Essential Minerals Content and Nutritive Contributions of Edible Parts of Some Mucilaginous Food Plants from Some Regions of Cote D'lvoire

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Abstract— *The aim of this study is to contribute to a better valorization of the mucilaginous food plants (MFPs) by the content determination in essential minerals, also to evaluate the nutritive contributions from the consumption.*

Thus different edible parts constituted of leaves, fruits, flowers, calyx and kernels of nine mucilaginous food plants of Ivorian flora have been analyzed. It's about I. gabonensis, I. wombolu, C. olitorius, the varieties tomi and koto of A. esculentus, B. buonopozense, A. digitata, M. arboreus and B. mannii. The analysis of the macroelements (K, P, S, Ca and Na) gave the following contents: potassium (0.73±0.02-4.53±0.03 g/100g DM), Phosphorus (0.40±0.03-1.70±0.04 g/100g DM), sulphur (0.1±0.04-0.75±0.03 g/100g DM), Calcium (0.06±0.01-4.54±0.06 g /100g DM) and sodium (0.06±0.01 and 0.32±0.02 g /100g DM). The plants provided the microelements (Mg, Fe, Cu, Mn and Zn) contents following: magnesium (0.15±0.01-1.36±0.25 g/100g DM), Iron (6.73×10^{-3}±2.84-55.94×10^{-3}±6.96 g/100g DM), copper (4.96×10^{-3}±2.07-54.04×10^{-3}±4.63 g/100g DM). The kernels of I. wombolu and the leaves of M. arboreus provided 7.38×10^{-3}±6.79 and 27.67×10^{-3}±28.9 g/100g DM respectively in Zinc. The daily quantities of mucilaginous food plants consumed are consisted between 0.1 g/day and 0.7 g/day. This consumption provided to Ivorian adult of 70 kg the daily contributions estimated following: potassium (1.5-27.70 mg/day), calcium (0.1-31.80 mg/day), magnesium (1.1-25.5 mg/day), iron (0.12-1.18 mg/day). The leaves of M. arboreus provided the best daily contributions (0.19 mg/day) in Zinc. The leaves and the flowers among the parts investigated gave on the whole, the biggest daily contributions. They contributed for the majority of minerals, between 1% and 4% of the organism needs.

Keywords— Essential Minerals, Mucilaginous Food Plants, Daily Contributions Estimated.

I. INTRODUCTION

The mucilaginous food plants (MFPs) are consumed through the whole world. In Côte d'Ivoire, these plants serve to the confection of sauces very valued [1].The leaves of *Adansonia digitata* (baobab) and the fruits of *Abelmoschus esculentus* (gumbos) are used by numerous communities in the culinary preparations [2,3].They are part of a big group designated under the name of non ligneous forest plants. In the tropical and subtropical forests of Africa, Asia and Latin America, the importance of the non ligneous forestry products is not anymore to demonstrate. These products complete the agricultural production of the households while bringing them some food stuff rich in essential nutritive constituent to the good functioning of the organism [4]. A big number of nutritive substances provided by forest food fill significant functions for health and development. Thus, their absence in the diet could mean important consequences on health and well-being [5].

The non ligneous forestry products also permit a real increase of the incomes. They can be also one of the elements on which a strategy of valorization of the products of a soil can lean and generate many jobs. One of the true characteristic to these products, according to [6], resides in their accessibility, even to people not having arable earth and/or sufficient incomes. Indeed, the mucilaginous food plants are endowed with interesting properties bound to the presence of mucilages, substances of polysaccharide nature and/or protein, inflatable to the contact of water. Mucilage is a complex carbohydrate [7] with a highly branched structure that contains variable proportions of L-arabinose, D-Galactose, L-Rhamnose and D-xylose as well as in galacturonique acid [8].The possibilities of use of the mucilaginous plants are numerous. Mucilages are used in the agroalimentary, pharmaceutical and cosmetic domains [9,10,11,12].

