



Survey and Chemo-physiological Assessment of Biochemical Preservatives and Physicochemical Properties of plants used for preservation of fruits

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ABSTRACT

The rate at which agricultural produce such as fruits are being infected by pests or spoilt as a results of lack of appropriate natural preservatives posed threat to food security and safety in many communities of Ogun State. However, there is need for study that can evaluate natural preservatives and physicochemical properties of some plants. In the present study, survey of indigenous plants commonly used for preservation of fruits was conducted using one hundred structured questionnaires randomly administered on fruit-sellers to elicit information on spoilage as threat affecting sales of fruits in Abeokuta. Also, biochemical constituents and physicochemical properties in the leaves of most plants used for fruits preservation were determined using standard procedure. Data were analysed using Statistical Analysis System. Means were separated using Duncan's Multiple Range Test at 5% level of significance ($p < 0.05$). *Nauclea latifolia*, *Chromolaena odorata*, *Psidium guajava*, *Azadirachta indica*, *Moringa oleifera* and *Aloe vera* were the plants commonly used for preservation of fruits in the study area. Fruit spoilage (84.0%) was the major threat affecting the sales of fruits in Abeokuta. Saponin (0.68 ± 0.03 mg/100g) and terpenoid (0.22 ± 0.08 mg/100g) were significantly higher ($p < 0.05$) in *A. indica* leaves as well as alkaloid (16.49 ± 0.01 mg/100 g) in *M. oleifera* leaves. Also, phenol (0.41 ± 0.02 mg/100g) and flavonoid (0.71 ± 0.09 mg/100g) were significantly higher ($p < 0.05$) in *C. odorata* and *A. vera* leaves. Phytate (0.35 ± 0.01 mg/100 g) and oxalate (0.32 ± 0.03 mg/100 g) were significantly higher ($p < 0.05$) in the leaves of *C. odorata*. Furthermore, specific gravity of *M. oleifera* leaves (0.98 ± 0.05) was significantly higher ($p < 0.05$) compared with leaves of other plants. Iodine value (81.65 ± 0.03 mg/100 g) and acid value (22.72 ± 0.07) were significantly ($p < 0.05$) higher in *Aloe vera* leaves. The study revealed that spoilage was the major challenge facing the sales of fruits in Abeokuta. Also, leaves of the plants contained high proportions of natural preservatives and physicochemical properties. Spoilage was the major challenge facing the sales of fruits, however, leaves of the plants contained high amount of preservative and physicochemical parameters that could be adopted for preservation of fruits.

Keywords: Chemo-physiological assessment; preservation; physicochemical properties; plant materials; fruits sellers; fruit spoilage; Anti-nutrients

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Introduction

The use of organic products for preservation of farm produce to improve their shelf-life is now being clamored for by crop producers, consumers and pharmaceutical industries (Jay, 2003; Olanipekun and Agbadaola 2013; Irokanulo *et al.*, 2015). This is due to adverse effect of synthetic preservatives commonly used on agricultural products; yet, agricultural products such as fruits need to be protected against biodegrading agents such as pest, fungi, bacteria and nematodes among others. Most fruits and other farm products are easily infected by pest and rodents in-situ when not quickly sold or preserved properly after production. Also, some fruits easily damage and spoil even at points of sales due to longer time the fruits stayed in the markets before selling them. This eventually results to massive destruction of foods such as fruits, thereby making them unfit for human consumption and poor marketing values. Preservatives according to Olanipekun and Agbadaola (2013) are chemical or natural ingredients usually used to protect plants and plant products against decay or prevent spoilage. The use of plants base preservatives over synthetic preserves is receiving more attention nowadays due to safety and health implications of agricultural products preserved using synthetic chemicals. However, plants are used as preservatives because they are natural, cheaper, holistic in nature, accessible and do not need skilled personnel before their administration (Rees and Banks, 2001).

In many communities, wastage and deterioration of agricultural products such as fruits through spoilage and decay are some of the problems facing sales of fruits in major local and city markets. The scenario, if not controlled may eventually increase food insecurity and decrease food safety in the communities. This is because many of these fruits are harvested at the same time without proper preservative measures in place. Also, lack of storage facilities and inadequate materials needed for preservation of the fruits among others make

the situation alarming and eventually lead to artificial fruit scarcity, fruit insecurity and safety in many households most especially outside the season of the fruits. In cases when some of these fruits are preserved, they are done using synthetics or chemicals which are detrimental to health status and environment of consumers (Mkindi *et al.*, 2015; Youmsi 2017; Sergio *et al.*, 2017).

Furthermore, in recent times, fruits are preserved using synthetic chemicals to enhance ripening and meet the increasing fruits demand of consumers most especially outside the harvest season of the fruits.

However, the use of synthetic chemicals for fruit preservation is now being massively discouraged with little or no alternatives for the purpose. Based on this, the present study was conducted out to evaluate natural preservative and physicochemical properties of some plants used for preservation fruits.

Materials and Methods

Description of the study area

The study was conducted in Abeokuta, Ogun State, Nigeria. The town is surrounded by rocks and hence it's called Rock City. The town is predominantly occupied by the Egbas and other yoruba ethnic group (Kadiri *et al.*, 2015). There are two main local Government areas in Abeokuta; Abeokuta North and Abeokuta South.

