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Research Article

Nutritional Properties of the Pulp of *Cola lateritia* Fruit: A Common Native Fruit in Cameroon (Sub-Saharan Africa)

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Abstract

Generalities: *Cola lateritia* (*C. lateritia*) is a tropical rainforest neglected and unutilized plant, used as fruits by Cameroonian populations. The present work aimed to study nutritional potential (proximate composition and minerals content) of pulp of *C. lateritia* fruit.

Methods: The fresh fruits of *C. lateritia* were purchased at Mfoundi market (Centre Region, Cameroon), they were washed and the pulp was manually removed, dried and powdered before being used. The proximate composition (crude fiber, ash, moisture, total fat, crude protein and carbohydrates) was assessed using the standard operating procedures of AOAC and the minerals content was evaluated using an atomic absorption spectrophotometer standard procedure method.

Results: The results indicated that pulp of *C. lateritia* fruit contain higher levels of carbohydrates (61%) and moisture (85%) and it could be a source of dietary fibres (14%). High levels of potassium (2157.15 ± 44.65 mg/100g DM), calcium (240.75 ± 0.75 mg/g DM) and magnesium (96.81 ± 0.37 mg/100g DM) were also observed in *C. lateritia* pulp.

Conclusion: The pulp of *C. lateritia* can be consumed as rich source of energy, fiber, potassium and calcium

Keywords: *C. lateritia* fruit; Pulp; Proximal composition; Minerals content

Abbreviations

PCLf: Pulp of *Cola Lateritia* Fruit; AOAC: Association of Official Analytical Chemists

Introduction

Several studies have shown that fruits are not only used as food, but also have beneficial effects on human health and help prevent diseases [1,2]. This could explain why people have achieved a good quality of life by eating fruits and vegetables, other plant-derived foods, and using nutraceuticals, dietary supplements or herbal medicine. Fruits, including vegetables, are therefore essential components of the human diet [3]. Fruits are a good source of macronutrients (crude protein, fiber and fat) and micronutrients (Ca, Mg, Zn, Cu, β-carotene and niacin). Generally, the pulp is a good source of ash, starch, carbohydrates, K, P and Se [4]. Studies have shown that the fibers content of fruits and vegetables has beneficial effects on blood cholesterol and contributes to the prevention of large bowel diseases [5].

The African tropical sub-regions is home to many valuable fruit species whose potential have not been fully identified and evaluated for their nutritional and functional properties and are therefore under-exploited [3]. Furthermore, Essein et al. [6] pointed out in their work that there is a need to identify, integrate and domesticate various indigenous plants as a means of biological protection and provision of adequate food, especially for developing countries. Because, modern agricultural systems promote cultivation of a very limited number of crop species, which contribute to relegate indigenous crops to the status of neglected and underutilized crop species; population pressure require innovative strategies to address food insecurity. This justify why, underutilized and alternative fruits appear to be a good opportunity for local producers to access small and large markets where, consumers appreciate the presence of nutrients that can prevent most metabolic diseases, energy and nutrients deficiencies. This is the case of Cola Schott and Endlicher, which is one of the under-utilised genera belonging to the Malvaceae family. This genus has about 125 species of plants from West and Central Africa [7]. Monkey cola is a popular nomenclature for the lesser-known members of the Cola species that produce edible and tasty fruits [8]. An example of this

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plant fruit species is *Cola lateritia*. However, the indigenous people of southern Nigeria and Cameroon enjoy its fruits [9]. It has also been introduced to other countries such as Cape Verde, where its fruits have become naturalized. It is also known as (small) Ouara in French, Amoreira in Portuguese or Efok ahié in Cameroon [10].

