*Journal of Food and Nutrition Research, 2023, Vol. 11, No. 10, 621-629*
Available online at http://pubs.sciepub.com/jfnr/11/10/3
Published by Science and Education Publishing
DOI:10.12691/jfnr-11-10-3

# Shelf-Life Extension of Fresh Cassava (*Manihot Esculenta* Crantz) Roots by Starch Gel Coating and Edible Materials

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*Received September 16, 2023; Revised October 17, 2023; Accepted October 24, 2023*

**Abstract** The use and marketing of cassava is affected by its short shelf life. This study aims to extend the shelf life of cassava roots through the application of edible coatings. Three batches of cassava roots were preserved: one batch of uncoated and unbleached roots and two batches of bleached and coated roots with cassava starch, *Garcinia kola* oil (20%) and *Cocos nucifera* microfibres (5%) and cassava starch and *Garcinia kola* oil (40%) formulations respectively. The results showed significant changes in colour, firmness, weight loss and dry matter content of the coated cassava roots due to coating. Our study therefore suggests that coating with cassava starch, *Garcinia kola* oil (20%) and *Cocos nucifera* microfibres (5%) better prolongs the shelf life of cassava and would thus be an effective alternative for the fresh preservation of cassava roots.

***Keywords:*** *cassava, post-harvest losses, cassava starch, coconut fibre, Garcinia kola oil, edible coatings*

**Cite This Article:** Adjouman Yao Désiré, Konan Amoin Georgette, Adou Marc, Doh Amenan Aline, Tetchi Fabrice Achille, and Amani N'Guessan Georges, "Shelf-Life Extension of Fresh Cassava (Manihot Esculenta Crantz) Roots by Starch Gel Coating and Edible Materials." Journal of Food and Nutrition Research, vol. 11, no. 10 (2023): 621-629. doi: 10.12691/jfnr-11-10-3.

## 1. Introduction

Cassava (*Manihot esculenta* Crantz) is one of the major tropical root crops in Latin America, Asia, and Africa [1]. Indeed, according to Sowmyapriya [2], cassava is an important food source of carbohydrates for about 800 million people in these regions. Global production of this root food is estimated at over 300 million tonnes, with Africa accounting for about 57% of production. In West Africa, after Nigeria, which is the world's and Africa's largest producer, and Ghana, comes Côte d'Ivoire with more than 6 million tonnes [3]. Cassava is potentially the basic raw material for many processed products [4]. It thus contributes to agricultural transformation and economic growth in developing countries.

However, the effective use and marketing of cassava is affected by its short shelf life due to a rapid process of post-harvest physiological deterioration (PHD) [5]. PPD results in a loss of market value and acceptance and significantly reduces post-harvest shelf life. This is directly related to the fact that cassava roots do not have natural dormancy, making them very susceptible to spoilage [6]. This deterioration takes place 2 to 3 days after the roots are harvested. This rapid post-harvest deterioration of cassava roots imposes serious constraints on their use in the marketing of fresh products and the conservation of stocks for large-scale processing. Many methods are used to reduce losses of cassava roots in the fresh state or after processing [8]. Among the techniques to extend the shelf life of cassava roots in the fresh state, wax or paraffin coating of roots is widely used, especially for export [9]. Wax or paraffin, classified as a chemical preservative, is widely used on fruits, vegetables, and sweets to make them shiny and attractive, reduce moisture loss and spoilage. However, the adoption of paraffin coating for cassava is a challenge for smallholder farmers. This is because the temperature of the wax and the timing of application must be precise, otherwise the root is charred [10]. Indeed, PPD is retarded by heating food grade wax (paraffin) to a temperature of 140-160°C and dipping the tuber for 1-2 seconds [11]. In addition, some paraffins are not intended to be ingested, such as those sold for candle making, which are often used for coating cassava roots. In addition, concerns about non-biodegradable or inorganic chemical-based waxes have recently become a major focus, with increased emphasis on the use of waxes from renewable and biodegradable polymers of agricultural origin [10].

Nowadays, new edible materials have been obtained from many natural sources traditionally considered as waste materials or even inexpensive sources [12]. Edible films and coatings containing essential oils can be incorporated into conventional food packaging systems with a dual-purpose preservative, edible and natural, which can maintain quality, extend shelf life, and reduce the risk of pathogen growth especially in unprocessed or minimally processed foods [13]. Studies in Benin [14] and Nigeria [15] have shown that *Garcinia kola* has high levels of flavonoids, total phenols, and anthocyanins. Flavonoids are known to have protective anti-inflammatory, antioxidant, anticancer, antiviral and antiproliferative effects [16,17,18]. *Garcinia kola* extracts could be an anti-aging agent that can be found in a cassava starch matrix and form a film that will have an antioxidant and antibacterial coating effect to prevent the rapid deterioration of cassava roots after harvesting, the main causes of which are physiological and microbiological.