Concerning the food habits of the populations of numerous regions, the mucilaginous plants act as agent of inflation in the local culinary preparations [1]. They are also used in the flocculation and the decanting of numerous local drinks [13]. The mucilaginous plants can be considered like functional food thanks to their properties of regulation of several parameters of health (blood sugar, blood-pressure, cholesterol, homeostasis of the nutriments). They possess the organoleptic properties and cut hunger [12,14,15].Therefore, the objective of this study is to contribute to a better valorization of the mucilaginous food plants by the determination of the content in essential minerals of different edible parts of some plants descended of Ivorian flora.

II. MATERIAL AND METHODS

2.1 Vegetable material

The biological material is constituted of different edible parts of 9 mucilaginous plants exits of 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 of 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 Côte 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 Kple	kernels
Irvingia wombolu (Vermoesen)	Irvingaceae	Kaclou Kple	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	Tlan	Fruits
Abelmoschus esculentus(Linn) var. tomi	Malvaceae	Gumbo baoule	Fruits
Abelmoschus esculentus (Linn) var. koto	Malvaceae	Gumbo dioula	Fruits

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 of January 2013 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 bought 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 bought to the Gouro market in the District of Abidjan. In each of the regions, the different products have been collected to 3 farmers or sellers.

2.3 Mucilaginous plants treatment

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* (gumbo) 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 (**Figure 1**).