The town lies in the tropical rain forest zone of South Western Nigeria but the vegetation is now derived savannah due to human factor. In addition, the town falls within the longitude 3°21' East and latitude 7°11'' North.

Validity and reliability of instrument

Validity and reliability of the instrument used for this study were carried out using test-retest method described by Ojewumi *et al.* (2016). Using split half method, Cronbach alpha values; 0.79 (97 %) was generated.

Sample Size and administration of questionnaire

Twenty (20) questionnaire each were administered on farmers and fruit sellers in Osiele, Lafenwa, Oja-Agbe, Olodo and Adatan, Abeokuta making a total of 100 questionnaires. The questionnaire sought to source information on plants used for preservation of fruits.

Sample collection

Fresh leaves of the most prioritized plants during survey aspect of this study were collected from nearby farms in Abeokuta and used for further analysis.

Determination of phytochemicals in *Nauclea latifolia*, *Chromolaena odorata*, *Psidium guajava*, *Azadirachta indica*, *Moringa oleifera* and *Aloe vera* leaves

Phytochemical contents in leaves of the plants were determined according to the methods of Harborne, (1973) described in Awoyinka *et al.* (2016).

Alkaloids: Alkaloids were determined using distillation and titrimetric method (Harborne, 1973). Three grams (3 g) of finely ground leaves of each plant was weighed into a 100 ml beaker and 20 ml of 80 % absolute alcohol was added to give a smooth paste of the samples. The mixture was transferred to a 250 ml flask and more alcohol was added to make up to 100 ml after which 1 g magnesium oxide was added. The mixture was digested in a boiling water bath for 1.5 hrs under a reflux air condenser and shook occasionally. The mixture was filtered. The residue was returned to the flask and re-digested for 30 minutes after which 3 drops of 10 % HCl was added. The whole solution was later transferred into a 250 ml volumetric flask. Thereafter, 5 ml of zinc acetate solution and 5 ml of potassium ferrocyanide solution were added and mixed thoroughly to give a homogenous solution. The flask was allowed to stand for 30 minutes after which 10 ml of the filtrate was transferred into a separatory funnel. The alkaloids present were extracted by shaking with five successive portions

of chloroform. The residue obtained was dissolved in 10 ml hot distilled water and transferred into a kjeldahl tube. Also, 0.20 g sucrose and 10 ml concentrated H₂SO₄ and 0.02 g selenium were added and digested to a colourless solution and % N was determined using Kjeldahl distillation method. Nitrogen (%) determined was converted to % total alkaloid by multiplying by a factor of 3.26 i. e % total alkaloid = % N X 3.26

$$\% \text{ alkaloids} = \% \text{ N} \times 3.26$$

Flavonoids: One (1g) gram of finely ground sample was weighed into a 100 ml beaker and 80 ml of 95 % ethanol was added and stirred with a glass rod to prevent lumping, filtered into a 100 ml volumetric flask and made up to mark with ethanol. Also, 1 ml of the extract was pipetted into a 50 ml volumetric flask, four drops of concentrated hydrochloric acid was added after which 0.5 g of magnesium turnings was added to develop a magenta red colouration. Standard flavonoid solution of range 0-5 ppm was prepared from 100 ppm stock solution and treated in the same way with HCl and magnesium turnings sample. The absorbance of magenta red colouration of sample and standard solutions were read on a digital Jenway V6300 Spectrophotometer at a wavelength of 520 nm. The percentage flavonoid was calculated using the mathematical relationship.

$$\text{Flavonoids} = \frac{\text{Absorbance of sample} \times \text{average gradient factor} \times \text{dilution factor}}{\text{Weight of sample} \times 10000}$$

Saponins: One (1g) of finely ground sample was weighed into a 250 ml beaker and 100 ml of isobutyl alcohol was added. The mixture was shaken on a UDY shaker for 5 hours to ensure uniform mixing. Thereafter, the mixture was filtered through a Whatman No.1 filter paper into a 100 ml beaker and 20 ml of 40 % saturated solution of magnesium carbonate was added. The mixture obtained with saturated magnesium carbonate was again filtered to obtain a clear colourless solution. One (1ml) of the colourless solution was pipetted into a 50 ml volumetric flask and 2 ml of 5 % Iron

(III) chloride solution was added and made up to mark with distilled water. It was allowed to stand for 30min for blood red colour to develop. Also, 0-10 ppm standard saponin solutions were prepared from saponin stock solution. The standard solutions were treated similarly with 2 ml of 5 % Iron (III) chloride solution as done for 1ml sample above after which absorbance of the sample and standard saponin solutions were read after colour development in a Jenway V6300 Spectrophotometer (380 nm).

$$\% \text{ Saponin} = \frac{\text{Absorbance of sample} \times \text{gradient factor} \times \text{dilution factor}}{\text{Weight of sample} \times 10000}$$

