Proximate and Microbial Composition of Cooking Banana Dried Using an Active Indirect Mode Solar Dryer

Promise Joseph Etim*, Kayode Joshua Simonyanb, and Akachukwu Ben Ekeb

*Department of Agricultural Engineering, Akwa Ibom State University, Ikot Akpaben, Mkpat Enin, Nigeria; bDepartment of Agricultural and Bioresources Engineering Michael Okpara, University of Agriculture Umudike, Umudike, Nigeria

ABSTRACT
The proximate and microbial composition of cooking banana was determined after an active indirect solar drying experiment. The study was aimed at comparing the quality of dried cooking banana with similar products like banana and plantain. Fresh samples of the product were obtained from a local market in Umudike, Nigeria. The samples were washed, peeled, and sliced to the desired thickness (4 to 20 mm), before being loaded onto the dryer. The crude protein, crude lipid, carbohydrate content, ash content, and moisture content were determined after the drying experiment. The microbial load of the dried samples was also determined. The moisture content (10.20%), crude protein (7.18%), crude lipid (3.61%), and carbohydrate (85.61%) were higher than 6.00, 3.06, 2.80, and 82.90% respectively obtained for unripe banana. The ash content (2.21%) was lower than that of unripe banana (2.95%). A total of thirty-eight (38) bacterial isolates were observed from the sample and some of which were identified as Staphylococcus sp, bacillus subillus, and micrococcus sp. Eleven (11) molds (Fungal) were isolated from the dried samples, with Asperligillusniger and Absidia sp dominant. The frequency of occurrence was observed to had been higher in fungal than bacterial isolates.

KEYWORDS
Cooking banana; drying; proximate composition; microbial density; fungal count; bacterial isolates

Introduction
Cooking banana is a banana cultivar in the genus Musa, whose fruit is cooked similar to banana and plantain. They can be either eaten ripe, unripe, or in starchy form. The primary origin of cooking banana is South East Asia and South Asia, but its secondary origin is West Africa. Cooking banana can be boiled, fried, or roasted before being eaten. When roasted, it is referred to as boli, and usually eaten with palm oil, groundnut, or locally made vegetable sauce. Cooking banana is one of the commonly available staple food dominant in the Southern and Eastern regions of Nigeria. The model of harvesting, cooking, and preservation of cooking banana is similar to that of banana and plantain. Some nursing mothers in Nigeria adopt cooking banana as a good recipe for infants, to complement breast milk. Cooking banana takes an average of nine months to grow and produce bunches. It can be harvested once the fruit on the upper hands changes its color from dark green to light greenish-yellow and the fruit is plump. According to Akintobi et al. (2011), there is a huge demand for snacks made from cooking banana as well as plantain in the market, because of its huge nutritional value. A good number of products can be obtained from processing cooking banana, examples can be found in the production of flour, banana chips, banana juice, and country wine amongst others. Cooking banana can also be sliced and dried in the sun, but the method is generally characterized by an infestation by insects and infiltration by other unwanted materials as well as dirt. Chips produced from cooking banana...
contain some appreciable levels of Iron, Zinc, and Carotenoids (Adebayo-Tayo et al., 2012). An estimated 30% of banana produced globally is lost as a result of inadequate post-harvest handling (Akintobi et al., 2011). These losses are large as a result of rapid ripening of the fruit, inadequate storage, and a general lack of awareness on best post-harvest handling practices for the fruit. Processing cooking banana into flour, wine, beer, and weaving food products is a sustainable means of adding value to the fruit as well as prolonging its shelf life. It can also be processed into chips. Cooking banana can also be used in the production of banana juice as well as wine. It can make a delicious and economic snack when properly processed. The dried products can further be stored in containers or sealed plastic bags (Adeniji et al., 2010). The value chain of cooking banana is highly dependent on how moisture can be removed from the product (Harrigan and McCance, 1990). This is however deeply concerned with the proximate composition of the product after drying as well as its microbial load. These parameters which include crude protein, carbohydrate, crude lipid, ash content, and moisture are very critical when assessing the product before and after drying, to examine the quality of the final product, before further processing. There is no data of these parameters for cooking banana, unlike similar products like banana and plantain. This study was aimed at addressing the gap, to ensure a lead into the proximate composition of cooking banana using an active indirect mode solar dryer as a means of drying the product.

