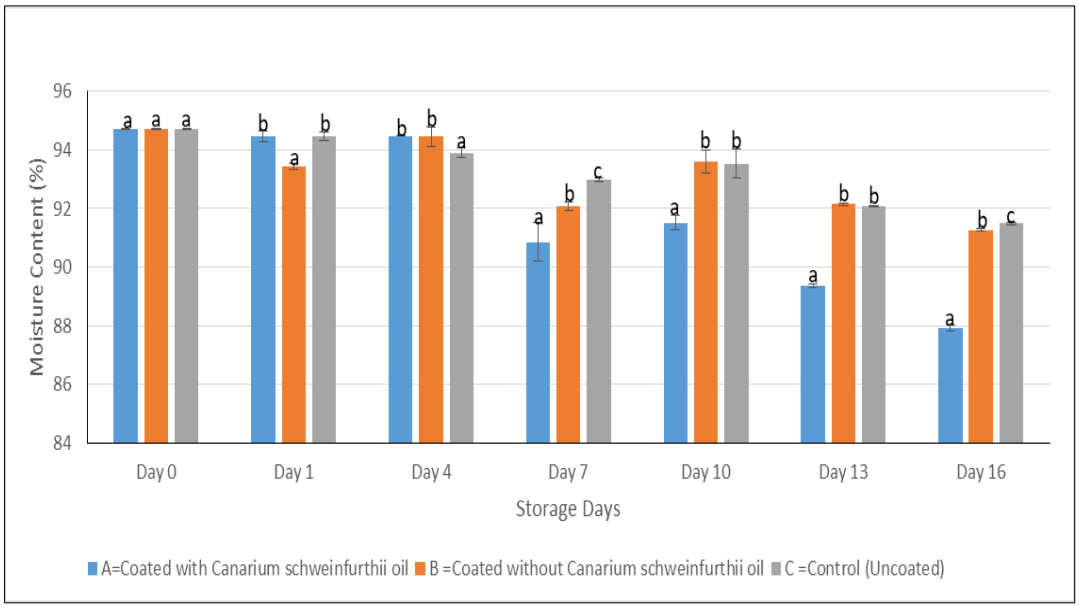



**Figure 4** Effect of *Canarium schweinfurthii* oil on moisture content of tomatoes during storage

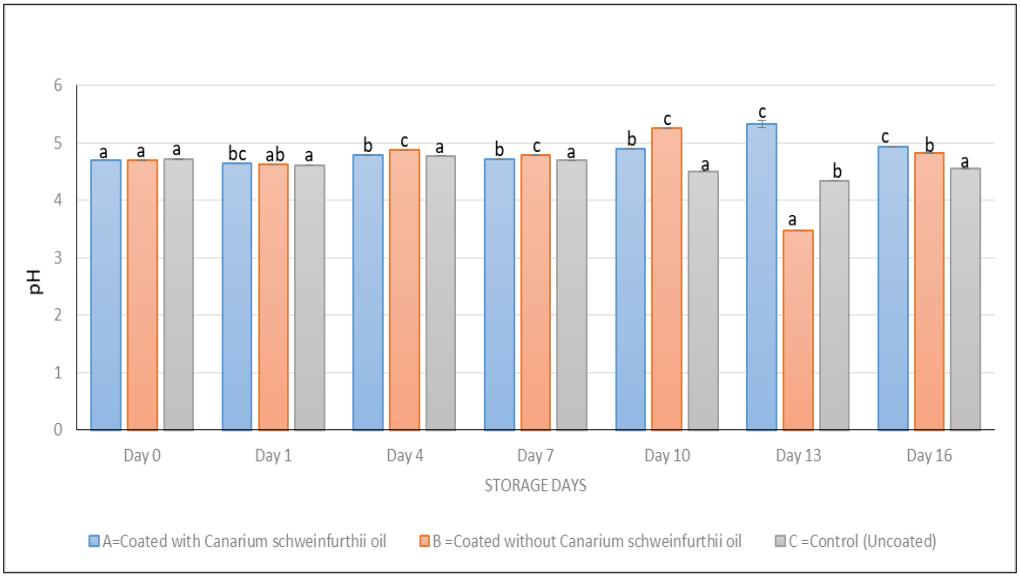



**Figure 5** Effect of *Canarium schweinfurthii* oil on pH content of tomatoes during storage

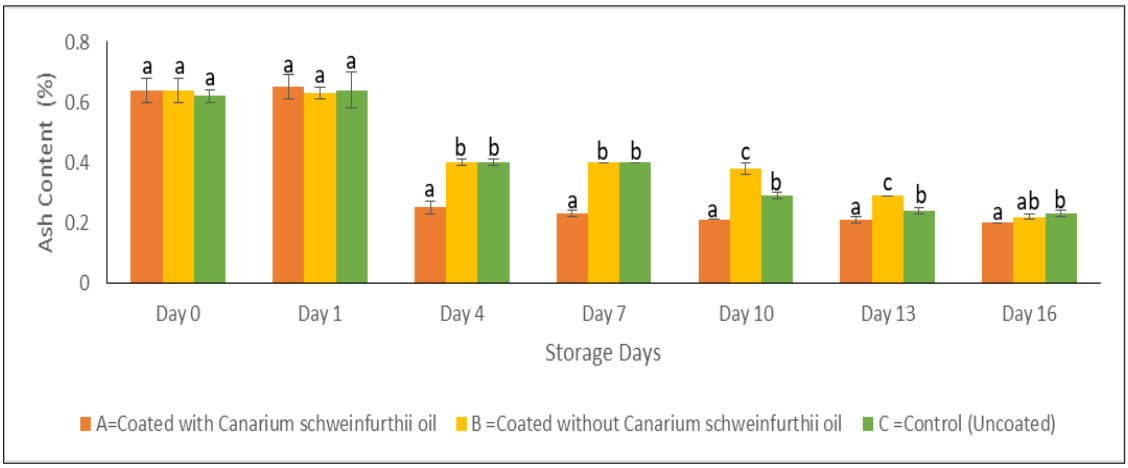