Phenol: One gram (1 g) of sample was weighed into a 50 ml beaker, 20 ml of acetone was added and homogenized properly for 1hr to prevent lumping. The mixture was filtered into a 100 ml Volumetric flask using acetone to rinse and made up to mark with distilled water. One (1ml) of sample extract was pipetted into 50 ml volumetric flask, 20 ml water added. Also, 3 ml of phosphomolybdic acid added followed by the addition of 5 ml of 23 % Sodium carbonate and mixed thoroughly, made up to mark with distilled water and allowed to stand for 10 min to develop bluish-green colour. Standard phenol of concentration which ranged 0-10 mg/ml were prepared from 100 mg/L stock phenol solution from Sigma-Aldrich chemicals, U.S.A. The absorbance of sample and standard concentrations of Phenol were read on a Digital Spectrophotometer at a wavelength of 510 nm. The percentage Phenol is calculated using the formula:

$$\% \text{ Phenol} = \frac{\text{Absorbance of sample} \times \text{gradient factor} \times \text{dilution factor}}{\text{Weight of sample} \times 10,000}$$

Terpenoids: Five grams (5 g) of leaf powder of each plant was taken and soaked in alcohol for 24 hours. The solution was filtered and filtrate extracted with petroleum ether; this ether extract was treated as total terpenoids according to Ferguson, (1956) cited in Theng and Korpenwar (2013)

Determination of carotenoids

Carotenoid extraction: Carotenoids were extracted according to the methods of Rodriguez-Amaya, (2001); Rodriguez-Amaya and Kimura (2004) cited in Darwin *et al.* (2011). Five grams (5 g) of fresh leaf tissues of the plants were homogenized for 1 minute using 10 ml acetone: petroleum ether (1:1) using a polytron homogenizer (IKA T18, Staufen, Germany), followed by centrifugation (Eppendorf 5804R, Hamburg, Germany), at 3000 rpm, for 10 min, at 4 °C. The liquid phase was collected and the residue was extracted, followed by centrifugation. This was repeated until it turned colourless. The extracts were then combined with 10 ml of 0.1 M NaCl solution and petroleum ether phase containing the carotenoids separated from the lower aqueous-acetone phase.

Carotenoid quantification: Total carotenoid content (TCC) was determined using visible absorption spectrophotometry (Cecil CE2021, Cambridge, UK), at an absorbance of 450 nm and using the absorption coefficient of beta-carotene in petroleum ether (2592) (Rodriguez-Amaya, 2001; Rodriguez-Amaya *et al.*, 2004). All-trans-carotene quantification was done by high performance liquid chromatography. From the petroleum ether solution used for spectrophotometric quantification of total carotenoid, aliquots (15 ml) were taken, partially dried by total-evaporation (Laborota 4000, Schwabach, Germany) and completely dried with nitrogen. Immediately before injection, the dry extract was dissolved in 1 ml of Methanol:Methy tert-butyl Ether (1:1) HPLC-grade and filtered through a 0.22 µm PTFE syringe filter.

Separation and quantification of carotenoid were achieved using an YMC Carotenoid S-5 C30 reversed-phase column (4.6 × 150 mm: Particle size, 5 µm), with a YMC Carotenoid S-5 guard column (4.0 × 23 mm) in a HPLC system (Agilent Technologies 1200 series, Waldbronn, Germany), with a cooling auto-sampler unit at 4°C to avoid evaporation of the injection solvent and degradation of carotenoids by heat and DAD detector with

wavelength set at 450 nm. Peaks were identified by comparing retention time and spectral characteristics against a pure standard and available literature.

Quantity was determined by integration of peak area against a standard curve prepared with known concentrations of all-trans-carotene. TCC and TBC were estimated on a fresh (TCC-FW and TBC-FW) and dry weight (TCC-DW and TBC-DW) basis. Before making any determination, the method was previously validated according the requirements of Thompson *et al.* (2002) and Eurachem (2002). The method used has linearity (correlation coefficient) of 0.99925 at 2, 6, 10, 14, 18, 25, 30 ppm levels, and three replicates. The relative standard deviation in repeatability conditions was 2.1 % and CIAT participated in an inter-laboratory study involving several laboratories worldwide (Ciat, 2007; Darwin *et al.*, 2011).

Determination of anti-nutrients in *N. latifolia*, *C. odorata*, *P. guajava*, *A. indica*, *M.oleifera* and *A. vera* leaves

Phytic acid: Phytic acid was determined according to method of Sofowora, (1993). Two grams (2g) of each sample was weighed into a 250 ml conical flask. 100 ml of 2 % hydrochloric acid was added to soak each sample in the conical flask for 3 hours and filtered through a double layer of hardened filter paper. Then, 50 rnl of each filtrate was placed in a 0.50 ml conical flask and 107 ml distilled water was added in each case to give proper acidity. Thereafter, 10 ml of 0.3 % ammonium thiocyanate (NH₄SCN) solution was added into each solution. This was titrated with standard iron (III) chloride solution which contained 0.00 195 g Iron per ml. The end point was slightly brownish-yellow which persisted for 5 minutes. The % phytic acid was calculated using mathematical relationship below:

$$\% \text{ Phytic acid} = \frac{\text{Titre value} \times 0.00195 \times 1.19 \times 100 \times 3.55}{\text{Weight of sample}}$$

