Evaluation of Chemical Composition, Physicochemical and Anti-nutritional Properties of Giant Yellow Mulberry Fruit (*Myrianthusarboreus*)

ABSTRACT

The study aimed at evaluating the nutritional value of the pulp and seeds of the giant mulberry (*Myrianthusarboreus*) fruit, and determine the physicochemical properties of its seed oil. Using the complete randomized design, matureripe fruits of the fruits were harvested fromFontem, South west region, Cameroon and analyzed at the life science laboratory of the University of Buea following standard procedures. Results revealed the proximate composition of the pulps and seeds were 5.03% and 28.06% for carbohydrates, 17.22% and 24.40% for proteins, 6.50% and 42.05% for lipids respectively.Antinutritional analyses revealed moderately low content of phytate, tannin and oxalate.The oil quality indices demonstrated acceptable values foracid, saponification value, iodine, peroxide and P-anisidine. Fatty acid profiling showed that the oil was 45.06% saturated and 54.94% unsaturated fatty acids accounts. These findings suggest that *M. arboreus* fruit as potentials as a nutritious food source with health benefits.

Keywords: Myrianthusarboreus fruit, chemical composition, Antinutrients, physicochemical properties, fatty acid profile.

1. INTRODUCTION

"Food security still remains of utmost concern in sub-Saharan Africa. In Cameroon, the continuous high levels of insecurity in the Northwest and Southwest regions, the rise in conflicts over natural resources (water, pastures, etc.), and floods (in the Far North, North and West) continue to have a severe impact on food security. Update for the 2023 Global Report against Food Crises, reveals that 22% and 10% of the population are respectively in phase 2 and 3 of acute food insecurity in 2023. Consequently, there has been an increase in malnutrition and nutritional deficiencies with over thirty-seven percent (37%) of children under 5 years of age being stunted" [1].

"As food based coping strategy to the poor and borderline food consumption score in Cameroon, it is important to diversify foods and diets using agricultural biodiversity to improve nutrition and health. One of alternative responses to this is using indigenous edible fruits. They are plant species known by populations for their fruits edible and they grow spontaneously in the wild. The majority of most regions of Cameroon is covered by equatorial forests full of many little-exploited forest fruits that could nevertheless contribute to improving the nutritional status of its populations. Indigenous fruit trees, growing spontaneously, has made enormous contribution to nutrition and security, health and income generation in sub-Saharan Africa in general and in Cameroon in particular" [2-5].

Indigenous fruit tree leaves are consumed as vegetables with high nutritive values as well medicinal properties, their fruits are edible and sometimes contain seeds of high nutritional and economic importance. Fruits not only offer easily available energy, but also micronutrients necessary to sustain and support human growth and activity [6]. "They are naturally rich in antioxidant compounds, their by-products (peels and seeds) also contain high levels of antioxidants and phytochemicals that can be

used as functional ingredients to fortify foods. In addition to their high nutritional value, indigenous fruit trees bridge the ¨hunger gap¨ producing even when staple crops fail during times of food shortage. In the last two decades, research efforts have been channeled towards harnessing the nutrient potentials of both conventional and unconventional fruits as a way of enhancing food security. Most available edible indigenous fruits in Cameroon are at present not fully utilized. At their different levels of utilization, the fruits are eaten and their seeds are commonly cooked and consumed, either directly as snack or complimentary foods, or fermented and used as condiments in soups and sauces. Hence, the lesser-known or under-exploited fruits and their seeds have recently assumed a new status in developing countries, especially with the focus on sustainable agriculture and nutrient requirements" [7].

"Cameroon's flora and diversity, contains many indigenous fruit tree plants that could provide a balance for human food, health, and industrial utilization, however there is a limitation of consumer awareness regarding the nutritional and health benefits of regular fruit consumption. *Myrianthusarboreus* commonly called giant yellow mulberry or monkey fruit is one of such tree. It occurs in the forest zone of tropical Africa and widely distributed in the tropical regions of West Africa (Côte d'Ivoire, Guinea, and Nigeria), Central Africa (Angola, Cameroon) and East Africa (Ethiopia, Tanzania)" [8]. This fruit is known under various vernacular appellations in various African countries, Ivorian call it "wougnan "and "oujoujou "(Ibo). In Cameroon, it is locally called "pernambuco" monkey or bush pineapple and its fruit pulp is edible, its seeds are oilseeds and are eaten cooked or raw in some regions, yet the extraction of its oil is not widespread in Cameroon unlike in other African countries where the fruits are found[9,10]. In previous studies conducted in and around Kahuzi-Biega National Park (KBNP) Eastern D.R. Congo, more than 40 oil producing plant species were identified, *Myrianthusarboreus* was one of such plant species [9]. Moreover, in Côte d'Ivoire, Katou et al. [11], highlighted this potential, characterizing the fatty acids and showed it's predominance of unsaturated fatty acids (95.58%). The study also showed that, the seeds of *M. arboreus* are rich in fat matter; making this plant a promising source of oil.

Despite the increase research and consumption of *Myrianthusarboreus* fruit in other African countries, its consumption and utilization in Cameroon is limited in that, the fruit trees are mostly known only in their immediate localities, also, there is a severe shortage of research data on its nutritional value and utilization. To fully appreciate this under-exploited fruit, its current status in terms of its nutrient potentials, current nutrition and health uses, concentrations of anti-nutritional and toxic factors and functionality in food systems and appropriate processing techniques will need to be examined. The results to such information about the fruit could justify the call for wider exploitation and full utilization in other food systems, which may encourage their wider distribution. It is for the aforementioned reasons that this research aimed at evaluating the chemical, antinutritional and physicochemical properties of the pulps and seeds of *Myrianthusarboreus* fruits harvested from Cameroon.

2. MATERIAL AND METHODS

2.1 Study Area

The study was conducted in Fontem a locality found inLebialem division of the South West Region of Cameroon. This locality found at latitude 5° 28' 0" North and longitude 9° 53' 0" East. This town was chosen because it isknown for its designated conservation and rich biodiversity.

2.2 Sample collection

Mature ripe fruits of*Myrianthusarboreus*(evident by a deep yellow colour, soft to feel and a sweet fruity aroma) samples were harvested in a secondary forest in Fontem based on their abundance, in June 2023. The fruits were transported in ice cold box to the life science laboratory of the University of Buea for preparation and analyses.

2.3 Sample preparation

Preparation of pulp and seeds Samples were done by adopting the method according toOmujalet al.[12], with slight modifications. *Myrianthusarboreus* fruits (Fig 1) were washed and their pulps

removed while the seeds (Fig 1) dehulled. The freshly pooled pulpswere crushed using a mortar and pestle and dried in a vacuum oven at 50°C for 48 h and latercrushed into fine powder using an electric blender. Similarly, the dried seeds were de-husked using a manual grinding machine to remove the kernels which were further dried for another 48 hours until moisture content was less than 12%. The dry kernels were then ground using an electric grinder to obtain fine powder. The finepowder (Fig 1) obtained from the seed was divided into two portions, the first potion (1kg) was used for proximate and nutritional analysis while the second portion (4kg) was used for oil extraction.

2.4 Oil extraction

"The method employed was that of solvent extraction with the Soxhlet extractor apparatus as described by AOAC"[13]."A 250 ml Soxhlet extractor apparatus and hexane was used as the solvent. A mass of 30 g of yellow mulberry seeds powder was weighed into a muslin cloth which was placed in a Soxhlet apparatus thimble. A round bottom flask containing 250 ml of hexane was placed to the end of the apparatus and a condenser, tightly fixed at the bottom of the extractor. The set up was heated up in a water bath at a temperature of 60 ^{0}C. The excess solvent in the oil was recycled by heating in a heating mantle at a temperature of 60 ^{0}C after the extraction. Quantity of oil extracted was determined gravimetrically". [13] The oil yield was then evaluated as the ratio of the weight of the extracted seed oil to the weight of seed powder sample. Oil yield was calculated as;

$$\% \text{ Oil yield} = \frac{Weight\ in\ gram\ of\ extracted\ \ oil}{Weight\ in\ gram\ of\ extracted\ \ seed\ powder\ \ sample}$$

Figure 1: Photos showing sample preparation of *Myrianthusarboreus* pulp, seeds and oils
A = a typical giant yellow mulberry tree with fruits, **B** = fresh giant yellow mulberry fruit, **C** = ripe fruits with seeds, **D** = fresh decorticated seeds, **E** = oven dried seeds, **F** = powdered seeds prior to oil extraction, **G** = Extracted oil, **H** = defatted flour.

