Nutritive Compounds Contained In Some Mucilaginous Plants Consumed In Côte d' Ivoire

Olivier Yapo ASSI[1*], Daouda SIDIBE[1], Rachel Rebecca ASSA[1], Ysidor N'guessan KONAN[1], Adama COULIBALY[3], Henri Godi BIEGO[1,2]

[1]Laboratory of Biochemistry and Food Science, Training and Research Unit of Biosciences, Felix HOUPHOUET-BOIGNY University of Abidjan, 22 BP 582 Abidjan 22, Côte d'Ivoire
assiolivier@gmail.com
[2]Department of Public Health, Hydrology and Toxicology, Training and Research Unit of Pharmacological and Biological Sciences, Felix HOUPHOUET-BOIGNY University, BP 34 Abidjan, Côte d'Ivoire
[3]Training and Research Unit of Biological Sciences, Peleforo Gon Coulibaly University, Korhogo, Côte d'Ivoire

ABSTRACT

Aims: To assess the nutritive compounds contents in different edible parts of nine mucilaginous food plants (MFPs) from Côte d'Ivoire**.**
Study Design: MFPs edible parts were dried and nutritive compound analyzed.
Place and Duration of Study: The study was conducted in Laboratory of Biochemistry and Food Sciences, Biosciences Unit, at Felix Houphouet-Boigny University between January and December 2014.
Methodology: The acquirement of the plants has been done in 3 big regions (Tonkpi, Bélier and District of Abidjan) of Côte d'Ivoire. To achieve this study, 100 kg of fresh fruits and masts of the species *I. gabonensis, I. wombolu* and *B. mannii* have been collected to the farmer in the region of the Tonkpi. A same quantity of leaves, calyx and flowers of *B. buonopozense* has been harvested in the region of Belier. As well as 100 kg of leaves of *C. olitorius*, *M. arboreus*, *A. digitata* and varieties tomi and koto of *A. esculentus* have been collected to the Gouro market in the District of Abidjan. So a biochemical characterization of the kernels (IG and IW), leaves (CO, AD, MA and BB), fruits (BM and AE) and flowers (BB) has been achieved.
Results: The results reveal richness in nutritive components of the studied food plants. The ash contents are consisted between 2.5±0.14% and 10.70±0.07% and are raised more in the leaves and the fruits of A. esculentus. The leaves, flowers and fruits also expressed the best concentrations in polyphenols of 116.40±2.11 to 521.76±5.13 mg/100 g DM. These same parts showed the best concentrations in proteins especially leaves (10.06±0.85% to 12.69±0.64% DM). The mucilaginous food plants provided some contents in carbohydrates varying from 10.33±0.04% to 60.64±0.71%. The concentrations in lipids are generally weak below 6% but very strong (55.79±1.45% and 75.99±2.25%) in the kernels of Irvingia spp, providing thus big calorific value (567.90±4.07 and 689.98±1.41 kcal/100 g DM). The fibers are recovered in important quantity in the leaves of all studied species (28.5±0.55% to 36.5±0.42%).
Conclusion: MFPs valorization could contribute to ensure the nutritional safety to Ivorian populations.

Keywords: mucilaginous food plants, nutritive characteristic, Côte d'Ivoire.

E-mail: assiolivier@gmail.com

1. INTRODUCTION

The importance of the non ligneous foodstuffs in African population's food is incontestable [1]. In a lot of countries, food plants assure more than 80% of the food needs [2]. They are precious sources of nutriments, especially in farming environment where, they contribute to the satisfaction of the needs in proteins, minerals, vitamins, fibers, lipids [3]. In their big majority, the leafy vegetables are all year present on the markets, even during the periods of soldering. They play an inescapable role in the strategy of the food security of the populations and contributing thus to the nutritional balance and procuring by their sale, non negligible incomes to the families [4, 5, 6]. In Africa, population food habits knew changes bound to the life styles imposed by the setting process of the persons and the extraordinary development of the African cities [7]. Therefore, it lands more and more the linked problems of health due to the non balanced food diets. In addition to deficiencies illnesses, the metabolic illnesses as obesity, diabetes, arterial high blood pressure and cancers become public health problems whose handling remains very heavy for persons and health structures [8]. The promotion of some non ligneous forestry products and their integration in the food diets become inescapable for a good health and well being; it's the case of the mucilaginous food plants. Indeed, these plants, in addition to their richness in essential nutrients, constitute important sources of indispensable metabolites for a good health [9] thanks to their organoleptic properties, cut hunger, regulation of the blood sugar, tension, cholesterol and some parameters of homeostasis [10, 11]. The mucilages that they contain make them the primary commodities in the food of the populations of several regions of Cote d'Ivoire [12]. These plants can replace also some synthesis food additives whose abuse would be dangerous for health. Mucilage is a complex carbohydrate with a containing highly branched structure of variable proportions of L-Arabinose, D-Galactose, L-Rhamnose and D-xylose and of galacturonic acid [13, 14]. The use possibilities of mucilaginous plants are numerous. Mucilages are used in the agroalimentary, pharmaceutical and cosmetic domains [15, 16, 17, 18]. Concerning the population food habits of numerous regions, the mucilaginous plants act as agent of swelling in the local culinary preparations [12]. They are also used in the flocculation and the decanting of numerous local drinks [19]. In the struggle against poverty and the pauperization of African populations, the mucilaginous plants can constituted a non negligible source of incomes [20]. Therefore, the aims of this study is to contribute to a better valorization of mucilaginous food plants from Ivorian flora, by a biochemical characterization of the different edible parts.

2. MATERIAL AND METHODS

2.1 Vegetable material

The biological material is constituted of different edible parts of 9 mucilaginous plants from Ivorian flora. It's notably about *Irvingia gabonenesis* (IG), *Irvingia wombolu* (IW), *Bombax buonopozense* (BB), *Adansonia digitata* (AD), *Beilschmiedia mannii* (BM), *Corchorus olitorius* (CO), *Myrianthus arboreus* (MA) and varieties koto and tomi of *Abelmoschus esculentus* (AE). The kernels (IG and IW), leaves (CO, AD, MA and BB), fruits (BM and AE), calyx and flowers (BB) that constitute the parts consumed by several populations of Cote d'Ivoire have been collected (Table 1). These plants have been authenticated by the Centre National de Floristique (CNF) of the University Felix HOUPHOUET-BOIGNY.

