Original Research Article

Biochemical characteristics and Nutritional profile of the stem bark extracts from the red variety of *Byttneria catalpifolia*, an edible wild plant growing in the Western part of Côte d'Ivoire.

ABSTRACT

Aims: The objective of this work is to characterize the bark extracts of the red variety of *Byttneria catalpifolia*.
Study design: Dried bark powder and mucilage extracted from the fresh bark of the red variety of *Byttneria catalpifolia* were used to evaluate biochemical composition, minerals and nutritional profile.
Place and Duration of Study: The study was conducted in Laboratory of Biocatalysis and Bioprocesses, Food Sciences and Technology Unit, at Nangui Abrogoua University, between January 2015 and December 2017
Methodology: The AOAC method was used to evaluate the biochemical composition in bark and mucilage. The minerals were analysed by a variable pressure scanning electron microscope (SEM), amino acid and organic acid by HPLC and the nutritional profile was determined.
Results: The proximate analysis revealed high rates of ashes (11.51 %), crude fibre (50.33 %), reducing sugar (26.37 %), total sugar (44.88 %), caloric energy (135.18 Kcal /100g dw) in Bark powder while the amount of protein (6.01%) and carbohydrate (30.95%) were moderate and that of fat was low. Mucilage showed a content of ashes (3.82 %), total sugar (24.84 %), carbohydrate (87.79 %) and caloric energy (336.19 Kcal /100g dw) whereas the rate of crude fibre (0.5 %), reducing sugar (1.80 %) and fat (0.6 %) found to be low and that protein (7.29 %) was moderate. This study indicated that the both samples contained the amino acids and organic acids. The results also showed the both samples appeared to be good sources of minerals such as K, Ca, P, Mg and Fe.
Conclusion: The bark extracts of the red variety of *Byttneria catalpifolia* contain appreciable amounts of nutrients. Their nutritional profile by SAIN and LIM method showed that they belong to the group of foods recommended for health.

Keywords: Byttneria catalpifolia, mucilage, nutritional profile, vegetable, stem bark

1. INTRODUCTION

Many plants are consumed as vegetables [1]. Vegetables are the edible parts of plant that are consumed wholly or in parts, raw or cooked as part of main dish or salad. A vegetable includes leaves, stems, roots, flowers, seed, fruits, bulbs, tubers and fungi [2] [3]. It is worthwhile to note that consumption of numerous types of edible plants as sources of food could be beneficial to nutritionally marginal population especially in developing countries

where poverty and climate is causing havoc to the rural populace. Like other plants, Lianas, the woody climbing plants, have been intensively studied in the tropics [4] [5]. It is well known that they are an important component of tropical forests where they constitute up to 32 % of the stems and up to 35 % of the woody species diversity [6]. Further, lianas are more diverse and typically more abundant in tropical than temperate forests, with subtropical forests being intermediate [7] [8]. Otherwise, the studies concerning the lianas were carried out on geographical, taxonomical and ecological aspects [9]. Among the liana species, *Byttneria catalpifolia* is a perennial plant that is widely distributed in the tropics of Africa, Asia and America. It belongs to the Family Sterculiaceae and it is the most abundant of the genus *Byttneria*. Based on the colour of the bark, there are two varieties of *Byttneria catalpifolia*. The white variety is characterized by the white colour of the bark when the skin is scraped while the red variety, by a purple colour of the bark. It is an edible wild plant whose bark is used to make a sticky sauce that is well appreciated by the populations of Western Côte d'Ivoire. However, information on the nutritional composition of this plant species is scarce or non-existent. Note that, proximate and nutrient analysis of wild edible plants plays a crucial role in assessing their nutritional significance [10]. The considerable use of wild edible plant species by the local people in their diet motivated us to carry out the present proximate and nutrients analysis. In spite of their importance as a food source, to the best of our knowledge, there are no published studies on the nutritional composition of the stem bark and the mucilage extracted from fresh bark of *Byttneria catalpifolia*. The mucilage of some plants is well known to science and has been studied by pharmacologists and found to possess biologically active principles. Therefore, the present study was designed to evaluate the biochemical composition and nutritional profile of the dried stem bark powder and the mucilage extracted from fresh bark of the red variety of *Byttneria catalpifolia* and provides consumers with the most appropriate mode of consumption which would give them health benefits.

