




EFFECTS OF PROCESSING METHODS ON THE CHEMICAL PROPERTIES OF SPROUTING LEAF (*BRYOPHYLLUM PINNATUM*)

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ABSTRACT

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This study was carried out to determine the effects of processing methods on the chemical properties of sprouting leaf (*Bryophyllum pinnatum*). Fresh leaves of *B. pinnatum* "Oda opue" were collected, destalked, sorted, washed and drained. The prepared samples were divided into four portions. Three portions were processed by sun drying (14hrs), shade drying (7days) and blanching (90°C for 2mins), the fresh leaves that were neither dried nor blanched served as control. The sun-dried leaf (DL), shade dried leaf (SD), blanched leaf (BL) and the fresh leaf (FL) were analyzed for proximate, vitamin, mineral and phytochemical compositions. The proximate composition ranged as follows; moisture content (8.94 to 89.57%), protein (4.50 to 22.0%), ash (0.81 to 13.81%), fibre (0.84 to 6.86%), fat (0.21 to 2.06%), and carbohydrate (3.52 to 48.57%). The vitamin A content which ranged from 1.40 to 3.92 mg/100g was highest in shade dried leave. Vitamin B₁ and C ranged from 210.00 to 295.40 mg/100 g and 18.25 to 27.60 mg/100g, respectively with the shade dried leaves having the highest value. The mineral composition; calcium, magnesium, zinc and iron were highest in shade dried leaf sample and was significantly ($p < 0.05$) different from fresh, sun dry, and blanched leaves samples. The phytochemical composition ranged from 0.17 to 0.44, 0.60 to 0.85% for saponin and alkaloid, 0.34 to 1.05, 0.17 to 0.58, 0.29 to 0.54 mg/100g and 0.32 to 0.70% for oxalate, phytate, tannin and flavonoid, respectively. The shade dried leaves was found to have higher nutritional composition.

Contribution/Originality: The study document reveals the processing treatment that had higher nutrient retention and reduced anti-nutritional factors of *Bryophyllum pinnatum*. The data on the nutrient composition could enhance its incorporation into the diet as food supplement in combating micro-nutrients deficiency, which would increase the availability and consumption of micro-nutrient rich food.

1. INTRODUCTION

In the ever increasing quest to improve the efficacy of food, scientists found out that some foods are consumed to satisfy hunger, provide nutrients, enhance the immune system, protects the body against diseases, infections and illnesses. Some of the foods we consume just provide nutritional value; some are therapeutic in nature while some others have both nutritional and therapeutic properties. Most of these food products that are being promoted to serve dual purposes (nutritional and therapeutic) find their origin in plant kingdom (Sofowora, 1982). These plants having dual purpose can be classified as Nutraceuticals. Nutraceuticals was coined from "nutrition" and "pharmaceutical" by Stephen DeFelice, MD, founder and chairman of the Foundation for Innovation in medicine (Brower, 1998).

Nutraceuticals plants produce healthy phytochemicals. Nutraceuticals can be defined as plants that have proven to offer physiological benefits or to reduce the risk of chronic disease, or both, beyond their basic nutritional functions (Morganti, 2009). Many edible plants are rich in specific constituents, referred to as phytochemicals that may have health promoting effects (Dillard & German, 2000). Some plants that have nutraceutical activities are Aloe vera, Aloe ferox, Amaranth oil (*Amaranthus* spp.) for cardiovascular disease, Echinacea for reducing common cold, Fennel for colic and constipation, mint for relieving tension headaches and *Moringa oleifera* among others. *Bryophyllum pinnatum* having both nutritional and therapeutic properties and recognized as a leafy vegetable containing phytochemicals can as well be classified as nutraceuticals plant. However, plant foods are mostly known to contain phytochemical especially vegetables.

Vegetables are fresh edible portion of herbaceous plants, which can be eaten raw or cooked (Dhellit et al., 2006). Vegetables are important source of iron, potassium, calcium, magnesium, zinc, pro-vitamin A, thiamine, ascorbic acid, riboflavin and folic acid (Uwaegbule, 1989). It adds flavor, taste, colour and aesthetic to diet. Green leafy vegetables as component of traditional foods are essential for rural subsistence livelihood and health. Leafy vegetables are important items of diet in many Nigeria homes. These nutrients are essential for metabolism, tissue formation and reproduction in the body system. Comparing vegetables and other foods of animal origin, it can be said that vegetable products have lower food value and lower energy, but have special importance in human nutrition. Leafy vegetables are important source of vitamins, minerals and fibres. They have high water content and abundant in cellulose. The cellulose is in form which although not digested by man, serves a useful purpose in the intestine as roughages, thus promoting normal elimination of waste products. They provide the most affordable sources of micronutrients and health promoting phytochemicals for low income people in developing countries especially those in rural communities (Ejoh, Nkonga, Innocent, & Mosses, 2007). Food processing may have beneficial or deleterious effect on the constituents of leafy vegetables. Maximizing nutrient retention during processing has been a considerable challenge for food industry (Ramaswany & Marcotte, 2006). Processing is usually aimed at separating the components of the food altering nutritional and sensory quality of each fraction compared with the raw material.

Leaves are bright green with a purplish red marginal indentations, oinnate venation, 10 cm long and 5 to 6 cm broad. The margins are notched with irregular, blunt or rounded teeth Plate 1.



Plate 1. Fresh *Bryophyllum Pinnatum*.

2. MATERIALS AND METHODS

2.1. Sample Collection and Preparation

The fresh leaves of *Bryophyllum pinnatum* were collected from a private farm at Nru in Nsukka Local Government Area, Enugu State, Nigeria and were identified in the department of Plant Science and Biotechnology, University of Nigeria, Nsukka. The *Bryophyllum pinnatum* leaves were destalked, sorted to remove immature, insects and mould

infested substandard materials. The *B. pinnatum* leaves were washed and rinsed to remove dirt and other foreign materials left after sorting and allowed to drain naturally. The drained leaves were divided into four (4) treatment groups. The first group was shade dried, the second group was dried under the sun; the third group was blanched; while the drained sample that was neither dried nor blanched served as control. Samples from four (4) treatments were analyzed for their chemical composition.

Blanching: Hot water blanching was adopted. The sample after washing and draining was heated in excess water at 90°C for 2 minutes. The sample was cooled after blanching prior to analysis.

Drying: The second and third samples were subjected to two drying methods; sun and shade drying.