Table 1: Some mucilaginous food plants of Ivorian flora

Designation	Family	Local name	Edible parts
Irvingia gabonensis (Aubry Lecomte)	Irvingaceae	Kaclou, Kplé	kernels
Irvingia wombolu (Vermoesen)	Irvingaceae	Kaclou, Kplé	kernels
Bombax buonopozense (P.Beauv)	Bombacaceae	Kapokier	calyx, leaves, flowers
Corchorus olitorius(Linn)	Tiliaceae	Kplala	Leaves
Adansonia digitata (Linn)	Bombacaceae	Baobab	Leaves
Myrianthus arboreus (P.Beauv)	Cecropiaceae	Tikliti	Leaves
Beilschmiedia mannii (Meisn)	Lauraceae	sran	Fruits
Abelmoschus esculentus(Linn) var. tomi	Malvaceae	Gumbo baoule	Fruits
Abelmoschus esculentus (Linn) var. koto	Malvaceae	Gumbo dioula	Fruits

E-mail: assiolivier@gmail.com

2.2 Samples processing

The acquirement of the plants has been done in 3 big regions (Tonkpi, Bélier and District of Abidjan) of Côte d'Ivoire from January to December 2014. To achieve this study, 100 kg of fresh fruits and masts of the species *I. gabonensis, I. wombolu* and *B. mannii* have been collected to the farmer in the region of the Tonkpi. A same quantity of leaves, calyx and flowers of *B. buonopozense* has been harvested in the region of Bélier. As well as 100 kg of leaves of *C. olitorius*, *M. arboreus*, *A. digitata* and varieties tomi and koto of *A. esculentus* have been collected in the Gouro market of the Abidjan district. In each of the regions, the different products have been collected to 3 farmers.

2.3 Treatment of the mucilaginous plants

The fruits of *Irvingia* have been stocked several days then the seeds have been ground to isolate the kernels. As for the fruits of *B. mannii*, they have been cut in small pieces (less than 5 mm of thickness) before drying. In return, the fruits of *A. esculentus* (okra) have been cut in gill, whereas the leaves, the calyx and the flowers were sorted, cleaned and drained before being dried. After drying, plants parts collected have been reduced in powder with a grinder of Heavy Duty mark.

2.4 studied parameters determination methods

2.4.1 Dry matter content

The method used for dry matter determination is the one described by [21] that consists to put to dry a sample until the obtaining of a constant mass. Thus, 10 g of sample has been weighed in a known mass capsule (m_0). Then the capsule containing the sample (m_1) has been placed in an oven (Memmert, Germany) at 105°C until constant weight. After cooling in desiccators, the capsule is weighed again (m_2). The content in dry matter has been expressed in percentage of mass as follows:

$$\text{Dry matter (\%)} = [(m_2 - m_0)/ (m_1 - m_0)] \times 100$$

m_0: mass (g) empty capsule
m_1: mass (g) capsule + sample
m_2: mass (g) capsule + sample after desiccation.

2.4.2 Ash content

The method used for ashes determination is the one described by [21] that consists to incinerate a sample until the obtaining of white ashes. Thus, 5 g of sample has been weighed in an incineration capsule in china of known mass (m_0). Then the capsule containing the sample (m_1) has been placed in a muffle furnace (PYROLABO, France) and incinerated to 550°C during 24 h. After calcinations and cooling in desiccators, the capsule is weighed again (m_2). The ash content has been expressed in percentage of mass as follows:

m_0: mass (g) empty capsule
m_1: mass (g) capsule + sample before incineration.

$$\text{Ash (\%)} = [(m_2 - m_0)/ (m_1 - m_0)] \times 100$$

m_2: mass (g) capsule + sample after incineration.

2.4.3 Lipids content

The contents in fat matters have been determined according to the method described by [22] and using the Soxhlet as extractor. Thus, 10 g of sample ground have been placed in a cartridge of extraction in cellulose and gulp by cotton. The cartridge has been introduced in the reservoir of a Soxhlet then the extraction of oil has been achieved by a system of flux and reflux of solvent with 300 mL of hexane. After 7 h of extraction, the solvent has been recovered with the help of a rotary evaporator (HEIDOLPH). The ball initially weighed and containing oil has been weighed to determine the mass of oil extracted. The content in fat matters has been expressed in percentage of mass as follows:

$$\text{Lipids (\%)} = (m/m_E) \times 100$$

m: mass (g) of oil extracted
m_E: mass (g) of sample ground

2.4.4 Proteins content

The raw proteins have been determined according to the method of Kjeldhal [21] from the dosage of the total nitrogen. In a matras of mineralization containing 1 g of sample, have been added a pinch of the catalyst successively (selenium) and 20 mL of concentrate sulfuric acid. The mineralization has been achieved, to 400°C during 2 h, in a digester (BUCHI). After cooling to the ambient temperature, mineralized it has been decanted in a vial sized up of 100 mL and completed with distilled water. To a solution of 10 mL of mineralized, are added 10 mL of NaOH 40% (p/v) and the mixture has been placed in the distiller's reservoir. The extension of the distiller's refrigerator has been dived in a ball containing 20 mL of boric acid added of a mixed indicator (red of methyl + green of bromocresol). The distillation has been achieved during 10 min until the obtaining of a purple distillate. The distillate has been measured out by a solution of sulfuric acid 0,1N until the green turn. A white

E-mail: assiolivier@gmail.com

has been achieved with the distilled water. The content in total proteins has been expressed in

$$\textbf{Proteins (\%)} = [(V_1 - V_0) \times 14 \times 6.25] \times 10 \times m_e$$

percentage of mass as follows:

V_0: volume (mL) of sulfuric acid (0,1N) added to white.
V_1: volume (mL) of sulfuric acid (0,1N) added to sample.
m_e: mass (g) of sample ground

2.4.5 Total and reducing sugars content

2.4.5.1 Extraction of the ethanosoluble sugars

The ethanosoluble sugars are extracted according to the method described by [23]. A trial hold of 1 g of sample has been diluted in 10 mL of ethanol (80%; v/v). To the gotten mixture have been added 2 mL of zinc acetate (10%; p/v) and 2 mL of oxalic acid (10%, p/v). The mixture has been centrifuged then at 3000 rpm for 10 min. The cheek has been taken with 10 mL of ethanol (80%; v/v) centrifuged then again at 3000 rpm for 10 min. The supernatant has been decanted in a vial of 50 mL and the excess of ethanol evaporated to the sand bath during 10 min. Then the gotten solution has been completed to 50 mL with the distilled water.