2.5 Chemical Composition of the pulps and seeds

2.5.1 Proximate Analyses

Nutrient composition of the samples was determined using the standard procedures as described by AOAC[13]. To determine the moisture, the samples were dried to a constant weight in a vacuum oven at 100°C for 24 h. Protein (N × 6.25) was determined by the Kjeldahl method. Crude lipid was quantified gravimetrically and calculated as percentage of oil using soxhlet extractor. Ash was determined by incineration (550°C) of known weights of the samples in a muffle furnacefor 24 h. Crude fiber content of the samples were determined by mixing of the fine powder of the sample with 1.25% sulfuric acid and 1.25% sodium hydroxide solutions under specific conditions for ignition and dried residue remaining after digestion of the samples was considered as crude fiber.The results for the proximate analysis were presented on dry matter basis.Digestible carbohydratecontent was determined by difference using the formula;

% Digestible carbohydrate = 100 – (% crudeprotein + % crudefat + % crude fibre + % Ash + %Moisture).

2.5.2 β-carotene/Vitamin A analysis

"The β-carotene was determined by soaking 1 g of the sample (that is the paste or pulp of the fresh fruits) in 5 ml of methanol for 2 h at room temperature under dark condition in order to get a complete extraction. The β-carotene layer was separated using hexane through separating funnel. The volume was made up to 10 ml with hexane and then this layer was again passed through sodium sulphonate through a funnel in order to remove any moisture from the layer. The absorbance of the layer was measured at 436 nm using hexane as a blank"[14]. The beta carotene was calculated using the following formula:

Beta-carotene (µg/100g) = Absorbance (436 nm) x V x D x100 x 100/W x Y.

Where: V = Total volume of extract; D = Dilution factor; W= Sample weight; Y = Percentage dry matter content of the sample.

Vitamin A determination was calculated using 1 µg retinol = 1 RE method used. Variation

1 µg β-carotene = 0.167 µg RE.

2.5.3 Determination of vitamin C content

Vitamin C was determined by the titration method using the protocol described by Harris and Ray[15]. A volume of 1 mL of the oil and 90% acetic acid was titrated with a solution of 50 µM DCIP. The endpoint titration was determined when the blue colour changes to a pale pink colour. A blank titration was performed against 90% acetic acid while a standard titration was performed against 40 mg/L pure L-ascorbic acid. The amount of Vitamin C was expressed in mg/100ml of sample.

2.5.4 Mineral Determination

Minerals were assayed by atomic absorption spectroscopy [13]. The principle is based on the fact that when atoms of an element are in contact with a flame, they emit wavelengths of radiation whose intensity can be measured spectrophotometrically. The concentration of the cation to be determined was calculated from the absorbance values by linear regression equations. Hollow cathode lamps of the different metals were used as radiation sources for the instrument. The instruction manual of the instrument was used as guide for all measurements. Calibration standards were first aspirated into the AAS to calibrate the instrument and check its linearity response. After all necessary set up, standardization and calibration procedures had been completed then the powdered samples were aspirated into the AAS instrument for precise measurement of metal concentration. The minerals determined were Potassium, Sodium, Magnesium, Calcium, Iron, Phosphorus and Zinc.

2.6 Anti-nutritional factors of pulp and seed flour

2.6.1 Determination of Total Phenolics Content (TPC).

The total phenolics content of the pulp and seed was determined using the Folin-Ciocalteu colorimetric method described by Chlopickaet al. [16].

2.6.2 Estimation of tannins content

The content of Tannins was estimated by the Vanillin-HCl method of Price et al. [17]. Defatted *M. arboreus* flour and pulp flour (5g) were treated with acidic methanol for extraction of tannins. From the diluted extract, 1 ml was mixed with 5 ml of freshly prepared vanillin-HCl reagent, and the optical density was determined at 500 nm by using a spectrophotometer. The results were expressed mg/100 g dm using catechin as standard.

2.6.3 Determination of phytates content

Phytates content was determined according to Wheeler & Ferrel. [18]. The amount of phytate phosphorus content was calculated from the standard curve by assuming that 4:6 iron-to-phosphorus molar ratio.

2.6.4 Determination of oxalates content

"To determine oxalates content in *M. arboreus* seed flour and pulp, 2 g of flour were extracted with 100 ml of boiling distilled water for 30 min, filtered, and adjusted to 200 ml. The hot water extract residue was further extracted with 150 ml of boiling 1 M HCl for 30 min, adjusted to 200 ml, and filtered. The two filtrates were combined and titrated with potassium permanganate"[13].

2.7 Determination of Fatty acids profile

The fatty acid composition was determined by conversion of oil to fatty acid methyl esters prepared by adding 950µl of n-hexane to 50mg of oil followed by 50µl of sodium methoxide using the method of Liuet al*.* [19]. The mixtures were vortexed for 5s and allowed to settle for 5 min. 1µl of the top layer was injected into a gas chromatograph (Model GC-14A, Shimadzu Corporation, Kyoto, Japan) equipped with a flame-ionisation detector and a polar capillary column (B PX 70 0 .25), 0.32 mm internal diameter, 60m length and 0.25µm film thickness (SGE Incorporated, USA) to obtain individual peaks of fatty acid methyl esters. The detector temperature was 240°C and column temperature was 110°C held for one minute and increased at the rate of 8ºC.min-1 to 220 ºC and held for one minute. The run time was 32 min. The fatty acid Methyl ester peaks were identified by comparing their retention time with those of standards. Percent relative fatty acid was calculated based on the peak area of a fatty acid species to the total peak area of all the fatty acids in the oil sample.

Fatty acid profiling (ΣSFA, ΣMUFA, ΣUFA, ΣPUFa, Σ*n*-3/*n*-6 ratio, Σ omega-3, Σomega-6**,** ΣPUFA/Σ*SFA* ratio was done by summing different classes of fatty acid and the atherogenicity index (AI) and thrombogenicity index (TI) were calculated according to Ulbricht & Southgate [20]as;

$$AI = \frac{[(C12{:}0+(4\times C14{:}0)+C16{:}0)]}{(\sum MUFA+\sum \omega 6+\sum \omega 3)}$$

$$TI = \frac{(C14{:}0+C16{:}0+C18{:}0)}{[(0.5\times\sum AGMI)+(0{,}5\times\sum \omega 6+(3\times\sum \omega 3)+(\sum \omega 3/\sum \omega 6)]}$$

The ratio of hypocholesterolemic and hypercholesterolemic (H/H) by the method of Santos-Silva et al. [21] as;

$$H/H = \frac{(C18{:}1cis9 + C18{:}2\omega6 + 20{:}4\omega6 + C18{:}3\omega3 + C20{:}5\omega3 + C22{:}5\omega3 + C22{:}6\omega3)}{(C14{:}0 + C16{:}0)}$$

2.8 Determination of physicochemical properties of oil

Evaluation of *Myrianthusarboreus* seed oil was done by measuring the following parameters: free fatty acid, iodine, peroxide, saponification, P-anisidine and TOTOX values. These parameters were measured using standard methods of AFNOR [22].