The major constraint linked to the production, processing, and marketing of cassava on a large scale is the preservation of the tuberous roots in a fresh state. Conservation techniques exist but are expensive and the petrochemical paraffins used to coat cassava roots must not be ingested. This study proposes to preserve fresh cassava roots, a product with high economic potential, by coating them with biodegradable edible film made from cassava starch, *Cocos nucifera* microfibre and *Garcinia Kola* oil.

# 2. Materials and Methods

## 2.1. Plant Material

The cassava roots (Manihot esculenta Crantz) used for the coating, specifically the Cameroon variety, were harvested at maturity 12 months after planting the cuttings in an experimental field of the Centre National de Recherche Agronomique (CNRA) in Bimbresso/Abidjan. After harvesting, the fresh roots were transported to the Laboratory of Food Biochemistry and Technology of Tropical Products (LBATPT) of the NANGUI ABROGOUA University.

## 2.2. Methods

### 2.2.1. Preparation of the Starch Gel

#### 2.2.1.1. Extraction and Obtaining of the Native Starch

Starch extraction was done according to the method described by Ehui *et al*. [19]. Cassava roots were peeled, washed, and cut into cossettes of about 10 cm length. The cylinders were then ground using an electric grinder. The resulting grind was weighed and mixed in equal proportions with water, macerated with a spatula. The mixture was filtered through a series of sieves with mesh sizes of 500, 250, 100 µm respectively. The resulting starch milk was alternately decanted and washed (at least 4 times). The product obtained was spread out on trays covered with aluminium foil and then dried in an oven at 45°C for 48 hours. The dry product was ground with a blender (Silver Crest, SC-9520) and weighed.

#### 2.2.1.2. Oil Extraction from Garcinia Kola Nut By Solvent Maceration

The oil contained in *Garcinia kola* seeds was extracted by maceration in hexane at room temperature according to the method described by Ungo-kore *et al*. [20]. In this process, *Garcinia kola* seeds were dried at 50°C for 48 h in an oven (Biobase model BOV-T105F) and then coarsely ground using a silver crest blender. Approximately 1500 g of pulverised seeds were placed in a sealed container with 1000 mL of n-hexane and allowed to stand at room temperature for a period of 3 d with intermittent agitation. The mixture was then filtered, and the oil was recovered from the mixture (oil and solvent) using a rotary evaporator at 40°C. The oil was collected in a shaded glass vial and placed in a refrigerator (4°C) to await analysis.

#### 2.2.1.3. Extraction of Cellulosic Microfibres from Coco Nucifera Fibres

The cellulosic coconut fibres were physico-chemically pre-treated. The cellulosic fibre samples were washed with distilled water to remove impurities. They were then dried in an oven (Biobase model BOV-T105F) for 72 h at 60 °C. This was followed by grinding with a blender (Silver crest blender) and then sieving with a 250 µm mesh screen. This was followed by further grinding with a laboratory mortar to crush the fibres without destroying the fibrils [21]. The resulting fibres were then sieved with a 100 µm mesh sieve to de-agglomerate them and, above all, to obtain fine microfibres of very small size.

#### 2.2.1.4. Preparation of Coating Gels

Two (2) gels were prepared for coating cassava roots according to the method established by Adjouman [22]. These coating gels contained cassava starch of the Olékanga variety, glycerol, *Garcinia kola* oil, soy lecithin and/or *Cocos nucifera* L. (coconut) microfibres. The different preparations of the gels were done in 3 steps.

##### 2.2.1.4.1. Coating Gel Containing Cocos Nucifera Microfibres and Garcinia Kola Oil

For the first step, *Cocos nucifera* L microfibres (5%) by mass of starch were mixed with two thirds (2/3) of distilled water of the final mixture for 24 hours under constant stirring using a mechanical stirrer (BIOBASE, Model: SK-0330-Pro, China) at 300 rpm. To this solution were added 4 g of powdered cassava starch of the Olékanga variety, 30% glycerol (plasticizing agents) (on a dry basis of the starch w/w). The resulting mixture was heated for 20 minutes from 30 to 75°C using a magnetic stirrer and heater (BIOBASE, Model: MS7-H550-S, China). The second step was to mix 20% of the Garcinia kola oil (by weight of starch) and soy lecithin (5% by weight of oil) with one third of distilled water of the total mixture. The resulting mixture was also heated for 20 minutes from 30 to 75 °C under constant agitation at 750 rpm with a heated magnetic stirrer (BIOBASE, Model: MS7-H550-S, China). The solution of Garcinia kola, soy lecithin and distilled water was homogenised at 26,000 rpm for 1 minute using the Ultra Turrax. In the third step, the homogenised solution was mixed with that of starch, microfibres and glycerol and then heated from 75 to 95 °C for 25 minutes at 750 rpm with a heated magnetic stirrer (BIOBASE, Model: MS7-H550-S, China). The resulting gel was allowed to cool to 70 °C before the coatings.