Tannin: One gram (1 g) of sample was measured into a 50 ml beaker and 20 ml of 50 % methanol was added, covered with paraffin and placed in a water bath at 77-80 °C for 1 hour and shaken to ensure a uniform mixing. The extract was quantitatively filtered using a double layered Whatman No. 41 filter paper into a 100 ml volumetric flask, 20 ml water added, after which 2.5 m; folin Denis reagent and 10 ml of 1 % sodium carbonate were added and mixed properly. The mixture was made up to mark with water mixed well and allowed to stand for 20 min. Bluish-green colour was developed at the end of range 0-10 ppm and treated similarly as 1 ml sample above. The absorbance of the tannic acid standard solutions as well as samples was read after colour development on a spectronic 21D spectrophotometer at a wavelength of 760 nm. % tannin was calculated using the formula.

$$\% \text{ Tannin} = \frac{\text{Absorbance of sample} \times \text{average gradient factor} \times \text{dilution factor}}{\text{Weight of sample} \times 10,000}$$

Trypsin inhibitor: One gram (1 g) of each sample was dispersed in 50 ml of 0.5 M Sodium Chloride solution. The mixture was stirred for 30 minutes at room temperature and centrifuged at 1500 rpm for 5 min. The supernatant was filtered and the filtrate was used for the assay. Two millilitres of the standard trypsin solution were added to 10 ml of the substrate of each sample. The absorbance of the mixture was taken at 410 nm using 10 ml of the same substrate as blank

Oxalates: Two grams (2 g) of the sample was boiled in 40 ml of water for 30 minutes in a reflux condenser and 10 ml of 20 % sodium carbonate was added and boiled for another 30 minutes. The mixture was filtered and liquid extract washed with hot water until the wash water does not show any alkaline reaction. The combined wash water was filtered to a small volume and cooled. With constant stirring, hydrochloric acid (HCL) (1:1) was added drop-wise until the final acid concentration after neutralization was about 4 % at which stage a heavy precipitate appeared and the

extract was filtered into a 250 ml flask to make up to mark and kept overnight. Aliquot of this filtrate was taken in a 400 ml beaker, diluted with water to 200 ml and made just ammoniacal, and reacidified with lactic acid. In the cold medium, 10 ml of a 10 % calcium chloride solution was added, stirred to include calcium oxalate precipitate to appear and allowed to settle overnight. Clean supernatant liquid was decanted off through Whatman No. 42 filter paper, without disturbing the precipitate. The precipitate was dissolved in HCL (1:1). Oxalic acid was re-precipitated by adjusting the pH with ammonium hydroxide solution. The contents were boiled, allowed to settle overnight and oxalic acid was determined by titrating against 0.05 N Potassium permanganate solution.

Calculation

1ml of 0.05 N KMnO_4 = 0.00225 anhydrous oxalic acid

= % Oxalic Acid

$$\frac{\text{Titre value} \times 0.00225}{2} \times \frac{100}{1}$$

= T. V x 0.1125.

Cyanogenic glycoside: Five grams (5 g) of each sample were weighed into a 250 cm³ round bottom flask, 200 cm³ of distilled water was added and allowed to stand for 2 hours for autolysis to occur. An-anti foaming agent (tannic acid) was added and full distillation carried out in a 250 cm³ conical flask containing 20 cm³ of 2.5 % NaOH (Sodium hydroxide). To 100 cm³ of each distillate containing cyanogenic glycoside, 8cm³ of 6 M NH_4OH (ammonium hydroxide) and 2 cm³ of 5 % (Potassium Iodide was added, mixed and titrated with 0.02 M AgNO_3 (silver nitrate) using a micro-burette against a black background. Permanent turbidity indicated the end point.

Cyanogenic glycoside content of the sample was calculated as:

Cyanogenic glycoside

$$= \frac{\text{Titre value (cm}^3\text{)} \times 1.08 \times \text{extract volume}}{\text{Aliquot volume (cm}^3\text{)} \times \text{sample weight (g)}} \times 100$$

Oil extraction from *N. latifolia*, *C. odorata*, *P. guajava*, *A. indica*, *M. oleifera* and *A. vera* leaves

Oils were extracted from leaves of the six plants according to the method of AOAC. (1998) described in Afolayan and Idowu. (2014). Two hundred grams (200g) of leaves of each of the six plants were pulverized, packed in muslin cloth and inserted into the soxhlet extractor using hexane as extraction solvent. The solvent was recovered using rotary evaporator and residual oil was oven dried at 75°C for one hour and stored for physicochemical analysis.

Determination of physicochemical properties in *N. latifolia*, *C. odorata*, *P. guajava*, *A. indica*, *M. oleifera* and *A. vera* leaves

Specific gravity of the extracted oil: Ten (10 cm³) of oil of each plant was measured in a pre-weighed measuring cylinder. The weight of the cylinder and oil was measured; after which weight of the oil was obtained by deducting weight of the cylinder from the weight of the oil and cylinder. The specific gravity of oil was obtained using the following relationships:

$$\text{Density of water} = \frac{W_1 - W_0}{V_0}$$

Where;

W_1 = weight of empty measuring cylinder + water

W_0 = weight of measuring cylinder

V_0 = volume of water used

$$\text{Density of oil} = \frac{W_1 - W_0}{V_0}$$

where:

W_1 = weight of empty measuring cylinder + oil

W_0 = weight of measuring cylinder

V_0 = volume of oil used

$$\text{Therefore, specific gravity} = \frac{\text{Density of water used}}{\text{Density of oil used}}$$

Saponification value of the extracted oil: Two grams (2 g) of oil from *N. latifolia*, *C. odorata*, *P. guajava*, *A. indica*, *M.oleifera* and *A. vera* leaves were added to a flask with 30 ml ethanolic KOH and attached to a condenser for 30 minutes such that the sample was fully dissolved. After the sample had cooled, 1 ml of phenolphthalein was added and

titrated with 0.1 HCl until a pink endpoint was reached. Saponification of the oil was determined using the mathematical relationship.

$$\text{Saponification value} = \frac{(S-B)XM}{\text{Sample weight(g)}} \times 56.1$$

where:

S = Sample titre value

B = Blank titre value

M = Molarity of the HCl

56.1 = Molecular weight of KOH

Peroxide value of the extracted oil: Two (2 g) of oil extracted were added to 22 cm³ of a solution mixture of 12 cm³ chloroform and 10 cm³ acetic acid. Thereafter, 0.5 cm³ of saturated potassium iodide was added to the flask. The flask was corked and allowed to stand, with occasional shaking for 1 minute. Thirty millilitres of distilled water were then added to the mixture and titrated against 0.1 M of Na₂S₂O₃ until yellow colour disappeared. Also, 0.5 cm³ of starch indicator was quickly added and titration continued until blue colour just disappeared. A blank titration was also carried out at the same condition.

$$\text{Peroxide value} = \frac{(S-B)XN}{W} \times 1000, \text{ where:}$$

Peroxide value = Meq peroxide per 100 g of sample

S = Volume of titrant (cm³) for sample

B = Volume of titrant (cm³) for blank

N = Molarity of Na₂S₂O₃ solution (mEq/cm³)

1000 = Conversion of units (g/kg)

W = Weight of oil sample

Iodine value of the extracted oil: One gram (1g) of the oil sample was weighed into a conical flask and 20 cm³ of carbon tetrachloride were added to dissolve the oil. Then, 25 cm³ of wj's reagents were added to the flask using a safety pipette in fume chamber. Stopper was inserted and the content of the flask was vigorously swirled. The flask was placed in the dark for 2 hours 30 minutes. At the end of this period, 20 cm³ of 10 % aqueous potassium iodide and 125 ml of water were added using a measuring cylinder. The content was titrated with 0.1 M sodium-thiosulphate solutions

until the yellow colour almost disappears. Few drops of 1 % starch indicator was added and the titration continues by adding thiosulphate drop wise until blue colouration disappears after vigorous shaking. The same procedure was used for blank test and other samples.

The iodine value (I.V) was given by the expression

$$\text{Iodine value} = \frac{12.69C(V_1-V_2)}{M}, \text{ where:}$$

C = Concentration of sodium

V₁ = Volume of sodium thiosulphate used for blank

V₂ = Volume of sodium thiosulphate used for determination

M = Weight of the sample.

12.69-Molecular weight of sodium-thiosulphate

Free fatty acid of the extracted oil: Two (2 g) of oil of each plant was measured separately into a 250 cm³ Erlenmeyer flask, then 100 cm³ of ethanol was added followed by addition 2 cm³ of phenolphthalein indicator. The mixture was titrated against 0.1 M NaOH with continuous shaking until the endpoint was reached and indicated a slight pink colour that persisted for 30 seconds, the free fatty acid content was expressed as

$$\% \text{FFA} = \frac{V \times N \times 282 \times 100}{W}$$

where:

% FFA = Percent free fatty acid (g/100g)

V = Volume of NaOH (cm³)

N = Molarity of NaOH

282 = Molecular weight of oleic acid

W = Weight of oil sample

Acid value of the extracted oil: Twenty-five (25cm³) of 5 % ethanol was boiled in a water bath. The heating was to ensure the removal of dissolved gases. Two gram (2.0 g) of each plant was added separately to about 25 cm³ of hot ethanol and the mixture was heated to boil. Then few drops of 1 % phenolphthalein indicator were added and titrated against 0.1 M KOH with constant shaking until a permanent pink colour was obtained. The acid value was expressed as;

$$\text{Acid value} = \frac{56.1 \times M \times V}{W} \times 56.1 \times M \times V$$

where:

M = Concentration of KOH

V = Titre value

56.1 = Molecular weight of KOH

W = Weight of oil sample

Statistical analysis

Data obtained were analysed using statistical analysis system (SAS, 2000). One-way analysis of variance (ANOVA) was conducted to determine significant difference between parameters. Means were separated using Duncan's Multiple Range Test at $p < 0.05$.