2. MATERIAL AND METHODS

2.1. Sample collection and preparation

The stem samples of the red variety of *Byttneria catalpifolia* were collected from the western part of Côte d'Ivoire (7° 24'45 "North latitude and 7 ° 33'13" West longitude). These samples were immediately transported to the laboratory. After removing the epidermis with a kitchen knife, the barks were removed from the stems and chopped. The bark sample was divided into two parts. Part of sample was used for the extraction of mucilage. To do this, 20 g of fresh stem bark were ground in 200 mL of demineralized water using a crusher (Moulinex). The homogenate was centrifuged at 4000 rpm for 10 min. The pellet was ground again in 200 mL and centrifuged under the same conditions as those previously described [11]. The two viscous supernatants were mixed and kept in the freezer for physicochemical analysis. The other part was dried in an oven at 65°C for 72 h. The dried samples were ground using a crusher (Moulinex) and the resulting sifted (Ɵ 2 mm) powder was stored in sealed plastic boxes for biochemical analysis.

2.2. Proximate analysis

Moisture, ash, crude fibre, crude protein, fat and carbohydrate contents were determined in accordance with the standard methods of the [12]. All determinations were run in triplicates. The moisture content was determined by the difference of weight before and after drying the sample (10 g) in an oven (memmert, germany) at 105°C until constant weight at least or 72 h. Ash fraction was determined by the incineration of dried sample (5 g) in a muffle furnace

(Pyrolabo, France) at 550°C for 12 h. The residue weight percentage was expressed as ash content. Crude fibre content was obtained from the loss in weight of dried residue following the digestion for fat-free samples with 1.25% each of sulfuric acid and sodium hydroxide solutions. The crude protein content (N × 6.25) was estimated by the macrokjeldahl nitrogen assay method using a digestion apparatus. The fat content was determined by Soxhlet extraction using hexane as a solvent. Reducing sugar content was determined by extracting with 80% neutral aqueous ethanol followed by evaporation of the ethanol and subsequent measurement using the dinitrosalicylic acid method according to [13]. Total soluble sugar content in ethanolic extract was assessed using the phenol-sulfuric acid method according to Dubois et al. (1956). Carbohydrate and calorific values were calculated using the following formulas [14]:

Carbohydrates (dry weight basis): 100- (% moisture + % proteins + % lipids + % ash + % fibre)

Calorific value (dry weight basis): (% proteins × 2.44) + (% carbohydrates × 3.57) + (% lipids × 8.37). The results of ash, crude fibre, crude protein, fat and carbohydrate contents were expressed on dry weight basis.

2.3. Minerals analysis

The mineral elements were analysed after wet-ashing using the scanning electron microscope (SEM) with variable pressure (SEM FEG Zeiss Supra 40 VP). This SEM is equipped with an X-ray detector (Oxford Instruments) connected to an energy diffusion spectrometry (EDS) microanalyzer platform (Inca Cool Dry, without liquid nitrogen). About 10 mg of the sample ash residue were applied evenly to a primed platform with double-sided adhesive carbon for analysis. To measure the content of chemical elements, the device performs a measurement of the transition energy of the electrons from electronic clouds of the K, L and M series of atoms of the sample.

2.4. Amino acids determination

Amino acids were assayed by reverse phase high performance liquid chromatography (PTC column RP-18, 220 mm in length, 2.1 mm internal diameter) equipped with a pre-column (SHIMADZU SPD 20A). The sample was vacuum hydrolysed at 150 °C for 60 min in a Waters Pico-Tag work station (Waters' associates, Milford, MA, USA) in grade 6 N HCl at 1% phenol. It was then taken up in ultra-pure water and derivatized automatically by means of an auto-derivator-analyzer-420 (SHIMADZU SPD 20A). The amino acid derivatives in the form of phenyl isothiocyanates (PITC-amino acids) were separated by chromatography system consisted of mobile phase A (45 M sodium acetate, pH 5.9) and mobile phase B (30% 105 mM sodium acetate pH 4.6; 70% acetonitrile) with a linear gradient of 7-36% at 1.5 mL/min. The detection was done at a wavelength of 254 nm and the total duration of the analysis was 31 min. The acquisition and exploitation of the results were carried out using the Model 600 Data Analysis System (SHIMADZU SPD 20A) software.