#### 2.2.1.4.2. Coating Gel not Containing Cocos Nucifera Microfibres

For the first step, 4 g (w/w, starch) of cassava starch was mixed with glycerol (30 % based on starch mass) with 2/3 distilled water in the final mixture. The mixture was heated for 20 minutes from 30 to 75 °C at 750 rpm using a magnetic and heating stirrer (BIOBASE, Model: MS7-H550-S, China). In the second step, 40 % of the *Garcinia kola* oil (by weight of starch) and soybean lecithin (5 % by weight of oil) were mixed with one third of the total mixture of distilled water. The resulting mixture was heated for 20 minutes from 30 to 75 °C under constant agitation at 750 rpm with a magnetic and heating stirrer (BIOBASE, Model: MS7-H550-S, China). The solution of Garcinia kola, soy lecithin and distilled water was homogenised at 26,000 rpm for 1 minute using the Ultra Turrax. In the third step, the homogenised solution was mixed with that of starch and glycerol and then heated from 75 to 95 °C for 25 minutes at 750 rpm using a magnetic and heating stirrer (BIOBASE, Model: MS7-H550-S, China). The resulting gel was allowed to cool to 70 °C before the coatings.

#### 2.2.1.5. Cassava Root Coating Process

The cassava roots were washed thoroughly twice with 50 L of tap water to remove debris and sand. The roots selected for coating were heat bleached at 65 °C for 1 minute. The roots were then left to air dry before coating. They were immersed in the coating gel previously placed in a basin for 1 min. Then, they were drained for 3 min and left to dry at room temperature for 8 h. The cassava roots were stored at room temperature (25 ± 2 °C; 91 ± 2 % RH) for 33 days. The roots were stored in 3 batches; one batch of uncoated and unbleached cassava roots (control), one batch of bleached cassava roots coated with a formulation containing cassava starch, *Garcinia kola* oil and *Cocos nucifera* L. microfibres and one batch of bleached roots coated with a gel formulation containing cassava starch, *Garcinia kola* oil.

### 2.2.2. Determination of Weight Loss

Weight loss was determined by the method described by Athmaselvi *et al*. [23]. Four (4) cassava roots from each batch were weighed and the mass of coated and uncoated (Control) roots was recorded on day 0 and every 3 days for 33 days (D0, D3, D6, D9, D12, D15, D18, D21, D24, D27, D30, D33). Cumulative mass losses were calculated using formula (1) below:

$$\Delta M\ (\%) = (M_i - M_f / M_{i)} \times 100 \qquad (1)$$

With:

**ΔM**: Mass loss;
**Mi**: Initial mass;
**Mf:** Final mass.

### 2.2.3. Determination of Dry Matter Content

The dry matter content of the different cassava samples was determined according to the A.O.A.C 15.955.03 [24] method. Five grams (5 g) of each cassava root sample was weighed (M1) using a balance (SARTORUIS BP 310S, Germany) into a crucible of known mass (M0). They were dried in an oven (BIOBASE, Model: BOV-V125F), at 100 ± 5°C for 24 h ± 30 min until a constant mass was obtained. On leaving the oven, the samples were cooled in a desiccator and weighed (M2). The dry matter content was determined from equation 2.

$$TMS\ (\%) = (M_2 - M_0 / M_1) \times 100 \qquad (2)$$

With:

**$M_0$:** Mass of the empty crucible
**$M_1$:** Mass of the sample
**$M_2$:** Mass of crucible + dry sample

### 2.2.4. Determination of Cassava Root Firmness

The firmness of the root flesh was measured using a digital penetrometer (FC GAUGE PCE - FM 200, Milan, Italy) according to the manufacturer's instructions. The tip (8 mm diameter) of the penetrometer equipped with an electronic force indicator was placed on the underside of the flesh of each sample after a longitudinal cut. The force required to pierce the fruit skin was measured and expressed in Newton (N).

### 2.2.5. Determination of Cassava Root Colour

The flesh colour of cassava roots was assessed using a Konica Minolta chromameter (Chromameter CR-10 plus, Japan). The colour of the roots was measured on the inner side (flesh) after a longitudinal cut of the cassava roots. The average value of L*, a*, b* values was measured and the chroma value (ΔE) was calculated using formula 3 shown below [25].

$$(\Delta E) = \sqrt{(L^*)^2 + (a^*)^2 + (b^*)^2} \qquad (3)$$

With:

**ΔE:** Difference in colour difference;
**L***: black to white transition;
**a***: colour change from green (negative values) to red (positive values);
**b***: colour change from blue (negative values) to yellow (positive values).