**Materials and Methods**

**Sample Preparation**

Fresh samples of cooking banana were bought from a local market in Umudike. The samples were peeled, washed, and sliced at five different thicknesses: 4; 8, 12, 16, and 20 mm. A study on a similar product utilized 15 mm used by Udensi et al. (2017). The optimum thickness of cooking banana dried with an active solar dryer has not been established. The initial and final weight of the product was obtained using an electronic weighing balance (KERRO BL5002 Model – India). Open sun drying of the product served as control. The samples were dried in batches of three replicates.

**Proximate Composition**

The chemical composition of the samples was determined using the standard methods of analysis of the Association of Official Chemists (Ayodele and Erema, 2010). Crude protein, crude lipid, carbohydrate, Moisture, and ash contents in the samples were analyzed. The methods are described below. The experiment was replicated three times for the dried samples, while fresh products served as control.

**Moisture Determination**

Five grams (2 g) of the ground sample was placed in an oven at 105°C for 24 hours. On cooling, the sample was weighed again and the weight loss was recorded and the moisture content was calculated according to the Equation (1).

\[
\text{Moisture content(\%)} = \frac{(B - A) - (C - A)}{(B - A)} \times 100
\]

\[\text{Dry matter(\%)} = 100 - \, \text{moisture content}\]

Where

- \(A\) = weight of clean dry crucible (g)
- \(B\) = weight of crucible + wet sample (g)
- \(C\) = weight of crucible + dry sample (g)
**Determination of Crude Protein**

One gram (1 g) of the ground sample was weighed and placed in a Kjeldahl flask (KINMAX Model – US). Ten grams (1.5 g) of sodium sulfate (Na₂SO₄), 1.5 g of Copper Sulfate (CuSO₄), and 10 ml of concentrated sulfuric acid (H₂SO₄) were added to the sample in the flask. The flask was placed tilted to an angle in the digester, boiled, and allowed to stand until the solution turned bluish. The solution was allowed to cool gradually, 90 ml of distilled water was added to the digested sample and the volume was made up to 100 ml using 100 ml volumetric flask. 20 ml of the digested solution and 20 ml of 40% sodium hydroxide solution were added 250 ml flat bottom flask. The flask was quickly connected to the distillation unit and the distillate was collected under 10 ml saturated boric acid in a 250 ml conical flask. At the end of the distillation, the distillate was titrated 0.1M hydrochloric acid (HCL) using drops of the mixed indicator until the solution changes from blue to reddish-brown. This procedure shall be repeated for all samples in triplets. The crude protein content was calculated equation using equation (4) (Ayodele and Erema, 2010).

\[
Nitrogen\ in\ sample(\%) = \frac{\text{titre} - \text{blank} \times 0.014 \times 20 \div 10 \times 100 \times 0.1}{\text{weight of sample}}
\]  
\[\text{Crude protein(\%)} = \text{nitrogen sample} \times 6.25 \tag{3}
\]

**Lipid Determination**

Five grams (2 g) of the ground sample was poured into a PTFE extraction thimble and placed in the extraction unit. An extraction flask containing petroleum ether was connected to the extractor, refluxed for six hours. Thereafter, the ether was evaporated in a rotary evaporator. On cooling, the sample was reweighed and the loss in weight is recorded as the crude lipid. This procedure was repeated for all samples. The crude lipid was calculated using equation (5) (Ayodele and Erema, 2010).

\[
\text{Crude lipid(\%)} = \frac{B - A}{wt\ of\ sample} \times 100
\]  
\[\text{Where A} = \text{weight of empty flask (g)}
\]
\[B = \text{weight of flask} + \text{sample (g)}
\]
\[C = \text{weight of sample (g)}
\]