2.5. Organic acids determination

Organic acids were extracted from 1 g of sample with 50 mL of 80 % methanol saturated with NaCl and were analysed according to the method of [15] using a HPLC system (Shimadzu Corporation, Japan) consisting of a pump (Shimadzu LC-6A Liquid Chromatograph), a UV detector (Shimadzu SPD-6A UV Spectrophotometric detector) and an integrator (Shimadzu CR 6A Chromatopac). All separations were carried out in isocratic mode with an ICSep ICE ORH-801 ion exclusion column (40 cm x 5 µm, Interchrom, France) maintained at 35 °C using a Meta ThermTM furnace (Interchrom, France). The HPLC conditions are shown in the table 1. Organic acid standards (citric, fumaric, malic, oxalic, tartaric acid, quinic acid, ascorbic acid, succinic acid and fumaric acid) were obtained from Aldrich Co. (Sigma-Aldrich Chemie, Steinheim, Germany). The standard solutions were prepared individually at different concentrations with double distilled water. The analysis was carried out in triplicate. The levels of the organic acids in the samples is obtained by comparing the retention times of the eluted compounds with the retention times of the reference solutions.

Table 1: HPLC running conditions

Column	ICSep ICE ORH-801 ion exclusion column (40 cm x 5 µm, Interchrom, France)
Mobile phase	Isocratic mode: 0.004N Sulfuric acid, pH (HPLC-Grade)
Flow rate	0.6 mL/min
Oven Temperature	35 °C
UV Detection	Wavelength : 210 nm
Injection Volume	20 µl
Runtime	35 min + 10 min post-run

2.6. Determination of B vitamins

A 5 g of liquid/powder sample was extracted with 20 mL of methanol (80%). The stock of standard (Sigma Aldrich analytical grade reagent) was prepared by dissolving 0.01 g of each standard in methanol (80%). A HPLC system (SHIMADZU SPD 20A) equipped with UV detector (PAD) and C18 ODS column (250 x 4.6 de, Cluzeau France) was used in isocratic mode for analysis. Mobile phase consisted of acetonitrile (55 mL), tetrahydrofurane (37 mL) and water (8 mL) at 1.5 mL/min flow rate and 10 µl of each sample/standard were injected and monitored at 325 nm wavelength.

2.7. Nutritional profile of extracts of the red variety of *Byttneria catalpifolia* according to the SAIN and LIM method

To establish the nutritional profiling of *Byttneria catalpifolia* extracts, several successive steps have been carried out. First, it was necessary to establish the nutritional value of each extract based on the nutrients that are needed to calculate SAIN and LIM. For this purpose, it has been necessary beforehand, to establish for each of the extracts, a table of composition which details the contents of these nutrients. The nutrient content is expressed

based on 100 g of raw material (RM). These data were collected from the French table Ciqual [16] and the FAO table.

The SAIN score of *Byttneria catalpifolia* extracts was calculated using proteins, crude fibre, calcium, iron and iodine. As for the LIM score, only sodium was used. The extracts of *Byttneria catalpifolia* contained either saturated fatty acids or added sugars.

$$SAIN = \frac{\frac{Prot}{65} + \frac{Fib}{30} + \frac{Ca}{900} + \frac{Vit.C}{110} + \frac{Fe}{12.5} + \frac{Iod}{150}}{\frac{6}{Energy}} \times 100 \times 100$$

$$LIM = \frac{\frac{Na}{3153} + \frac{SFA}{22} + \frac{Added\ sugar}{50}}{3} \times 100$$

Prot : proteins, Fib : fiber, Ca : calcium, Vit. C : vitamin C, Fe : iron, Iod : Iodine, Na : sodium, SFA : saturated fatty acids

2.8. Statistical analysis

All analyses were carried out in triplicates. Results were expressed by means of ± SD. Means of proximate composition, amino acid, mineral, and organic acid contents of the dried bark powder and mucilage of *Byttneria catpilfolia* were separated according to The Student's t-test ($P<0.05$), with the help of JMP® Pro software (version 12, SAS Institute Inc., Cary, NC, 2007).

3. RESULTS

3.1. Proximate composition

Results of the composition of dried stem bark powder and mucilage extracted from the fresh bark of the red variety of *Byttneria catalpifolia* are presented in table 2. The pH value of dried stem bark powder (5.95 ± 0.02) and mucilage (5.95 ± 0.01) was similar. The dry matter content observed in fresh bark (45.03 ± 0.34 %) was significantly ($p\leq 0.05$) higher than that obtained in the mucilage (6.21 ± 1.15 %). The ash contents obtained in dried stem bark powder and mucilage were 11.51 ± 0.45 % and 3.82 ± 0.62 % of dry weight (dw), respectively. There was meaningful difference ($p\leq 0.05$) between ash contents of dried stem bark powder and mucilage. Our results showed that protein content (7.29 ± 1.01 % dw) and caloric energy (336.19 ± 1.18 kcal /100 g dw) were significantly ($p\leq 0.05$) higher in mucilage than those observed in dried stem bark powder, with values of 6.01 ± 0.20 % dw and 135.18 ± 2.26 kcal /100 g dw, respectively. Crude fibres observed in the dried stem bark (50.33 ± 0.22 dw) was largely higher than that obtained in the mucilage (0.50 ± 0.01 dw). Furthermore, this study revealed the presence of parameters such as fat, reducing sugar, total soluble sugar, vitamin B9 and vitamin B2 in the both samples.