2.4.5.2 Total sugars content

Total sugars content has been determined according to the method to the phenol-sulphuric as described by [24]. 100 µL of ethanosoluble sugars extracted have been introduced in a test glass then 0.9 mL of distilled water, 1 mL of phenol 5% (p/v) and 5 mL of concentrate sulfuric acid have been successively added. After agitation then cooling of the tube, the absorbance has been read to the spectrophotometer (PG INSTRUMENTS) at 490 nm, against a white. The determination of the quantity of total sugars has been achieved from a range of glucose solution mother (1 mg/mL) realized in the same conditions that the test.

2.4.5.3 Reducing sugars content

The quantification of reducing sugars has been achieved according to the method of [25]. To 1 mL of sugars ethanosoluble extract contained in a test glass has been added 0.5 ml of distilled water and 0.5 mL of DNS solution. The whole has been heated to the boiling bath, during 5 min. After cooling, 2 mL of distilled water has been added then the absorbance of the solution has been read to the spectrophotometer (PG INSTRUMENTS) at 540 nm, against a white. Range standards established in the same conditions that the test from a solution mother of glucose (1 mg/mL) permitted to determine the quantity of reducing sugars.

2.4.6 Carbohydrates

Carbohydrates content has been determined by difference according to the following formula [26]:

% Carbohydrates = 100 - (% Lipids + % proteins + % Ash + % fibers)

2.4.7 Fibres content

The raw fibres regroup the cellulose, some hemicelluloses and the lignine. The contents in raw fibres have been determined by the method of [27]. So, 1 g of sample (m) has been carried to boiling point in 50 mL of sulfuric acid (1,25 N) then in 50 mL of sodium carbonate (1,25N) during 1 h. The gotten residual is dried to 105°C during 8 h (m_1) incinerated then to 550°C during 3 h (m_2). The content in total raw fibres expressed in percentage of dry matter has been determined by the formula**:**

$$\textbf{Fibres (\%)} = [(m_1 - m_2)/ (m \times DM)] \times 100$$

DM= Dry matter

2.4.8 Polyphenols content

Polyphenols content was determined using the method reported by [28]. A quantity (1 g) of dried powdered sample was soaked in 10 mL of methanol 70% (w/v) and centrifuged at 1000 rpm for 10 min. An aliquot (1 mL) of supernatant was oxidized with 1 mL of Folin-Ciocalteu's reagent and neutralized by 1 mL of 20% (w/v) sodium carbonate. The reaction mixture was incubated for 30 min at ambient temperature and absorbance was measured at 745 nm by using a spectrophotometer (PG Instruments, England). The polyphenols content was obtained using a calibration curve of Gallic acid (1 mg/mL) as standard.

2.4.9 Energy value

The theoretical calorific value of the samples of plants has been calculated from the specific coefficients for proteins, lipids and carbohydrates [26].

Energy value (kcal/100g DM) = (% Proteins x 2.44) + (% carbohydrates x 3.57) + (% Lipids x 8.37)

The results of ash, fibres, proteins, lipids and carbohydrates contents were expressed on dry matter basis (DM).

E-mail: assiolivier@gmail.com

2.5 Statistical analysis

All the analyses were performed in triplicate and data were analyzed using the software SPSS (SPSS 16.0 for Windows, SPSS Inc.). It consisted in a variance analysis (ANOVA) to 1 criteria of classification (parts of the plants). The averages have been compared by the test of Newman Keuls at 5%. A principal components analysis (PCA) has been achieved also and the coordinates of the individuals of the PCA have been used for an ascending hierarchical clusters analysis (AHC) at 1500 by STATISTICA 7.1 (StatSoft). The 2 groups descended of the AHC have been characterized either by their richness in energy, lipid, protein and fibre, either by a wealth in polyphenols, reducing sugar and carbohydrates. The PCA also permitted to structure, to distribute and to regroup the similar individuals.

3. RESULTS

All biochemical parameters differentiate ($p < 0.001$) the food resources studied (table 2 and 3). Indeed, the dry matter contents are consisted between 15.40±1.11% and 94.70±0.15%. The kernels provide dry matters contents more than 91%. To the level of the ash contents, the averages fluctuate between 2.15±0.14% and 10.70±0.07% of dry matter. The table 2 shows that the leaves of *A. digitata* (10.70±0.07%), *M. arboreus* (10.01±0.61%) and *B. buonopozense* (8.40±0.12%) and the fruits of *A. esculentus* (10.02±1.24% to 10.30±0.68%) are provided more in ashes.

The presence of polyphenols is also various in the studied samples ($p < 0.001$). However, the kernels contain the weakest contents in polyphenols (<100 mg/100 g DM), whereas the fruits of *B. mannii* (439.86±0.56 mg/100 g DM), the leaves of *A. digitata* (375.96±0.90mg/100 g DM) and the different parts of *B. buonopozense* (436.39±0.50 in 521.76±5.13 mg/100 g DM) are some well provided.

The samples of studied mucilaginous food plants present variable carbohydrates contents ($p < 0.001$). The kernels of *I. wombolu* contain the weakest carbohydrates content (10.33±0.04%) whereas the fruits of *B. mannii* are the more of them provided (60.64±0.71%). In return, the leaves of *B. buonopozense* (1.12±0.33%) and the fruits of the variety *koto* of *A. esculentus* presents less non polymerized sugars (1.67±0.41%) that the other samples that have 2.44±0.36% to 8.10±0.55%. Some of these carbohydrates have reducing properties. The table 2 shows that the reducing sugars are less present in the kernels (0.49±0.35% and 0.60±0.09%) but more concentrated in the flowers of *B. buonopozense* (3.76±0.05%).

Concerning the fat matter, the kernels provide contents of 55.79±1.45% and 75.99±2.25%, superior to the values descended of the samples of fruits, leaves and mucilaginous flowers that oscillate between 0.62±0.74% and 5.79±0.84% (table 3).

With an average of 5.25±0.15%, the kernels are statistically less provided in proteins that the other analyzed food resources. The strongest contents in proteins are observed in the leaves that contain 10.06±0.85% to 12.69±0.64%. To the level of the fibres, the contents vary from 29.55±0.15% to 36.50±0.51% in the fruits, leaves and mucilaginous flowers, but they are statistically more reduced in the kernels (11.6±1.18% and 4.53±0.89%).