**Determination of Crude Fiber**

2.00 g of sample was defatted in 200 ml of N-hexane for 2 hours in a 250 ml conical flask (Garg Borosilicate Glass 3.3 – India); after this 200 ml of 5 M sulfuric acid was added to the flask and the mixture was boiled under reflux for 30 minute. The hot solution was quickly filtered under suction. The insoluble matter was washed several times with hot distilled water until it was acid-free. It was quantitatively transferred into the flask and 200 ml of 5 M NaOH solution was added, the mixture boiled under reflux for 30 minute and filtered under suction. The residue was washed with boiling water until it was base-free, dried to constant weight in an oven at 100°C, cooled in desiccators, and weighed (A). The weighted sample was then incinerated in a muffle furnace at 550°C for two hours, cooled and in desiccators, and reweighed (B). The crude fiber was calculated using the formula in Equation (6).

\[
\text{Crude fibre content (\%)} = 100 \times \frac{B - A}{C}
\]  
\[\text{Where A} = \text{weight of the crucible with dry residue (g)}
\]
\[B = \text{weight of crucible with ash (g)}
\]
\[C = \text{weight of sample (g)}
\]
**Determination of Total Ash**

Total ash content was determined by igniting previously dried sample (2.00 g) in a muffle furnace (Protech Model PT-M1700 – China) at 500°C for 4 hours. The same procedure was repeatedly done. The ash content was be calculated by the equation (7) (Ayodele and Erema, 2010).

\[
Ash(\%) = \frac{\text{weight of ash}}{\text{weight of dried sample}} \times 100
\]  

(7)

**Total Carbohydrate Content**

Available carbohydrate content in the samples was calculated as the difference obtained after subtracting the lipid, ash and fiber values from the total dry matter using the equation (8):

\[
\%\text{carbohydrate} = 100 - (a + b + c + d)
\]  

(8)

Where 
- \(a\) = percentage of crude protein
- \(b\) = percentage of crude lipid
- \(c\) = percentage of ash content
- \(d\) = percentage of crude fiber.

**Microbial Analysis of the Dried Product**

**Serial Dilution of Dried Food Samples**

10 g of each sample was homogenized and 90 ml of sterile water was added and shaken for 1 min. This method disrupted the material and randomly distributed the microbes. Treated samples were allowed to settle for 10 mins prior to withdrawal of supernatant for serial dilution. 1 ml of the aliquot was aseptically transferred into sterile test tubes containing 9 ml of diluents to give a dilution of \(10^{-1}\). This was repeated until the third dilution factor was attained.

**Estimation of Microbial Densities in the Sample**

Standard microbial techniques were employed for the microbial analysis of the food samples (Khandekar et al., 2005).

**Determination of Total Microbial and Fungal Counts**

The total heterotrophic bacterial count and fungal count in the food samples were estimated by the pour plate and spread plate techniques using Nutrient agar (NA) and Sabouraud Dextrose agar as analytical media respectively. The total coliform count were estimated using MacConkey agar (MCA), total Staphylococcus count using Mannitol Salt agar and Clostridium count using reenforced Clostridial agar (RCA).

**Incubation of Microbial Culture Plates and Counting of Microbial Colonies**

The microbial plates were incubated for 24hrs at 28°C in a Gallenkamp incubator (Model INR 200010 V – Netherlands) and fungal plates at room temperature (28°C ± 2°C) for five to seven days. Microbial colonies that emerged on the incubated plates after 24hrs were enumerated with the aid of a Quebec colony counter (Reichert Model 13332600 – USA) and recorded as colony forming unit (cfu) per gram of the food sample. Fungi colonies that emerged after seven days of incubation were also counted and recorded.
Purification and Maintenance of Microbial Isolates

Representatives or discrete colonies from culture plates were picked for characterization. Bacterial colonies were sub-cultured into freshly prepared Nutrient agar plates by streaking method and incubated for growth at 28°C for 24 hours before transferring them to agar slants (Collins and Lyne, 2008). The pure isolates of bacteria were maintained on agar slant as stock and preserved in a refrigerator for biochemical characterization and further use.