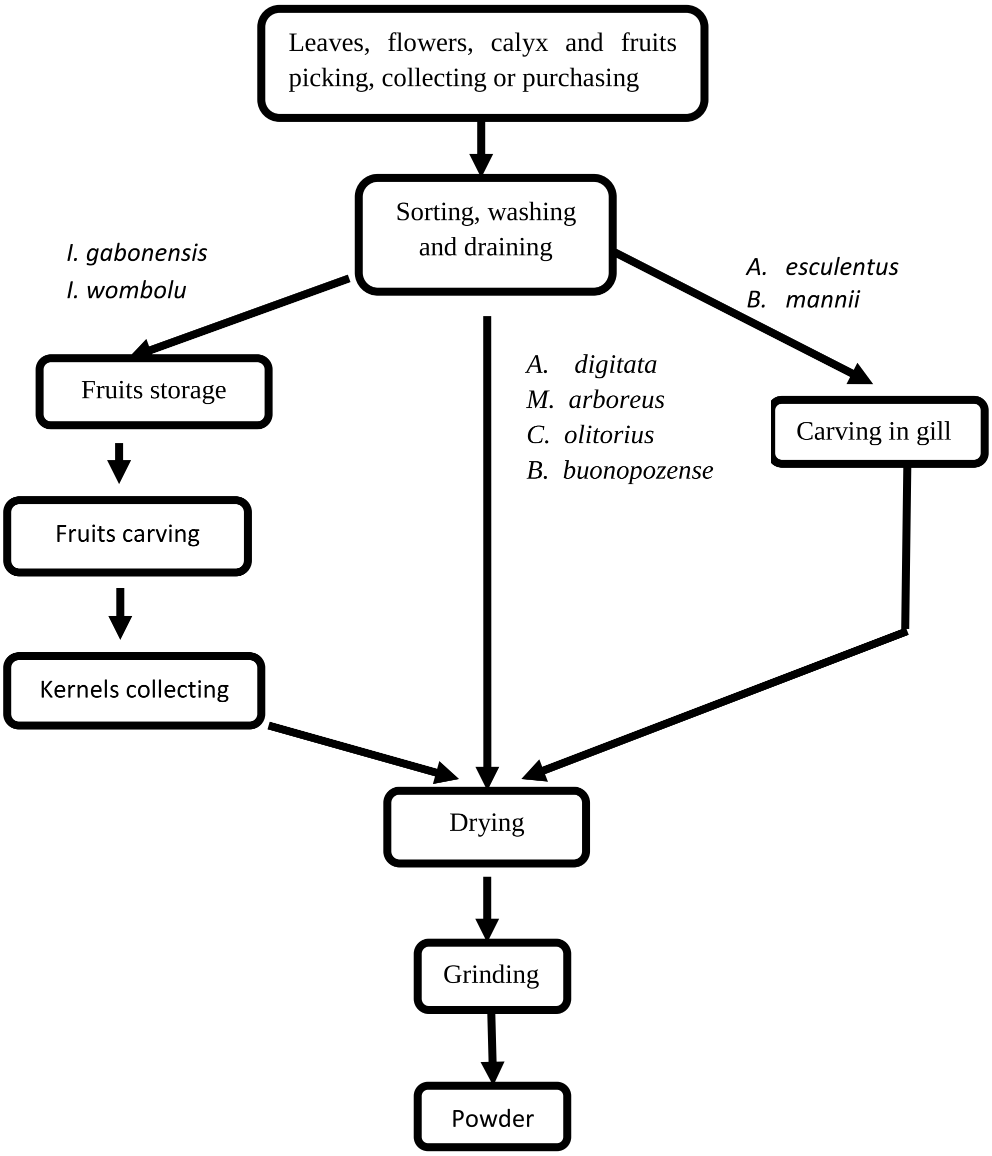

FIGURE 1 DRYING METHODS OF PLANTS PARTS

2.4 Minerals determination

2.4.1 Samples mineralization

The method of determination of ashes was described by **[16]** that consisted to incinerate a sample to 550°C until the obtaining of white ash. Thus, 5 g of dry matter has been introduced in a capsule of incineration. The capsule has been placed in muffle furnace (PYROLABO, France) and incinerated to 550°C during 24 h. After calcinations and cooling in desiccators, the white ashes have been collected for analysis.

2.4.2 Operative conditions of the energy dispersive spectrophotometer (EDS)

The apparatus used for minerals determination was an energy dispersive spectrophotometer coupled to scanning electron microscope (SEM). This device to variable pressure (MEB FEG Supra 40Vp Zeiss) was equipped of an X-ray detector (Oxford instruments) bound to a flat shape of EDS microanalyser (Inca cool dry, without liquid nitrogen). The operative conditions of the EDS-SEM were the following:

- Enlargement : 10x to 1000000x;
- Resolution : 2 nm;
- Variable voltage : 0.1 KeV à 30 KeV ;

- Acquirement of the elementary chemical composition: enlargement, 50x; borer diameter, 30 nm and 120 nm; borer energy, 20 KeV and 25 KeV; work distance (WD), 8.5 mm.

The chemical composition has been done on 3 different zone then data have been transferred on an Excel file. An average and a standard deviation (SD) have been determined.

2.4.3 Validation test of the minerals determination method

Validation has been achieved according to the method of AFNOR **[17,18]** This procedure consists of studies of the linearity, the repeatability, the reproducibility, the extraction yields, detection limits and quantification limits. The linearity of 10 mineral elements has been tested between 25% and 125% with the help of 5 points of standardization (25%, 50%, 75%, 100% and 125%). The tests of repeatability and reproducibility have been achieved with standards of the different mineral to a concentration of 25%. Thirty tests have been achieved respectively for the tests of repeatability and reproducibility. Additions of 5% of the standards have been achieved for the determination of the extraction yields of the minerals. Ten distinct tests have been achieved for the addition measured**.**

2.5 Contributions estimated in essential elements at the consumer

The contributions in mineral elements have been estimated according to the method of the Codex Alimentarius that takes into account the concentrations in minerals recovered in the food and the daily consumption of an adult individual of 70 kg (table 2) of this food **[19].** These quantities of foods are given by World Health organization studies [20]**.** The contribution of this food in daily requirement has been calculated also from the values of daily recommended intakes [21]**.**

$$\textbf{Estimated Daily Intake (EDI)} = C \times Q$$

$$\textbf{Contribution (\%)} = (EDI \times 100)/DRI$$

C: mineral concentration measured
Q: food daily consumption
DRI: Daily Recommended Intake