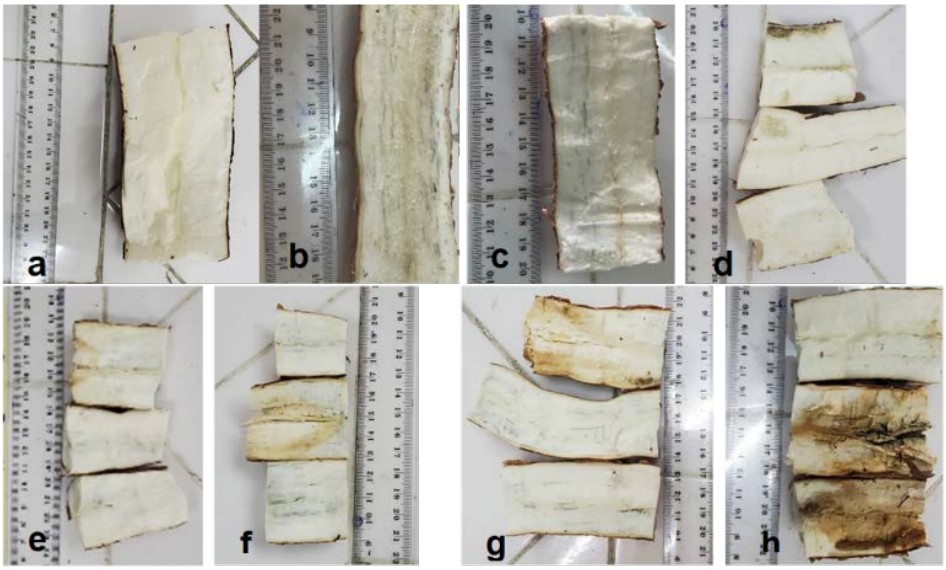
### 2.2.6. Statistical Analyses

The physico-chemical analyses were carried out in trials of 3. The values are means ± standard deviations. The results of the analyses were subjected to an analysis of variance (ANOVA) at a significance level of 0.05 with the STASTISTICA 7.1 software. In case of significant differences in the samples, Tukey's Test was used to determine which samples differed from each other.

## 3. Results and Discussion

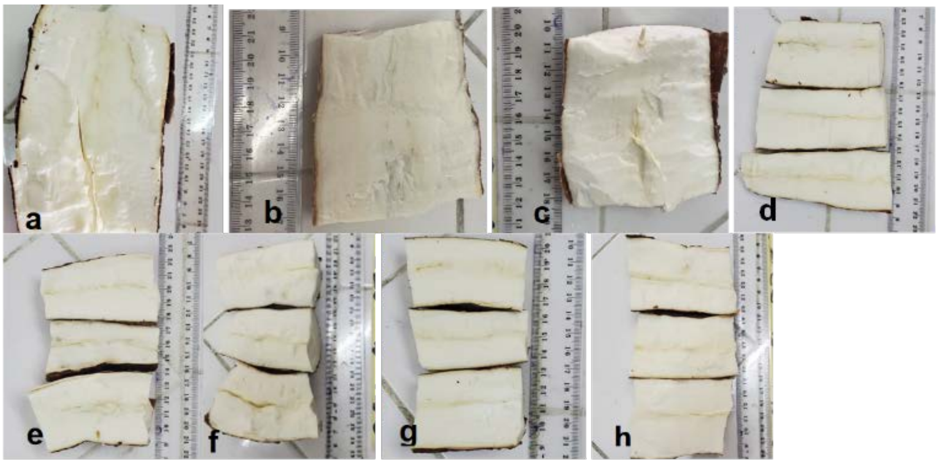
### 3.1. Appearance of Coated and Uncoated Cassava Roots

Figures 1, 2 and 3 show the visual appearance of unbleached and uncoated cassava roots, bleached, and coated with the starch, *Garcinia kola* and coconut microfibre formulations. These cassava roots were stored for 33 days. The colour change of the pulp of the uncoated and unbleached roots is observed from day 9 of storage. The blue-black streaks on the vascular tissues from day 9 onwards will evolve to brown, blue-black or black and totally dark on day 33 of storage (Figure 1). In contrast to the uncoated roots, only the bleached cassava roots coated with the solution of cassava starch, *Garcinia kola* oil (20%) and coconut microfibre (5%) did not show any change in pulp colour over the 33 days of storage. The pulp colour remained unchanged from day 3 to day 33 of storage (Figure 2). The cassava roots coated with the solution of cassava starch and *Garcinia kola* oil (40%) experienced the colour change from day 27 of storage. On this day, blue-black streaks on the vascular tissues started to be observed (Figure 3). This indicates the onset of post-harvest physiological deterioration (PHD) of cassava roots. PPD leads to a loss of market value and acceptance and significantly reduces the post-harvest shelf life, which is between 2 and 3 days depending on cultivar, age and environmental conditions [26]. PPD is accompanied by an unpleasant odour and flavour and appears as blue-black streaks on the xylem vascular tissues [27], as observed on unbleached cassava roots. The treatment with cassava starch gel and Garcinia kola oil (40%) applied to cassava roots significantly delayed the appearance of blue-black streaks on the vascular tissues. The treatment with cassava starch gel, *Garcinia kola* oil (20%) and coconut microfibre (5%) applied to cassava roots prevented the appearance of blue-black streaks on the vascular tissue. This would be because these treatments controlled the physiological and microbiological reactions that are the main causes of rapid post-harvest root deterioration [28]. Physiological deterioration is a complex and incompletely understood process of response to oxidative injury involving numerous enzymes, including catalase, peroxidase, and polyphenol oxidase. Microbiological deterioration causes decay [28].