Table 2: Proximate composition of the dried stem bark and mucilage from the fresh bark of the red variety of *Byttneria catalpifolia*

Parameters	Dried bark powder	Mucilage
pH	5.95 ± 0.02[a]	5.95 ± 0.01[a]
Dry matter* (%)	45.03 ± 0.34[b]	6.21 ± 1.15[a]
Ashes (% dw)	11.51 ± 0.45[b]	3.82 ± 0.62[a]
Fat (% dw)	1.20 ± 0.01[b]	0.60 ± 0.01[a]
Proteins (% dw)	6.01 ± 0.20[a]	7.29 ± 1.01[a]
Carbohydrates (% dw)	30.95 ± 0.51[a]	87.79 ± 1.01[b]
Crude fibres (% dw)	50.33 ± 0.22[b]	0.50 ± 0.01[a]
Reducing sugar (mg/100g dw)	26.37 ± 0.05[b]	1.80 ± 0.08[a]
Total sugar (mg/100g dw)	44.88 ± 0.16[b]	24.84 ± 0.16[a]
Vitamin B2 (mg/100g dw)	694.83 ± 32.23[b]	102.18 ± 0.61[a]
Vitamin B9 (mg/100g dw)	31.97 ± 1.37[b]	2.09 ± 0.01[a]
Caloric Energy (Kcal/100g dw)	135.18 ± 2.26[a]	336.19 ± 1.18[b]

Each value is an average of three replicate
Values are mean ± standard deviation
*Means not sharing a similar letter in a line are significantly different (p ≤ 0.05) as assessed by the test of student; dry weight: dw; *Dry matter of the fresh bark of the red variety of Byttneria catalpifolia*

3.2 Amino acid contents

The amino acid compositions of the dried stem bark powder and mucilage from the fresh bark of the red variety of *Byttneria catalpifolia* are illustrated in Table 3. These results indicated that proline, valine, methionine, arginine, glycine, glutamic acid, tyrosine, threonine, lysine and cysteine were found in the both analysed samples. The amino acid contents of dried stem bark powder ranged from 0.11 ± 0.02 mg/ 100g dw (threonine) to 3.70 ± 0.01 mg/ 100g dw (arginine), while those of mucilage varied from 0.02 ± 0.01 mg/ 100g dw (arginine) to 7.57 ± 0.31 mg/ 100g dw (cysteine). This study revealed the presence of essential amino acids such as valine, methionine, threonine and lysine in both samples. Their levels ranged from 0.11 ± 0.02 mg/ 100g dw (threonine) to 1.64 ± 0.01 mg/ 100g dw (methionine) for dried stem bark powder, whereas those of mucilage varied from 1.09 ± 0.01mg/ 100g dw (lysine) to 4.77 ± 0.03mg/ 100g dw (methionine). The statistical analysis showed that the essential amino acids contents of dried stem bark powder were lower meaningfully ($p \leq 0.05$) than those observed in mucilage. Besides, proline, arginine, glutamic acid and glycine (non-essential amino acids) contents in dried bark powder were found also to be lower significantly ($p \leq 0.05$) than those obtained in mucilage, excepted for tyrosine and cysteine contents.

Table 3: Amino acid contents of the dried stem bark powder and mucilage from the fresh bark of the red variety of *Byttneria catalpifolia*

Amino acids (mg/ 100g dw)	Dried stem bark powder	Mucilage
Proline	0.34 ± 0.11[a]	2.33 ± 0.04[b]
Valine	0.81 ± 0.28[a]	1.11 ± 0.06[a]
Methionine	1.64 ± 0.01[a]	4.77 ± 0.03[b]
Arginine	3.70 ± 0.01[a]	7.57 ± 0.31[b]
Glycine	0.60 ± 0.01[a]	0.81 ± 0.06[b]
Glutamic acid	0.43 ± 0.03[a]	1.06 ± 0.29[b]
Threonine	0.11 ± 0.02[a]	2.28 ± 0.07[b]
Tyrosine	0.15 ± 0.02[b]	0.07 ± 0.00[a]
Cysteine	0.43 ± 0.13[b]	0.02 ± 0.01[a]
Lysine	0.17 ± 0.02[a]	1.09 ± 0.01[b]

Each value is an average of three replicates
Values are mean ± standard deviation
Means not sharing a similar letter in a line are significantly different p ≤ 0.05 as assessed by the test of student; dry weight: dw.