1. **Sun drying:** The samples were weighed, sliced, spread in trays and kept outside under the sun for drying. The samples were covered with a net to prevent contact and contamination with insects, flies and dirt. The samples were dried for 14 hours.
2. **Shade drying:** weighed samples were sliced, spread in trays, kept at room temperature. The samples were continuously dried and monitored for 7 days. Figure 1 shows the flowchart for the preparation of samples.

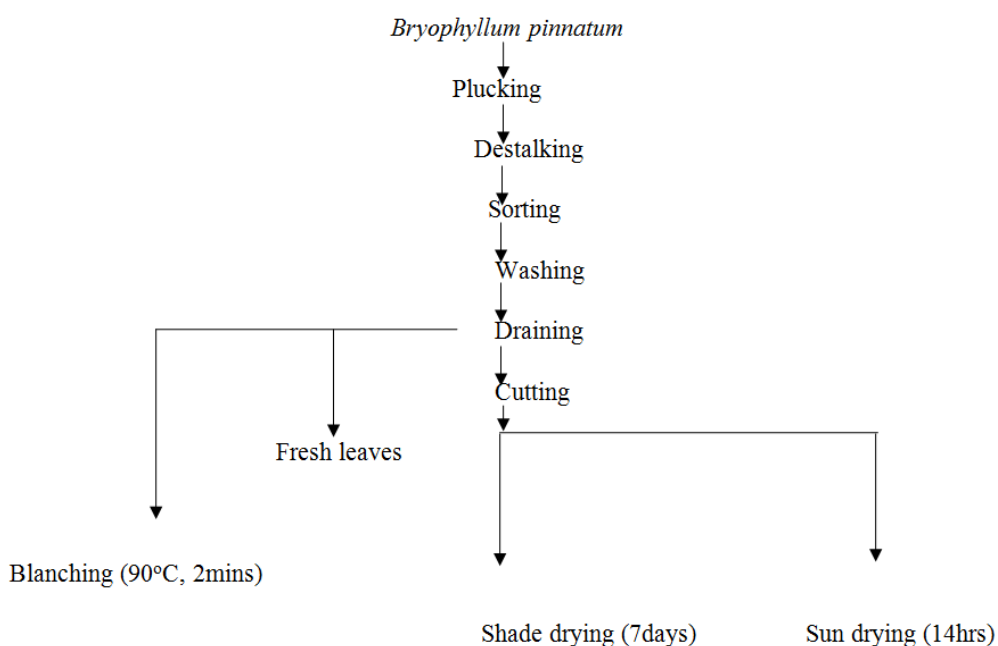


Figure 1. Flow chart for preparation of samples from *Bryophyllum pinnatum*.

2.2. Proximate Analysis of *Bryophyllum Pinnatum*

2.2.1. Moisture Content

The moisture content of the leaves was determined using the method described by AOAC (2010). The stainless steel oven dishes were washed, oven dried, and allowed to cool inside a desiccator and the weight was taken (W_1). Two gram (2 g) of sample was weighed into a cooled stainless dish and the weight determined (W_2). The sample and stainless dish was placed in the oven and dried at 100°C for 1hr. Each dish and its content (sample) were cooled inside the desiccator and after cooling were weighed. The process of drying, cooling, and weighing was continued until a constant weight was obtained (W_3). The percentage moisture was calculated using the weight loss.

$$\% \text{ moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where W_1 = weight of empty dish.

W_2 = weight of dish + sample before drying.

W_3 = weight of dish + sample after drying.

2.2.2. Crude Protein Determination

The crude protein content of the sample was determined using semi-micro Kjeldahl method described by AOAC (2010). Two gram (2 g) of sample was put into a Kjeldahl flask and 3 g of cupric sulphate (catalyst) and 10ml of concentrated sulphuric acid were added. The flask and its content were swirled, heated until the liquid becomes clear and free from black specks. The clear solution was cooled and transferred into a 100 ml volumetric flask and made up to 100 ml with distill water. Five (5 ml) of the diluted digest was collected for distillation. Five (5 ml) volume of sodium hydroxide solution was added in the distillation flask. The digest was left to distill until 60 ml of the distillate were collected in boric acid indicator. The ammonia collected in boric acid was titrated against 0.1 M hydrochloric acid. The total nitrogen was calculated and the percentage crude protein was obtained by multiplying the total nitrogen with a factor (6.25).

$$\% \text{ Total nitrogen} = \frac{T \times 0.0014 \times 100}{W}$$

% Crude protein = Total nitrogen x 6.25

Where

W = Weight of sample.

T = Titre value.

2.2.3. Crude Fat Determination

The soxhlet extraction method (AOAC, 2010) was used in determining fat content of sample. Two (2 g) of each samples were weighed and put in extraction thimble. The thimble was placed back in the soxhlet extraction tube fitted with condenser. Weighed flat bottom flask was filled to three quarter of its volume with petroleum ether (40 – 60 °C), connected to the extraction tube. The extraction apparatus were set up and experiment carried out for a period of 3 hours. The petroleum ether was recovered for reuse, fat in flask was dried in an oven at 80 °C for 30 minutes, cooled in desiccator and weighed. Thereafter the difference in the weight of the empty flask and the flask with oil was calculated as percentage fat content.

$$\% \text{ fat content} = \frac{C - B}{A} \times \frac{100}{1}$$

A = weight of sample.

B = weight of empty flask.

C = weight of flask + oil.

2.2.4. Ash Content Determination

Ash content was determined by the AOAC (2010) method. Two grams of each sample was weighed into a preheated and cooled crucible. The samples were transferred into a muffle furnace and were heated at 500 °C for 3 hours. The crucible plus sample was cooled in desiccator before weighing. Percentage ash was calculated using the expression below:

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

W₁ = weight of empty dish.

W₂ = weight of empty dish + sample before ashing.

W₃ = weight of dish + ash.

2.2.5. Crude Fiber Determination

The crude fiber content of the sample was determined using the method of AOAC (2010). Two grams of each sample was weighed (W₁). The weighed sample was boiled for 30 minutes with 200 ml of 0.21 M H₂SO₄ then filter

through a funnel. The residue was washed with boiling water until the sample is no longer acidic. The washed residue was boiled for another 30 minutes with 200 ml of 0.02 M sodium hydroxide solution, filtered and washed three times with hot water and methylated spirit. The residue was allowed to dry at 100 °C to a constant weight (W_1). It was transferred into a dry crucible and weighed (W_2). The weighed residue was ashed at 500 °C for 3 hour, cooled and reweighed (W_3). The percentage crude fiber was calculated using the expression;

$$\% \text{ crude fiber} = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}$$

W_1 = weight of sample.

W_2 = weight of sample + weight of crucible.