**Figure 6** Effect of *Canarium schweinfurthii* oil on Ash content of tomatoes during storage

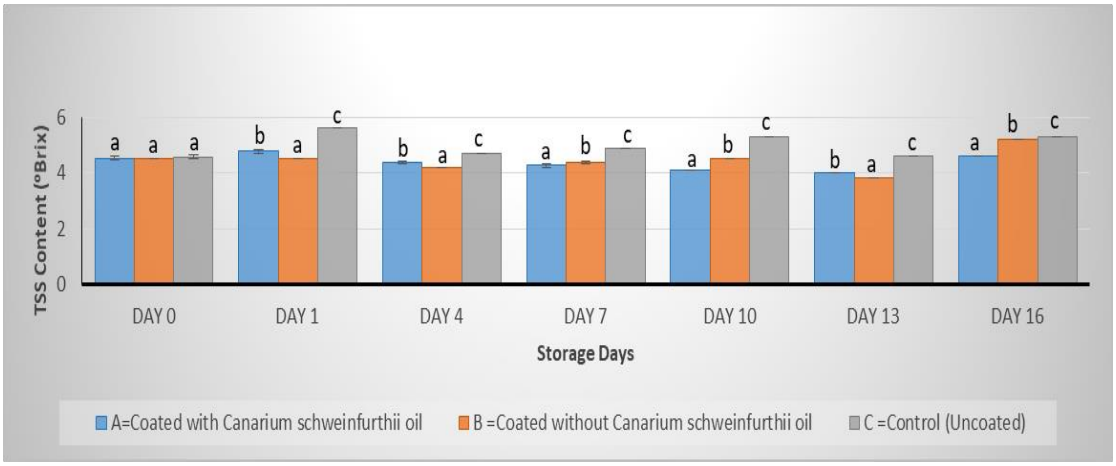



**Figure 7** Effect of *Canarium schweinfurthii* oil on Total Soluble Solids (TSS) of tomatoes during storage

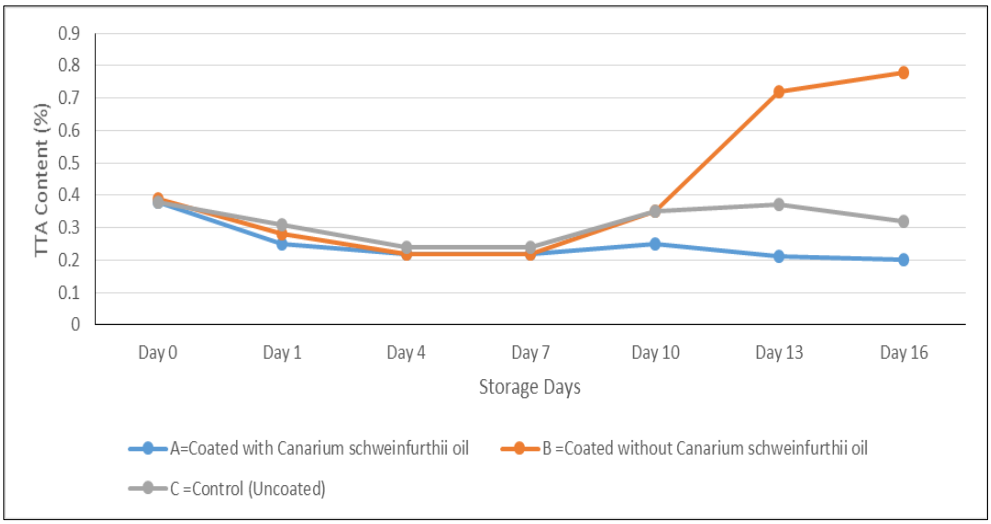



**Figure 8** Effect of *Canarium schweinfurthii* oil on Total titratable Acidity (TTA) content of tomatoes during storage