3.3. Mineral composition

Table 4 summarizes some mineral composition of the dried stem bark powder and mucilage from the fresh bark of *Byttneria catalpifolia*. The minerals detected were magnesium (Mg), phosphorus (P), potassium (K), calcium (Ca), sodium (Na), iron (Fe), copper (Cu), Zinc (Zn) and iodine (I). The amounts of these minerals in dried stem bark powder appeared significantly higher (P≤0.05) than those of mucilage. Ca (414.17 ± 27.97 - 1104.36 ± 223.30 mg/ 100g dw) and K (440.00 ± 20.93- 990.69 ± 227.31 mg/100g dw) were the abundant minerals. The least concentrated macro-elements in the mucilage and stem bark powder was Na (8.02 ± 1.27 - 28.72 ± 17.92 mg/ 100g dw, respectively). The micro-elements observed in the dried stem bark powder were Fe, Cu, Zn and I. Cu and Zn were not detected in mucilage. Iodine (I) content of the mucilage (6.99 ± 1.10 µg /100g dw) was meaningfully lower (p ≤ 0.05) than that obtained in dried stem bark powder (14.61 ± 1.10 µg /100g dw).

Table 4: Minerals and mineral ratios of the dried stem bark and mucilage from the bark of the red variety of *Byttneria catalpifolia*

Minerals (*mg/ 100 g dw)	Dried bark powder	Mucilage	Pellet
Mg	381.56 ± 162.27[c]	198.47 ± 16.88[b]	129.24 ± 18.18[a]
P	38.50 ± 9.46[c]	35.09 ± 7.36[b]	8.01 ± 1.57[a]
K	990.69 ± 227.31[c]	440.00 ± 20.93[b]	368.40 ± 3.78[a]
Ca	1104.36 ± 223.30[c]	414.17 ± 27.97[a]	543.79 ± 85.62[b]
Na	28.72 ± 17.92[c]	8,02 ± 1.27[a]	15.24 ± 0.62[b]
Fe	11.05 ± 5.07[c]	5.42 ± 2.92[a]	6.85 ± 0.1[b]
Cu	0.49 ± 0.02[b]	ND	0.21 ± 0.01[a]
Zn	0.46 ± 0.01[b]	ND	0.14 ± 0.00[a]
I (µg /100g dw)	14.61 ± 1.10[b]	6.99 ± 1.10[a]	13.55 ± 0.37[b]
[Ca]/[P]	28.68	11.80	67.89
[Ca]/[Mg]	2.89	2.09	4.21

Each value is an average of three replicates
Values are mean ± standard deviation
Means not sharing a similar letter in a line are significantly different p ≤ 0.05 as assessed by the test of student; dry weight: dw. Not detected: ND

** the unit does not apply to ratios.*

3.4. Quantitative determination of organic acids

The organic acids were extracted from the powder of dried stem bark and mucilage of *Byttneria catalpifolia*. They were identified and measured using HPLC system. Tannic, oxalic, citric, tartaric, sulfanilic, salicylic, adipic, fumaric and benzoic acids were observed. All of these organic acids were present in both samples. Table 5 clearly indicates that content organic acids contents of the dried bark powder was found to be lower ($p \leq 0.05$) than those observed in the mucilage except tannic acid and citric acid. In both samples, levels of fumaric and benzoic acids did not vary significantly ($p > 0.05$). In addition, organic acids varied from 0.09 ± 0.02 mg /100 g dw to 51.35 ± 0.75 mg /100 g dw and from 0.11 ± 0.02 mg /100 g dw to 55.45 ± 0.12 mg /100 g dw for dry bark powder and mucilage, respectively.