2.8.1 Free fatty acid

One gram of the oil sample was weighed into a 250-ml Erlenmeyer flask and 12ml of ethanol added. Five drops of phenolphthalein indicator was added and the mixture shaken to dissolve the sample completely. The mixture was titrated with 0.05N KOH, shaking vigorously until a slight pink colour that persisted for 30s. The free fatty acid value was calculated using the following formula:

$$\%FFA \text{ (as oleic)} = \frac{(V \times N \times 282)}{W \times 100}$$

Where;

% FFA = Percent free fatty acid (g/100 g), expressed as oleic acid

V = Volume of KOH titrant (mL)

N = Normality of KOH titrant (mol/1,000 mL)

282 = Molecular Weight of oleic acid (g/mol)

W = sample mass (g)

2.8.2 Peroxide value

Peroxide value is the number of mg of active peroxides in 1g of oil that reacts with KI with the liberation of I_2. 1g of the oil sample was weighed into two 250ml glass-stoppered Erlenmeyer flasks and 5ml acetic acid-chloroform solution (3:2) added and swirled to dissolve. 0.5ml of saturated potassium iodide solution was added and allowed standing with occasional shaking for 1 min followed by addition of 10ml distilled water. 0.5ml of 1% starch solution was added and the samples were slowly titrated with 0.01N sodium thiosulfate solution, with vigorous shaking to release all iodine from chloroform layer, until blue color just disappears. The volume of titrant used was recorded. (If <0.5ml of the sodium thiosulfate solution is used, repeat determination). A blank sample was prepared and titrated and the volume of the titrant recorded.

$$\text{Peroxide value} = \frac{((S-B) \times N)}{W \times 1000}$$

Where:

Peroxide value = mEq peroxide per kg of sample,

S = volume of titrant (ml) for sample,

B = volume of titrant (ml) for blank,

N = normality of $Na_2S_2O_3$ solution (mEq/ml),

1000 = conversion of units (g/kg)

2.8.3 Iodine value

The Iodine value of a fatty substance is the amount of iodine, in grams, that is taken up by 100 grams of the oil under the conditions of the experiment [23]. 0.1g of oil sample was weighed in a beaker and 4ml of carbon tetrachloride (CCl_4) was added. The mixture was shaken for homogeneity and 4ml of wijz reagent added and the mixture stored in the dark for 10 minutes, followed by the addition of 5ml of a 10% potassium iodide solution and 4ml of distilled water. This mixture was carefully titrated with a 0.01N sodium thiosulphate. Iodine value was derived using the formula;

$$IV = \frac{(Vi - Vo)}{m \; x \; 126.9 \; x \; C}$$

Where;

IV = Iodine value

Vi = Volume of sample

Vo = volume of blank

m = Mass of oil

C = Concentration of sodium thiosulphate

126.9 = Molecular weight of iodine in g/mol

2.8.4 Saponification value

Saponification value provides information of the average molecular weight of all fatty acids present in the oil. It will show the amount of long chain fatty acids in the oil. 1g of oil sample was weighed into a 250-ml Erlenmeyer flask and 12ml of ethanol added. Five drops of phenolphthalein indicator was added and the mixture shaken to dissolve the sample completely. The mixture was titrated with 0.5N KOH, shaking vigorously until the endpoint is reached. The endpoint was indicated by a slight pink color that persisted for 30s. The free fatty acid value was calculated using the following formula:

$$SV = \frac{(Vo - Vs) \; xCHCLx \; 56.1)}{m}$$

Where:

SV= Saponification value

Vo= Volume of blank

Vs= Volume of sample

CHCL= concentration of HCL

m= Mass of oil

56.1 =Molecular weight of KOH in mg/mol

2.8.5 P-anisidine value (AV)

Anisidine value was determined by the standard method of the American Oil Chemists' Society Cd 18-90 (p-anisidine value) using a Perkin Elmer UV-Visible Spectrophotometer. In accordance with the method, 0.5-1 g of oil sample was weighed into a 25 mL volumetric flask. The sample was dissolved and diluted to 25 mL of volume with isooctane. Then the absorbance of the solution (Ab) was measured in a cuvette at 350 nm with the spectrophotometer, using the reference cuvette filled with isooctane solvent as a blank. After the measurement of absorbance, 5 ml of this solution and 5 ml of isooctane was transferred into 2 different tests tubes and 1 ml of 0.25% acetic acid solution of p-anisidine was added and the mixtures shaken on a vortex. After exactly 10 minutes of incubation at room temperature, the absorbance (As) of the solution containing sample was read at 350 nm, using the second solution as blank. P-anisidine value was calculated as followed:

$$P - An = \frac{25(1.2As - Ab)}{m}$$

Where:

As is the absorbance of test solution after reaction with the p-anisidine reagent;

Ab is the absorbance of the fat solution; m is the sample weight.

2.8.6 Total Oxidation (TOTOX) value

A scientist, Holmin 1972, suggested a combined expression of peroxides and secondary oxidation products, and therefore developed the concept TOTOX value. Together this established a value of the total oxidation status in oil [24]. TOTOX value of the oil sample was determined based on the obtained peroxide and P-Anisidine values using the formula;

$$TOTOX = 2PV + AV$$

2.9 Statistical Analysis

The mean and standard error of means (SEM) of the triplicate analyses of the samples were calculated. The data obtained was subjected to the complete randomized design (CRD) analysis which was used to compare the nutritional and antinutritional content between the pulps through the use of the two way analysis of variance (ANOVA) to determine significant differences followed by turkey multiple comparison test to compare the means. The statistical significance was set at $P < 0.05$.

3. RESULTS AND DISCUSSION

3.1.1 *Chemical Composition of pulp and seed of Myrianthusarboreus fruit*

Table 1 shows the chemical characterization of *Myrianthusarboreus* pulp and seed in percentages. The moisture content of the pulp and seed were 84.48% and 12.69% respectively. Crude protein, crude fat, total ash, total fiber and total carbohydrate were 17.22%, 6.10%, 1.04%, 70.60% and

73.63% respectively for pulp, and 24.40%, 42.05%, 3.65%, 1.50% and 29.56% respectively for seed. The pulp recorded 143.95 kcal of energy, and that for the seed was 589.67 Kcal.

Table 1: Proximate Composition of Pulp and Seed.

Proximate composition (% DM)	Pulp	Seed
Moisture	84.48 ± 0.32[a]	12.69 ± 2.12[b]
Crude protein	17.22 ± 1.28[b]	24.40 ± 2.12[b]
Crude fat	6.10 ± 2.74[c]	42.05 ± 1.28[a]
Total ash	1.04 ± 1.83[c]	3.65 ± 0.82[c]
Total fiber	70.60 ± 0.45[a]	1.50 ± 059[c]
Digestible carbohydrate	5.03 ± 0.90[c]	28.06 ± 0.01[b]
Total carbohydrate	75.63 ± 1.81[a]	29.56 ± 0.06[b]
Energy value (Kcal/100g)	143.95 ± 2.75[a]	589.67 ± 2.80[b]

**Values with different letters on a row are significant at P < 0.05; Mean ± S.E.M = Mean values ± Standard error of means of three experiments*

The moisture content obtained from the pulp (84.48%) is significantly higher than that obtained for the seed (12.69%). This result is high when compared to 6.23±0.09% of Malaysian-grown tropical almond nuts [25] and 9.88% of *Lepidiumsativium* seed collected in morocco [26]. However, for the pulp, the moisture content was found to be 84.48%. This results are similar to 91.1% and 89.23% from *Myrianthusarboreus* pulp harvested from Belabo and Doume in Eastern Cameroon respectively[27]. The moisture content has an effect on the shelf life, texture and taste of a food product. The lower moisture content in the seed implies it has a longer life span whereas the pulp like most fruit pulps with high moisture content, cannot be kept for long unless if well preserved.

Proteins play a major role in our body due to their many metabolic and regulatory functions in biochemical processes. The results obtained for the protein content of *Myrianthusarboreus* pulp 17.22% was lower than that of the seeds 24.72%. These results are similar to those of Edmond et *al.*[28] who showed that *M. arboreus* fruit harvested in Cote D'Ivoire had a protein content of 13.62% and 25.38% for the pulp and seeds respectively. This CP content (24.72%) in seeds is higher than that of cereals [29] but lower than 39.24% obtained for soya beans [30]. The pulp content (13.62%) was similar with the CP (18.35%) content of jack fruit pulps [31], lower than 19.74 % and 20.96% obtained for *Myrianthusarboreus* pulp from Belabo and Doume localities in East Cameroon respectively [27] and also close to those of Ene-Obong et al.[32]who showed that *M. arboreus* fruit pulp harvested in Nigeria had a protein content of 18.74%. These differences could be attributed to different climatic conditions, and soil composition of the various study sites.

The fat content is significantly greater in the seeds (42.05%) than in the pulps (6.10%). This value is very similar to the 6% recorded for *M. arboreus* pulp from Doume, lower than that harvested from Belabo in Eastern Cameroon [27] and higher than 2.28% obtained for pulps from Ivory Coast [33]. The value obtained for the seeds in this study is greater than 30.31% in soya bean obtained by Bayeroet al.[30] and 13.30% obtained from cotton seeds by Bosede&Efomah[34]and lower than 52.11% for Indian almond nuts reported by Barkuet al.[35]. These results in line with other reports on *M. arboreus* seeds, affirms it as an oilseed with a rich source of fats, a good oil source which could be used as an alternative edible oil for cooking and for industrial applications.