Characterization and Identification of Microbial Isolates

Bacterial isolates were characterized and identified presumptively based on their morphological, cultural and physiological characteristics, confirmatory identification was based on biochemical reactions. The following biochemical tests were carried out; Gram staining, motility, coagulase, catalase, spore staining, urease, citrate, starch hydrolysis, Methyl Red Voges Proskawres (MR-VP) test sugar fermentation using different sugars (lactose, glucose, mannitol, maltose, galactose and fructose). The results derived from the test for various isolates were collected and the identification was carried out by comparing the characteristics of known taxa (Cheesbrough, 2006).

Serial Dilution of Dried Food Samples

10 g of each sample was homogenized and 90 ml of sterile water was added and shaken for 1 min. This method disrupted the material and randomly distributed the microbes. Treated samples were allowed to settle for 10 mins before the withdrawal of supernatant for serial dilution. 1 ml of the aliquot was aseptically transferred into sterile test tubes containing 9 ml of diluents to give a dilution of 10⁻¹. This was repeated until the third dilution factor was attained.

Estimation of Microbial Densities in the Sample

Standard microbial techniques were employed for the microbial analysis of the food samples (Khandekar et al., 2005).

Determination of Total Microbial and Fungal Counts

The total heterotrophic bacterial count and fungal count in the food samples were estimated by the pour plate and spread plate techniques using Nutrient agar (NA) and Sabouraud Dextrose agar as analytical media respectively. The total coliform count was estimated using MacConkey agar (MCA), total Staphylococcus count using Mannitol Salt agar, and Clostridium count using reenforced Clostridial agar (RCA).

Incubation of Microbial Culture Plates and Counting of Microbial Colonies

The microbial plates were incubated for 24 hours at 28°C in a Gallenkamp incubator (Model INR 2000010 V – Netherlands) and fungal plates at room temperature (28°C ± 2°C) for 5–7 days. Microbial colonies that emerged on the incubated plates after 24 hours were enumerated with the aid of a Quebec colony counter (Reichert Model 13332600 – USA) and recorded as a colony-forming unit (cfu) per gram of the food sample. Fungi colonies that emerged after 7 days of incubation were also counted and recorded.
Purification and Maintenance of Microbial Isolates

Representatives or discrete colonies from culture plates were picked for characterization. Bacterial colonies were sub-cultured into freshly prepared Nutrient agar plates by streaking method and incubated for growth at 28°C for 24 hours before transferring them to agar slants (Collins and Lynne, 2008). The pure isolates of bacteria were maintained on agar slant as stock and preserved in a refrigerator for biochemical characterization and further use.

Characterization and Identification of Microbial Isolates

Bacterial isolates were characterized and identified presumptively based on their morphological, cultural, and physiological characteristics, confirmatory identification was based on biochemical reactions. The following biochemical tests were carried out; Gram staining, motility, coagulase, catalase, spore staining, urease, citrate, starch hydrolysis, Methyl Red Voges Proskauers (MR-VP) test sugar fermentation using different sugars (lactose, glucose, mannitol, maltose, galactose, and fructose). The results derived from the test for various isolates were collected and the identification was carried out by comparing the characteristics of known taxa (Cheesbrough, 2006).

Results and Discussions

Nutritional Content of Fresh and Solar Dried Cooking Banana

The moisture contents of fresh and dried cooking banana was lower than that of plantain and banana (Abiodun and Adeleke, 2010; Onuorah et al., 2016). The result of the pair-wise comparisons for the percentage moisture content in the fresh and solar dried samples revealed that there is a statistically significant difference at between the percentage moisture content in fresh and dried samples of the unripe cooking banana.