A shiny red hairless skin, a short stalk, and a pronounced beak characterize *C. lateritia*. It is boat-shaped and may be ribbed. The waxy mesocarp (pulp), which is the edible part of the follicle, is whitish in colour and has a sweet taste [11]. The seeds are obliquely ovoid with two flat, rough, reddish brown or green surfaces [11]. *Cola lateritia* is used as an alternative to food intake, but its potential is not yet fully exploited. The different parts of the *Cola lateritia* plant (inner bark, leaves, etc.) can be prepared as ointments or decoctions, for their therapeutic properties (treatment of tuberculosis, skin rashes or coughs). Many strategies including sensory and nutritional characteristics of the food with biologically active molecules should be studied. Finally, it is very important to study the toxicity of this fruit in its natural state. In Ivory Coast, decoctions of the bark are used as a vaginal wash against sterility. In Cameroon as in Ivory Coast, the pulp of *Cola lateritia* is the edible part. The product is present in the Cameroonian market, and foreign studies (Nigeria) report its medical properties. In addition, few data exist on this fruit in Cameroon with regard to the climatic conditions, soil composition and variety, which could affect the nutritional composition; this work was intended to study the nutritional potential of the pulp of *Cola lateritia* fruit, the only edible part of the fruit, in the perspective of its nutritional valorization. This therefore appears to be an opportunity in the search for new innovative sources of natural nutraceutical functional foods and may contribute to generate new needs in the food supply.

Materials and Methods

Chemical reagents

Sodium Hydroxide (NaOH; Merck), Bromocresol Green, Red Methylene, Boric acid (H3BO3; Merck), Sulfuric acid (H2SO4; 98%), Nitric acid (HNO3, 98%), Copper sulphate (Cu2SO4, Merck); Potassium sulphate (K2SO4, Merck); Acetone; Hexane.

Collection, identification and preparation of plant material

The fruits of *Cola lateritia* were purchased in October 2022 at the Mfoundi market (Yaoundé), Centre Region of Cameroon. Botanical identification was carried out by comparative study by the taxonomists of the National Herbarium of Cameroon under the reference number 41643/HNC. Once brought back to the laboratory, the plant material was washed and rinsed; the pulp of fruit was removed manually, dried in a ventilated oven at 40°C (Heraeus, Germany) for one week until a constant weight before being reduced to powder and stored dry, at room temperature (25°C ± 2°C) in glass bottles protected from light and humidity. A part was used for food composition analysis.

Evaluation of the nutritional composition of the pulp of *Cola lateritia* fruit

Determination of proximal composition:

Determination of dry matter content: The Dry Matter (DM) content was determined on the pulp according to the AOAC method (1980). Five (5) g of sample was oven dried at 105°C until a constant weight was obtained (three trials for each variety). The dry matter content was determined by differential weighing according to the following formula:

$$DM\ (\%) = \left(\frac{P_2 - P_0}{P_1}\right) \times 100$$

P_0: Empty weight of crucible (g); P_1: Weight of fresh sample (g), P_2: Weight of dried sample and crucible (g), DM: Dry Matter

The final dry matter content was obtained by averaging the three tests.

Determination of the moisture content: The Moisture Content (MC) is the effective (total, measurable) proportion of water in the food. The moisture content was determined by the gravimetric method (AOAC, 1980). Approximately, five (5) g of fresh pulp (P1), weighed in an aluminum capsule, was placed in an oven at a temperature of 105°C and weighed regularly until a constant weight was obtained. The dry matter was cooled in a desiccator containing a desiccant for 1 hour (h) and its weight P2 determined after weighing the capsule to the nearest 0.001 g according to the following formula:

$$MC\ (\%) = \left(\frac{P_2 - P_0}{P_1}\right) \times 100$$

P_0: empty capsule weight (g); P_1: wet sam

ple weight (g); P_2: sample-core weight after incineration (g); MC: moisture content expressed as % dry matter