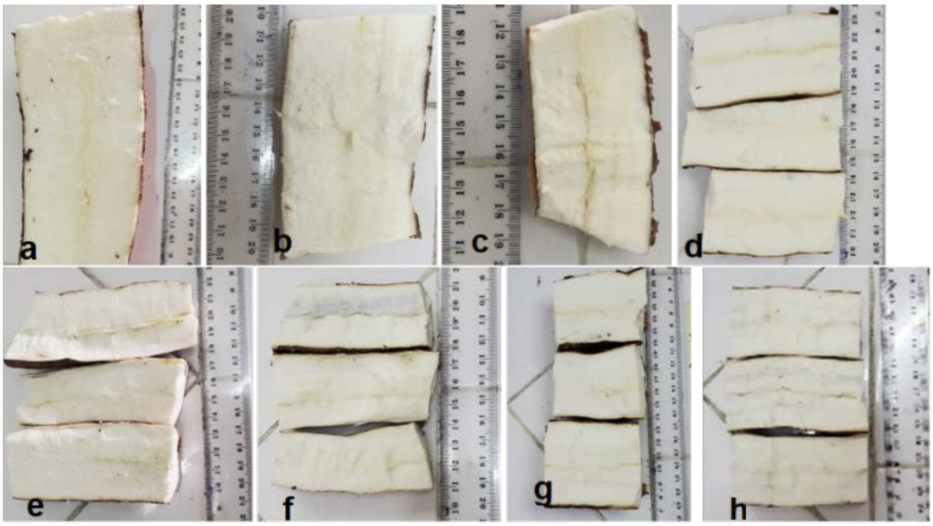

a: day 3 of storage; b: day 9 of storage; c: day 15 of storage; d: day 21 of storage; e: day 27 of storage; f: day 30 of storage; h: day 33 of storage

**Figure 1**. Appearance of unbleached and uncoated cassava roots



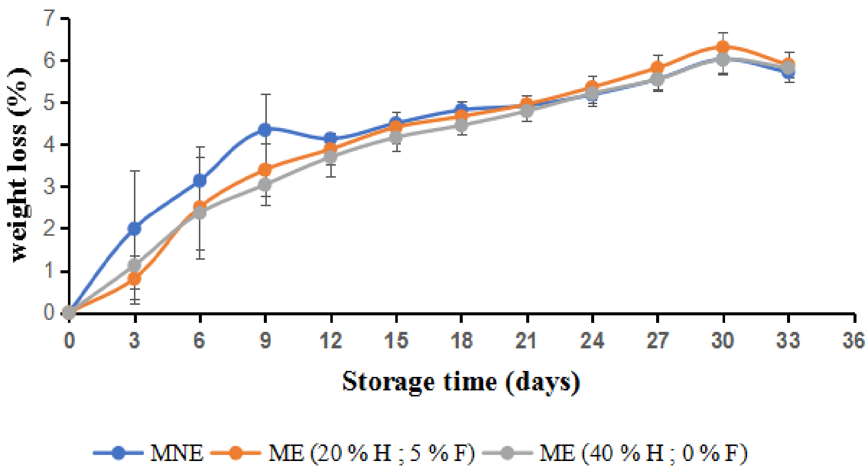

a: day 3 of storage; b: day 9 of storage; c: day 15 of storage; d: day 21 of storage; e: day 27 of storage; f: day 30 of storage; h: day 33 of storage

**Figure 2.** Appearance of bleached cassava roots coated with the formulation of starch, 20% *Garcinia kola* oil and 5 % coconut microfibre




a: day 3 of storage; b: day 9 of storage; c: day 15 of storage; d: day 21 of storage; e: day 27 of storage; f: day 30 of storage; h: day 33 of storage

**Figure 3**. Appearance of bleached cassava roots coated with the formulation of starch, 40% *Garcinia kola* oil and 0% coconut microfiber




MNE: Uncoated cassava; ME (20% H; 5% F): Cassava coated with 20% Garcinia kola oil and 5% Cocos nucifera microfibre. ME: (40% H; 0% F): Cassava coated with 40% Garcinia kola oil.

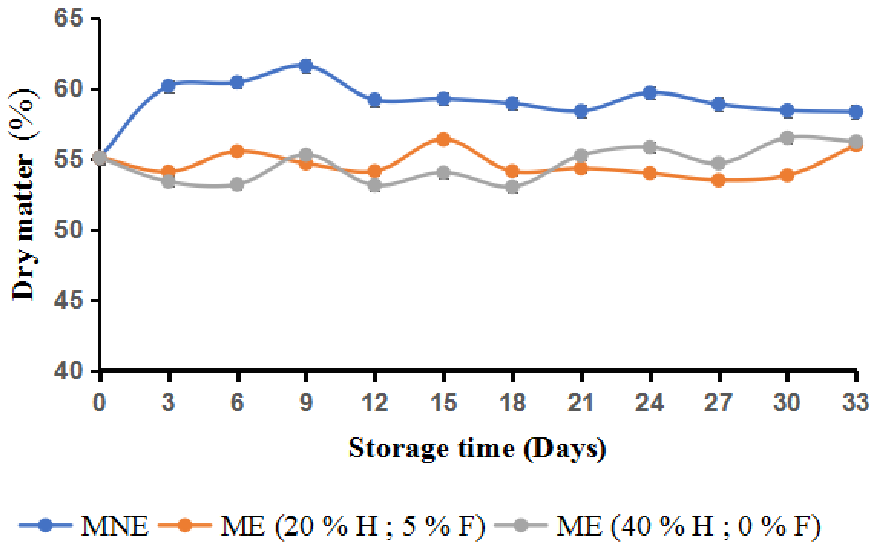
**Figure 4.** Evolution of weight losses of cassava roots during storage.