Table 5: Organics acids contents of the dried stem bark and mucilage extracted from the fresh bark of red variety of *Byttneria catalpifolia*

Organic acids (*mg/ 100g dw)	Dried bark powder	Mucilage
Tannic acid	6.57 ±0.03[b]	4.64 ± 0.31[a]
Oxalic acid	1.39 ±0.36[a]	5.28 ± 0.11[b]
Citric acid	15.63 ±0.22[b]	13.39 ± 0.30[a]
Tartric acid	51.35 ±0.75[a]	55.45 ± 0.12[b]
Sulfanilic acid	0.15 ±0.03[a]	0.31 ± 0.01[b]
Salycilic acid	0.32 ±0.03[a]	2.86 ± 0.23[b]
Adipic acid	0.31 ±0.02[a]	0.50 ± 0.06[b]
Fumaric acid	0.23 ± 0.07[a]	0.25 ± 0.02[a]
Benzoïc acid	0.09 ± 0.02[a]	0.11± 0.02[a]
[oxalic acid]/[Ca]	0.001	0.061

Each value is an average of three replicates
Values are mean ± standard deviation
*Means not sharing a similar letter in a line are significantly different p ≤ 0.05 as assessed by the test of student; dry weight: dw. * the unit does not apply to ratios.*

3.5. Nutritional profile

The figure 1 shows the SAIN and LIM scores of *Byttneria catalpifolia* extracts (Dried bark and mucilage). The SAIN score for the dried bark was 49.05 and its LIM score was 0.91. As for mucilage, the SAIN score was 11.69 and its LIM score recorded was 0.25. The extracts of this stem vegetable had a high SAIN (SAIN> 5) and a low LIM (LIM <7.5).

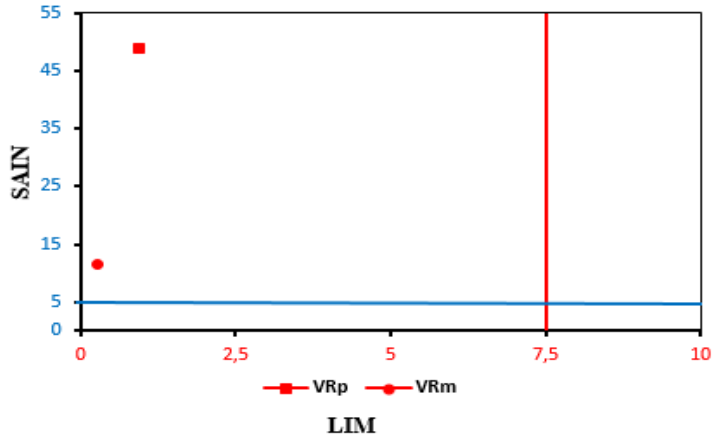

Fig. 1. SAIN and LIM profile of powder and mucilage extracted from the bark of *Byttneria catalpifolia*
(VRp: powder of dried bark of red variety; VRm: mucilage extracted from fresh bark of red variety)

4. Discussion

4.1. Proximate composition

This work revealed that ash contents of the dried stem bark and mucilage from the red variety of *Byttneria catalpifolia* differed meaningfully ($p \leq 0.05$). Note that, ash content is useful in assessing the quality grading of food materials and also gives an idea of the amount of their mineral composition [17]. This suggested that a significant part of the minerals was not extracted with the mucilage. The recorded values of ash were lower than that of the bark from *Bridelia thermifolia* (12.14 ± 0.63 %) and *Corchorus olitorius* (18.2 %) [18] [19]. By contrast, they were higher than that found by [20] in tubers of *Tacca leontopetaloides* (0.80 ± 0.01 %).

The fat contents of samples testified that the red variety of *Byttneria catalpifolia* is poor in lipids. Indeed, fat contents of dried stem bark and mucilage of this plant species were low compared with those of the seeds of *Daniella oliveri* (7.09 %) and *Olax subscorpoidea* (3.66%) [21]. Our results were also found to be slightly higher than those reported by [22] for the seed of *Parkia filicoidea* (0.43%).

Dietary fibre is an important component of food in human nutrition because it promotes intestinal mobility and reduces serum cholesterol, breast cancer and hypertension [23] [24]. In fact, there is evidence that dietary fibre is likely to reduce the absorption rate of glucose and fat [25], leading to health benefit. Our results revealed that the crude fibre of stem bark was high while it was low in mucilage. Moreover, the crude fibre of the dried bark powder of *Byttneria catalpifolia* was higher than that of *Melochia corchorifolia* (23.33 ± 2.89 %), a leafy vegetable [26]. According to [27], the recommend limit for fibre intake is from 1.4% to 3.5%. Based on this report, only the dried stem bark powder was good source of dietary fibre.