### 3.5. Effect of coating on the nutritional contents of stored tomatoes

The effect of the storage treatment on the physicochemical properties of the tomato fruits over a period of 16 days is as summarized in Figures 9-11 below.

#### *3.5.1. Vitamin C content*

Tomato fruits are a rich source of vitamin C, the fruit has an average vitamin C content of about 23 mg/100 g [38], which varies with the cultivars. According to [39], the vitamin C content of tomato reduces with storage time. This can be attributed to vitamin C loss through respiration as well as water loss through transpiration. The result of vitamin C gotten from this study agrees with the above claim, in that a significant decrease was observed for vitamin C content in all the treatments at day 16. It was also observed that at day 16, the control fruits had a high vitamin C content retention than the coated fruits, recording 81.51 mg/100mL against 49.36 and 40.92 mg/100mL for oil coated and non oil-coated samples respectively.

#### *3.5.2. Lycopene and β-carotene contents*

Lycopene and β-carotene are the main characteristic red pigments of ripe tomatoes. They are responsible for the colour change in the fruit from green to red as it matures [40; 41]. Carotenoid is an important parameter in tomato fruits, as β-carotene helps to protect the living system from lung and oral cavity cancers and protects eyesight from aging-related damages. Lycopene prevents skin damage from UV rays and offers protection from prostate cancer [42]. Tomato fruit ripening is a complex process, which is also characterized by the synthesis of carotenoids. In other words, the carotenoid content of tomato fruit increases as the fruit matures [44]. However, ripening process could be delayed to elongate the shelf-life of the fruit. Edible coating is an alternative way to modify the ripening process. This modifies the internal atmosphere of the fruit causing an increased $CO_2$ production at a reduced $O_2$ utilization, thus lowering the ripening rate as well as the risk of scenesense of the fruit (43). From the result of carotenoids (lycopene and β-carotene) obtained in this study, a significant ($p<0.05$) increase was observed for both parameters at day 16 of storage. It was also observed that at day 16, the control samples had higher carotenoid contents compared with the coated fruits. This can be attributed to the coatings lowering the rate of synthesis of carotenoids, thus slowing down the ripening rate of the fruits, which further confrims the claim of Zapata *et al*. [43] that edible coatings tend to create a modified atmosphere around the fruits, thus lowering the rate of ripening and senscenesing of the fruits.