Results

Results of this study revealed that most (72.0 %) of the respondents (fruit sellers) surveyed were predominately females, mainly between 40-49 years (55.0 %) and married (92.0 %) with 5 and above family members. They were educated and practiced predominantly Islam (Table 1). Largest percentage (48.0%) of them sold fruits in dozens (70.0%) and that the products stayed for approximately a week before they could be completely sold (82.0 %). Fruit spoilage (84.0 %) among others was the main challenge affecting regular (73.0 %) sales of the fruits. Virtually all the fruit sellers (100.0%) claimed to preserve fruits using leaves (80 %) for as long as two weeks and some days (55.0 %). More than half (56.0 %) of the fruits sellers reported that the plant materials they used for preservation of the fruits had no observable physical side effect on the fruits (Table 2). The preservative properties of plants used for preserving the fruits showed significant difference ($p < 0.05$) across leaves of the plants investigated. Highest saponin (0.68 ± 0.03 mg/100 g) and terpenoid (0.22 ± 0.08 mg/100 g) were significantly higher ($p < 0.05$) recorded in *A. indica* leaves while least of saponin (0.02 ± 0.04 mg/100 g) and terpenoid (0.16 ± 0.02 mg/100 g) were recorded in the leaves of *M. oleifera* and *Aloe vera* respectively. Also, highest alkaloid (16.49 ± 0.01 mg/100g) and carotenoid (15.65 ± 0.03 mg/100 g) were recorded in *M. oleifera*. Least alkaloid (1.09 ± 0.01 mg/100 g)

was recorded in *A. indica* while carotenoid (0.14 ± 0.05 mg/100 g) was observed in *P. guajava*. Also, phenol (0.41 ± 0.02 mg/100 g) and flavonoid (0.71 ± 0.09 mg/100 g) were significantly $p < 0.05$ higher in *C. odorata* and *Aloe vera* leaves respectively (Table 3).

Furthermore, anti-nutrient contents in the leaves of the six plants investigated showed significant difference ($p < 0.05$). Results showed that phytate (0.35 ± 0.01 mg/100 g) and oxalate (0.32 ± 0.03 mg/100 g) were significantly higher ($p < 0.05$) in the leaves of *C. odorata*, *A. indica*. Similar observation was noticed in the tannin (0.35 ± 0.06 mg/100 g) recorded in *N. latifolia* leaves. Least trypsin inhibitor (0.11 ± 0.01 mg/100 g), cyanogenic glycoside (0.03 ± 0.00 mg/100 g) and tannin (0.14 ± 0.02 mg/100 g) were recorded in *C. odorata*, *N. latifolia* and *M. oleifera* leaves (Table 4).

Low amount of anti-nutrient recorded may suggest that leaves of the plants contain moderate quantities of anti-nutrients which may not have negative impacts the fruits being preserved as well as their consumers.

Physicochemical analysis of leaves of the plants revealed that the specific gravity of *M. oleifera* (0.98 ± 0.05) was significantly higher ($p < 0.05$) compared with specific gravity of leaves of other plants under investigation. Also, saponification (188.30 ± 0.12 mg/KOH g), iodine value (81.65 ± 0.03 mg/100 g) and acid value (22.72 ± 0.07) were significantly ($p < 0.05$) higher in *A. vera* leaves compared with other plants investigated. Furthermore, peroxide value (73.70 ± 0.52 mg/kg) was significantly $p < 0.05$ higher in the leaves of *N. latifolia* as well as volatile matter (4.94 ± 0.01) in the leaves of *C. odorata*. Least saponification value (174.88 ± 0.05 mg/KOH g) was recorded in *A. indica* leaves, peroxide value (59.53 ± 0.34 mg/kg) in *C. odorata* leaves, iodine value (57.41 ± 0.29 mg/100 g) in *P. guajava* leaves, acid value (3.71 ± 0.02) in *M. oleifera* leaves while least volatile matter (3.15 ± 0.01) was recorded in *A. vera* leaves (Table 5).

Table 1: Socio economic characteristics of fruit sellers on Abeokuta

Variables	Frequency	Frequency (%)	Mode
Gender			
Male	28	20.0	
Female	72	72.0	72.0
Age classes			
20-29years	10	10.0	
30-39years	22	22.0	
40-49years	55	55.0	55.0
50-59years	13	13.0	
Marital status			
Married	92	92.0	92.0
Single	8	8.0	
Family size			
1-4Members	46	46.0	
5 members and above	54	54.0	54.0
Educational status			
Primary school	16	16.0	
Secondary school	40	40.0	
Tertiary institution	44	44.0	44.0
Religion			
Islam	57	57.0	57.0
Christianity	43	43.0	

Table 2: Sales and indigenous method of fruits preservation among fruits sellers in Abeokuta

Variables	Frequency	Frequency (%)	Mode
Economic chain of fruit trading you operate			
Farmers/producers	42	42.0	
Sellers	48	48.0	48.0
Middle men	10	10.0	
Quantity of fruits you produce or sell			
Dozen	70	70.0	70.0
Full bag/basket	8	8.0	
Cartoons	22	22.0	
Duration of fruits stay in farm after harvest or shop after purchasing them			
Within a week	82	82.0	82.0
More than 3 weeks	18	18.0	
Major challenge of sales of fruits			
Spoilage	84	84.0	84.0
Low sales	8	8.0	
Loss of weight	8	8.0	
Frequency of experiencing fruit spoilage			
Daily	18	18.0	
Regularly	73	73.0	73.0
Occasionally	9	9.0	
Do you preserve fruit with plant materials			
Yes	100	100.0	100.0
Duration of fruits preservation with herbal materials before spoilage			
a week	24	24.0	
Two weeks	21	21.0	
More than two weeks	63	63.0	53.0
Plant parts used for fruit preservation			
Leaves	80	80.0	80.0
Seeds	12	12.0	
Bulbs	6	6.0	
Barks	2	2.0	
Effect of preservation using herbs on the fruits			
Colour of the fruit changes	4	4.0	
Odour of the fruit changes	2	2.0	
taste of the fruits changes	12	12.0	
No observable physical effect	56	56.0	56.0
Maintain the quality and shelf life of the fruits	26	26.0	