From their biochemical composition, the samples of kernels present a calorific value (567.90±4.07 and 689.98±1.41Kcal/100 g DM) superior to flowers, fruits and leaves value that varies from 185.44±0.36 to 246.81±1.73 Kcal/100 g DM (table 3).

Table 2: Biochemical composition of mucilaginous food plants consumed in Côte d'Ivoire.

Edible parts		DM (% FM)	TCE (%DM)	TPT (mg/100 g DM)	TST (%)	TSR (%)
[illegible]	IG	94.70±0.15^{A}	2.66±0.17^{H}	16.34±0.43^{I}	2.44±0.36^{I}	0.60±0.09^{J}

E-mail: assiolivier@gmail.com

	IW	91.60±0.23^{B}	2.15±0.14^{I}	71.82±1.09^{H}	4.27±0.67^{F}	0.49±0.35^{K}
Fruits	AE-*koto*	16.98±0.75^{H}	10.30±0.68^{B}	118.38±0.75^{G}	1.67±0.41^{J}	1.47±0.86^{E}
	AE-*tomi*	18.56±0.25^{G}	10.02±1.24^{C}	116.40±2.11^{G}	8.10±0.55^{A}	0.78±0.44^{H}
	BM	89.24±0.57^{C}	3.50±0.13^{G}	439.86±0.56^{C}	5.74±0.34^{E}	2.17±0.72^{B}
Leaves	AD	20.87±0.18^{E}	10.70±0.07^{A}	375.96±0.90^{D}	3.53±0.78^{G}	1.21±0.31^{G}
	CO	15.40±1.11^{I}	6.11±0.91^{E}	171.38±1.50^{E}	6.93±0.22^{D}	1.61±0.59^{D}
	MA	19.25±1.69^{F}	10.01±0.63^{C}	151.90±3.75^{F}	3.12±0.98^{H}	1.25±0.02^{F}
	BB	21.79±0.23^{D}	8.40±0.12^{D}	482.05±0.37^{B}	1.12±0.33^{K}	0.67±0.47^{I}
Flowers	BB-*calyx*	16.89±0.62^{H}	6.20±0.75^{E}	521.76±5.13^{A}	7.21±0.64^{C}	1.76±0.63^{C}
	BB-*flower*	18.96±0.37^{G}	5.02±0.24^{F}	436.39±0.50^{C}	8.03±1.01^{B}	3.76±0.05^{A}
	F	41886.98	6098.43	4705.77	218613.9	6307.75
	p-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

From the same column, values with different uppercase letters are statistically different at 5% significance. F, statistical value of ANOVA ; p-value, probability value of ANOVA ; DM, dry matter content ; TCE, ash content; TST, total sugars content ; TSR, reducing sugars content ; TPT, polyphenols content.

Table 3: Biochemical composition of mucilaginous food plants consumed in Côte d'Ivoire

Edible parts		TGT (%)	TMG (%)	TPR (%)	Fibres (%)	VEN (Kcal/100g DM)
Kernels	IG	24.7±0.33^{I}	55.79±1.45^{B}	5.25±0.15^{J}	11.6±1.18^{I}	567.90±4.07^{B}
	IW	10.33±0.04^{J}	75.99±2.25^{A}	7.00±0.08^{H}	4.53±0.89^{J}	689.98±1.41^{A}
Fruits	AE-*koto*	45.33±0.47^{F}	3.74±0.09^{D}	9.63±0.33^{E}	31±0.71^{F}	216.58±6.11^{E}
	AE-*tomi*	43.56±0.11^{G}	1.61±0.67^{F}	8.31±0.96^{F}	36.5±0.51^{A}	189.24±2.08^{I}
	BM	60.64±0.71^{A}	0.62±0.74^{H}	5.69±1.25^{I}	29.55±0.15^{H}	235.54±7.83^{D}
Leaves	AD	42.7±0.12^{G}	2.71±0.11^{E}	10.06±0.85^{D}	33.83±0.73^{E}	199.65±1.04^{H}
	CO	46.89±0.88^{E}	5.79±0.84^{C}	12.69±0.64^{A}	28.52±0.55	246.81±1.73^{C}
	MA	40.22±0.36^{H}	1.56±0.20^{F}	11.81±0.69^{B}	36.4±0.42^{B}	185.44±0.36^{J}
	BB	49.31±0.94^{B}	1.12±0.82^{G}	10.94±0.53^{C}	30.25±0.09^{G}	212.09±2.44^{G}
Flowers	BB-*calyx*	47.26±1.05^{D}	1.01±0.54^{G}	9.63±0.01^{E}	35.9±0.20^{C}	200.65±8.06^{H}
	BB-*flower*	48.61±0.44^{C}	2.73±0.05^{E}	7.88±0.66^{G}	35.76±0.19^{D}	215.60±4.01^{F}
	F	51878.65	285856.57	21301.71	36824.27	54722.64
	P-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

From the same column, values with different uppercase letters are statistically different at 5% significance. F, statistical value of ANOVA ; p-value, probability value of ANOVA TMG, lipid content ; TGT, carbohydrate content; TPR, protein content ; VEN, energy value.

3.1 Biochemical contents variability

The principal components analysis has been done while considering the first two factors (F1 and F2) that express the biggest part of the variability (79.14%). The projection of the biochemical contents and the parts of studied plants is presented on the figure 1. This representation regroups the kernels around the strongest lipoids contents (55.79% and 75.99%) and calorific value (567.90 and 689.98 Kcal/100 g DM); whereas the leaves are the biggest sources of proteins (10.06% to 12.69%). Concerning the samples descended of the flowers, they provide the strongest carbohydrates contents (reducing sugars and carbohydrates) and polyphenols content. In return, the fruits are more concentrated in carbohydrates constituent (total

E-mail: assiolivier@gmail.com

sugars, reducing sugars, carbohydrates) and polyphenols, either in proteins. The classification of the samples in the figure 2 confirms this structuring. Besides, it reveals that the leaves are not all more concentrated in proteins and fibres; nor all fruits in carbohydrates and polyphenols.