TABLE 2
TESTS RESULTS OF MINERAL ANALYTIC VALIDATION BY MEB/SDE

Mineral	Linearity		CV Repeat. (%, n=10)	CV Reprod. (%, n=15)	Ext yield (%, n=10)	LOD (µg/kg)	LOQ (µg/kg)
	Standard	*CD (R^2)*					
K	Y = 3838 + 3821x	1	1.3±0.04	4.7±0.32	98.4±1.51	581±0.04	796±0.09
P	Y = 1742 + 2667x	0.99	1.4±0.11	3.7±1.22	99.4±0.66	334±0.21	467±0.88
S	Y = - 332 + 4958x	1	1.0±0.06	2.8±0.07	97.6±0.92	667±0.52	947±0.001
Ca	Y = 5287 + 6581x	1	1.5±0.43	2.3±0.93	97.3±0.84	514±0.15	704±0.47
Na	Y = 147 + 2083x	0.99	1.2±0.05	3.4±0.48	98.8±0.33	261±0.74	365±0.07
Mg	Y = 237 + 1452x	0.99	1.1±0.21	3.1±1.44	97.9±0.68	426±0.11	635±0.19
Fe	Y = - 88 + 2285x	0.99	1.4±0.07	3.6±0.01	99.5±0.17	107±0.32	149±0.55
Cu	Y = 6951 + 1953x	0.99	1.8±0.95	2.5±0.03	98.8±0.43	104±0.05	146±0.63
Mn	Y = 74454 + 3659x	1	1.2±1.01	2.9±0.77	99.0±0.78	337±0.81	488±0.60
Zn	Y = - 523 + 4365x	0.99	1.3±0.51	3.2±0.96	98.3±0.03	281±0.58	396±0.29

***CD**, coefficient of determination ; **CV repeat**, coefficient of variation de repeatability ; **CV Réprod,** coefficient de variation de la reproductibilit ; **Ext yield,** extraction yield ; **LOD,** limit of detection ; **LOQ,** limit of quantification.*

2.6 Statistical analysis

Minerals concentrations means have been calculated with their standard deviations. The coefficients of variation have been determined then to express the repeatability and the reproducibility. The square of the coefficient of Pearson correlation has been calculated to appreciate the linearity. The proportion of minerals added and measured served to express extraction yields. The statistical treatment consisted in a variance analysis (ANOVA) at 1 criteria of classification (parts of the plants). The means 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 served for an ascending hierarchical classification (AHC) with truncation at 1400. Two groups descended of the AHC have been characterized either by their weak concentration in mineral, either by their concentration in mineral raised. The PCA also permitted to see how the variables have been structured and how the individuals have been distributed. Finally, the Ascending Hierarchical Classification (AHC) permitted to regroup the similar individuals. All the analyses were performed in triplicate and data were analyzed using the software SPSS (SPSS 16.0 for Windows, SPSS Inc.) and STATISTICA 7.1 (StatSoft).

III. RESULTS

3.1 Validation results

The results of the validation tests are presented in the table 3. The square of the correlation coefficient (R^2) is 0.999 for different minerals studied. The variations determined coefficients for the repeatability and reproducibility tests are consisted respectively between 1.0±0.06% and 1.8±0.95% and between 2.3±0.93% and 4.7±0.32%. These results translate a stability and a satisfy precision of microanalysis technics. The percentages of additions measured out are consisted between 97.3±0.84% and 99.5±0.17%. The method is reliable and exact.