W_3 = weight of ashed sample + weight of crucible.

2.2.6. Carbohydrate Content Determination

The carbohydrate content of each sample was determined by difference. The difference between 100 and sum of percentage moisture, protein, fat, fiber and ash of each sample was determined. The result was expressed as percentage carbohydrate content.

$$\% \text{ Carbohydrate} = 100 - (\% \text{ moisture} + \% \text{ protein} + \% \text{ ash} + \% \text{ crude fiber} + \% \text{ crude fat})$$

2.3. Determination of Minerals

2.3.1. Digestion of Samples

Two grams (2g) were taken from each sample and placed respectively in 100 ml kjeldal digestion tubes. A digestion mixture containing 30 ml of normal HCL and 10 ml of HNO_3 was added to each tube and the mixture heated by kjeldal heating digester until clear solution was obtained. Acid blank was also prepared but without sample in order to ensure that samples and reagents used were not contaminated. The digested portions were filtered using whatman filter paper (125 mm) and each diluted to a volume of 100 ml using de-ionised water.

2.3.2. Calibration Solution

Standard solution of each element; magnesium, calcium, iron and zinc were prepared according to AA-7000 manufacturer procedure for Atomic Absorption Spectroscopy to be used.

2.3.3. Determination of Heavy Metals and Minerals Concentrations

Concentrations of calcium, magnesium, iron and zinc in *Bryophyllum pinnatum* were determined using the methods described by AOAC (2010) by the method of Atomic Absorption Spectrophotometer using atomic absorption spectrophotometer (AA-7000). Each metal was analyzed using its respective wavelength after which its concentration was generated from the standard graph by the instrument.

2.4. Determination of Vitamins

2.4.1. Vitamin A

The colorimetric method of AOAC (2010) method was adopted. This measure the unstable color at the absorbance of 620 nm that will result from the reaction between vitamin A and SbCl_3 pyrogallol (antioxidant) was added to 2 g sample prior to saponification with 200 ml alcohol KOH. Saponification took place in water bath for 30 minutes. The solution was transferred into a separating funnel where water was added. The solution was extracted with 1.0 to 1.5 ml of hexane. The extract was washed with equal volume of water. The extract was filtered through filter paper containing 5 g anhydrous Na_2SO_4 into a volumetric flask. The filter paper was rinsed with hexane and made up to the volume. The hexane was evaporated and blank. About 1 ml chloroform and SbCl_3 solution was added to the extract and blank was taken to the colorimeter adjusted to zero absorbance.

Calculation:

$$\text{Vitamin A (mg)} = A_{620} \text{ nm} \times \text{SL (v/wt)}.$$

Where

$A_{620} \text{ nm}$ = absorbance at 620 nm.

Slope of standard curve (Vit. A Conc / A_{620} reading).

V = final volume in colorimeter tube.

Wt = weight of sample.

2.4.2. Vitamin B (thiamin)

Thiamin was determined using the AOAC (2010) method. A 75 ml of 0.2 N HCL was added to 2 g sample and the mixture boiled over a water bath. It was cooled and 5 ml of phosphatase enzyme solution was added to the mixture and incubated at 37 °C overnight. The solution was transferred to 100 ml volumetric flask and the volume was made up with distilled water.

The solution was filtered and the filtrate was purified by passing through silicate column. To 25 ml of the filtrate in the conical flask, 5ml acidic KCl eluate, 3 ml of alkaline ferricyanide solution, 15 ml isobutanol was added and shook for 2 minutes. About 3 g of anhydrous sodium sulphate was added to the alcoholic layer. A 5 ml of thiamin solution was accurately measure into another 50 ml stopper flask. The oxidation and extraction of thiochrome as already carried out with the sample was repeated using the thiamin solution. A 3 ml of 15% NaOH was added to the blank instead of the alkaline ferricyanide. The blank sample solution was then poured into a fluorescence reading tube for reading to be taken as expressed below:

$$\% \text{ thiamin (mg)} = \frac{X}{Y} \times \frac{1}{5} \times \frac{25}{V} \times \frac{100}{W}$$

Where

W= weight of sample.

X = reading of sample – reading of blank standard.

Y = reading of thiamin standard – reading of blank standard.

V = volume of solution use for test on the column.

2.4.3. Vitamin C (Ascorbic acid)

The vitamin C content of the sample was determined according to the methods described by AOAC (2010). A 2, 6- dichlorophenol titrimetric method was used. Vitamin C standard solution was prepared by dissolving 50 mg standard ascorbic acid tablet in 100 ml volumetric flask with water.

Two gram (2 g) of the sample was extracted by homogenizing in acetic acid solution and diluting to 100 ml. The solution obtained was filtered.

Ten milliliter (10 ml) of the clear filtrate was pipetted into a conical flask containing 2.6 ml acetone. This was titrated with indophenoldye solution (2, 6-dichlorophenol indophenols) until a faint pink colour appears which persisted for 15 seconds. The procedure was repeated for the standard as well.

Calculation:

$$\text{Ascorbic acid (mg)} = C \times V \times (\text{DF}/\text{wt})$$

Where:

C = mg ascorbic acid / 1ml dye.

V = volume of dye used for titration of diluted sample.

DF = dilution factor.

Wt = weight of sample.

2.5. Phytochemical Content Determination

2.5.1. Phytate

Phytate content was determined according to the method described by Pearson (1976). A 0.5 g of the sample was weighed into a 500 ml flat bottom flask. The flask with the sample was shook in a shaker and extract with 100 ml 2.4% HCl for one hour at 25°C. It was decanted and filtered. Five milliliter (5 ml) of the filtrate was diluted to 25 ml with distilled water. Fifteen milliliter (15 ml) of 0.1M sodium chloride was added to 10 ml of diluted sample and pass through whatman No. 1 filter paper to elute inorganic phosphorus, and 15 ml of 0.7M sodium chloride was also added to elute phytate. The absorbance was read at 520 nm and was calculated as follow:

$$\text{Phytate mg/100g} = \frac{A}{A_s} \times \frac{100}{W} \times \frac{V_e}{V_a} \times C$$

Where

A = Absorbance of test sample.

A_s = Absorbance of standard solution.

W = Weight of sample used.

V_e = Total volume of extract.

V_a = Volume of extract analysed.

C = Concentration of standard solution.