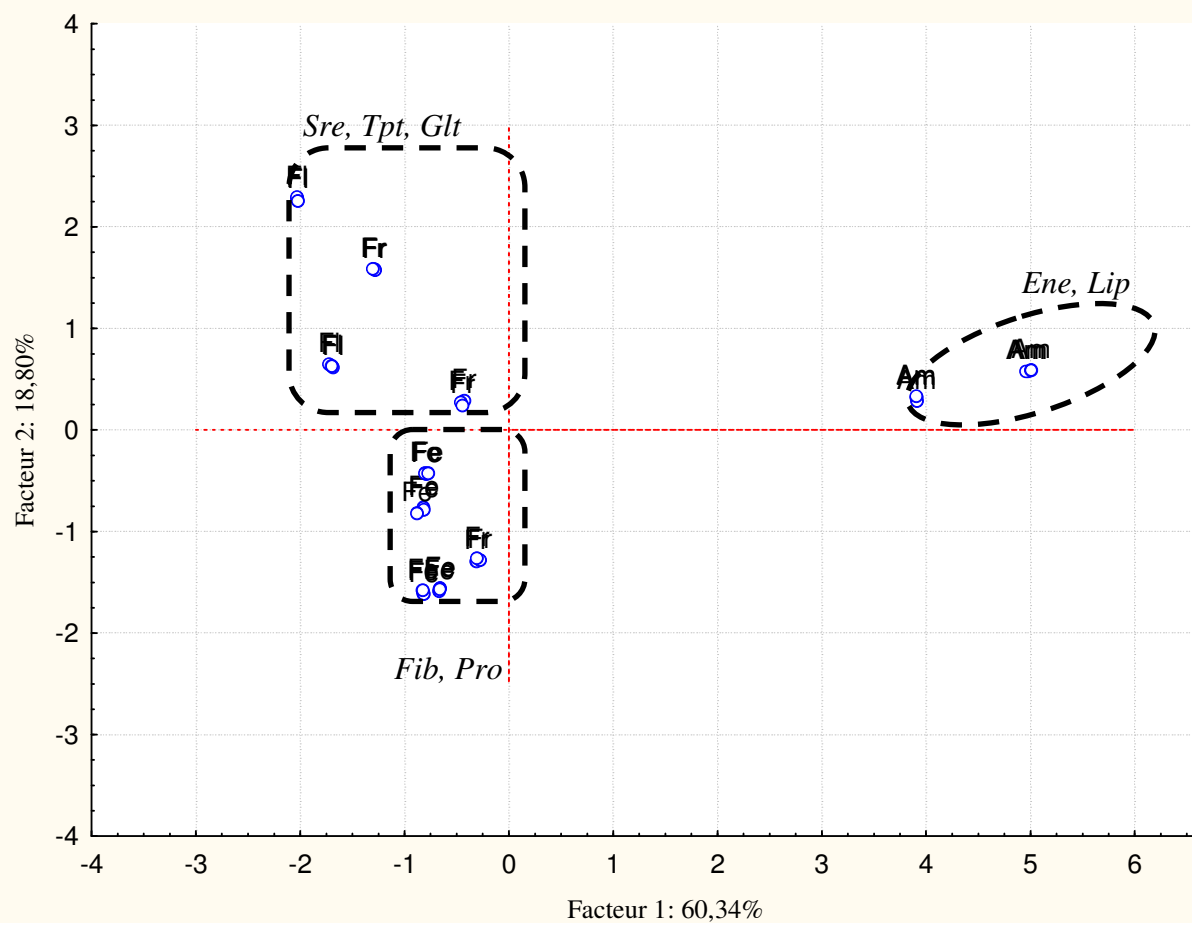

Figure 1: Regrouping of the biochemical contents and edible parts of the mucilaginous plants in the plan formed by the factors F1 and F2 of the principal components analysis.

Fr, fruits ; Fe, leaves ; Fl, flowers ; Am, kernels ; Fib, fibres ; Pro, proteins ; Sre, reducing sugar ; TPt, polyphenols Ene, energy ; Lip, lipids