Determination of total ash content: The Total Ash Content (TAC) was determined by the AOAC method (1980). A porcelain capsule was carefully washed with water and rinsed with 10% nitric acid to remove all traces of mineral matter and was dried in an oven at 65°C for 1h. It was then placed in an incinerator at 550°C for 3h to destroy any trace of organic matter. After incineration, it was cooled in a desiccator for 1h and its dry weight (P1) was determined. About 2 g of dry matter (P0) of the sample was weighed into the capsule. The whole was put in an incinerator at 550°C for 48 h. After removal from the oven, the capsule containing the ash was cooled in a desiccator for 1h and weighed (P2) to the nearest 0.001 g. After incineration of the pulp at 550°C for about 12 h the total ash content was determined by differential weighing according to the following formula:

$$TAC\ (\%) = \left(\frac{P_2 - P_0}{P_1}\right) \times 100$$

P_0: empty weight of the capsule (g); P_1: weight of the wet sample (g); P_2: weight of the sample after incineration (g); TAC: Total Ash Content expressed in g ash/100 g dry matter

Determination of total lipids content: The Total Lipids Content (TLC) of the pulp was determined according to the AOAC method (1980), after hot extraction in the Soxhlet extractor followed by distillation using a rotary evaporator under vacuum in a water bath at 60°C. About 5 g of dry matter (P0) was weighed, carefully wrapped in Whatman N° 3 filter paper and placed in a cellulose cartridge. The whole was introduced into the extractor of the Soxhlet apparatus, mounted on a flask (washed and dried) containing three glass beads. The solvent was put into the extractor until siphoning and more solvent was added into the extractor until halfway through the siphon. The refrigerant was mounted on the extractor and the flask was heated for at least 6 h. It was subsequently placed on the rotary evaporator to remove the solvent from the collected oil. The flask was dried in an

oven at 65°C for 24 h to remove all traces of solvent and moisture from the flask. It was then cooled in a desiccator and weighed. Let P1 be the weight of the flask plus glass beads before extraction, P2 the weight of the flask plus glass beads after extraction. The lipid content was then calculated using the following formula:

$$TLC\ (\%) = \left(\frac{P_2 - P_0}{P_1} \right) \times 100$$

P_2: Weight of flask + glass beads before extraction (g); P_1: Weight of flask + glass beads before extraction (g); P_0: Weight of dry matter (g), TLC: Total Lipids Content

Determination of crude fibers content: Crude Fibers (CF) or insoluble fibers include cellulose, some hemicellulose and lignin. The crude fiber content of the pulp was determined by Weende's method [12]. This method consists of boiling the sample with concentrated sulphuric acid (98%) and then with soda. The residue obtained is dried and then calcined and weighed. A quantity M of sample was introduced into a beaker containing H2SO4 (0.255N). The mixture was then boiled for 30 min, and then filtered. To the residue, was added Sodium Hydroxide (NaOH, 0.313 N), then the mixture was again brought to boiling point for 30 min. After filtration, the residue was washed 3 times with hot distilled water and 2 times with acetone; the insoluble material obtained was dried at 105°C for 8 h and weighed (M1). This dry residue was subjected to incineration at 550°C for 3 hours and the ashes were weighed (M2). The crude fiber content (g/100 g DM) was given by the following relationship:

$$CF\ (\%) = \left(\frac{(P_1 - P_2)(100 - Wc)}{M * (100 - Wc)} \right) \times 100$$

P_2: Weight of flask + glass beads after extraction (g); P_1: Weight of flask + glass beads before extraction (g); M: Weight of dry matter (g), CF: Crude Fibers; Wc: Moisture

Determination of total proteins content: The Crude Proteins Content (CPC) was determined on the pulp of *C. lateritia* fruit according to the Kjeldahl method [1]. This was done in three steps:

Mineralization: In a carefully washed and oven-dried matrass, was put about 0.5 g of DM of the pulp, 10 mL of concentrated sulphuric acid (98%) and a pinch of mineralization catalyst (copper sulphate+potassium sulphate). The whole was heated on a mineralization ramp placed in the fume hood for 2 h to 3 h with the neck of the matrass engaged in a smoke collecting tube. The mineralization was complete when the black syrup mixture at the beginning of the heating became colourless. The resulting mineralization was left to cool for 24 h.