The ash content gives an indication of the mineral content. This study observed a slight difference in the ash content between the seeds (3.65%) and the pulps (1.04%). This suggests that the mineral content of the seeds is higher than that of the pulps. Similar results (3.78%) were obtained for *Terminalia catappa* seeds [25]. However these values were higher compared to those obtained for *Myrianthusarboreus* fruits from Cote D'Ivoire which recorded 0.66% and 2.27% for pulp and seeds respectively [33].

Fiber is important in the diet as its aids in digestion by increasing peristalsis in the small intestines. The fiber content of the pulps obtained in this study is very high compared to the values obtained in a previous study [27]. Studies have shown that a diet low in fiber is undesirable as it could cause constipation and that such diets have been associated with diseases of the colon. The value for the seeds was higher than the crude fiber obtained for almond nuts [36] and lower than that obtained for most legumes like cashew nuts [37] and soya beans [30] which were of the range 5-7%.The carbohydrate values obtained in this study were in close range to values obtained for *Myrianthusarboreus* in a previous study, which recorded 70.58% and 17.54% for pulp and seeds respectively [28] but was higher than values for pulps from Doume 42.28% and Belabo 42.4% [27]. Carbohydrates are responsible for the sweetness of the nectar from the fruit and they give the fruit a sweet taste and pleasant aroma. The high content in the pulps could facilitate the transformation of *M. arboreus* into food products such as: jams, syrups, chips and juices.

The caloric value of the seeds was significantly greater than that of the pulps. This justifies the greater proportion of energy sources like fat, carbohydrates and proteins found in the seeds. The energy value of the pulps is lower compare to (339.7 Kcal/100g) obtained[27] on *Myrianthusarboreus* pulps from Doume East region of Cameroon and *Myrianthusarboreus* pulps powder (168 Kcal/100g) obtained by Due et al.[33]. All these differences can be attributed to the differences in temperature, humidity, soil composition and climatic conditions from one study area to another. However, the general trend indicates a high energy value of *Myrianthusarboreus* seeds.

3.1.2 Vitamin Analyses of pulp and seedof pulp and seed of *M. arboreus* fruit

Table 2 below shows the vitamin A and C contents of the pulp and seed of *Myrianthusarboreus*fruit. The pulp recorded 237.95 mg/100g for vitamin A and 1098.04 mg/100g for vitamin C while vitamin A content was 435 mg/100g and Vitamin C was 796.5 mg/100g for the seed.

Table 2: Vitamin Analyses of pulp and Seed

Vitamin (mg/100g)	Pulp	Seed
Vitamin A	237.95 ± 0.002^{a}	435 ± 7.07^{b}
Vitamin C	1098.04 ± 1.32^{b}	796.5 ± 6.37^{a}

** Values with different letters on a row are significant at P < 0.05; Mean ± S.E.M = Mean values ± Standard error of means of three experiments*

Vitamins are required by the body to performs functions such as boosting the immune system, regulating hormones, and aids in the prevention of deficiency diseases. The vitamin composition of the pulps revealed that Vitamin C with 1098.04 mg/100g had the highest concentration, followed by Vitamin A 237.95 mg/100g. Vitamin C concentration was greater than 228 mg/100g and 257 mg/100g obtained from cashew (*Anacardium occidentale*) and guava apple (*Hibrido de psidiumguajava*) pulps respectively [38]. However, in the seeds, Vitamin C and Vitamin A concentrations were 796.5 mg/100g and 435 mg/100g respectively. These values are higher when compared to 2.18 mg/100g and 38.20 mg/100g for Vitamin A and Vitamin C respectively on fresh*Myrianthusarboreus* fruits from Nigeria [32]. The relatively high Vitamin C and Vitamin A contents in the pulp and seeds obtained in this study suggests that its consumption can provide sufficient amount of Vitamin C and β-carotene which can be particularly beneficial for individuals with both vitamin deficiencies or are at risk of developing one.

3.1.3Mineral Analyses of pulp and seed of *M. arboreus* fruit

Fig 2 below presents the mineral composition for the pulp and seed of *M. arboreus* fruit. The composition of P, K, Mg, Ca, Zn, Na and Fe were 237.95 mg/100g, 1098.04 mg/100g, 53.46 mg/100g, 624 mg/100g, 0 mg/100g, 117.07 mg/100g and 5.01 mg/100g respectively for the pulps, while for the seeds, the values obtained were 435 mg/100g, 796.5 mg/100g, 980 mg/100g, 27.05 mg/100g, 7.81 mg/100g, 3.75 mg/100g and 445 mg/100g respectively.

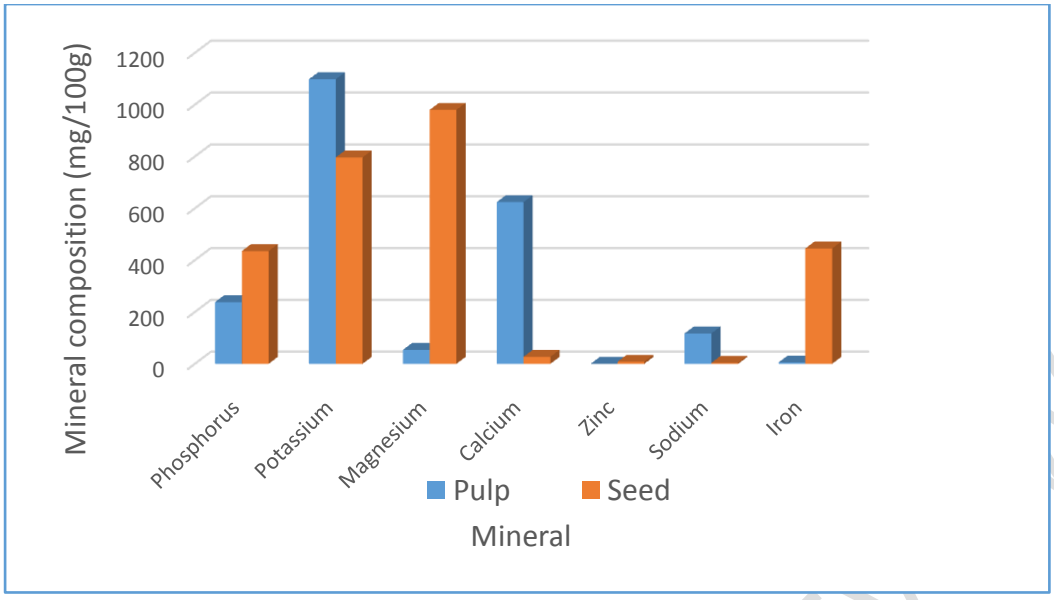

Fig. 2.Mineral Analyses of pulp and seed of *M. arboreus* fruit
Mean ± S.E.M = Mean values ± Standard error of means of three experiments

Minerals are vital components of food and they fulfil a wide variety of functions in the body including regulation of body processes. The mineral analysis of *M. arboreus* almonds and pulps (Fig 2) indicated that sodium (Na), iron (Fe), calcium (Ca), magnesium (Mg), phosphorous (P), potassium (K) and zinc (Zn) were present in appreciable amounts. The most abundant minerals present in the pulps were K, Ca, P, and Na while the least abundant were Mg and Fe, no Zn was detected in the pulps. On the other hand, the most abundant minerals in the seeds were Mg, K, Fe and P while Ca, Zn and Na were the least abundant amongst the minerals analyzed. All the mineral elements present in this study were found to be higher than those of cashew nuts, almond nuts and *M. arboreus* from previous studies [35-40].

Potassium is the key mineral required in the body for cellular functions due to its significant function of controlling the volume of fluid within a cell: therefore, an increase intake of K can help relax blood vessels and promote the excretion of salts of the body hence decreasing blood pressure. The mineral analysis for this study revealed that K was the most abundant mineral present in the pulp (1098.04 mg/100g) of *M. arboreus* and the second most abundant in the seeds (796.5 mg/100g). The very high content of K in the seeds and pulp suggests that *Myrianthusarboreus* fruit pulp and seeds are suitable for consumption by hypertensive people. Mg was found to be highest mineral component in the seeds. Magnesium is important in its role as an activator of many enzymes systems and maintains the electrical potential in nerves. *Myrianthusarboreus* pulp and seeds contains large amounts of magnesium and an adequate serving would satisfy the Recommended Daily Allowance (RDA) for Mg.These results were in line with results obtained by Edmond et al.[28] who found out that Potassium was the most important mineral found in the pulps while that for the seeds was Magnesium. However, the values for potassium (123.42 to 422.62 mg/100g) and Magnesium (86.26 to 340.58 mg/100g) obtained in this study was higher compared than those obtained in the aforementioned study.