E-mail: assiolivier@gmail.com

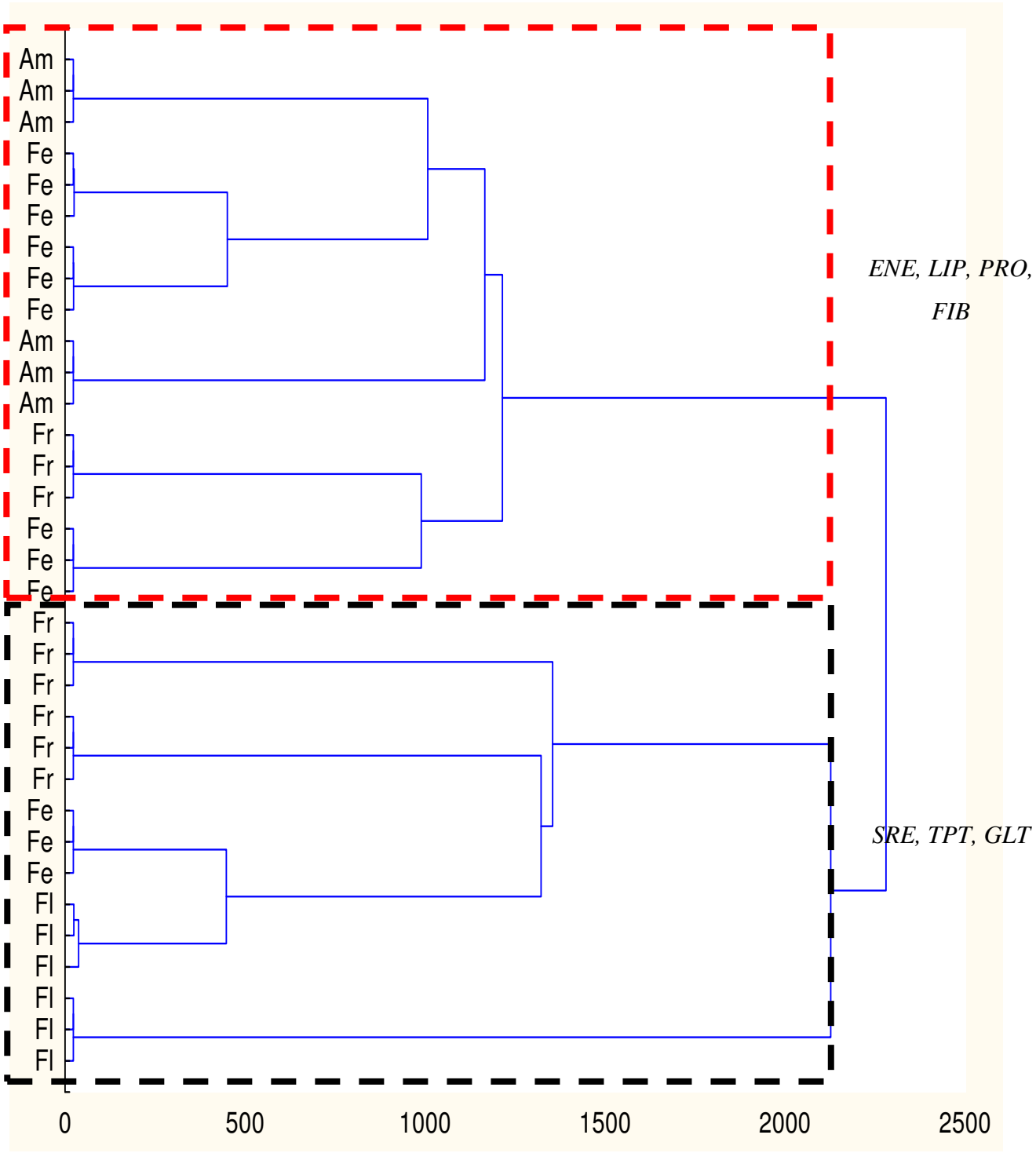

Figure 2: Dendrogram representing ascending hierarchical classification of the parts of the mucilaginous plants according to the biochemical contents.

Fr, fruits; Fe, leaves; Fl, flowers; Am, kernels

E-mail: assiolivier@gmail.com

4. DISCUSSION

The kernels of *Irvingia* and the fruits of *B. mannii* distinguished themselves by a strong content in dry matter, superior to 89% of the fresh matter contrarily to leaves, flowers and fruits of *A. esculentus*. These strong contents in dry matters could be bound to an important presence of organic molecules in the samples. Nnamani and other [29] found similar moisture in the leaves of *B. buonopozense* (78.85%) and the fruits of *A. esculentus* (80.85%). This wealth in water would be favorable to the actions of damage agents [30, 31]. In return, to the level of *M. arboreus* leaves (19.25%), Kouame and other found more dry matters contents (36%) [12].
The leaves (6.11% to 10.70%) and *A. esculentus* fruit (10.30% and 10.02%) presented the most important ash contents. Adetuyi found similar concentrations (9.63%) in *A. esculentus* [32], while Amata discovered bigger ashes proportions in the leaves of *M. arboreus* (16.4%) [33]. the ash gotten after incineration of the organic matter showed the presence of essential minerals. The presence of mineral in this plant part, confirmed that leaves and fruits, are preferential zones of mineral accumulation [34].

The study also shows that the leaves, the fruits and the flowers are more concentrated in polyphenols, especially *B. buonopozense* (436.39 to 521.76 mg/100g DM), *A. digitata* (375.96 mg/100 g DM) and *B. mannii* (439.86 mg/100 g DM). In *C. olitorius* leaves (171.38 mg/100 g DM), Acho found more elevated contents (244.20 mg/100 g DM) [35]. This character is an important advantage in the valorization of the plant food. Indeed, polyphenols are important antioxidant agents that protect the biologic macromolecules against the deterioration. Thus, they fight efficiently against the ageing and the intervening of cancerous cells [36, 37]. The food base on mucilaginous plants could provide to the needs in polyphenols of the organism and reinforce population's health.

Carbohydrates are more concentrated in content varying from 40.22% to 60.64% DM in leaves, fruits and flowers. The kernels provided less elevated contents (10.33% and 24.70% DM) in accordance with the results (15.77% to 38.54% DM) found by Matos and other [38]. Total sugars (6.93% DM) and reducing sugars (1.61% DM) gotten in *C. olitorius* leaves are extensively weak to Tchiégang and other results (43.35% and 39.76% DM) [39].
The majority of plant parts studied provided weak contents in lipids, under 6% DM, as well as confirmed by Nnamani with *A. esculentus* fruits (0.40%) and *B. buonopozense* leaves (0.70%) [29]. However, the kernels studied presented lipids contents more than 55%. This observation has been confirmed by several previous works [40, 41, 42]. Indeed, lipids are indispensable to the organism, by their implication in the cerebral functions and their role in fat-soluble vitamins absorption [43, 44]. These contents in fat represent an advantage for kernels valorization like peanut and palm oil.
The leaves, fruits and flowers studied provided protein contents in the order of 10.06%. Sena and collaborators [45] obtained similar contents (11.2%) in *A. digitata* leaves, contrary to Dickson [46] who got bigger concentrations (20.06%) in *C. olitorius* leaves. These plants could contribute to the needs of the populations. Indeed, the proteins are essential to the formation of the bodily cloths, to the antibodies production and to the cells functioning [47]. Also, Agbo [48] showed the interference of the agricultural techniques with protein contents because the use of nitrogenous manure during production could influence the concentrations.
Plant parts studied revealed fiber contents, confirmed by the results gotten by Amata [33]. In fact, the gluey aspect of sauces, assessed by several consumers, is due to fiber presence precisely mucilage. These fibers play an important role in lipids and carbohydrates metabolism. They reduce the risks of constipation and cancer. Also, they intervened especially on blood sugar by lowering the intestinal absorption of the glucose [10, 49, 50]. The fibres warn cholesterol absorption [11].
The kernels generated high energy values. Our results are in conformity with the results obtained by Kehlenbeck and other on the energizing tendency of some plants [51]. Kernels consumption could be recommended therefore at the time of intense muscular activities. On the other hand, leaves, flowers and fruits have weak energy values, corroborative the deductions of several works on most mucilaginous food plants [52, 53]. But, a very weak energy values has been found in *M. arboreus* (83.52 Kcal/100g) [54]. So, mucilaginous food plants consumption could help population's victims of metabolic illnesses as the arterial high blood pressure, the hyperglycemia and the hypercholesterolemia [55].