TABLE 3
CONCENTRATIONS IN MACROELEMENTS RECOVERED IN THE DIFFERENT PARTS OF THE MUCILAGINOUS FOOD PLANTS ANALYZED

Edible parts		Concentration (g/100 g DM)				
		K	**P**	**S**	**Ca**	**Na**
kernels	**IG**	1.38±1.05^{f}	0.42±0.06^{g}	0.18±0.02^{e}	0.41±0.03^{h}	0.06±0.01^{b}
	IW	0.73±0.02^{g}	0.58±0.01^{f}	0.19±0.01^{e}	0.25±0.01^{i}	< 2.61.10^{-5c}
Fruits	**AE-*koto***	4.53±0.03^{a}	1.70±0.04^{a}	0.44±0.01^{b}	1.78±0.04^{c}	< 2.61.10^{-5c}
	AE-*tomi*	3.99±1.77^{b}	1.62±0.03^{a}	0.35±0.03^{c}	1.95±0.07^{b}	0.32±0.02^{a}
	BM	2.47±0.03^{de}	0.46±0.03^{g}	0.31±0.01^{d}	0.06±0.01^{j}	< 2.61.10^{-5c}
Leaves	**AD**	3.24±0.23^{c}	1.51±0.13^{b}	0.16±0.01^{ef}	4.54±0.06^{a}	< 2.61.10^{-5c}
	CO	260±0.07^{d}	0.72±0.05^{e}	0.13±0.01^{fg}	1.08±0.03^{g}	< 2.61.10^{-5c}
	MA	3.95±0.05^{b}	1.02±0.04^{d}	0.75±0.03^{a}	1.47±0.06^{e}	< 2.61.10^{-5c}
	BB	3.96±0.08^{b}	1.14±0.07^{c}	0.19±0.02^{e}	1.70±0.05^{d}	< 2.61.10^{-5c}
Flowers	**BB-*calyx***	2.65±0.08^{d}	0.45±0.02^{g}	0.10±0.04^{g}	1.68±0.06^{d}	< 2.61.10^{-5c}
	BB-*flower*	2.34±0.06^{e}	0.40±0.03^{g}	0.14±0.01^{ef}	1.18±0.01^{f}	< 2.61.10^{-5c}
F		389.56	249.03	229.18	2304.59	473.94
P-value		**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Data are represented as Means ± SD (n = 3). Means in the column with no common letter differ significantly (p<0.001) for each edible parts; *DM, dry matter*

3.2 Mineral concentrations recovered in the plants

3.2.1 Essential macroelements concentrations

The concentrations in essential macroelements (K, P, S, Ca, Na) recovered are summarized in the table IV. A significant difference is observed between the concentrations measured. Potassium is in the majority in the fruits, leaves and flowers, with concentrations understood between 2.34±0.06 and 4.53±0.03 g/100g DM. Concerning the phosphor, the gotten concentrations are consisted between 0.40±0.03 and 1.70±0.04 g/100g DM, with the maximal contents observed in the fruits of *A. esculentus*. The concentrations in sulfur vary between 0.10±0.04 and 0.75±0.03 g/100g DM. As for the calcium, the observed concentrations vary between 0.06±0.01 and 4.54±0.06 g/100g DM. The most elevated contents are gotten in the leaves, the fruits and the flowers except the fruits of *B. mannii* (0.06±0.01 g/100g DM). Finally, sodium remained the least abundant macroelement. The most elevated concentrations are recovered in the kernels of *I. gabonensis* (0.06±0.01 g/100g DM) and the fruits of the variety koto of *A. esculentus* (0.32±0.02 g/100g DM).