The percentage ash contents for the fresh and dried cooking banana are 2.20 and 2.44% respectively, while the percentage ash content for the dried samples of the cooking banana ranged from 2.20 to 2.21% (Table 1), having a higher ash content as compared to others, but less than the ash content in the fresh sample of the unripe cooking banana. The ash contents of the fresh and dried samples of the cooking banana were higher than the unripe banana (Abulude et al., 2007; Abiodun and Adeleke, 2010; Onuorah et al., 2016). The result of the pair-wise comparisons for the percentage ash content in the fresh and dried samples of the cooking banana revealed that there is a statistically significant difference between the percentage ash content in fresh and dried samples of the unripe cooking banana. The protein contents for the fresh and dried cooking banana are 5.030 and 6.737% respectively, while the percentage ash content for the dried samples of the cooking banana ranged from 5.030

Table 1. Proximate composition of fresh and dried cooking banana.

| Nutritional parameters | Control (Fresh Samples) | Solar Dried Samples | Unripe Cooking Banana flour (Musa bulggeae) (Ramarjuna and Jayaraman, 1980) | Unripe Banana (Agbagba cultivar) (Adeniji et al., 2010) | Unripe Banana (IITA PTA 26) (Adeniji et al., 2010) |
|------------------------|-------------------------|---------------------|------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------|
| Moisture Content (%)   | 68.80                   | 10.20               | 10.00                                                                  | 6.00                                                 | 5.90                                                  |
| Ash Content (%)        | 2.01                    | 2.21                | 3.83                                                                   | 2.95                                                 | 3.89                                                  |
| Crude Protein (%)      | 5.01                    | 7.18                | 4.49                                                                   | 3.06                                                 | 3.94                                                  |
| Crude Lipid (%)        | 6.34                    | 3.61                | 0.85                                                                   | 2.80                                                 | 2.90                                                  |
| Crude Fiber (%)        | 9.67                    | 1.46                | N/A                                                                   | 2.26                                                 | 6.99                                                  |
| CHO (%)                | 76.97                   | 85.608              | 79.88                                                                  | 82.90                                                | 76.50                                                 |
| Caloric Value (Kcal)   | 403.342                 | 403.460             | N/A                                                                    | 369.00                                               | 347.90                                                |
to 7.401% (Table 1). Fresh samples of the unripe cooking banana had higher protein content. The result of the pair-wise comparisons for the percentage ash content in the fresh and dried samples of the cooking banana revealed that there is no statistically significant difference between the percentage ash content in fresh and dried samples of the unripe cooking banana. The percentage of crude fiber contents for fresh and dried cooking banana is 1.914 and 1.450% w.b respectively, while the percentage crude fiber content for the dried samples ranged from 1.450 to 1.46% w.b.

**Microorganisms in Fresh and Solar Dried Cooking Banana**

The microorganisms isolated from the unripe cooking banana are presented in Table 2. Thirty-eight bacterial isolates were recovered from the samples and were identified as *Staphylococcus sp*, *Bacillus subtilis*, and *Micrococcus sp*, while eleven molds (fungi) were isolated from the samples which were identified as *Aspergillus niger* and *Absidia sp*. The predominant bacteria isolated were the gram-negative rods while molds were the fungi isolated.

The frequency of occurrence of the bacterial and fungal isolates in the unripe cooking banana is shown in Table 3. For the bacterial isolates, *Bacillus subtilis* occurred most frequently (36.84%), while *Staphylococcus* and *Micrococcus* had a lower frequency of occurrence of 31.58%. This result agreed with the report on the study of microorganisms associated with ripe and unripe plantain (Baiyewu et al., 2007; Onimisi and Ovansa, 2015). For the fungal isolates, *Aspergillus niger* had the highest occurrence of 58.33%, while *Absidia* had the lowest frequency of occurrence of 41.67%. This agreed with other findings that the species of *Aspergillus* and *Rhizopus* occurred most frequently, though their frequency of occurrence was slightly different from that obtained in this work (Adebayo-Tayo et al., 2012; Onwuka et al., 2015). These pathogens have been reportedly isolated from fruits in Nigeria (Barnett and Hunter, 1987). *Aspergillus* were found to be the most common fungi responsible for post-harvest-loss of fruits in South-Western Nigeria (Adamson and Ganiyu, 2012; AOAC, 2010).