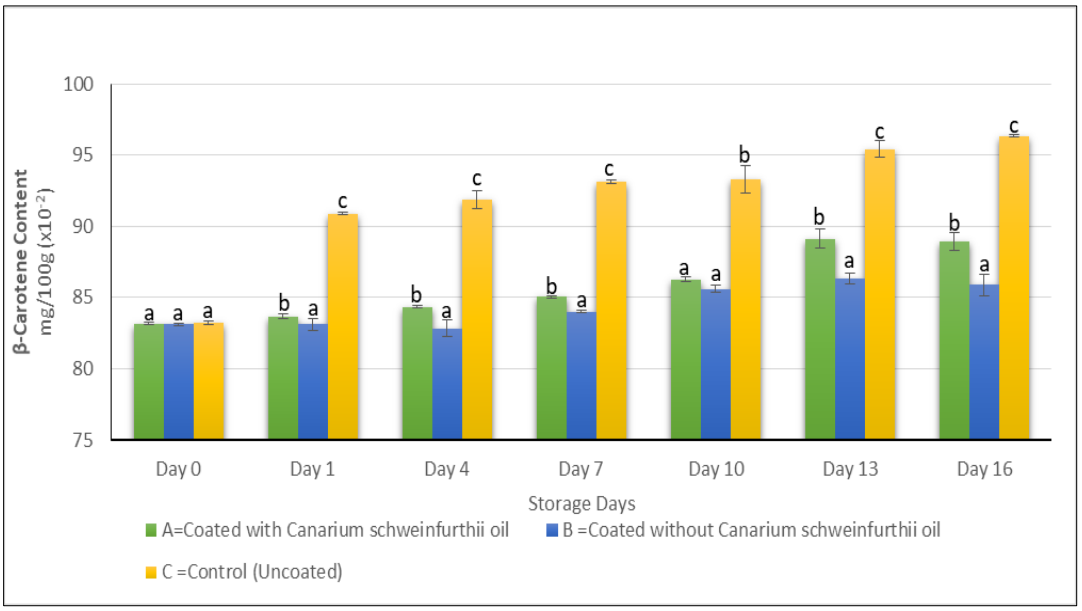



**Figure 9** Effect of *Canarium schweinfurthii* oil on β-Carotene content of tomatoes during storage

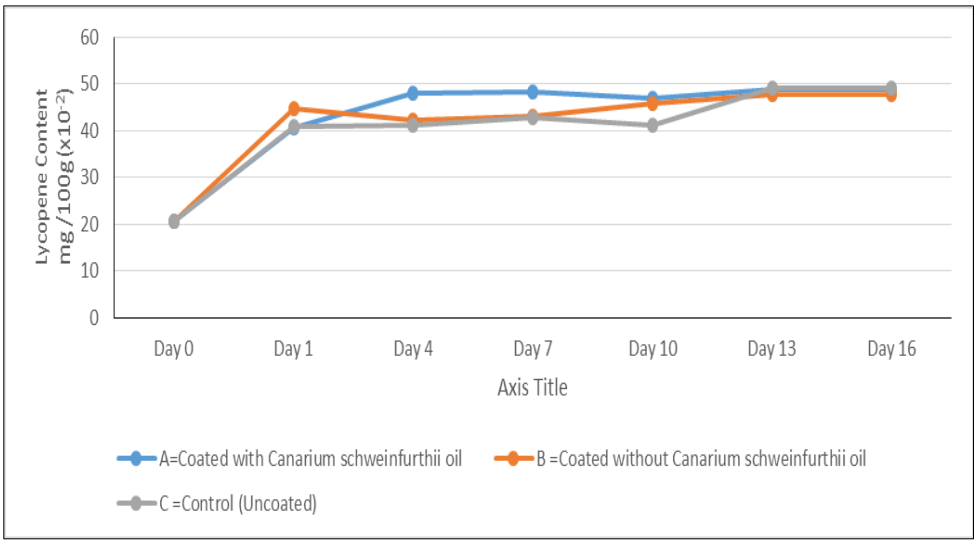



**Figure 10** Effect of *Canarium schweinfurthii* oil on Lycopene content of tomatoes during storage

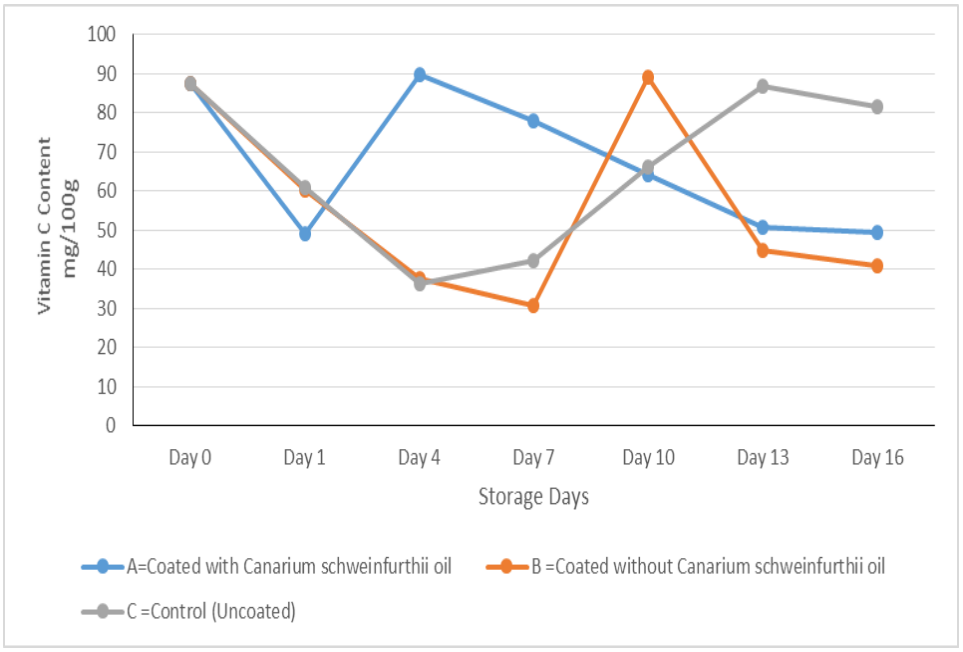



**Figure 11** Effect of *Canarium schweinfurthii* oil on Vitamin C content of tomatoes during storage

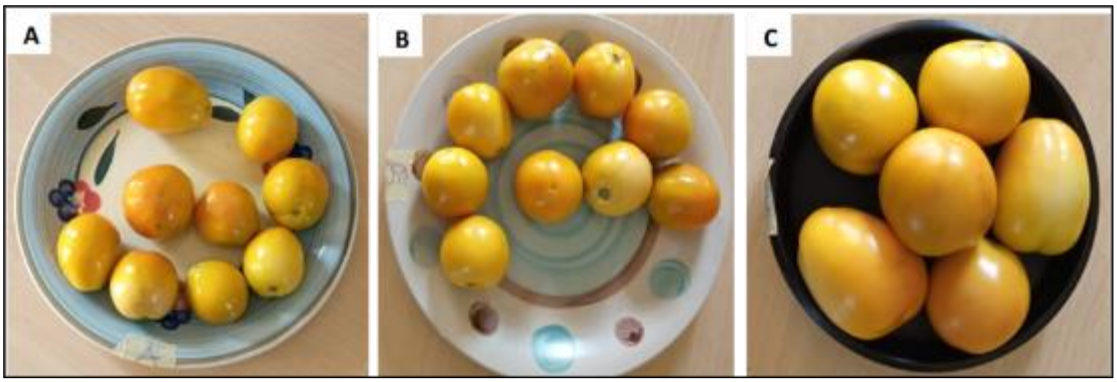
### 3.6. Sensory attributes of the stored tomatoes

The result for the sensory attributes of the tomatoes after a storage period of 16 days is as summarized in Table 5. It was observed that the tomatoes coated with *Canarium schweinfurthii* oil had significantly ($p<0.05$) higher rating for each of the sensory attributes observed by the panelists, followed by the non-oil coated control. The untreated control had the lowest rating. This result revealed that the coating treatment had a good storage impact on the aesthetic appeal and the observed sensory properties (colour, appearance, aroma and firmness) as well as the general/overall acceptability of the tomatoes. It could further be said that the coating treatment, was able to preserve the firmness and aroma of the tomatoes to a significant ($p<0.05$) level higher than the non-oil treated and untreated control samples. This result corroborates the study of [35] where tomato fruits at different maturity stages were treated with chitosan-based coating and stored over a period of 20 days. The coating was reported to preserve the strength of the fruit's cell wall thereby making it firm after the storage period.