2.5.2. Tannin

The Folin – Denis spectrophotometric method as described by Pearson (1976) was used. One gram (1 g) of the sample was dispersed in 10 ml distilled water and agitated. This was left to stand for 30 minutes at room temperature and was shook every 5 minutes. After this it was centrifuged at 3000 rpm for 5 minutes to obtain the extract. A quantity of 0.1 ml Folin – Denis reagent was measured into each flask, followed by 2.5 ml of saturated Na₂CO₃ solution. It was diluted to the mark in volumetric flask (50 ml) and incubated for 90 minutes at room temperature. The absorbance was taken at 250 nm and reagent blank at zero. Tannin content was calculated as follow:

$$\text{Tannin (mg)} = \frac{A}{A_s} \times \frac{100}{W} \times \frac{V_e}{V_a} \times C$$

Where

A = Absorbance of test sample.

A_s = Absorbance of standard solution.

W = Weight of sample used.

V_e = Total volume of extract.

V_a = Volume of extract analysed.

C = Concentration of standard solution.

2.5.3. Alkaloids

The gravimetric method of Harborne (1980) was used to determine alkaloid content of the sample. Five (5 g) of the sample was dispersed into 50 ml of 10% acetic acid solution in ethanol. The mixture was shook and allowed to stand for 4 hours before it was filtered. The filtrate obtained was evaporated to ¼ of its original volume. Concentrated ammonium hydroxide was added to precipitate the alkaloids. The precipitate was filtered with a weighed filter paper and washed with 1% NH₄OH solution. The precipitate in the paper was dried in an oven at 60°C for 30 minutes and was reweighed.

$$\text{Alkaloid mg/100g} = \frac{W_3 - W_2}{W_1} \times 100$$

Where;

W_1 = Weight of sample.

W_2 = Weight of empty filter paper.

W_3 = Weight of filter paper + precipitate.

2.5.4. Saponin

Saponin was determined using the method described by AOAC (2010). Five gram (5 g) of each sample was weighed and dispersed in 100 ml of 20% ethanol. The suspension was heated at 55 °C in hot water bath for 4 hours with continuous stirring. The residue after filtration was re – extracted with another 100 ml of 20% ethanol. The combined extract was reduced to 40 ml in a water bath at 90°C. The concentrate was transferred into a 250 ml separating funnel and 20 ml of diethyl ether was added, shook vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated and about 30 ml of n- butanol was added. The combined n-butanol extracts was washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation the samples was dried in the oven to a constant weight.

$$\text{Saponin} = \frac{W_2 - W_3}{W_1} \times 100$$

Where

W_1 = weight of sample.

W_2 = weight of empty filter paper.

W_3 = weight of filter paper and precipitate.

2.5.5 Oxalate

The determination of oxalate was carried out by the titration method of AOAC (2010). Two gram (2 g) of sample was suspended in a mixture of 190 ml of distilled water and 10 ml of HCl in a 250 ml volumetric flask and digested for one hour at 100°C; it was cooled and made up to 100 ml with distilled water. The digest was filtered through whatman filter paper No. 1 using a suction pump.

A duplicate proportion of 125 ml of the filtrate was measured into 250 ml beakers and 4 drops of methyl red indicator was added into each beaker. Concentrated NH_4OH or NH_3 solution was added drop wise until the test solution changed from its salmon pink color to a faint yellow color (pH 4.0 – 4.5). Each portion was heated up to 90°C and 10 ml of 5% CaCl_2 was added with continuous stirring. After heating, it was cooled and left over night at 5°C. The supernatant was decanted and the precipitate completely distilled in 10 ml of 20 % (v/v) H_2SO_4 solution. At this point, the filtrate resulting from digestion of 2 g of the sample was combined and made up to 300 ml. Aliquot (125 ml) of the filtrate was heated until near boiling and then titrated against 0.05M standard KMnO_4 solution to a faint pink color. Oxalic acid content was calculated using the formula;

$$\text{Oxalate (mg/100g)} = \frac{T \times (\text{Vme}) (\text{Df}) \times 105}{\text{ME} \times \text{M}}$$

Where

T = volume of KMnO_4 .

Vme = volume – mass equivalent (i.e 1 ml of 0.05M KMnO_4 solution is equivalent to 0.00225 g anhydrous oxalic acid).

Df = dilution factor.

ME = molar equivalent of KMnO_4 in oxalic acid.

M = Mass of sample used.

2.5.6. Flavonoids

This was determined according to the method of Harborne (1980). About 5 g of the sample was boiled in 50 ml of 2MHCL solution for 30 minutes under reflux. It was allowed to cool and subsequently filtered through a filter paper. A measured volume of the extract was recovered by filtration using weighed filtered paper.

The flavonoid content was calculated as follows:

$$\text{Flavonoids (mg)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where

W_1 = weight of sample.

W_2 = weight of empty filter paper.

W_3 = weight of filter paper plus flavonoid.

2.6. Experimental Design

The experimental design used was complete randomized design (CRD).

2.7. Statistical Analysis

All the data generated was subjected to statistical analysis using a one-way analysis of variance (ANOVA) using Statistical Product for Service Solution (SPSS) version 20. Means were separated by Duncan's Multiple Range Test (DMRT) method and level of significance accepted at $p < 0.05$ (Steel & Torrie, 1980).

3. RESULTS AND DISCUSSIONS

3.1. Plate 2,3,4 Represent Samples Processed by Different Methods



Plate 2. Shade dried *B.pinnatum*.



Plate 3. Sundried *B.pinnatum*.



Plate 4. Blanched *B.pinnatum*.

3.2. Effects of Processing on the Proximate Composition of *Bryophyllum Pinnatum* Leaves.

Plates 2,3,4 shows the proximate composition of *Bryophyllum pinnatum* processed by sun drying, shade drying and blanching.

Table 1. Proximate composition of *Bryophyllum pinnatum* leaves processed by sun drying, shade drying and blanching.

Samples	Moisture (%)	Protein (%)	Ash (%)	Fibre (%)	Fat (%)	CHO (%)
FL	89.57 ^a ± 0.00	4.50 ^c ± 0.19	0.81 ^c ± 0.01	0.84 ^c ± 0.01	0.51 ^c ± 0.00	3.52 ^d ± 0.35
DL	8.94 ^d ± 0.05	22.00 ^a ± 0.00	13.38 ^b ± 0.02	5.40 ^b ± 0.09	1.94 ^b ± 0.01	48.57 ^a ± 0.02
SL	10.13 ^c ± 0.01	20.00 ^b ± 0.02	13.81 ^a ± 0.20	6.86 ^a ± 0.22	2.06 ^a ± 0.05	47.14 ^b ± 0.42
BL	78.62 ^b ± 0.00	4.75 ^c ± 0.29	0.96 ^c ± 0.09	0.94 ^c ± 0.08	0.21 ^d ± 0.00	14.52 ^c ± 0.07

Note: Values are means ± SD (standard deviation) of duplicate determinations. Values carrying different superscripts along the same column are significantly different ($p < 0.05$).