**Microbial Density of Fresh and Solar Dried Cooking Banana**

The result of the microbial analysis of fresh and solar dried cooking banana is presented in Table 4. The results revealed that the Total Heterotrophic Count (THB), Total Coliform Count (TCC), Fungal Count (FC), Count (SC) in the cooking banana is higher in the fresh samples compared to that obtained for the solar-dried samples (Etim et al., 2020). This result is in agreement with a study of

| Table 2. Microorganisms isolated from the dried Cooking Banana. |
|------------------|------------------|
| **Bacterial Isolates** | **Fungal Isolates** |
| Fresh Samples (Control) | Dried Products | Fresh Samples (Control) | Dried Products |
| *Staphylococcus aureus* | *Staphylococcus spp* | *Aspergillus terreus* | *Aspergillus Niger* |
| *Bacillus Subtilis* | *Bacillus Subtilis* | *Aspergillus Flavus* | *Absidia sp* |
| *Micrococcus sp* | *Micrococcus sp* | *Aspergillus niger* | *Absidia sp* |
| *Staphylococcus aureus* | *Staphylococcus spp* |

| Table 3. Frequency of occurrence of the bacterial and fungal isolates in the solar dried cooking banana. |
|------------------|------------------|
| **S/N** | **Number Isolated** | **Frequency of Occurrence (%)** |
| **Bacterial Isolates** | **Fungal Isolates** |
| *Staphylococcus spp* | 12 | 31.58 |
| *Bacillus subtilis* | 14 | 36.84 |
| *Micrococcus sp* | 12 | 31.58 |
| *Aspergillus niger* | 7 | 58.33 |
| *Absidia sp* | 5 | 41.67 |
microbial quality of intermediate moisture banana stored at 0°C and 37°C and showed that at 0°C the total plate count was 250 to 300 colonies/g, but at room temperature and 37°C, it was negligible and the product was microbiologically safe for direct consumption (Udensi et al., 2017). A study on standard plate count of fig toffee (which were treated with sodium benzoate) after six months of preservation reported lower microbial count (11103/g) compared to untreated toffee (23103/g) (Ogbuji et al., 2012).

## Conclusions and Recommendations

The proximate composition of the dried samples revealed less than 10% of ash, protein, lipid, and fiber in its crude state. There was a strong presence of carbohydrates and high caloric value as observed. Bacteria isolated from the dried products were: Staphylococcus spp, Bacillus subtilis, and Micrococcus sp. The fungal isolates observed were: Aspergillusniger and Absidia. The maturity and ripeness index of the product, as well as other products, should be determined before being subjected to drying, as this could affect the microbial and proximate composition of the product. The proximate and microbial composition should also be done for the product using other means of drying like an oven, infrared-ray system, and solar drying systems other than active-indirect mode dryer, to enable a more efficient comparison of result with similar products like banana and plantain.

## Acknowledgments

The authors thank all teaching and technical staff of the Department of Agricultural Engineering, Michael Okpara University of Agriculture, Umudike, Nigeria.

## Disclosure Statement

No potential conflict of interest was reported by the author(s).