Calcium plays a role as a secondary messenger helping in muscle contraction, heartbeat, blood clotting and nerve function. Calcium was found to be present at significant levels in the pulp and also relatively high in the seeds. WHO/FAO recommends an intake of 400–500 mg per day of calcium for adults and hence a serving of about 100g of *Myrianthusarboreus* pulp can supply an adult's daily calcium need. An implication that the consumption of *M. arboreus* fruit can supplement other sources of dietary calcium especially when consumed mainly as snack. Phosphorus together with calcium in the body contributes in controlling body fluids and its presence in the body as phosphates salt in

bones indicates that it would serve as good source of mineral for bone formation.The values for Calcium and phosphorus obtained for the pulp in this study was lower than that obhtained for *Myrianthusarboreus* harvested from two localities of the East regions of Cameroon (Belabo and Doume) which recoreded values of 124-276 mg/100g) for *Myrianthusarboreus* pulp [27].

Sodium is vital in maintaining the body fluid volume, osmotic equilibrium and acid-base balance and it constitutes 2 % of the total mineral content of the body. The results shows that sodium content was considerably higher in the fruit pulp than in the seeds. This suggests that, a significant consumption of *M. arboreus* pulp will provide the RDA of sodium. Similarly, Edmond et al.[28] found out that the mineral content of *Myrianthusarboreus* almond powder harvested from Cote D'Ivoire were statistically above the 5% threshold of the fruit pulp powder.

Iron is a constituent of hemoglobin, myoglobin, and a number of enzymes, which catalyzes oxidation, and reduction processes in the cell. A deficiency of iron in the diet could lead to anaemia. The results shows the iron content in the seeds was higher than that for the pulps. The high iron content in the seeds and the relatively good level in the pulps makes *Myrianthusarboreus* seeds and pulp a good source of Iron. The values for Iron were very high when compared to values obtained in previous studies done on *Myrianthusholistii* where the concentration of Iron in the pulp was 16.262 mg/100g. However, this value was stated to be exceptionally high because it is able to meet 163% and 90% of the RDA for iron for 4-8 years and 90% in female adults respectively[12].

Zinc acts as a cofactor for many enzymes in vital biochemical metabolic processes such as DNA and protein synthesis. However, an excessive high Zn content in plant based foods can affect the absorption and metabolism of other minerals like Ca, Mg, P and Fe. It may disrupt the balance of these minerals in the body, potentially leading to imbalances or deficiencies. The Zn content obtained in this study is very less when compared to other elements as this metal element was not found in the pulp but a comparative low amount was found in the seeds.These results were in line with results obtained in previous studies where the Zinc concentration of *Myrianthusarboreus* pulp was lower (2.9 mg/100g) than that of the almonds (10.44 mg/100g)[28].

3.1.4 Antinutrients Composition of pulp and seed of *Myrianthusarboreus*fruit

Theantinutritional components of *M. arboreus* fruit pulp and seed are summarized on Table 3. The results show Total phenolic content of pulp and seed to be 1113.71 mg/100g and 355.71 mg/100g respectively. Phytate, oxalates and tannins contents were 14.09 mg/100g, 30.54 mg/100g and 15.45 mg/100g respectively for pulps while for seeds the values were 20.81 mg/100g, 70.79 mg/100g and 24.53 mg/100g respectively.

Table 3: Antinutrients Composition of pulp and seed

Antinutrients (mg/100g)	Pulp	Seeds
TPC	1113.70 ± 0.15^{a}	355.71 ± 0.05^{b}
Phytate	14.09 ± 0.28^{b}	20.81 ± 0.06^{a}
Oxalate	30.54 ± 0.02^{c}	70.79 ± 0.01^{b}
Tannin	15.45 ± 0.13^{b}	24.53 ± 0.07^{a}

** Values with different letters on a row are significant at P < 0.05; Mean ± S.E.M = Mean values ± Standard error of means of three experiments*

The content of antinutrients gives an idea about the bioavailability of the constituent elements of the pulp and the seeds of *Myrianthusarboreus*. The total phenolic content (TPC) gives an indication of the antioxidant activity of the sample. The major components are polyphenols, which have anti-inflammatory properties. The TPC of almonds and pulps of *Myrianthusarboreus* fruit was 1113.70 mg/100g and 355.71 mg/100g respectively. Similar results were obtained for *M. arboreus* pulps and seeds [33]. Polyphenols are beneficial in that they have antioxidant potentials, there by protect the body's cells from damaged caused by harmful free radicals. However, their effectiveness and benefits

depends on the specific polyphenol compounds and the concentration found in foods. The high value of TPC recorded in this study suggests that, consuming *Myrianthusarboreus* fruits with their seeds will make available a substantial amount of beneficial phenolic compounds in the body.

Phytate at higher concentration >5% are detrimental as they prevent the absorption of minerals such as Mg, Ca and Fe which are important for many biochemical processes. The phytate content in this study recorded 14.09 mg/100g for pulp and 20.81 mg/100g for seeds. These results were very close to values obtained for *Myrianthusarboreus* pulps and seeds in previous studies [27,28]. Oxalates had the highest concentration of 30.54 mg/100g and 70.79 mg/100g for both pulps and seeds respectively, Eating large amount of food high in oxalate is dangerous. That is, oxalate crystals accumulate at the kidney causing kidney stones and renal failure especially in enteric hyperoxaluria patient. This result is far lower than results obtained in a previous study, which recorded 54.38 mg/100g and 260.7 mg/100g for *M. arboreus* pulp and seeds respectively, harvested in Ivory Coast [33]. However, the oxalate content in this study was higher than the ones harvested in Eastern Cameroon [27] but far lower than values obtained for Jackfruit from Eastern Cameroon [27].

The tannin content in the pulp was 15.45 mg/100g while that for the seeds was 24.53 mg/100g. These values were in close agreement to values obtained by Due et al.[33] but higher when compared to values obtained for pulps by Bemmo*et al.*[27] but lower than those obtained for tropical almond seeds by Akpakpan&Akpabio[41]. Tannins are known to interfere with the absorption of some minerals like Fe and Zn by forming insoluble complexes that can precipitate, making them difficult for the body to break them down and absorb thereby reducing bioavailability of these essential minerals. And making them less accessible for absorption. The result recorded for tannins, oxalates, and phytates showed that these antinutrients were found to be within the recommended level (2-5%) as reported by Tijjani[42]. Although, the concentration is within the acceptable range, care should to be taken during consumption and food formulation.

3.1.5 Fatty Acid profile of *Myrianthsuarboreus* seed oil

Table 4 shows the fatty acid profile of the *Myrianthusarboreus* seed oil. The major unsaturated fatty acids present in the oil were Oleic acid (34.87%) and Linoleic acid (8.93%) while the major saturated were Lauric (25.02%), Caprylic acid (5.50%), Stearic (4.76%), Capric (4.43%) and Palmitic (2.06%) acids. Total saturated fatty acids account for 45.06% while total unsaturated fatty acids recorded 54.94% of the total seed fatty acids and 46.01% of these are monounsaturated while 8.93% are polyunsaturated.

The major unsaturated fatty acids present in the oil were Oleic acid (34.87%) and Linoleic acid (8.93%) while the major saturated were Lauric (25.02%), Caprylic acid (5.50%), Stearic (4.76%), Capric (4.43%) and palmitic (2.06%) acids. Total saturated fatty acids account for 45.06% while total unsaturated fatty acids recorded 54.94% of the total seed fatty acids and 46.01% of these are monounsaturated while 8.93% are polyunsaturated. Linoleic acid, an omega 6 fatty acid, have been known to prevent high blood pressure and serves as a structural component of the plasma membrane. Oleic acid is one of the most important unsaturated fatty acids in human food because of its antioxidant, antibacterial and anti-inflammatory properties. The high percentage of unsaturated fatty acid (54.94%) in *Myrianthusarboreus* seed oil is an indication that this oil can help reduce the risk of heart disease, lower bad cholesterol and improve overall cardiovascular health. These results revealed that Cameroonian's *Myrianthusarboreus* seeds oils were in agreement with all other studies *Myrianthusarboreus* studies whichwere rich in linoleic acid (over 80%) and very low in linolenic and oleic acid (0.5-1.5%)[11, 27-28].