Distillation: It was done in the distillation unit: ("Kjeltee System 1002 Distilling Unit"). In a conical flask, 20 mL of distilled water, 10 mL of H3BO3 (4%) and four drops of Fashiro were introduced; this solution will trap the nitrogen during the mineralization. Ten (10) mL of distilled water was added to the content of the matrass to mitigate the acidity of the medium. The conical flasks were placed in the distillation apparatus, each in its place. Using a lever, 10% soda from canister was brought in to neutralize the acidity of the matrass contents. The ammonia (NH4OH) displaced by the soda was carried away in vapour form and condensed in the cooler, which was constantly supplied with tap water. The distillate, collected in the conical flask containing the "trap" solution, was condensed as ammonium borate. As soon as the first drop of the distillate fell into the conical flask, the pinkish-purple coloration at the beginning turned progressively to green. The distillation was complete after 4 min and resulted in two equations:

$$\underset{\text{Sulphuric acid}}{(NH_4)SO_4} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{ammoniac}}{2\,NH_4OH} + \underset{\text{Sodium sulphate}}{Na_2SO_4}$$

$$\underset{\text{Borate}}{H_3BO_3} + \underset{\text{ammoniac}}{3\,NH_4OH} \longrightarrow \underset{\text{Ammonium borate}}{(NH_4)_3BO_3} + 3\,H_2O$$

Titration: The distillate is titrated with 0.1 N sulphuric acid. During this step, ammonium sulphate was formed and boric acid was regenerated according to the following equation:

$$\underset{\text{Ammonium borate}}{(NH_4)_3BO_3} + \underset{\text{Sulphuric acid}}{3/2\,H_2SO_4} \longrightarrow \underset{\text{Ammonium sulphate}}{3/2(NH_4)_2SO_4} + \underset{\text{borate}}{H_3BO_3}$$

A matrass containing fresh sample- "blank" was subjected to the same procedure. It permits to evaluate the traces of nitrogen which could come from the reagents. Let CN be the Normality (N) of the sulphuric acid, Ve and Vt, the volumes in mL of acid necessary to titrate the test and the blank respectively. The total proteins content was obtained by multiplying the nitrogen content (%) by the general conversion factor (F=6.25) recommended for complex feed

$$CPC(\%) = \frac{(Ve - Vt) \times N \times 1.401 \times 6.25}{m}$$

Ve: volume of HCl used for titration (ml); Vt: volume of HCl used for titration of the control (ml); N: titre of the acid used for titration; M: mass of the sample (g); 6.25: factor of conversion of nitrogen to protein; 1.401: constant

Determination of the total carbohydrate content: In the field of carbohydrates, the global determinations that can be made concerns reducing sugars (including the determination of sucrose) dietary fibres mainly composed of non-assimilable polysaccharides.

The measurement of the total amount of carbohydrates (or assimilable carbohydrates) in a foodstuff is usually done by calculation (difference with other nutrients). When it is not necessary to know the different sugars present in a food, it is sufficient to calculate the overall carbohydrate content (or assimilable carbohydrates) by difference with the other components:

Total Carbohydrate=Total - (Water + Proteins + Fibers + Lipids + Ash)

Determination of some micronutrients content

The principle is based on calcination at 450°C and extraction of the ash with nitric acid (1N) followed by atomic absorption spectrophotometric determination of the minerals. The influence of the integrated absorbance in wavelength on the sensitivity and the precision for the determination of Ca, Fe and Zn was carried out in 3 passages according to the sequence air/acetylene flame. Measurements were performed on the main atomic lines for Fe (248.327 nm) and Zn (213.857 nm), on the secondary lines for Ca (239.856 nm), using a wavelength selected absorbance equivalent to 3 pixels for the minerals (Ca, Fe, Mg, K, Na and Zn). Recovery tests for spiked samples were performed by adding appropriate aliquots of 5000 mg/L, 1000 mg/L, or 100 mg/L of single standard solution to the sample digests to obtain

extracts containing 10 mg/L Ca, 0.5 mg/L Fe, and 0.2 mg/L Zn. The Limits of Detection (LOD) and Limits of Quantification (LOQ) for all analytes were calculated according to IUPAC recommendations.