Key: FL = Fresh leaves; DL = Sun dried leaves; SL = Shade dried leaves; BL = Blanched leaves.

3.2.1. Moisture

The moisture content of the four samples as shown in the Table 1 ranged from 8.94 to 89.57% with the fresh leave (FL) having the highest moisture content of 89.57%. The value of moisture content of the fresh leave was within the range expected for fresh vegetables as reported by Oboh, Ekperigin, and Kazeem (2005); Mepha, Eboh, and Banigo (2007); Awogbemi and Ogunleye (2009). Generally, the high moisture content in leafy vegetables, such as *B. pinnatum* leaves, is indicative of freshness as well as easy perishability. High moisture content of fresh *B. pinnatum* makes it easy for the leaves to sprout. The fresh leaf contained significantly ($p < 0.05$) higher amount of moisture than blanched sample. This could be attributed to losses arising from heat of blanching (Mepha et al., 2007; Nkafamiya, Oseameahon, Modibbo, & Haggai, 2010). The sun dried (DL) and the shade dried leaves (SL) had the lowest moisture content due to effect of dehydration. This low moisture content of the dried samples is an advantage over the rest of the processed samples as the decrease in moisture level would lead to concentration of soluble solids that make up the nutrients (Joshi & Mehta, 2010; Mepha et al., 2007).

3.2.2. Protein

The protein content ranged from 4.50 to 22.00 % lower than some other vegetable reported by Asaolu, Adefemi, Oyakilome, Ajibulu, and Asaolu (2012). Plant foods that provide more than 12% of their calorific value from protein have been shown to be good sources of protein (Ali, 2009). This shows that moisture removal helped in concentrating the nutrients. The protein level of the sun dried was significantly ($p < 0.05$) higher than the shade dried, fresh and blanched leaves respectively. This could be as a result of concentration resulting in loss of moisture and method of processing. Protein increase during blanching was not significantly ($p > 0.05$) different from the fresh leave. Because of the low content of protein in *B. pinnatum* leaves in relation to other leaves, it cannot be regarded as a good source of protein. Protein is a vital nutrient which is responsible for body growth and repair of worn out tissues from body cell.

3.2.3. Ash

The result for ash content of processed leaves ranged from 0.81 to 13.81% with the fresh leaves having ash content lower than bitter leaf (50.64%), bush-buck (66.60%), scent leaf (622.71%), *Amaranthus hybridus* (49.02%) and *Telfaira occidentalis* (61.70%) leaves reported by Asaolu et al. (2012). The fresh and the blanched leaves were not significantly ($p > 0.05$) different and this could be as a result of minimal mineral loss during blanching. Drying appeared to concentrate the ash content per unit weight. The ash content of the shade dried leaves was found to be 13.81 %. This value was found to be significantly ($p < 0.05$) higher than ash content of fresh, blanched and sundried leaves. The ash content is used as a measure of the nutritionally important mineral contents present in the food material (Lewu, Adebola, & Afolayan, 2009).

3.2.4. Fibre

Fibre content of the samples ranged from 0.84 to 6.86%. The fibre content of fresh and blanched leaves was not significantly ($p > 0.05$) different. The fibre content of the fresh leaf was lower than the fibre content of bitter leaf (12.08%), bush-buck (4.02%) and scent leaf (7.04%) reported by Asaolu et al. (2012). The fresh leaves having lowest fibre content can be a result of high moisture content when compared to the sun dried and shade dried samples as a result of concentration of other components including the fibre content. The blanched leaves was not significantly ($p > 0.05$) higher than the fresh leaves even though there was reduction in moisture content. Fibre helps to prevent colon cancer and other gastrointestinal disorder (Shokunbi, Anionwu, Sonuga, & Tayo, 2011). It is also vital to note that fibre plays highly important role in promoting soft stools with increased frequency and regularity of elimination (Kubmarawa, Andenyang, & Magomya, 2008; Okaka, Akobundu, & Okaka, 2000). Adequate intake of high fibre diet can lower the serum cholesterol level, risk of coronary heart disease and hypertension (Akubugwo, Obasi, Chinyere, & Ugbogu, 2007).

3.2.5. Fat

The fat content of the fresh leaf was observed to be 0.51%. The lipid content of *B. pinnatum* leaf was within the range of leafy vegetable as reported by Awogbemi and Ogunleye (2009) and was below the range of *M. oleifera* and *B. cosatum* with the values of 2.96 and 3.12% respectively reported Nkafamiya et al. (2010). The fresh leaves were observed to have higher fat content than the blanched leaf sample as a result of blanching effect Nkafamiya et al. (2010) as some fat components are lost during blanching. The fat content of the dried leaves was low but significantly ($p < 0.05$) higher than the fresh leaves. The shade dried leaves had the highest fat content. This increase could be attributed to concentration due to moisture loss. From the result it is concluded that *B. pinnatum* is a poor source of lipids. This is in agreement with the findings that leafy vegetables are low lipid containing foods and would be an advantage to people suffering from obesity.

3.2.6. Carbohydrate

In the carbohydrate content of the processed leaves, it was observed that fresh leaves had a value of 3.52% lower than some of the vegetables reported by Asaolu et al. (2012). The carbohydrate composition of *B. pinnatum* was low and may not be a good source of energy. The blanching process had a significant effect on the carbohydrate content. This suggests that as the moisture is lost, the carbohydrate accumulate. The shade dried sample (47.14%) and sun dried sample (48.57%) were significantly ($p < 0.05$) different as a result of moisture loss during drying with the sun dried sample having the highest carbohydrate content.

3.3. Effects of Processing on the Selected Micronutrients Composition of *Bryophyllum Pinnatum* Leaves.

The result on Table 2 shows the vitamin composition of *B. pinnatum* processed by sun drying, shade drying and blanching.

Table 2. Vitamin composition of *Bryophyllum pinnatum* leaves processed by sun drying, shade drying and blanching.

Samples	Pro Vitamin A (mg/100g)	Vitamin B1 (mg/100g)	Vitamin C (mg/100g)
FL	1.47 ^c ±0.01	246.10 ^c ±0.02	21.40 ^c ±0.14
DL	3.21 ^b ±0.01	262.80 ^b ±0.42	24.86 ^b ±0.09
SL	3.92 ^a ±0.19	295.40 ^a ±0.01	27.60 ^a ±0.00
BL	1.40 ^d ±0.00	210.00 ^d ±0.19	18.25 ^d ±0.29

Note: Values are means ± SD (standard deviation) of duplicate determinations. Values carrying different superscripts along the same column are significantly ($p < 0.05$) different.