The percentage of UFA/SFA was 0.82. A UFA/SFA ratio of 0.2 has been associated with high cholesterol levels and with high risk of coronary heart disorders, while a ratio as high as 0.8 is associated with desirable levels of cholesterol and reduced coronary heart diseases [43]. This indicates that the oil may have a cholesterol-lowering potential tends to suggest that this seed has the potential to be used in the dietetic management of certain coronary heart diseases. PUFA/SFA is an

indicator used to evaluate lipid quality. It is recommended by the British Department of Health that the minimum value is 0.45 [44].The levels recorded for this study was less than 0.45, indicating that the oil may not be of good quality.

Table 4: Fatty Acids of *Myrianthusarboreus* seed oil

Fatty Acids	Common Name	IUPAC (Systematic name)	(%)
C8:0	Caprylic acid	Octanoic acid	4.43
C10:0	Capric acid	Decanoic acid	5.50
C12:0	Lauric acid	Dodecanoic acid	25.02
C14:0	Myristic acid	Tetradecanoic acid	0.18
C15:0	Pentadecanoic acid	Pentadecanoic acid	0.18
C15:1	Pentadecenoic acid	14-Pentadecenoic acid	8.93
C16:0	Palmitic acid	Hexadecanoic acid	2.06
C16:1 (9)	Palmitoleic acid	Hexadecenoic acid	2.21
C18:0	Stearic acid	Octadecanoic acid	4.76
C18:1(9)	Oleic acid	Octadecenoic acid	34.87
C18:2(9,12)	Linoleic acid	Octadecadienoic acid	8.93
C18:3(9,12.15)	Linolenic acid	Octadecadienoic acid	0.00
C20:0	Arachidic acid	Eicosanoic acid	2.92
ΣSFA	Saturated Fatty acids		45.06
ΣMUFA	Monounsaturated fatty acids		46.01
ΣUFA	Unsaturated fatty acids		54.94
ΣPUFA	Polyunsaturated Fatty acids		8.93
Σ(ω-6)	Omega-6		8.93
UFA/SFA	unsaturated/saturated ratio		0.82
PUFA/SFA	polyunsaturated/saturated ratio		0.20
AI	Atherogenicity Index		0.51
TI	Thrombogenicity index		0.25
H/H	Hypocholesterolemic/ hypercholesterolemic ratio		19.52

**Values with different letters on a row are significant at P < 0.05; Mean ± S.E.M = Mean values ± Standard error of means of three experiments.*

**Atherogenicity Index (AI), Thrombogenicity index (TI), Hypocholesterolemic/ hypercholesterolemic ratio (H/H), saturated fatty acid (SFA), unsaturated fatty acid (UFA), monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), omega-6 (ω-6)*

The atherogenicity index (AI) and thrombogenecity index (TI) are proposed to evaluate risky factors that are implicated in coronary heart disease development [42-44]. Lower values of AI and TI suggests that an oil might be beneficial to cardiovascular health. The AI value (0.51) was relatively high when compared to the so-called Eskimo diet (0.28). The TI value (0.25) obtained was low which indicates a very low incidence of coronary heart disease [21]. The very high ratio of the Hypocholesterolemic/ hypercholesterolemic (19.52) suggests a relatively greater hypocholesterolemic potential of the oil.

3.1.6 Physicochemical properties of *Myrianthusarboreus* seed oil

Table 5 shows the results for the oil quality indices of oil extracted from the seeds of *M. arboreus*seeds. These indices were determined in order to know the safety of the oil for consumption. The acid value, free fatty acid, saponification value, iodine value, peroxide value, P-anisidine value and total oxidation value obtained all fell within the recommended Codex Alimentarius commission range for safety.

Table 5: Physicochemical properties of *Myrianthusarboreus* seed oil

Oil quality parameters	*Myrianthusarboreus*	*Codex standard*
Acid index (mgKOH/g)	5.61 ± 0.39	≤ 4.0
Free Fatty Acid (mgKOH/g)	2.82 ± 0.19	1.5
Saponification value(mgKOH/g)	196.62 ± 0.38	188-194
Iodine value (g/100g)	171.45 ± 2.99	104-120
Peroxide value (meq/kg)	2 .04 ± 0.72	≤ 15
P-anisdine value	3.80 ± 0.11	≤ 20
Totox value	7.88 ± 1.55	≤40

**Values with different letters on a row are significant at P < 0.05; Mean ± S.E.M = Mean values ± Standard error of means of three experiments*

The acid value gives an indication of the total amount of free fatty acid in the oil due to enzymatic activity. It is used to evaluate the acidity of an oil which sometimes reflects its degree of oxidation. Its maximum acceptable level in refined oils is 0.6 mgKOH/g oil, while for cold pressed and virgin oils it is 4.0mgKOH/g oil [43].The result showed an acid index of 5.61 mgKOH/g and free fatty acid value of 2.82 mgKOH/g. these values are slightly higher than the recommended codex of a maximum acid value of 4.0 mg KOH/g for virgin oils. Free fatty acid is very important in determining the use of oil for industrial or edibility purposes. The value obtained is within the allowable limit for edible oils (0-3) [36]. The oil could therefore be used as edible oil. Low acid value in oil indicates that the oil will be stable over a long period of time and protect against rancidity and peroxidation. This value was higher compared to 0.35 mgKOH/g for soyabeans oil, 0.85 mgKOH/g groundnut oil, 0.48 mgKOH/g olive oil, 1.34 mgKOH/g sesame oil and 2.67 mgKOH/g palm oil [45]. Since the acid value and FFA value obtained for this study is slightly higher than the maximum permissible acid level of 4mgKOH/g fat or oil required for edible virgin fats and oils, this *M. arboreus* seed oil is suitable for consumption after undergoing some refining processes to improve its quality for industrial purposes.

Saponification value is a measure of oxidation during storage, and also indicates deterioration of the oils. An increase in saponification value in oil increases the volatility of the oils. It enhances the quality of the oil because it shows the presence of lower molecular weight components [46]. It has been reported by Pearson [47] that oils with high saponification values contain high proportion of lower fatty acids. High values normally over 200 are obtained with fats and hydrogenated oils, while oils tend to have values below 195. The saponification value obtained in this study was 196.62mgKOH/g. Kyari, [48] reported that SV for palm oil is 200 (mgKOH/g sample), for groundnut is 193 (mg KOH/g sample) and for coconut oil is 257 (mg KOH/g sample). However this result is higher than 148.3 mgKOH/g obtained by Tia & Digbeu[49] on dried *Myrianthusarboreus* seeds, similar to 195 mgKOH/g obtained on soybeans and less than 212.9 mgKOH/g of *Treculiaafricana* seeds and 246 mgKOH/g *Cocos nucifera* seeds [50]. Since high saponification values of fats and oils are due to the predominantly high proportion of shorter carbon chain lengths of the fatty acids [51]suggests low level of impurities and that the oil may be useful industrially for soap, shampoo and paints production [52-53]. Variation in oil quality values is determined by several physical and chemical parameters that are dependent on source of oil, processing and storage conditions [54].

The iodine value of oils measures the degree of unsaturation of a particular vegetable oil. Previous studies have shown that the greater the degree of unsaturation, the higher the iodine value and the greater the possibility of the vegetable oil to undergo oxidative rancidity. The iodine value obtained of

M. arboreus seed oil in this study 171.45 ± 2.99 g/100g agree with the values reported by Séverin et al. [55]and by Katou et al. [11] for *Myrianthusarboreus* seed oil harvested from Cote D'Ivoire (170.62 g/100g and 171.84g/100g respectively). This high IV in this study suggests that the oil may be more susceptible to rancidity by oxidation.