Statistical analyses

Experiments were performed in triplicate. Results were expressed as mean ± standard deviation. The data were analysed using a Statistical Package for Social Science (SPSS) software version 20.0 for Windows (IBM Corporation, USA) and the Excel spreadsheet was used for data processing.

Results

Proximal composition of pulp of *Cola lateritia* fruit

The Table 1 shows the food composition of the pulp of *Cola lateritia* fruit. The macronutrients content showed that the pulp had 14.85 g/100 g FM of dry matter, 85.14 g/100 g FM of moisture; 5.69 g/100 g DM of crude protein, 9.53 g/100 g of total lipids, 13.46 g/100 g DM of crude fibre, 2.29 g/100 g DM of ash and 61.30 g/100 g DM of carbohydrates content. Higher levels of carbohydrates (61%) and moisture (85%) was noticed in the pulp of *c. lateritia* fruit.

Minerals content of *Cola lateritia* pulp

The table below (Table 2) shows some mineral constituents present in *Cola lateritia* pulp. According to these results, zinc, calcium, potassium, magnesium, iron and sodium were found in the pulp of *C. lateritia* fruit; which showed a higher level of potassium with a value of 2157.15 mg/100 g DM, followed by calcium (240.75 mg/g DM), while the other mineral values were, 96.81 mg/100 g DM, 3.95 mg/100 g, 3.03 mg/100 g DM, and 1.51 mg/g DM respectively for magnesium, sodium, iron and zinc.

Table 1: macronutrients content of the pulp of the *Cola lateritia* fruit.

Macronutrients	Pulp
DM (g/100 g FM)	14.85 ± 0.20
Ash (g/100 g DM)	2.29 ± 0.16
Fat (g/100 g DM)	9.53 ± 0.13
Crude Fiber (g/100 g DM)	13.46 ± 0.24
Water Content (g/100 g FM)	85.14 ± 0.20
Total Proteins (g/100 g DM)	5.69 ± 0.16
Total Carbohydrates (g/100 g DM)	61.30 ± 0.68

DM: Dry Matter; g: gram; mg: milligram; FM: Fresh Matter
Values expressed as mean ± standard deviation of triplicate trails.

Table 2: Minerals content of the pulp of the *Cola lateritia* fruit.

Micronutrients	Pulp
Zinc (mg/100 g DM)	1.51 ± 0.01
Calcium (mg/100 g DM)	240.75 ± 0.75
Potassium (mg/100 g DM)	2157.15 ± 44.65
Magnesium (mg/100 g DM)	96.81 ± 0.37
Iron (mg/100 g DM)	3.03 ± 0.17
Sodium (mg/100 g DM)	3.95 ± .15

Discussion

It is now well accepted that the consumption of plant-based foods is beneficial to human health. The pulp of *C. lateritia* fruit is commonly consumed by many Cameroonian populations. The aim of this work was to determine the nutritional composition of the pulp of *C. lateritia* fruit. Concerning the proximal composition, the summary results for macronutrients (Table 1) reported that, moisture content of the pulp was very high. This is in agreement with the report of Hashimi et al. [13] which reported a very high moisture contents in various species of apple. The high moisture content suggested they are highly perishable because it is particularly prone to microbial growth [14]. The moisture content of any food is an index of its water activity [15] and can be used as a measure of the stability and susceptibility to microbial contamination [16]. This implies that, apple fruit juice may have a short shelf life due to its high moisture content. Water is the most abundant single component of fresh fruits and the amount varies among individual commodities due to structural differences.