Key: FL = Fresh leaves; DL = Sun dried leaves; SL = Shade dried leaf; BL = Blanched leaves.

3.3.1. Vitamin A

Vitamin A from the results obtained in Table 2 ranged from 1.40 to 3.92mg/100g with the shade dried leaves (SL) having the highest vitamin A content than the rest of the processed sample. The Vitamin A content of the fresh leaf was very low compared to the composition of the leafy vegetables reported by Nkafamiya et al. (2010) for non-conventional leaves. Blanching caused further losses of vitamin A in the leaves. The reduction of pro vitamin A in the blanched samples was attributed to effects of heat and leaching accompanying blanching (Nkafamiya et al., 2010). Drying resulted to higher composition of pro vitamin A in the samples showing that concentration occurred during drying as the moisture is being lost. The vitamin A content of these processed leaves were lower than that of *Amarathus hybridus* (3.29 mg/100g) reported by Akubugwo et al. (2007). Comparatively, greater losses of pro vitamin A occurred in the blanched leaf. Thus, the dried samples had significantly ($p < 0.05$) higher vitamin A content than the blanched leaf.

3.3.2. Vitamin C (Ascorbic acid)

Vitamin C (Ascorbic acid): The Vitamin C composition in the processed leaves of *B.pinnatum* ranged from 18.25 to 27.60 mg/100g sample. The shade dried leaves had the highest vitamin C composition when compared to other processed leaves. Each processed leaves significantly ($p < 0.05$) differed from the other in vitamin C composition. However, the fresh leaf samples had higher vitamin C contents compared to the blanched sample due to blanching treatments received resulting in leaching of some vitamins. Reduction in vitamin C can also be attributed to oxidation being that vitamin C is sensitive to light and heat and is easily oxidized.

3.3.3. Vitamin B₁

The vitamin B₁ content follows the same trend as vitamin C and pro vitamin A. The shade dried leaves had the highest composition of 295.40 mg/100g followed by the sun dried leaves with 262.80 mg/100g while the fresh and blanched leaves had values of 246.10 and 210.00 mg/100g respectively. Vitamin B₁ and C for fresh leaves are higher than that reported by Nkafamiya et al. (2010) for non-conventional leafy vegetables.

The result on Table 3 shows the mineral composition of *B. pinnatum* processed by sun drying shade drying and blanching.

Table 3. Mineral composition of *Bryophyllum pinnatum* leaves processed by sun drying, shade drying and blanching.

Samples	Calcium(mg/100)	Magnesium (mg/100g)	Zinc (mg/100g)	Iron (mg/100g)
FL	160.70 ^c ±0.72	17.19 ^c ±0.01	1.79 ^c ±0.01	2.04 ^c ±0.00
DL	570.74 ^b ±0.04	17.86 ^b ±0.02	6.34 ^b ±0.00	12.40 ^b ±0.01
SL	609.16 ^a ±0.09	17.95 ^a ±0.00	7.02 ^a ±0.04	28.89 ^a ±0.03
BL	157.52 ^d ±0.21	17.00 ^d ±0.05	1.53 ^d ±0.01	1.40 ^d ±0.01

Note: Values are means ± SD (standard deviation) of duplicate determinations. Values carrying different superscripts along the same column are significantly ($p < 0.05$) different.

Key: FL =Fresh leaves; DL = Sun dried leaves; SL = Shade dried leaf; BL = Blanched leaves.

3.3.4. Calcium

The calcium content of the processed leaves samples ranged from 157.52 to 609.16 mg/100g with the shade dried sample having the highest composition of 609.16 mg/100ml followed by sundried sample with a value of 570.74mg/100g. This could be attributed to concentration of solid content due to loss of moisture during drying. The calcium content of the fresh leaves were lower than the dried ones due to method of processing but higher than that of bitter leaf (71.50 mg/100g), bush-buck (72.65 mg/100g) and scent leaf(64.80 mg/100g) reported by Asaolu et al. (2012). The loss of calcium in blanched leaves sample could be attributed to loss of minerals in water during blanching. However, calcium is an important mineral required by both infants and adults for building and maintenance of strong bones and teeth. It helps in blood circulation among other functions. The deficiency of calcium

in the diet can lead to osteoporosis and fracture risk. The leaves of *B. pinnatum* can help to provide the body with calcium.

The magnesium, zinc and iron content of the processed leave samples followed the same trend as that of calcium. The shade dried leaf had the highest magnesium, zinc and iron composition with values of 17.95, 7.02, and 28.89 mg/100g respectively while the blanched sample had the least mineral contents (Mg-17mg/100g, Zn- 1.53mg/100g, Fe- 1.40mg/100g) respectively. The result showed that the fresh leaves are not a good source of iron and zinc. The consequences of iron deficiency include reduced work capacity, impairments in behaviour and intellectual performance and decreased resistance to infection. Zinc is found in cells throughout the body. It is needed for the body's immune system to properly work. It plays a role in cell division, cell growth, wound healing, and the breakdown of carbohydrates. Zinc is also needed for the senses of smell and taste. During pregnancy, infancy, and childhood the body needs zinc to grow and develop properly. Deficiency of zinc leads to skin sores, slow growth, difficult in sight in the dark and wounds that take a long time to heal.

3.4. Effects of Processing on Some Selected Phytochemicals

Table 4 shows selected phytochemical content of *Bryophyllum pinnatum* leave processed by sun drying, shade drying and blanching.

Table 4. Phytochemical composition of *Bryophyllum pinnatum* leaves processed by sun drying, shade drying and blanching.

Samples	Saponin (%)	Alkaloid (%)	Oxalate (mg/100g)	Phytate (mg/100g)	Tannin (mg/100g)	Flavonoid (%)
FL	0.21 ^a ±0.02	0.71 ^c ±0.04	0.40 ^b ±0.14	0.41 ^b ±0.02	0.32 ^c ±0.04	0.15 ^c ±0.03
DL	0.35 ^a ±0.00	0.80 ^{ab} ±0.00	0.95 ^a ±0.09	0.56 ^a ±0.28	0.47 ^b ±0.00	0.61 ^b ±0.01
SL	0.44 ^a ±0.01	0.85 ^a ±0.10	1.05 ^a ±0.04	0.58 ^a ±0.04	0.54 ^a ±0.14	0.70 ^a ±0.00
BL	0.17 ^a ±0.01	0.60 ^d ±0.01	0.34 ^b ±0.00	0.17 ^c ±0.03	0.29 ^c ±0.01	0.32 ^d ±0.02

Note: Values are means ± SD (standard deviation) of duplicate determinations. Values carrying different superscripts along the same column are significantly different ($p < 0.05$).