Peroxide value (PV) is the most common indicator of lipid oxidation/rancidity. The PV of the oil studied was 2 .04meq/kg. High values of PV are indicative of high levels of oxidative rancidity of the oil and also suggest absence or low levels of antioxidants. It gives an idea on the primary oxidation state of oils and fats by giving the concentration of hydroperoxides present [56, 57]. The CODEX [45] states a permitted maximum peroxide level of not more than 10 meq/kg, and values higher than 10 to 20 meq/kg are generally interpreted as rancidity. Thus, the low peroxide value recorded for this study indicates the resistance of the oil to peroxidation during storage suggesting therefore that, this oil was fresh with little or no oxidation.

P-anisidine value measures the products of hydroperoxide decomposition, especially aldehydes, and ketones. These compounds have a negative effect on human health and also affect oil taste, texture, smell and stability[58-60].TOTOX value on the other hand represents the total oxidation load to which the oil is exposed. Generally, the recommended levels should not be more than 19.5 mEq/kg and 20mEq/kg for TOTOX and P-anisidine values respectively [61]. In this study the TOTOX and p-anisidine values were 7.88 mEq/kg and 3.30 mEq/kg respectively. These values are within the acceptable range. This was therefore a clear indication that the oil was stable and not rancid.

4. CONCLUSION

Based on the results of this research, the fruits of *Myrianthusaboreus*, possessed enormous nutritional and energetic potential due to its biochemical composition. The pulps and almonds of *Myrianthusarboreus* from Cameroon have nutritional properties which are clearly acceptable compared to the well-known fruits. These nutrients would therefore give them advantages for their application in the food industry. The analysis of the antinutritional factors results showed that the studied samples had a very low content in phytate and oxalates. Fatty acid analysis showed that *M. arboreus*contains a high percentage of unsaturated fatty acids. Oils containing small amounts of saturated fatty acids and large amounts of monounsaturated fatty acids are highly favourable in the human diet. Also, its seed has high oil yield (>40%), which is comparable to the oil yields of some commercial seed oils. The physicochemical analysis and quality assessment suggest that its seed oil is consistent with most of the parameters with FAO/WHO values and CODEX standards. The quality evaluation show that the seed oil is of good quality and fit for consumption. The results obtained from this study can be used to promote the sustainable cultivation of *M. arboreus* tree in the mountain region of Cameroon for large-scale oil production.

REFERENCES

1. Food and Agricultural Organization. Precedented acute hunger affects millions of people in Cameroon. Report of a Joint WHO/FAO. Expert Consultation, Geneva, Switzerland. 2023.
2. Kehlenbeck K, Asaah E, Jamnadass, R. Diversity of indigenous fruit trees and their contribution to nutrition and livelihoods in sub-Saharan Africa: examples from Kenya and Cameroon. Using agricultural biodiversity to improve nutrition and health issues in agricultural biodiversity. 2013; 1(1):257–269.
3. Hyacinthe T, Charles P, Adama K, Diarra C et al. Variability of vitamins B1, B2 and minerals content in baobab (Adansonia digitata) leaves in East and West. Food Sci. & Nutri. 2015; 3(3):17–24. Doi: 10.1002/fsn3.184.
4. Otori AA, Mann A. Determination of chemical composition, minerals and antinutritional factors of two wild seeds from Nupeland, North central Nigeria. America J. of Chem& Appl. 2014; 1(2):20–26.
5. Stadlmayr K, Charrondiere B, Eisenwagen UR, Jamnadass S, Kehlenbeck R. Nutrient composition of selected indigenous fruits from sub-Saharan Africa. J. of the Sci. of Food & Agric. 2013; 61(96):2627–2636. Doi: 10.1002/jsfa.6196.
6. Mashile SP, Tshisikhawe MP, Masevhe NA. Indigenous fruit plants species of the Mapulana of Ehlanzeni district in Mpumalanga province. South African J. of Botany. 2019; 9(31):180–183.
7. Zhang YJ, Gan RY, Li S, Zhou Y, Li AN, Xu DP et al. Antioxidant Phytochemicals for the Prevention and Treatment of Chronic Diseases. Molecules. 2015; 20(12):38-56. Doi: 10.3390/molecules201219753. PMID: 26633317: PMCID: PMC6331972.
8. Olonode ET, Aderibigbe AO, Bakre AG. Anti-nociceptive activity of the crude extract of Myrianthusarboreus P. Beauv (Cecropiaceae) in mice. J Ethnopharmacol. 2015; 2(5):171: 94-8.
9. Kazadi M. Plantes sauvages d'Afrique Centrales, sources potentielles de corps gras. RecherchesAfricaines. 1999; 4(8):78-89. French
10. N'dri KE, Gore BN, Akaffou DS. Agro-Morphological characteristics of Myrianthusarboreus(P. Beauv) in Cote D'Ivoire. International journal of Advances in Scientific Research and Engineering. 2019; 5(8):158-168.
11. Katou SY. Physicochemical Analysis and Characterization of the Lipid Fraction from Côte D'ivoireMyrianthusArboreus (Cecropiaceae) Seeds. Asian Journal of plant Sciences and Research.2017; 7(1):16-22.
12. Omujal F, Okullo JL, Bigirimana C, Isubikalu P, Agea et al. Nutritional potential of Myrianthusholistii Fruit of Rwanda. Rwanda Journal of Agricultural Sciences. 2020;2(1):86-96.
13. Association of Official Analytical Chemists. Official Methods of Analysis. 15th .Edition. Association of Official Analytical.Chemistry,Washington DC. 1990;2(15).
14. Ranganna B, GowDA MC, Murthy DK, Raghavan GSV, Barrington SF. Energy requirement for crop production in Eastern parts of Karnataka (India)–A case study. Mysore Journal of Agricultural Sciences. 1999;33(5):49-59.
15. Harris LJ, Ray SN. Lancet. 1935;228:71.
16. Chlopicka J, Pasko P, Gorinstein S,Jedryas A, Zagrodzki P. Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudo cereal breads. Lebensmittel-Wissenschaftund-Technologie. 2012;46(2):548-555.
17. Price ML, Socoyoc S, Butter, LG. A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. J. of Agric & Food Chem. 1978;26(5):1214–1218.
18. Wheeler EL, Ferrel RE. A Method for Phytic Acid Determination in Wheat and Wheat Fractions. Cereal Chemistry. 1971; 48(2)312-320.

19. Liu Z, Ezernieks V, Rochfort S, Cocks B. comparison of methylation methods for fatty acid analysis of milk fat. J. Food Chem. 2018; 261(4):53. Doi: 10.1016/j.foodchem.2018.04.053.
20. Ulbright TLV, Southgate, D.A.T. Coronary Heart disease: Seven dietary factors. *Lancet*. 1991; 338(5):985-992.
21. Santos-Silva J, Bessa R, Santos-Silva M. Effect of genotype, feeding system and slaughter weight on the quality of light lambs II. Fatty acid composition of meat. Livestock Production Science. 2002; 77(3):187-194. Doi: 10.1016/S0301-6226(02)00059-3.
22. AFNOR (Association Française pour la Normalisation). Recueil Des Normes Françaises. Corps Gras, Graines Olèagineuses, Produits Dèrivès. 2ième Edition. Paris. 1989:438. French.
23. Chebet J, Kinyanjui T, Cheplogoi PK. Impact of frying on iodine value of vegetable oils before and after deep frying in different types of food in Kenya. Journal of Scientific and Innovative Research. 2016; 5(5): 193-196
24. Holm U. Abstracts. Goteborg, Sweden: International Society for Fat Research Congress. 1972.
25. Ng S, Lasekan O, Muhammad KS, Hussain N, Sulaiman R. Physicochemical properties of Malaysian-grown tropical almond nuts (Terminalia catappa). Journal of Food Science and Technology. 2015; 52(10):6623–6630.
26. Chatoui K, Harhar H, El Kamli T, Tabyaoui M. Chemical Composition and Antioxidant Capacity of Lepidium sativum Seeds from Four Regions of Morocco. Evidence-Based Complementary and Alternative Medicine. 2020; 73(2):7-27.Available: https://doi.org/10.1155/2020/7302727.
27. Bemmo UL, Mvongo C, Bindzi JM, Ekwelle WN, Zambou FN. Contribution to the valorization of Myrianthusarboreus fruits pulp from Cameroon: Physico-chemical Characterization and Nutritional Value. Measurement: Food. 2023; 10(3)10-83. Available: https://doi.org/10.1016/j.meafoo.2023.100083.
28. Edmond AD, Eudoxie MT, Achille FT, Marthin TK, Lucien PK. Biochemical and Nutritional Characteristics of Myrianthusarboreus Pulp and Almonds flour from Cote D'Ivoire. World Journal of Advance Health Care. 2019; 3(3):36-40.
29. Silveira CM, De LM, Salunkhe DK. Chemical characterization of chia (Salvia hispanica L) for use in food products. Journal of Food Nutrition. 2014; 2(5): 263-269.
30. Bayero AS, Datti Y, Abdulhadi M, Yahya AT, Salihu I et al. Proximate composition and the mineral contents of soya beans (Glycine max) available in Kano State, Nigeria. Chem Search Journal. 2019; 10(2):14-43. Available:https://doi.org/10.4314/csj.v10i2.
31. Ulrich-Landry KB, Jean MB, Pamela RT, Serge CH, Stephano TT et al.Physicochemical properties, nutritive value and antioxidant potential of jackfruit(Artocarpus heterophyllus) pulp and seeds from Cameroon Estern forests. Food science and Nutrition. 2023; 11(8):4722-4734. Available: https://doi.org/10.1002/fsn3.3437.
32. Ene-Obong HN, Sanusi RA, Udenta EA., Williams OI, Anigo KM et al. Data collection and assessment of commonly consumed foods and recipes in six geo-political zones in Nigeria: important for the development of a National Food Composition Database and Dietary Assessment. Food Chem. 2013; 140(3):539–546. Doi:10.1016/j.foodchem.2013.01.102.
33. Dué EA, Eudoxie ET, Siaka B, Elvis SE, Lucien PK. Ethnobotanic investigation, determination of physical charasteristics and anti-nutritional factors of fruits of Myrianthusarboreus from Cote D'Ivoire. European Journal of Pharmaceutical and Medical Research. 2019; 2(6):25-31.
34. Bosede O, Efomah A. Extraction and characterization of cottonseed (Gossypium) oil. International Journal of Basic and Applied Science. 2012; 2(1):384-388. Doi: 10.17142/ijbas-2012.2.1.26.