As concern reducing and total soluble sugars, their levels in the stem bark powder were higher than those observed in mucilage, whereas the carbohydrates content of mucilage was higher than that observed in dried bark powder. This showed that the mucilage could contain most complex sugars. The level of carbohydrates of the mucilage from the fresh bark of the red variety of *Byttneria catalpifolia* was high compared with the values of 52.6% in mucilage of *Ziziphus mauritiana* [28].

As for vitamin B2 and B9, the result showed that the both samples were a good source of the vitamin B9.

This work revealed that the calculated caloric energy of the both samples was low compared with the respective values of 1476.7KJ/ 100 g dw and 1513.5KJ/100 g dw in mushroom flours from *Ganoderma spp and Hebeloma mesophaeum* [29]. Therefore, the consumption of bark and mucilage of the red variety of *Byttneria catalpifolia* could be recommended to people suffering from obesity.

4.2. Amino acid contents

Amino acid composition is a reliable indicator of the nutritional value of food. Free amino acids are among the main constituents of functionally essential compounds that are found in stem bark and mucilage of the red variety of *Byttneria catalpifolia.* The amino acid contents found in the mucilage was higher than those of the bark. These low levels of amino acids could be due to the effects of the processing (drying, grinding, sieving) undergone by the bark to obtain the powder. [30] in their work on *Moringa oleifera* showed that the quality of a dried product is often lower than the original food with an important impact on nutritional value. Otherwise, amino acids contents of bark powder or mucilage of *Byttneria catalpifolia* were found to be very lower than those of 11 wild edible mushrooms (from 153.09 mg/100 g dw in *F. hepatia* to 2267.32 mg/100 g dw in *B. edulis*) from northeastern Portugal [31]. Besides, the essential amino acids contents of both samples studied were very low compared with the respective values of 154.3 mg/100 g in *B. craspedius* and 5232.5 mg/100 g in *T. microcarpus* [32]. This suggested that both samples were poor in essential and non-essential amino acids. Moreover, levels of some of them were very lower than that recommended by [33]. In addition to that, protein contents were relatively low in the mucilage as well as in the dried bark powder and were not sufficient to meet protein requirements or the balance of the amino acids. Thus, we recommend that consumers eat *Byttneria catalpifolia* with meat or fish to balance the diet in protein.

4.3. Mineral composition

The mineral composition indicated that the macro-elements such as Mg, P, K, and Ca had relatively high contents in *Byttneria catalpifolia* samples. These results showed a close agreement with those of [34] [35], who reported that Ca and K levels were highest in vegetables. Ca is the most abundant mineral in the body with 99 % in the teeth and bones. It is an essential nutrient that is needed for many functions in human health. Ca content of the dried bark of *Byttneria catalpifolia* was higher than that of the leaves of *Urtica urens* (830 mg / 100 g dw) [36], *Melochia corchorifolia* (750.37 mg / 100 g dw) [26] and that of mucilaginous vegetables such as *Irvingia gabonensis* (452 mg / 100 g dw) and *Beilschmedia manii* (104 mg / 100 g dw) [37]. Considering that the daily requirement of Ca is 1200 mg, one serving of the dried bark powder of *Byttneria catalpifolia* per day would help to meet daily Ca requirements [38].

The level of K in the dried bark of the red variety of *Byttneria catalpifolia* was higher than that of mucilage and both had high contents in K as well as leaves of *Urera trinervis* (1.25 %) and *Hippocratea myriantha* (1.29 %) [39]. K is known for its important role in the osmotic regulation of body fluids and in the acid-base balance. It also contributes to nerve and muscle excitability and carbohydrate metabolism [40].

Mg is closely associated with Ca and P and about 70% of the total Mg is found in the skeleton. Ca and Mg are essential elements of human physiology and are particularly important in the biological functions which are characteristics of the cardiovascular system [41]. Mg levels obtained in the bark and mucilage were greater than those reported by [42] and [43] in *Artocarpus altilis* flours (90.63 - 92.7 mg /100 g) and cassava (36.58 - 37.71 mg /100 g), respectively. Moreover, in the extracts of the bark of *Byttneria catalpifolia*, the [Ca] / [Mg] ratio was greater than 2. Note that, the absorption of Ca and Mg are interdependent, depending on their ratio. Diet is considered good if the ratio between these two minerals in the diet is from 2 to 1 in favour of Ca [44].