Table 3: Preservative properties in the leaves of plants used for preserving fruits in Abeokuta

Plant Leaves	Preservative properties (mg/100 g)					
	Phenol	Saponins	Alkaloid	Flavonoid	Terpenoid	Carotenoid
<i>Nauclea latifolia</i>	0.32±0.01 ^c	0.27±0.02 ^d	6.11±0.02 ^c	0.59±0.01 ^c	0.21±0.08 ^b	0.15±0.02 ^c
<i>Chromolaena odorata</i>	0.41±0.02 ^a	0.58±0.05 ^b	5.11±0.05 ^c	0.68±0.02 ^b	0.21±0.05 ^b	0.17±0.02 ^c
<i>Psidium guajava</i>	0.35±0.08 ^b	0.46±0.01 ^c	5.23±0.06 ^d	0.59±0.04 ^c	0.21±0.02 ^c	0.14±0.05 ^c
<i>Azadirachta indica</i>	0.29±0.02 ^d	0.68±0.03 ^a	1.09±0.01 ^f	0.57±0.05 ^d	0.22±0.08 ^a	0.32±0.02 ^c
<i>Moringa oleifera</i>	0.32±0.08 ^c	0.02±0.04 ^f	16.49±0.01 ^a	0.57±0.08 ^d	0.18±0.03 ^d	15.65±0.03 ^a
<i>Aloe vera</i>	0.14±0.05 ^e	0.12±0.01 ^e	10.47±0.04 ^b	0.71±0.09 ^a	0.16±0.02 ^e	10.69±0.02 ^b
p values (p < 0.05)	0.03	0.01	0.04	0.02	0.00	0.00

Means ± standard error with different superscripts in columns are significantly different using Duncan Multiple Range Test P<0.05

Table 4: Anti-nutrient Contents in the leaves of Plants used for Preserving Fruits in Abeokuta

Plant leaves	Anti-nutrient contents (mg/100 g)				
	Phytate	Oxalate	Trypsin inhibitor	Cyanogenic glycoside	Tannin
<i>Nauclea latifolia</i>	0.26±0.02 ^c	0.24±0.06 ^d	0.17±0.06 ^a	0.03±0.00 ^e	0.35±0.06 ^a
<i>Chromolaena odorata</i>	0.35±0.01 ^a	0.32±0.03 ^a	0.11±0.01 ^e	0.05±0.01 ^c	0.32±0.07 ^c
<i>Psidium guajava</i>	0.27±0.01 ^d	0.23±0.04 ^f	0.12±0.03 ^d	0.04±0.00 ^e	0.33±0.01 ^b
<i>Azadirachta indica</i>	0.32±0.03 ^b	0.29±0.01 ^b	0.13±0.00 ^e	0.12±0.01 ^a	0.31±0.02 ^d
<i>Moringa oleifera</i>	0.25±0.01 ^f	0.23±0.02 ^e	0.17±0.01 ^a	0.10±0.00 ^b	0.14±0.02 ^f
<i>Aloe vera</i>	0.31±0.02 ^c	0.25±0.06 ^c	0.16±0.00 ^b	0.04±0.00 ^d	0.15±0.02 ^e
p values (P<0.05)	0.01	0.00	0.04	0.03	0.03

Means ± standard error with different superscripts in columns are significantly different using Duncan Multiple Range Test P<0.05

Table 5: Physicochemical Properties of Plants used for Preserving Fruits in Abeokuta

Plant Leaves	Physicochemical properties					
	Specific gravity	Saponification value Mg/KOHg	Peroxide value Meg/kg	Iodine value (mg/100 g)	Acid value	Volatile matter
<i>Nauclea latifolia</i>	0.88±0.02 ^d	177.84±0.02 ^c	73.70±0.52 ^a	66.78±0.02 ^d	11.82±0.01 ^c	3.69±0.03 ^c
<i>Chromolaena odorata</i>	0.89±0.05 ^c	181.67±0.42 ^b	59.53±0.34 ^d	76.98±0.07 ^b	14.31±0.02 ^c	4.94±0.01 ^a
<i>Psidium guajava</i>	0.78±0.01 ^f	168.65±0.03 ^c	48.27±0.19 ^c	57.41±0.29 ^f	21.00±0.23 ^b	3.63±0.03 ^c
<i>Azadirachta indica</i>	0.88±0.03 ^c	174.88±0.05 ^d	62.89±0.14 ^c	75.52±0.25 ^c	12.33±0.29 ^d	3.88±0.03 ^b
<i>Moringa oleifera</i>	0.98±0.05 ^a	181.21±0.27 ^b	58.90±0.82 ^d	62.98±0.34 ^c	3.71±0.02 ^f	2.91±0.03 ^c
<i>Aloe vera</i>	0.89±0.00 ^b	188.30±0.12 ^a	71.00±0.23 ^b	81.65±0.03 ^a	22.72±0.07 ^a	3.15±0.01 ^d
p values (P<0.05)	0.00	0.03	0.01	0.04	0.02	0.03