35. Barku V, Nyarko HD, DordunuP. Studies on the physicochemical characteristics, microbial load and storage stability of oil from indian almond nut (Terminalia catappa). Food Science and Quality Management. 2012; 8(4):9-17.
36. Olatidoye OP, Sobowale SS, Akinlotan JV, Olorode OO. Chemical composition and physiochemical characteristics of tropical almond nuts (Terminalia catappa) cultivated in South West Nigeria. Journal of Medical and Applied Biosciences. 2011; 1(1):1-10.
37. Aremu MO, Olonisakin O, Bako DA, Madu PC. (2006). Compositional studies and physicochemical characteristics of cashew nut (Anarcadiumoccidentale) flour. Pakistan Journal of Nutrition. 2006; 5(4):328–333.
38. Rico R, Bullo M, Salas-Salvado J. Nutritional composition of raw fresh cashew (Anacardium occidentale) kernels from different origin. Food Science and Nutrition. 2015; 4(10):294.
39. Barreca D, Nabavi SM, Sureda A, Rasekhian M,Raciti R, Silva AS et al. (2020). Almonds (Prunus Dulcis Mill. D. A. Webb): A Source of Nutrients and Health-Promoting Compounds. Nutrients. 2020; 1(3):672-680.
40. Contreras-Calderón J, Calderón-Jaimes L, Guerra-Hernández E, García-Villanova B. Antioxidant capacity, phenolic content and vitamin C in pulp, peel and seed from 24 exotic fruits from Colombia. Food Research International. 2011; 7(44):2047-2053.
41. Akpakpan AE, Akpabio UD. Evaluation of proximate composition, mineral element and anti-nutrient in almond (Terminalia catappa) seeds. Research Journal of Applied Sciences. 2012; 7(9-12):489-493.
42. Tijjani M. Proximate Content and Chemical Composition of OcimumViridis Leaf and OcimumGratissium Leaf. International Research Journal of Pharmacy. 2012; 3(4).
43. Mann GV. Coronary Heart Disease: The Dietary Sense and Nonsense. An Evaluation by Scientists. Janus. London. 1993; 22-27.
44. Navarro RD, Silva FK, Oswaldo PN, Ribeiro P, Walter F et al. Quality of polyunsaturated fatty acids in Nile tilapias (Oreochromisniloticus) fed with vitamin E supplementation. Food Chemistry. 2012; 2(97):215-218.
45. CODEX Alimentarius Commission. Codex standard for named vegetable oils- Codex stan. Rome Italy. 2005; 210-1999.
46. Djikeng FT, Teyomnou WT, Tenyang N,Tiencheu B, Morfor AZ et al. Effect of traditional and oven roasting on the physicochemical properties of fermented cocoa beans. Heliyon. 2018; 1(4). Doi: 10.1016/j.heliyon.e00533.
47. Pearson D. Chemical Analysis of Foods. 7th Ed. Church Hill Livingstone, London. 1976.
48. Kyari M Z. Extraction and characterization of seed oils. International Agro physics. Longman Publishers: London, UK. 2008; 22:141-175.
49. Tia EM, Digbeu YD. Physicochemical Characteristics and Fatty Acids from Dried and Boiled Seeds Oils of Myrianthusarboreus from Côte d'Ivoire. The Saudi Journal of Life Science. 2018; 3(4):350-355.
50. Akanni MS, Adekunle SA, Oluyemi EA. Physico-Chemical properties of some non-conventional oil seed. Journal of Food Technology.2005; 3(1):177-181.
51. Sanina NM, Goncharova SN, Kostetsky EY. Seasonal changes of fattyacid composition and thermotropicbehaviour of polar lipids from marine macrophytes. Phytochemistry 2014; 69(14):1517-1527.
52. Ichu CB, Nwakanma HO. Comparative Study of the Physicochemical Characterization and Quality of Edible Vegetable Oils. International Journal of Research in Informative Science Application & Techniques. 2019; 3(2):56. DOI: 10.46828/ijrisat.v3i2.56.
53. Engler CR, Johnson LA. Effects of processing and chemical characteristics of plant oils on performance of an indirect-injection diesel engine, Journal of American Oil Chemical Society. 1983; 60(8):1592 –1596.
54. Akubugwo IE, ChinyereGC, Ugbogu AE. Comparative Studies on Oils from Some Common Plant Seeds in Nigeria. Pakistan Journal of Nutrition. 2008; 7(3):570-573. DOI: 10.3923/pjn.2008.570.573.

55. Séverin KY, Emmanuel KN, Alexis GL, Kessé NP, Akhanovna MB, Yves-Alain B. Characterization and Antioxidant Activity of Myrianthusarboreus Seed Oil Harvested from Cote D'Ivoire. Chemical Science International Journal.2021;30(6):1–9
56. Kirk R, Sawyer R. Pearson's composition and analysis of foods. 9th edition, Addison Wesley longman ltd. England. 1991; 9(29):608-640.
57. Kirschenbauer HG. Fats and oils: An outline of their chemistry and technology. Reinhold Publishing and Co. New York. 1965.
58. Shahidi F. Quality assurance of Fats and Oils. Bailey's Industrial oil and fat products. 6th Ed.2006
59. Tiencheu B, Egbe A, Achidi A, Eurydice TN, Tenyang N et al. Effect of oven and sun drying on the chemical properties, lipid profile of soursop (Annona muricata) seed oil, and the functional properties of the defatted flour. Food Science & Nutrition. 2021; 3(9):186-195.
60. Esfarjani F, Khoshtinat A, Zargaraan A, Mohammadi-Nasrabadi F, Salmani Yet al.Evaluating the rancidity and quality of discarded oils in fast food restaurants. Food Science & Nutrition. 2019; 7(7):2302–2311.
61. Tonfack DF, Djikeng C, Womeni H, Ndefo D, Pougoué A, Tambo S et al. Effect of Different Processing Methods on the Chemical Composition, Antioxidant Activity and Lipid Quality of Tiger Nuts (Cyperus esculentus). Applied Food Research. 2022; 2(2). Available: https://doi.org/10.1016/j.afres.2022.100124.
62. Konuskan DB, Arslan M, Oksuz A. Physicochemical properties of cold pressed sunflower, peanut, rapeseed, mustard and olive oils grown in the Eastern Mediterranean region. Saudi Journal of Biological Sciences. 2019; 26(2):340–344. Available: https://doi.org/10.1016/j.sjbs.2018.04.005.