Key: FL = Fresh leaves; DL = Sun dried leaves; SL = Shade dried leaf; BL = Blanched leaves.

Saponin, alkaloids, oxalate, phytate, tannin, and flavonoid were present in varying amounts in all the processed vegetable leaves. The saponin composition ranged from 0.17 to 0.4%. There was no significant ($p > 0.05$) difference among the four samples which might be an indication that *B. pinnatum* does not have noticeable profound bitter taste. Saponin has the property of precipitating and coagulating red blood cells. Some of the characteristics of saponins include formation of foams in aqueous solutions, hemolytic activity, cholesterol binding properties and bitterness (Okwu, 2004; Sodipo, Abdulrahman, Sandabe, & Akinniyi, 2011). These properties prove a high medicinal value of the *Bryophyllum pinnatum* leaves. Igile et al. (1995) reported that saponin is safe for consumption at <10%.

The alkaloid composition ranged from 0.60 to 0.85%. There was no significant ($p > 0.05$) difference between sun dried and shade dried leaves but significant ($p < 0.05$) difference existed between the fresh and blanched leaves. Aletor and Onibi (1990) in his research reported that alkaloid was toxic to fungi and man in excess dose of 20mg/100g of sample.

The oxalate composition ranged from 0.34 to 1.05mg/100g with the shade dried leaves having the highest concentration which was not significantly ($p > 0.05$) different from the sun dried leaves but significantly ($p < 0.05$) decreased after blanching as a result of high moisture content and method of processing. Though the levels of oxalate in *B.aegyptiaca* (13.11±0.50) and *S.indium* (7.83±0.12) are high, they are still lower than those associated with renal problems, as high oxalate diet can increase the risk of renal calcium absorption (Kubmarawa et al., 2008; Marshal, Buck, & Bell, 1967). Noonan and Savage (1999) reported that oxalate at 250mg/100g sample is within the safe level.

Phytate composition of the fresh leaf (FL) which ranged from 0.17 to 0.58mg/100g was highest in the shade dried leaves but not significantly ($p < 0.05$) different from the sun dried leaves and was reduced after blanching. Hurrell et al. (1992) reported that an intake of 4 – 9mg/100g dry weight of phytate decreased iron absorption. The

increase in phytate composition in shade dried leaves could be attributed to accumulation as a result of moisture lost during drying and was reduced during blanching as a result of leaching and high moisture content. Phytate has been reported to reduce the bioavailability of trace element and minerals (Kubmarawa et al., 2008).

Tannin and flavonoid followed the same trend where SL had the highest composition and BL had the lowest composition with the values of 0.54 and 0.70mg/100g, 0.29 and 0.32% for tannin and flavonoid in SL and BL respectively. The composition of tannin in fresh leaves was not significantly ($p < 0.05$) different from the blanched leaves with values of 0.32 and 0.29mg/100g respectively, but was significantly ($p > 0.05$) different from the shade dried and sun dried leaves. Tannin at 17.4mg/100g was within the acceptable level of consumption as reported by Idolo and Emeruwa (2011). The levels of the anti-nutritional factors generally reduced after blanching, though their level before the blanching were low to significantly ($p < 0.05$) interfere with the nutrients. Flavonoid followed the same trend as tannin. Flavonoid increased on drying and decreased on blanching. Flavonoids are potent water-soluble Antioxidants and free radical scavengers, which prevent oxidative cell damage, have strong anti-cancer activity (Okwu & Josiah, 2006). As antioxidants, flavonoids from these plants provide anti-inflammatory activity (Okwu, 2004). This may be the reason *Bryophyllum pinnatum* is used in treatment of wounds, burns and ulcer in herbal medicine. Increase in anti-nutrient in shade dried leaf (SL) and decrease in sun dried leaf (DL) is in agreement with Oni, Ogungbite, and Akindele (2015).

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

From the results of this research, it was evident that sun and shade drying caused a significant ($p < 0.05$) increase in proximate, vitamin and mineral composition of *B. pinnatum*. The shade dried leaves having high nutritional composition can be used to supplement food during food preparation. Blanching caused reduction in anti-nutritional composition though there was significant ($p < 0.05$) loss in minerals and vitamins content.

4.2. Recommendations

Based on this research findings, shade drying should be employed in processing *B. pinnatum* since there was increase in nutritional composition. It can also be incorporated into certain food such as in soup preparation since it has been proven to have high nutritional values and health benefits. Nutritional education awareness for the beneficial uses of sprouting leave needs to be created to enlighten them on how best to apply these processing method and the uses of processed vegetables.

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REFERENCES

- Akubugwo, I., Obasi, N., Chinyere, G., & Ugboogu, A. (2007). Nutritional and chemical value of *Amaranthus hybridus* L. leaves from Afikpo, Nigeria. *African Journal of Biotechnology*, 6(24), 2833 - 2893. Available at: <https://doi.org/10.5897/ajb2007.000-2452>.
- Aletor, V., & Onibi, O. (1990). Use of oyster shell as calcium supplement. Part 1. Effect on the utilization of gossypol-containing cotton seed cake by the chicken. *Food/Nahrung*, 34(4), 311-318. Available at: <https://doi.org/10.1002/food.19900340403>.
- Ali, A. (2009). Proximate and mineral composition of the marchubeh (*Asparagus officinalis*). *World Dairy and Food Science*, 4(2), 142-149.
- AOAC. (2010). *Official method of analysis* (18th ed.). Washington D.C., USA: Association of Analytical Chemists.