**Table 5** Effect of *Canarium schweinfurthii* oil coating on the Sensory attributes of tomato fruits during storage

| Sample | Colour | Appearance | Aroma | Firmness | General Acceptability |
|---|---|---|---|---|---|
| A | 4.20±0.62$^{c}$ | 4.35±0.59$^{c}$ | 4.20±0.77$^{b}$ | 4.30±0.66$^{c}$ | 4.20±0.52$^{c}$ |
| B | 3.35±0.75$^{b}$ | 3.25±0.72$^{b}$ | 3.90±1.02$^{b}$ | 3.65±0.75$^{b}$ | 3.60±0.60$^{b}$ |
| C | 2.10±0.64$^{a}$ | 1.90±0.85$^{a}$ | 2.25±1.07$^{a}$ | 1.80±0.62$^{a}$ | 2.05±1.00$^{a}$ |

Result shows Mean ± SD of 20 panelists on a 5-pont hedonic scale. Means with different superscript letters in the same column are significantly ($p<0.05$) different. A=Coated with *Canarium schweinfurthii* oil, B=Coated without *Canarium schweinfurthii* oil, C=Control (Uncoated).




A= Coated with *Canarium schweinfurthii* oil, B=Coated without *Canarium schweinfurthii* oil, C= Control (Uncoated)

**Figure 2** Turning stage tomato (Day 1 of storage)


A= Coated with *Canarium schweinfurthii* oil, B= Coated without *Canarium schweinfurthii* oil, C= Control (Uncoated)

**Figure 3** Turning stage tomato (Day 16 of storage)

## 4. Conclusion

Oil from *Canarium schweinfurthii* delayed ripening of the tomato fruit while maintaining the organoleptic properties of the tomato fruits, and as such can be developed as a safe, cheap, effective and eco-friendly coating for post-harvest management. The observed effects of the oil-incorporated coating may be ascribed to the fatty acids, phenolic and flavonoid contents of the fruit's oil.

## Compliance with ethical standards

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*Disclosure of conflict of interest*

The Authors declare no conflicts of interest.

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