## References

Abiodun, A.O., and R.O. Adeleke. 2010. Comparative studies on nutritional composition of four melon seeds varieties. Pakistan J. Nutr. 9(9):905–908. doi: 10.3923/pjn.2010.905.908.
Abulude, F.O., Y.S. Akin jagunla, T. Abe, B.E. Aw anlemhen, and O. Afolabi. 2007. Proximate composition, selected mineral, physical characteristics and in vitro multienzyme digestibility of cucumber (Cucumis sativus) fruit from Nigeria. Am. J. Food Tech. 2(3):196. doi: 10.3923/ajft.2007.196.201.
Adamson, S.S., and O. Ganiyu. 2012. Aqueous extracts from unripe plantain (Musa paradisiaca) products inhibit key enzymes linked with type 2 diabetes and hypertension in vitro. Jordan J. Bio. Sci. 5(4):239–246.
Adebayo-Tayo, B.C., N. Odu, C.U. Esen, and T.O. Okonko. 2012. Microorganisms associated with spoilage of stored vegetables in Uyo metropolis, Akwaibom State, Nigeria. Nat. Sci. 10(3):23–32.
Adeniji, T.A., A. Tenkouano, J.N. Ezurike, C.O. Ariyo, and I. Vroh-Bi. 2010. Value-adding post harvest processing of cooking bananas (Musa spp. ABB and ABB genome groups). Af. J. Biotech. 9(54):9135–9141.
Akinbode, A.O., I.O. Okonko, O.R. Akano, S.O. Agunbiade, and O. Onianwa. 2011. Isolation and identification of fungi associated with the spoilage of some selected fruits in Ibadan, South Western, Nigeria. Academia. Arena 3(11):1–10.
AOAC. 2010. Official methods of analysis of association of official analytical chemists. 18th ed. Washington, DC: AOAC International.
Ayodele, O.H., and V. Erema. 2010. Glycemic indices of processed unripe plantain (Musaparadisiaca) meals. Af. J. Food Sci. 4(8):514–521.

Baiyewu, R.A., N.A. Amusa, O.A. Ayoola, and O.O. Babalola. 2007. Survey of the post harvest diseases and aflatoxin contamination of marketed pawpaw fruit (Carica papaya L.) in South Western Nigeria. Af. J. Biotech. 6:178–181.

Barnett, H.L., and B.B. Hunter. 1987. Illustrated Genera of imperfect fungi. 3rd ed. New York and London: Macmillan Publishing Company.

Cheesbrough, M. 2006. District Laboratory practice in tropical countries. 2nd ed. Cambridge University Press, Cambridge, UK.

Collins, H.C., and P.M. Lyne. 2008. Microbial methods. 8th. p. 488. London, UK.: Published by Butterworths.

Etim, P.J., A.B. Eke, and K.J. Simonyan 2020. Design and development of an active indirect solar dryer for cooking banana. Sci. Af. doi: 10.1016/j.sciaf.2020.e00463.

Harrigan, W.F., and M.E. McCance. 1990. Laboratory methods in food and dairy microbiology. 8th ed. Academic Press, London.

Khandekar, S.V., U.D. Chavan, and J.K. Chavan. 2005. Preservation of pulp and preparation of toffee from fig fruit. Beverage Food World. 32:55–56.

Ogbuji, C., T. Odom, B. Nwankwo, I. Okeke, and O. Ojiako. 2012. Comparative studies of the glycemic indices of ripe and unripe plantain with different methods of preparation. J. Resour. Pharmacol. 1(1):015–019.

Onimisi, A.O., and J.U. Ovansa. 2015 Comparative studies on nutritional values of four varieties of cucumber. International Conference on Latest Trends in Food Biological and Ecological Sciences (ICLTFBE’15), UAE, Dubai, 11–12 Oct

Onuorah, S., O. Nriagu, and I. Obika. 2016. Isolation, characterization and identification of microorganisms from spoot carrots obtained from Ose Market Onitsha, Nigeria. Universal. J. Biomedical. Eng. 4(1):6–9. doi: 10.13189/ujbe.2016.040102.

Onwuka, G.I., A.D. Onyemachi, and N.P. David-Chukwu. 2015. Comparative evaluation of proximate composition and functional properties of two varieties of cooking banana. J. Env. Sci. Toxic. Food Tech. 9(1):01–04.

Ramarjuna, M.N., and K.S. Jayaraman. 1980. Studies on the preparation and storage stability of intermediate banana. J. Food Sci. Tech. 17:183.

Udensi, N.K., C.A. Onyenwoke, O.O. Onu, M.F. Umunna, and C. Austine. 2017. Design and development of a passive solar dryer primed with solar cell. Proceedings of 18th International Conference and 38th annual general meeting of the Nigeria Institution of Agricultural Engineering (NIAE), Umudike, 1st–4th Aug