- Asaolu, S. S., Adefemi, O. S., Oyakilome, I. G., Ajobulu, K. E., & Asaolu, M. F. (2012). Proximate and mineral composition of Nigerian leafy vegetables. *Journal of Food Research*, 1(3), 214-218. Available at: <https://doi.org/10.5539/jfr.v1n3p214>.
- Awogbemi, O., & Ogunleye, I. O. (2009). Effect of drying on the qualities of some selected vegetables. *International Journal of Engineering and Technology*, 1(5), 409 - 414. Available at: <https://doi.org/10.7763/ijet.2009.v1.77>.
- Brower, V. (1998). Nutraceuticals: Poised for a healthy slice of the healthcare market? *Nature Biotechnology*, 16(8), 728-731. Available at: <https://doi.org/10.1038/nbt0898-728>.
- Dhellot, J. R., Matouba, E., Maloumbi, M. G., Nzikou, J. M., Safou-Ngoma, D. G., Linder, M., & Parmentier, M. (2006). Extraction, chemical composition and nutritional characterization of vegetable oils: Case of Amaranthus hybridus (Variety 1 and 2) of Congo Brazzaville. *African Journal of Biotechnology*, 5(11), 1095 -1101.
- Dillard, C. J., & German, J. B. (2000). Phytochemicals: Nutraceuticals and human health. *Journal of the Science of Food and Agriculture*, 80(12), 1744-1756.
- Ejoh, R. A., Nkongu, D. V., Innocent, G., & Mosses, M. C. (2007). Effect of the method of processing and preservation on nutritional quality parameters of three nonconventional leafy vegetables. *Pakistan Journal of Nutrition*, 6, 3965 - 3977. Available at: <https://doi.org/10.3923/pjn.2007.128.133>.
- Harborne, J. B. (1980). Phytochemical methods: A guide to modern techniques of plant analysis (pp. 32 – 35). New York: Chapman and Hall Publisher.
- Hurrell, R. F., Juillerat, M.-A., Reddy, M. B., Lynch, S. R., Dassenko, S. A., & Cook, J. D. (1992). Soy protein, phytate, and iron absorption in humans. *The American Journal of Clinical Nutrition*, 56(3), 573-578. Available at: <https://doi.org/10.1093/ajcn/56.3.573>.
- Idolo, J., & Emeruwa, C. H. (2011). Nutritional and anti-nutritional characteristics of the larva oryctesmonoceros. *Agricultural and Biological Journal of North America*, 2, 42-46. Available at: <https://doi.org/10.5251/abjna.2011.2.1.42.46>.
- Igile, G., Olenszek, W., Jurzysta, M., Aquino, R., de Tommasi, N., & Pizza, C. (1995). Vemoniosides D and E, two novel saponins from Vernonia amygdalina. *Journal of Natural Products*, 58(9), 1438-1443. Available at: <https://doi.org/10.1021/np50123a016>.
- Joshi, P., & Mehta, D. (2010). Effect of dehydration on the nutritive value of drumstick leaves. *Journal of Metabolomics and Systems Biology*, 1(1), 5-9.
- Kubmarawa, D., Andenyang, I. H., & Magomya, A. M. (2008). Amino acid profile of two non-conventional leafy vegetables, Sesame indium and Balanileaegypticaca. *African Journal of Biotechnology*, 7(18), 3502 - 3504.
- Lewu, M., Adebola, P., & Afolayan, A. (2009). Effect of cooking on the proximate composition of the leaves of some accessions of Colocasia esculenta (L.) Schott in KwaZulu-Natal province of South Africa. *African Journal of Biotechnology*, 8(8), 1619 - 1622.
- Marshal, V. I., Buck, W. E., & Bell, G. I. (1967). Pig weed (Amaranthus repreflexas) an oxalate containing plant. *American Journal of Veterinary Research*, 28, 888 - 889.
- Mepha, H. D., Eboh, L., & Banigo, D. E. B. (2007). Effect of the processing treatment on the nutritive composition of some Nigerian edible vegetable. *African Journal of Food, Agriculture, Nutrition and Development*, 7, 1 -18.
- Morganti, P. (2009). The photoprotective activity of nutraceuticals. *Clinics in Dermatology*, 27(2), 166-174. Available at: <https://doi.org/10.1016/j.clindermatol.2008.01.009>.
- Nkafamiya, I., Oseameahon, S., Modibbo, U., & Haggai, D. (2010). Vitamins and effect of blanching on nutritional and anti-nutritional values of non-conventional leafy vegetables. *African Journal of Food Science*, 4(6), 335-341.
- Noonan, S. C., & Savage, G. P. (1999). Oxalate content of foods and its effect on humans. *Asia Pacific Journal of Clinical Nutrition*, 8(1), 64-74.
- Oboh, G., Ekperigin, M., & Kazeem, M. (2005). Nutritional and haemolytic properties of eggplants (Solanum macrocarpon) leaves. *Journal of Food Composition and Analysis*, 18(2-3), 153-160. Available at: <https://doi.org/10.1016/j.jfca.2003.12.013>.
- Okaka, J. C., Akobundu, E. N. T., & Okaka, N. C. (2000). Human nutrition: An integrated approach (2nd ed., pp. 1 - 66). Enugu, Nigeria: OC JANCO Academic Publishers.

- Okwu, D. E. (2004). Evaluation of the chemical composition of indigenous spices and flavouring agents. *Journal of Science*, 7, 455 – 459.
- Okwu, D., & Josiah, C. (2006). Evaluation of the chemical composition of two Nigerian medicinal plants. *African Journal of Biotechnology*, 5(4), 357-361.
- Oni, M. O., Ogungbite, O. C., & Akindele, A. K. (2015). The effect of different drying methods on some common Nigerian edible botanicals. *IJARB*, 1(1), 15-22.
- Pearson, D. (1976). *The chemical analysis of foods* (pp. 167). London New York: Chuchill and Livingstone.
- Ramaswany, H., & Marcotte, M. (2006). *Food processing principle and applications* (pp. 5). Bacon Raton: CRC Press.
- Shokunbi, O. S., Anionwu, O. A., Sonuga, O. S., & Tayo, G. O. (2011). Effect of post-harvest processing on the nutrient and anti-nutrient compositions of Vernonia amygdalina leaf. *African Journal of Biotechnology*, 10(53), 10980-10985. Available at: <https://doi.org/10.5897/ajb11.1532>.
- Sodipo, O., Abdulrahman, F., Sandabe, U., & Akinniyi, J. (2011). Effects of the aqueous fruit extract of Solanum macrocarpum Linn on the hematological parameters of triton-induced hyperlipidemic rats. *African Journal of Pharmacy and Pharmacology*, 5(5), 632-639. Available at: <https://doi.org/10.5897/ajpp10.288>.
- Sofowora, B. (1982). *Medicinal plants and traditional medicine in Africa* (pp. 289). New York: Johny Willey.
- Steel, R. G. D., & Torrie, J. H. (1980). *Principles and procedures of statistics. A biometrical approach* (2nd ed.). New York: McGraw-Hill Book Company.
- Uwaegbule, A. (1989). *Vegetables: Nutrition and utilization Food crops production* (pp. 39-44). Ibadan: Dotanpublishers Ltd.

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