## 3.2. Evaluation of Weight Loss of Cassava Roots

The weight loss of uncoated and coated cassava roots stored for 33 days at room temperature (25 ± 2 °C) is presented in Figure 4. It increased from the initial day of storage to the 30th day of storage and decreased on the 33rd day for uncoated cassava roots and cassava roots coated with cassava starch solutions with Garcinia kola oil and coconut microfibres or not. The loss was not significant for the coating solutions. However, the weight loss of uncoated roots was significantly higher ($p < 0.05$) from day 3 to day 12 of storage. The weight loss increased from 1.98% to 4.13% from day 3 to day 12 of storage. From day 12 onwards, the weight loss did not increase significantly, reaching a value of 6.01% on day 30 and decreasing suddenly on day 33 to 5.71%. For the coating solutions, the weight losses increased from 0.81% to 6.30% and from 1.12% to 6% from day 3 to day 30 of storage for cassava starch coating solution with 20% Garcinia kola oil and 5% coconut microfibres and cassava starch coating solution with 40% *Garcinia kola* oil respectively. The results obtained in this study show that the coating solutions used delayed the weight loss of cassava roots. These results are in line with those obtained by some authors who have worked on the issue of cassava root preservation [10,29]. Weight loss is normally due to transpiration and respiration, which are normal metabolic processes in cassava roots [30]. This is due to the diffusion of water vapour due to a pressure gradient between the inside and outside of the cassava root. The coating solutions may have acted as barriers to water loss, with a thicker film further reducing water loss by acting as a semi-permeable membrane around the cassava surface [31].

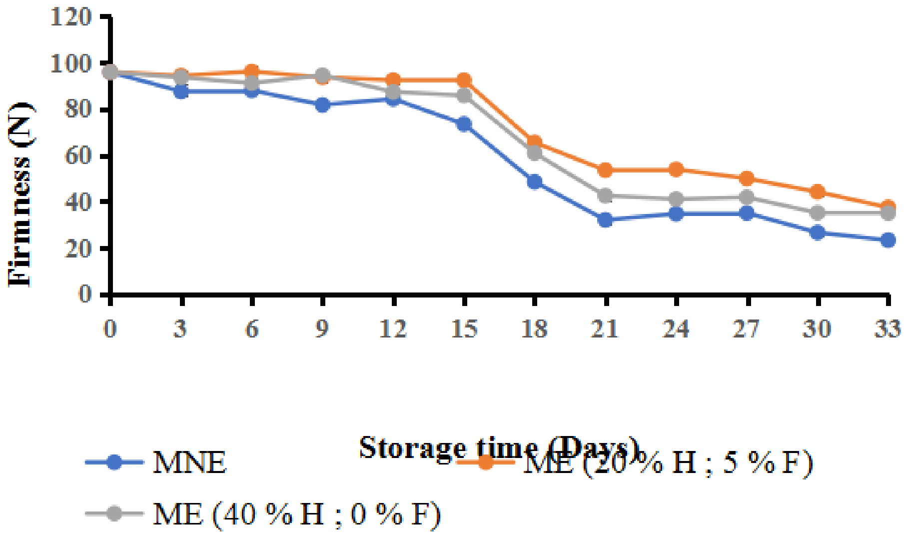
## 3.3. Evolution of Dry Matter Content

Figure 5 shows the evolution of the dry matter content of the control (unbleached and uncoated) and coated cassava roots stored for 33 days. The dry matter content of the control cassava roots was significantly different (p< 0.05) from that of the coated cassava roots over the 33 days of storage. The dry matter content of the control roots increased from the initial day (day 0) to day 33 of storage. The dry matter content values increased from 55.1% to 58.34%. However, the dry matter reached the value of 61.6% on the 9th day of storage. For blanched and coated roots, the values increased from 51.1% to 55.98% and 51.1% to 56.23% respectively for roots coated with cassava starch formulation, 20% *Garcinia kola* oil and 5% Cocos nucifera fibre and roots coated with cassava starch formulation and 40% *Garcinia kola* oil from the initial day (day 0) to day 33 of storage. This increase was not significant. Some authors [10,29] have shown that cassava varieties with a high dry matter content undergo post-harvest physiological deterioration (PPD) faster than those with a low dry matter content. The dry matter content of unbleached and coated cassava roots increased rapidly during storage. This rapid increase is directly correlated with the high rate of PPD on day 9 of storage. In contrast, coated cassava samples showed a delay in dry matter formation, which may be due to the reduced water loss allowed by the different coatings applied to the cassava roots. Atieno et al. [10] made such observations in their study on the effect of surface coatings on the shelf life and quality of cassava. It was also indicated that the increase in dry matter is caused by the reduction in water content of cassava roots during storage. The loss of water is a normal phenomenon that occurs gradually from the harvest period onwards.