5. CONCLUSION

Mucilaginous food plants study reveals that the leaves, the fruits and the flowers are rich in ashes, carbohydrates, proteins, polyphenols and fibres, with however, weak energy values. The consumption of these parts would be important for the human health. They could permit to fight against the diabetes, the arterial high blood pressure, the cancer and the obesity. The kernels provided raised contents in lipids and energy values also. They could be recommended to the person doing hard activities that requiring a lot of energy. The classifications regrouped

E-mail: assiolivier@gmail.com

mucilaginous food plants in 2 tendencies, on the one hand, the group of the parts rich in lipids, energy, proteins and fibres and on the other hand, the parts rich in polyphenols, reducing sugars and carbohydrates. This classification could orient the population in the better satisfaction of their needs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHOR'S CONTRIBUTIONS

The current study was achieved with the collaboration of all authors. Author OYA wrote the protocol, performed the laboratory analysis and wrote the first draft of the manuscript. Authors DS and YNK performed the statistical analysis, checked the first draft of the manuscript and achieved the submitted manuscript. Author AC took part in the interpretation of the results and corrected the first draft of the manuscript. Author RRA managed the literature and assisted the experiments implementation and the statistical analysis. Author HGB designed the study and supervised author OYA in recovering the results. All authors read and approved the submitted manuscript

REFERENCES

1. Ambé GA. Les fruits sauvages comestibles des savanes guinéennes de Côte d'ivoire: état de la connaissance par une population locale, les malinkés. Biotechnol. Agron.soc. environ. 2001;5:43-58.

2. Apema R, Mozouloua D, & Madiapevo SN. Inventaire préliminaire des fruits sauvages comestibles vendus sur les marches de Bangui, In : X. Van der Burgt, J. van der Maesen & J.M onana (eds), systémique et conservation des plantes africaines. Royal Botanic Gardens, Kew, Belgium. 2010; 313-319.

3. Mohammed MI, Sharif N. Mineral composition of some leafy vegetables consumed in Kano, Nigeria. Nigeria journal of basic and applied science. 2011; 19:208-211.

4. Torreilles JC. Les légumes dans la consommation et les préparations alimentaires des ménages brazzavillois. Rapport CIRAD-IRAT, Montpellier. 1991; 36 p.

5. Gockowski J, Mbazo'o G, Mbah T, Fouda, Moulende. African traditional leafy vegetables and the urban and peri-urban poor, Food Policy. 2003; 28:221-235.

6. Moustier P, De Bon H. Fonction d'alimentation et multifonctionnalité des agricultures périurbaines des villes du Sud. Les Cahiers de la Multifonctionnalité. 2005 8: 9-16.

7. FAO. Gestion durable des ressources naturelles dans l'équation de l'alimentation et de la nutrition dans les zones urbaines en Afrique. Faune & Nature. 2014; 28 (2): 19-22.

8. Anonymous. Etude de la consommation en Afrique de l'ouest. Rapport de synthèse. 2011; 1-82.

9. Iheanacho, Kizito ME, Udebuani, Angela C. Nutritional Composition of Some Leafy Vegetables Consumed in Imo State, Nigeria. J. Appl. Sci. Environ. Manage.2009; 13: 35-38.

10. Ishida H, Suzuno H, Sugiyama N, Innami S, Todokoro T, Maekawa A. Nutritional evaluation of chemical component of leaves stalks and stems of sweet potatoes (*Ipomea batatas* Poir). Food Chem. 2000; 68: 359-367.

11. Mensah JK, Okoli RI, Ohaju-Obodo JO & Eifediyi K. Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnology. 2008; 7: 2304-2309.

12. Kouamé NM, Soro K, Mangara A, Diarrassouba N, Koulibaly AV, Boraud NKM. Étude physico-chimique de sept (7) plantes spontanées alimentaires du centre-ouest de la Côte d'Ivoire. J. Appl. Biosci. 2015; 90: 8450-8463.

13. Sepúlveda E, Sáenz C, Aliage E, Aceituno C. Extraction and Characterization of Mucilage in *Opuntia* spp. Journal of Arid Environments. 2007; 68: 534-545.

14. Sáenz C, Sepúlveda E, Matsuhiro B. *Opuntia* spp. Mucilage's: A Functional Component with Industrial Perspectives. Journal of Arid Environments. 2004; 57: 275-290.

15. Dickinson E. Food polymers, gels and colloids. Royal Society of Chemistry, Special publication n° 82, Cambridge. 2003.

16. Siemonsma JS, Kouamé C. *Abelmoschus esculentus (L)* Moench. Internet Record from protabase. Grubben GJH. Denton OA (Ed). PROTA (plant resources of tropical Africa, Wageningen, Netherlands, 2004. http://database.prota.org/search.htm

E-mail: assiolivier@gmail.com

17. Kochhar SL. Okra (Lady's finger) In: Tropical crops. A textbook of economic Botany, Editor S.L Kochhar. 1986; 263-264.
18. Schalau J. Backyard Gardener. 2002. Available at http://ag.arizona.edu. /yavapai/anr/hort/byg/.

19. Saidou, Ndjouenkeu R, Tchatchueng JB, Ali A. Caractérisation physico-chimique et fonctionnelle des gommes hydrocolloïdes de quelques légumes locaux. Communication présentée à la conférence internationale sur ''la nutrition et les produits naturels'' du 12–14 Novembre 2008 à Yaoundé, Cameroun. 2011.

20. Awono A & Manirakiza D. Projet pour la mobilisation et le renforcement des capacités des petites et moyennes entreprises paysannes en relation avec l'exploitation des produits forestiers non ligneux au Cameroun et en RDC : étude de base sur la mangue sauvage (*Irvingia spp.*) (ed). CIFOR. 2007.

21. AOAC. Official methods of analysis 15th Edition, Association of Official Analytical Chemists. Washington D.C, Arlington. 1990.

22. AFNOR. 1986. Norme NF V05-101.

23. Agbo NG, Uebersax M &. Hosfield G. An efficient extraction technique of sugars from dry edible beans (*Phaseolus vulgaris* L.) estimation and H.P.L.C. University National of Côte d'Ivoire. Annals Series C Sciences. 1986; 21: 169-184.
24. Dubois M, Gilles KA, Hamilton JK, Roben FA, Smith F. Colorimetric method for determination of sugar and related substances. Anal. Chem. 1956; 28: 350-356.

25. Bernfeld P. Alpha and beta-amylases. In, Methods in Enzymology. Colowick S.P. and Kaplan N., eds. Academic Press, New York. 1955; 1: 149-158.

26. FAO. Food energy methods of analysis and conversion factors. FAO Ed, Rome. 2002; 97p.

27. Van Soest PS. Use of detergents in the analysis of fibrous feeds II- A rapid method for the determination of fiber and lignin. Journal of Association of Official Analytical Chemistry. 1963; 46: 829-835.