Means ± standard error with different superscripts in columns are significantly different using Duncan Multiple Range Test P<0.05

Discussion

Sales of fruits is one of the occupations being embarked upon by people in Abeokuta and its environs due to the availability of fertile lands used for production of such fruits. On the basis of this, the observation that majority of the fruits sellers surveyed by this study were females could indicate that the occupation is predominately taken over by females who are economically active and educated. However, Food spoilage caused by invasion of diseases is major challenge militating against the achievement of foods

(fruits) security and sustainability. However, the contributions of this study based on sales, duration the fruits stay in farm/duration of fruits preservation using herbal materials and perception of fruit sellers use of herbs for preservation indicate that fruit spoilage experienced by the fruit sellers could be traceable to invasion of microorganisms into the fruits due to long time taken to sell the products. Therefore, as a proactive approach towards eradication of fruit spoilage, all the fruit sellers preserved fruits using leaves of the plants investigated without observable physical side effect on the fruits. This may suggest that plants

materials used for preservation of fruits did not cause mechanical damage to the fruits which can initiate fruits spoilage (Pandey 2002).

The use of plants by the fruits sellers as preservative agents could be attributed to the presence of appreciable amount of phytochemicals determined in the leaves of plants. These phytochemicals such as saponins, alkaloids and flavonoids recorded may have ability to pose metabolic attacks on pathogenic organisms which may affect fruits. This assertion is in agreement with submissions of Soledade and Pedras (2011); Seetaramaiah *et al.*, (2011) Olanipekun and Agbadaola. (2013), Borgognone *et al.* (2014), and Sharif *et al.*, (2017) who opined that leaves contained a number of phytochemicals which have ability to inhibit growth of micro-organisms. Similarly, Petropoulos *et al.*, (2017) and Petropoulos *et al.*, (2018) reported that bioactive agents or chemical substances in plants are suitable for prevention of growth and development of pests such as weevil and repel or kill harmful insects thereby ameliorating fruits decay and sustainability of farm produce.

Also findings of Tajkarimi and Ibrahim (2012) and Ayse and Ebru (2017) established that phytochemicals such as flavonoids, polyphenols, anthocyanins and carotenoids are natural preservative agents potent enough to inhibit invasion of pathogenic microorganism, control traditionally microbial spoilage in foods (Negi 2012), preserve overall quality of food products and extend shelf life of farm produce naturally.

In addition, results of this study may be taken as a logical scientific evidence to substantiate submission that application of leaves of identified plants as preservatives measure will protect farm produce from spoilage and unwholesomeness during storage, delay antagonistic activities of pathogenic organisms and improve shelf life of farm produce (Rosal *et al.*, 2008; Moore *et al.*, 2013 Olanipekun and Agbadaola. 2013).

Low amount of anti-nutrients recorded suggest that leaves of the plants contain moderate quantities of anti-nutrients which may not have negative impacts the fruits being preserved as well as their consumers. Although anti-nutrients aside having ability to delimit availability of nutritional contents of foods by forming complexes with minerals such calcium, magnesium and others, they characterized ability to defend their host against predators. This principle may be applicable in controlling pathogenic organism which could cause fruit spoilage through the use of anti-nutrient contents of plants. This submission is in line with submission of Gargari *et al.* (2007); Ogunka-Nnoka and Mepba (2008); Seetaramaiah *et al.* (2011), Akoto *et al.* (2015); Jeremiah *et al.* (2017); Lawrence *et al.* (2017), Zhijun *et al.* (2017) who posited that plant defensive metabolites such as oxalate and phytate help plants and their products to respond to biotic and abiotic stresses and control growth of pathogenic organisms.

Appreciable amount of these physicochemical contents recorded in this study could indicate relevance of physicochemical of plants in the preservation of fruits. Physicochemical properties such as iodine value recorded in the leaves of these plants could indicate certain degree of unsaturation, nutritional value and edibility of the plants. This observation is in line with findings of Doreen *et al.* (2018). Also, according to Mahapatra *et al.* (2011), reduction in iodine value of any food items indicates quality changes which have occurred during preservation of the foods while saponification value indicates adulteration in the quality of fat and oil of products being preserved (Ramzya *et al.*, 2014; Bisht *et al.*, 2015 Samira and Somayeh, 2018).

Conclusion

Results of this study relaxed that spoilage was the main challenge facing the sales of fruits in markets visited in Abeokuta. Leaves of the plants investigated contained high amount proportions

of preservative and physicochemical properties that could be adopted for preservation of fruits.

Based on the presence of natural products in these plants, the plants are strongly recommended as precautionary measures not only to reduce fruit spoilage but also towards achievement of food security and safety in Abeokuta. Also, this study could be regarded as contributory efforts towards discouragement of use of synthetic chemicals for fruit preservation and ripening

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Competing Interest

The authors declare no competing interests

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