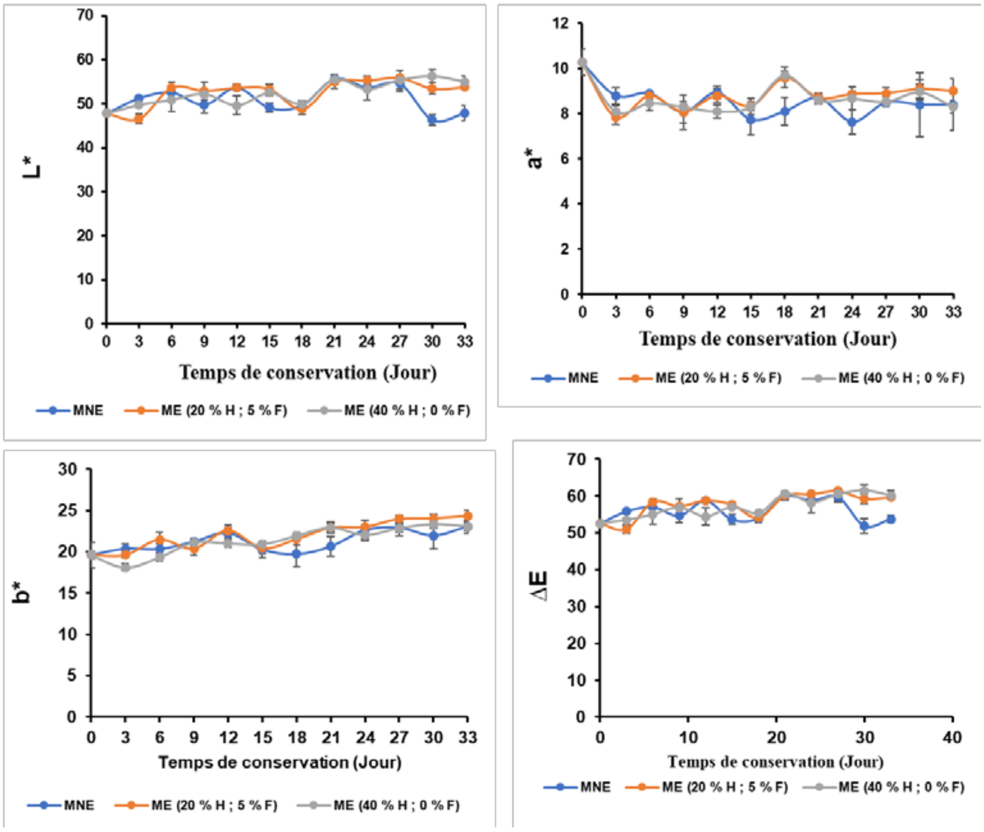

MNE: Uncoated cassava; ME (20% H; 5% F): Cassava coated with 20% Garcinia kola oil and 5% Cocos nucifera microfibre. ME: (40% H; 0% F): Cassava coated with 40% Garcinia kola oil.

**Figure 5**. Evolution of dry matter content of cassava roots




MNE: Uncoated cassava; ME (20% H; 5% F): Cassava coated with cassava starch, 20% Garcinia kola oil and 5% Cocos nucifera L. microfibre; ME: (40% H; 0% F): Cassava coated with cassava starch, 40% Garcinia kola oil and 0% Cocos nucifera L.

**Figure 6**. Evolution of cassava root firmness.




MNE: Uncoated cassava; ME (20% H; 5% F): Cassava coated with cassava starch, 20% Garcinia kola oil and 5% Cocos nucifera L. microfibre; ME: (40% H; 0% F): Cassava coated with cassava starch, 40% Garcinia kola oil and 0% Cocos nucifera L.