P has more functions than any other mineral element in the body. It forms a complex with Ca that gives stiffness to bones, teeth and muscles [45]. It acts as a cofactor for many enzymes and activates several of the B complex vitamins. It also affects the production of the adenosine triphosphate molecule, which is crucial for energy storage [46]. The P contents of powder and mucilage of *Byttneria catalpifolia* were higher than that of *O. gratissimum, T. occidentalis,* and *V. amygdalina* (13.8, 13.1 and 15.08 mg/100g dw, respectively) which are leafy vegetables eaten in South West of Nigeria [47]. It should be noted that, food is also considered "good" if the [Ca] / [P] ratio is greater than 1 and "mediocre" if less than 0.5 [44]. The [Ca]/ [P] ratio of dried bark powder and mucilage was 28.68 and 11.80, respectively. Thus, the levels of these minerals showed that the dried stem bark and mucilage of this plant may be used to complement the required macro-element needed for proper growth and development in human beings and other domesticated animals.

The high content of iodine (I) and other minerals in the pellet compared to the mucilage showed that the use of mucilage to prepare sauce does not allow access to all the minerals contained in this stem vegetable. The relative high concentration of I in dried stem bark powder compared with other vegetables such as eggplant leaves (7.6 µg / 100g dw) and melon leaves (6.13 µg / 100 g dw) [48] indicated that the bark could be a good source of I. Thus, its regular consumption would supply appreciable amount of I and would benefit consumers, particularly those in the western of Côte d'Ivoire, where endemic goitre is high (38.3%) [49]. Indeed, I is essential to produce thyroid hormones, thyroxine (T4) and triiodothyronine. Iodine deficiency can lead to goitre, hypothyroidism, poor growth and neurocognitive trouble [50].

4.4. Organic acids contents

The observed organic acids were Tannic, oxalic, citric, tartaric, Sulfanilic, Salicylic, adipic, fumaric and benzoïc acids. Citric and tartaric acids had the highest levels in both samples. Citric acid contents of samples were higher than that observed for *moringa* leaf (1.56 ± 0.45 mg/100 g dw) [51]. However, they were lower than that observed in kale (*Brassica oleraceae* L.var. acpehala DC.) leaf (2213 mg/100 g dw) [52]. As for tartaric acid contents of both samples, they were found to be lower than that obtained by [51] in Ceylon Spinach (1200 ± 11.56 mg/100g dw). In contrast, tartaric acid levels were higher than that found in moringa leaf by [51], who recorded the value of 0.45 ± 0.02 mg/100 g dw. Note that, the organic acid contents of foods do not only influence their flavour, but also their stability, nutrition, and acceptability [53]. The [oxalic acid] / [Ca] ratios of dried bark (0.001) and mucilage (0.061) were less than 2.25, which is the threshold value not to be exceeded. Indeed, oxalic acid interferes with Ca uptake. Thus, the [oxalic acid] / [Ca] ratios below 2.25 indicated that the amount of oxalic acid in both samples will not interfere with Ca [54].

4.5. Nutritional profile

The nutritional profile of extracts of the red variety of *Byttneria catalpifolia,* following the SAIN and LIM method showed that they belong to the group of foods recommended for health. These results corroborate those of [55] in their work on use of SAIN and LIM system for determination the nutritional profile of foods eaten by children under-five in the district of

Abidjan, Côte d'Ivoire. According to these authors, the different vegetable-based soups such as okra, tomato and eggplant have a good nutritional value because their SAIN > 5 and LIM < 7.5. [56] also showed that 80% of vegetables belong to the food group with a strong SAIN and a low LIM and therefore recommended for health. According to [57], non-starchy vegetables such as *Byttneria catalpifolia* are rich in fibres that improve intestinal transit by forming a mass, which leads to a more gradual absorption of nutrients, thus avoiding constipation. They are also very poor in energy and therefore can be consumed in relatively larger amounts to maintain a normal weight [58].

5. CONCLUSION

On the basis of the above results it can be concluded that the dried bark and the mucilage extracted from the fresh bark of the red variety of *Byttneria catalpifolia* contain appreciable amounts of nutrients such as carbohydrates, Proteins, essential amino acids, vitamins and minerals. Our findings indicated that the both samples were nutritionally important, since their nutritional profile by SAIN and LIM method showed that they belong to the group of foods recommended for health. The powder of the dried bark was very rich in iodine and other nutrients, therefore the consumption of this powder would be more beneficial to nutritional balance than the mucilage.

COMPETING INTERESTS

The authors declared that they have no conflict of interest.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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