The result also revealed a relative high carbohydrates, lipids and proteins contents (Table 1) respectively in the pulp. These values were higher compared to the results observed by Ogbu et al. (2007) [17] on three varieties of cola (*Cola pachycarpa*, *Cola lepidota* and *Cola lateritia*), and the results of Abdualrahman, (2013) on mango fruits [18]. Contrarily, results observed in this study apart from lipids content were lower than Essein et al. (2017) [19] study on the *Cola pachycarpa* species. According to Byeon and Lee in 2020, carbohydrates are the second most important constituents in fruits with values ranging between 50 g to 80 g/100 g DM [20]. In fact, carbohydrate stores energy and contributes to the cell structural framework. The sweet property (sensory quality) of the pulp of *C. lateritia* fruit can be referred as an important level of simple carbohydrates as in some fruits (pineapple, banana, carrot) such as monosaccharides sugars (glucose and fructose) which are the most common simple sugars in fruits and also, the presence of an important disaccharide (sucrose). Many studies have demonstrated that these three sugars are responsible for the sweet taste of fruits. Small amounts of some mono and disaccharides sugars (galactose, maltose, arabinose, mannose and xylose) may also be present. The lipids content in fruits depends on the commodity. In general, the lipid content of most fruit commodities is small, with values less than 1% (0.2% for grape, 0.1% for banana and 0.06% in apple). Lipids are an important group of compounds with crucial functions. They can be stored as energy reserves (triglycerides and fatty acid) or have precious structural functions (cell membranes, thermoregulation and hormone synthesis) for instance, phospholipids [21]. Proteins represent less than 1% of the fresh mass of most fruit. The high level of crude proteins in the pulp of *C. lateritia* fruit can be explained by the fact that, fruits may be also rich in some simple nitrogenous substances such as free amino acids, polyamines and substances such as alkaloids [22]. The Ash content was high compared to the report of Ogbu et al. (2007) [17] and Ekanem et al. (2019) [23-26] on pulp of *C. lateritia* fruit and apple respectively but lower than that of *Cola pachycarpa* (12.84%) as reported by Essein et al. (2017) [19]. The amount of ash present can be explained by the quantity of minerals present in the pulp [27].

Pulp of *Cola lateritia* fruit was analysed to be rich in Calcium (Ca), magnesium (Mg), zinc (Zn), potassium (K), sodium (Na) and iron (Fe) (Table 1) compared to most common fruits [25]. The values for Ca, Mg and K in this study were higher than those reported by Okudu et al. (2007) [26] for *Cola lateritia* and two other cola species; while Mg value fell within values reported for banana and colanut [25]. Minerals are important in human nutrition. It is well known that enzymatic activities as well as electrolyte balance of the blood fluid are related to adequacy of Na, K, and Mg. Calcium is needed in the body for bone formation and maintenance, nerve transmission, muscle contraction and blood clothing; Magnesium function as a cofactor for numerous reactions in the body apart from maintenance of bone [27]. The level of minerals in fruits can be affected by soil nutrient availability, fertilization practices and prevailing growing factors. In fruits, mineral contents can also be affected by the loss of water, respirable substrates and postharvest deliberate supplementations [28]. The high level of potassium in the pulp, suggests a potential

in lowering blood pressure, blunting NaCl effects. In fact, many studies indicated that the inadequate intake of potassium has been associated with the increased mortality and higher blood pressure [29]. Potassium also regulates heartbeat, assists in muscle contraction and is needed to send nerve impulses and release energy from fat, carbohydrates and proteins [30]. Seasonality and time of harvest are reported to significantly influence the phenolic compound content in plants, which could be another possible reason for the differences between results.

For the same plant foods species, research has shown that variation in proximate composition could be related to factors such as, harvesting time, plant maturity, environmental, and storage conditions [31].

Conclusion

These results suggested that the pulp of *Cola lateritia* fruit is a good source of nutrients (macro and micronutrients). This part of the fruit could be a good source of dietary fibre (14%).

Authors' Contribution

F.L.E.E and R.N designed the study. E.M.K, K.F.P.M, J.O.T.T and F.L.E.E carried out the experimentation, tests under the supervision of R.N and M.N. F.L.E.E drafted the article, and A.M.M, R.N, A.M.M and J.M.G.M checked the grammatical errors and corrected the last draft of the article. F.L.E.E and R.N performed analysis of Data. F.L.E.E, R.N and M.N supervised the article writing. All the authors read and confirmed the final draft of the article.

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