**Figure 7.** Evolution of colour parameters of cassava roots during storage

## 3.4. Evolution of Cassava Root Firmness

The flesh firmness of coated and uncoated cassava roots is shown in Figure 6. It generally decreased significantly ($p < 0.05$) for all roots during storage. The firmness of uncoated cassava roots decreased significantly from day 3 to day 33 of storage. It decreased from 87.46 N on day 3 to 23.23 N on day 33. For roots coated with cassava starch formulation containing 40% *Garcinia kola* oil, the firmness decreased significantly from day 12 to day 33 of storage. It decreased from 87.25 N to 34.96 N. The cassava starch gel containing *Garcinia kola* oil (20%) and coconut fibre (5%), however, maintained the firmness of the roots until day 15 of storage, then a significant decrease was observed from day 18 to day 33 of storage. The firmness decreased from 65.37 N to 37.41 N. Coating using the cassava starch formulation with 20% *Garcinia kola* oil and 5% coconut microfibre resulted in roots with the highest flesh firmness, as indicated by the strength of 37, 41 N on day 33 of storage, while roots coated with the starch formulation with 40% *Garcinia kola* oil showed a strength of 34.96 N and control roots showed a firmness of 23.23 N on the same day. The loss of firmness of cassava roots during storage is believed to be due to the action of pectin enzymes which cause loss of firmness as observed by Atieno et al. [10] in their study on the effect of surface coatings on the shelf life and quality of cassava. These enzymes are indeed responsible for depolymerising or shortening the chain length of pectin substances at the cell wall and thus degrading insoluble proto-pectins to more pectic pectins [33]. As the ripening process progresses, depolymerisation or shortening of the chain length of pectin substances occurs with an increase in enzymatic activities (pectinesterase and polygalacturonase) [34]. Compared to uncoated cassava roots, the decrease in firmness of those coated with cassava starch-based formulations and biodegradable edible materials (*Garcinia kola* oil and coconut microfibres) was delayed. The coatings were effective in delaying the softening of the cell wall of coated cassava roots. Respiration and transpiration are normal metabolic processes in cassava root [30]. This is due to the diffusion of water vapour due to a pressure gradient between the inside and outside of the cassava root. The coating solutions certainly acted as barriers to limit respiration and transpiration resulting in low O2 and high CO2 fluxes. Indeed, low O2 and high CO2 levels limit enzyme activities and allow retention of firmness during storage [35].

## 3.5. Colour Assessment

Hunter's L*a*b* colour scale is a visually uniform way of assessing the colour of substances, including cassava flesh. The measured colorimetric data of cassava roots during storage are presented in Figure 7. In this study, the colorimetric parameters presented were lightness (L*), attributes a*, b* and colour difference spread (ΔE). The results showed a significant difference ($P < 0.05$) in the colorimetric parameters of uncoated roots during storage. Clarity increased from 47.76 ± 0.15 at day 0 to 52.56 ± 0.37 at day 33 of storage. As for the parameters a*, b* and ΔE, they varied during storage. However, the lowest values recorded were 6.73±1.6 on day 9, 19.6±1.56 on day 0 and 51.96±1.98 on day 30 respectively and the highest values recorded were 10.26±0.58 on day 0; 23.05±0.77 on day 33 and 60.03±1.11 on day 21 respectively. For cassava roots coated with 20% *Garcinia kola* oil and 5% coconut microfibre, the results showed a significant difference ($P < 0.05$) in the different colorimetric parameters. The value of lightness (L*) and the attributes a*, b* and ΔE varied until the end of storage. The lowest values recorded were 46.5 ± 1.12; 7.33 ± 0.32; 19.6 ± 0.3 and 50.99 ± 1.07 on day 3, respectively, and the highest values recorded were 55.86 ± 0.41 on day 27, 9.1 ± 0.42 on day 30, 24.35 ± 0.63 on day 33 and 61.43 ± 0.47 on day 27 for lightness (L*) and attributes a*, b* and ΔE, respectively. During the 33 days of storage the data of colorimetric parameters of cassava roots coated with 40% *Garcinia kola* oil and 0% coconut microfiber differed significantly ($P < 0.05$). The results showed variation in clarity (L*) and attributes a*, b* and ΔE during storage time. The lowest values recorded were 49.6 ± 2.08 on day 12, 8.1 ± 0.26 and 53.50 ± 0.55 on day 3 respectively and the highest values recorded were 56.25 ± 1.48 on day 30, 9.70 ± 0.17 on day 18, 23.30 ± 0.28 and 61.53 ± 1.51 on day 30 respectively. The colour index L* indicates the change from white to black. This index increased in both uncoated and coated cassava roots. This result obtained in this study for the colour index L* is contrary to those obtained by Atieno *et al.* [10] in their study on the effect of surface coatings on the shelf life and quality of cassava. The colour index a* indicates the change from green to red. The b* indicates the change from blue to yellow. The ΔE* value, however, depends on the a* and b* values and indicates the colour intensity (saturation) of the sample. These different parameters increased for both coated and uncoated cassava roots. This increase can be justified by the colour change observed in the roots as shown in the appearance of the cassava roots in figures 1, 2 and 3. However, the starch coatings delayed the evolution of these parameters compared to the uncoated roots.

## 4. Conclusion

This study aimed at preserving fresh cassava roots, a product with high economic potential, by coating them with biodegradable edible film made of cassava starch, coconut microfibre and *Garcinia kola* oil. The coated samples showed improved post-harvest quality compared to control samples during 33 days of storage. The coating combinations of cassava starch, 20% *Garcinia kola* oil and 5% coconut microfibre were particularly effective in extending the shelf life of the cassava sample to 33 days at room temperature. The treated roots had better physical and physiological qualities. The coatings in this study, particularly the one consisting of cassava starch, 20% *Garcinia kola* oil and 5% coconut microfibre, are an effective treatment for delaying the post-harvest physiological deterioration of fresh cassava roots.

## ACKNOWLEDGEMENT

This research work was supported by a grant from the Academy of Sciences, Arts, Cultures of Africa, and African Diasporas (ASCAD).

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