28. Singleton VL, Orthofer R, Lamuela-Raventos RM. Analysis of total phenols and other oxidant substrates and antioxydants by means of folin ciocalteu reagent. Methods Enzymol. 1999; 299: 152-178.

29. Nnamani VC, Oselebe HO, Igboabuchi AN. Bio-Banking on Neglected and Underutilized Plant Genetic Resources of Nigeria: Potential for Nutrient and Food Security. American Journal of Plant Sciences. 2015; 6: 518-523.
30. Kahane R, Temple L, Brat P, Bon H. Les légumes feuilles des pays tropicaux : diversité, richesse économique et valeur santé dans un contexte très fragile. Colloque Angers. 2005; 10p.
31. George PM. Encyclopedia of Foods. Humane Press, Washington DC. 2003; 1: 526.
32. Adetuyi FO, Osagie AU, Adekunle AT. Nutrient, antinutrient, mineral and zinc bioavailability of okra *Abelmoschus esculentus* (L) Moench Variety. Am. J. Food. Nutr.2011; 1: 49-54.
33. Amata IA. Nutritive value of the leaves of *Myrianthus arboreus*. A browse plant. Int. J. Agric. Res. 2010; 5: 576-581.

34. Konan NY. Evaluation de la production et caractérisations biochimique et sensorielle de la sève d'inflorescences de quatre cultivars du cocotier (*Cocos nucifera* L.) en Côte d'Ivoire. Thèse unique de Doctorat, Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire. 2015; 154 p.
35. Acho CF, Zoue LT, Akpa EE, Yapo VG, Niamke SL. Leafy vegetables consumed in southern Cote d'Ivoire: a source of high value nutrients. Journal of animal & plant Sciences. 2014; 20: 3159-3170.

36. Scalbert A, Morand C, Rémésy C, Jiménez L. Dietary polyphenols and the prevention of diseases. Crit. Rev. Food Sci. Nutr. 2005; 45: 287-306.

37. Xia Q, Li R, Zhao S, Chen W, Chen H, Xin B, Huang Y, Tang M. Chemical composition changes of postharvest coconut inflorescence sap during natural fermentation. African Journal of Biotechnology. 2011; 10: 14999-15005.
38. Matos L, Nzikou JM, Matouba E, Pandzou-Yembe VN, Mapepoulou TG, Linder M, Desobry S. Studies of *Irvingia gabonensis* seeds kernels: Oil technological applications. Pak. J, Nutr. 2009; 8: 151-157.

39. Tchiegang C, Aïssatou K. Données ethno nutritionnelles et caractéristiques physicochimiques des légumes feuilles

E-mail: assiolivier@gmail.com

consommés dans la savane de l'Adamaoua (Cameroun). Tropicultura. 2004; 2: 11-18.
40. Silou T, Biyoko S, Heron S, Tchapla A, Maloumbi MG. Caractéristiques physico chimiques et potentialités technologiques des amandes de *Irvingia gabonensis*. La Rivista Italiana Delle Sostanze. 2004; 81: 49-57.
41. Ekpe OO, Umoh IB, Eka OU. Effect of a typical rural processing method on the proximal composition and animo acid profile of bush mango seeds (*Irvingia gabonensis*). Afr. J. Food. Agric., Nutr. And dev*., 7.* Eur. J. Clin. Nutr. 2007; 52: 164-171.

42. Womeni HM, Ndjouenkeu R, Kapseu C, Félicité Tchouanguep Mbiapo, Parmentier M, Fanni J. Influence des techniques de séchage sur la cinétique de perte en eau des amandes et la qualité de l'huile d'*Irvingia gabonensis.* Procédés Biologiques et Alimentaires. 2006; 3: 46-60.
43. Saidu AN, Jideobi NG. The Proximate and Elemental Analysis of some Leafy Vegetables Grown in Minna and Environs. Journal of Applied Science and Environmental Management. 2009; 13: 21-22.
44. Osborne DR, Voogt P. The analysis of Nutrients in Foods. Academic press, London. 1978; p.128.
45. Sena LP, VanderJagt DJ, Rivera C, Tsin ATC, Muhammadu I, Mahammadu O, Milson M, Pastosyn A, Glew RH. Analysis of Nutritional Components of eight famine foods of the Republic of Niger. Plant Foods Hum. Nutr. 1998; 52: 17-30.
46. Dickson RA, Annan K, Fleischer TC, Amponsah IK, Nsiah, Oteng JA. Phytochemical Investigations and Nutritive Potential of Eight Selected Plants from Ghana. Journal of Pharmacy and Nutrition Sciences. 2012; 2: 172-177.
47. Goodhart RS, Shills ME. Modern nutrition in health and disease. 6 ed. New York: Lea and Febiger. 1980.
48. Agbo AE, Kouamé C, Mahyao A, N'zi JC, Fondio L. Nutrition importance of Indigenous Leafy Vegetable of Côte d'Ivoire. Acta Horticultura. 2009*;* 806: 361-366.
49. Lairon D, Cherbut C, Barry JL. Fibres alimentaires. In : Apports nutritionnels conseillés. Paris : Tec et Doc. Lavoisier. 2001; 99-108.
50. Rao CV, Newmark HL. Chemo-preventive effect of Squalene on colon cancer. Carcinogenesis. 1998; 19: 287-290.
51. Kehlenbeck K, Asaah E and Jamnadass R. Diversity of indigenous fruit trees and their contribution to nutrition and livelihoods in sub-Saharan Africa: examples from Kenya and Cameroon, *In* J. Fanzo, D. Hunter, T. Borelli et F. Mattei, éds. Diversifying food and diets: using agricultural biodiversity to improve nutrition and health issues in agricultural biodiversity. 2013; 257-269.

52. Lintas C. Nutritional aspects of fruits and vegetable consumption. Options Mediterranean's. 1992; 19: 79-87.
53. Stadlmayr B, Charrondiere R, Eisenwagen S, Jamnadass R, Kehlenbeck K. Nutrient composition of selected indigenous fruits from sub-Saharan Africa. Journal of the Science of Food and Agriculture. 2013; 93: 2627-2636.
54. Chinma CE, Igyor MA. Micronutrients and anti-nutritional contents of selected tropical vegetables grown in Southeast Nigeria. Niger. Food J. 2007; 25: 111-116.
55. OMS. Global nutrition report. 2014. www.Globalnutritionreport.org/about/technical-notes

E-mail: assiolivier@gmail.com