TABLE 4
CONCENTRATIONS IN MICROELEMENTS RECOVERED IN THE DIFFERENT PARTS OF MUCILAGINOUS FOOD PLANTS ANALYZED

Edible parts		Concentration (g/100 g DM)				
		Mg	**Fe**	**Cu**	**Mn**	**Zn**
Kernels	**IG**	0.2±0.01[f]	6.91×10^{-3}±3.93[b]	4,96×10^{-3}±2.07[ab]	5.23×10^{-3}±4.00[b]	< 2.81×10^{-5}[c]
	IW	0.35±0.02[e]	6.73×10^{-3}±2.84[b]	13,40×10^{-3}±1.86[ab]	10.82×10^{-3}±2.5[b]	7.38×10^{-3}±6.79[b]
Fruits	**AE-*koto***	1.25±0.02[ab]	27×10^{-3}±23.73[ab]	30.02×10^{-3}±17.0[ab]	27.69×10^{-3}±18.7[a]	< 2.81×10^{-5}[c]
	AE-*tomi*	1.36±0,.25[a]	44.24×10^{-3}±27.97[ab]	21.26×10^{-3}±30.6[ab]	< 3.37×10^{-5}[c]	< 2.81×10^{-5}[c]
	BM	0.15±0.01[f]	9.3×10^{-3}±3.92[b]	< 1.04×10^{-5}[c]	6.05×10^{-3}±0.73[b]	< 2.81×10^{-5}[c]
Leaves	**AD**	0.98±0.06[c]	55.94×10^{-3}±6.96[a]	40.97×10^{-3}±31.2[ab]	< 3.37×10^{-5}[c]	< 2.81×10^{-5}[c]
	CO	0.42±0.04[e]	43.05×10^{-3}±4.88[ab]	21.32×10^{-3}±15.5[ab]	< 3.37×10^{-5}[c]	< 2.81×10^{-5}[c]
	MA	1.08±0.03[bc]	41.33×10^{-3}±6.03[ab]	50.67×10^{-3}±25.3[ab]	< 3.37×10^{-5}[c]	27.67×10^{-3} ± 28.9[a]
	BB	1.16±0.02[b]	29.68×10^{-3}±13.02[ab]	54.04×10^{-3}±4.63[a]	< 3.37×10^{-5}[c]	< 2.81×10^{-5}[c]
Flowers	**BB-*calyx***	1.16±0.01[b]	22.07×10^{-3}±16.42[ab]	36.93×10^{-3}±22.1[ab]	9.28×10^{-3}±6.89[b]	< 2.81×10^{-5}[c]
	BB-*flower*	0.77±0.02[d]	24.71×10^{-3}±2.57[ab]	23.88×10^{-3}±5.81[ab]	< 3.37×10^{-5}[c]	< 2.81×10^{-5}[c]
F		97.12	4.67	2.78	5.58	2.64
P-value		**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Data are represented as Means ± SD (n = 3). Means in the column with no common letter differ significantly (p<0.001) for each edible parts; *DM, dry matter*

3.2.2 Essential microelements concentrations

The concentrations in essential microelements (Mg, Fe, Cu, Zn, Mn) recovered in the different samples of mucilaginous plants are presented in the table 5. A significant difference at the risk of 5% is observed also between the measured concentrations. The concentrations in magnesium vary between 0.15±0.01 and 1.36±0.25 g/100g DM. The samples of leaves, fruits and flowers present the most elevated concentrations. Iron concentrations are consisted between 6.73×10^{-3}±2.84 and 55.94×10^{-3}±6.96 g/100g DM. The leaves are the parts richest in iron (29.68×10^{-3}±13.02 to 55.94×10^{-3}±6.96 g/100g DM). Concerning the copper, the contents are consisted between 4.96×10^{-3}±2.07 and 54.04×10^{-3} ±4.63 g/100g DM. The samples of fruit of *B. mannii* have the weakest concentrations. Manganese concentrations are consisted between 5.23×10^{-3}±4.00 and 27.69×10^{-3}±18.79 g/100g DM. As for zinc, the measured concentrations are raised more in the kernels of *I. wombolu* (7.38×10^{-3}±6.79 g/100g DM) and the leaves of *M. arboreus* (27.67×10^{-3}±28.9 g/100g DM).

TABLE 5
QUANTITIES OF MUCILAGINOUS FOOD PLANTS CONSUMED PER DAY
(Source : OMS, 2003b)

Edible parts		Quantity (g)
kernels	IG	0.2
	IW	0.2
Fruits	AE-*koto*	0.1
	AE-*tomi*	0.1
	BM	0.2
Leaves	AD	0.7
	CO	0.7
	MA	0.7
	BB	0.7
Flowers	BB-*calyx*	0.7
	BB-*flower*	0.7

3.3 Variability of minerals concentrations

The principal components analysis has been done while considering the first two factors (F1 and F2) that accumulate the most important proportion of the variability (60.41%). So, the projection of minerals concentrations in the plan formed by these two factors regroups Mn and Na significantly around the F2 axis, with a negative correlation. In return, the minerals (Fe, Cu, Ca, K, Mg, P) are distributed around the F1 factor with positive significant correlation (figure 2A). The samples of variety koto of *A. esculentus* superpose themselves to raised concentrations in Mn and Na, whereas those of the variety tomi of *A. esculentus* and most leaves (AD, CO and BB) generate the most elevated concentrations in Fe, Cu, Ca, K, Mg and P (figure 2B). The flowers and kernels have the weakest concentrations. This structuring is confirmed by the classification of the dendrogram (figure 3). The plant parts constituted by kernels and flowers present the weakest contents contrary to leaves and fruits.

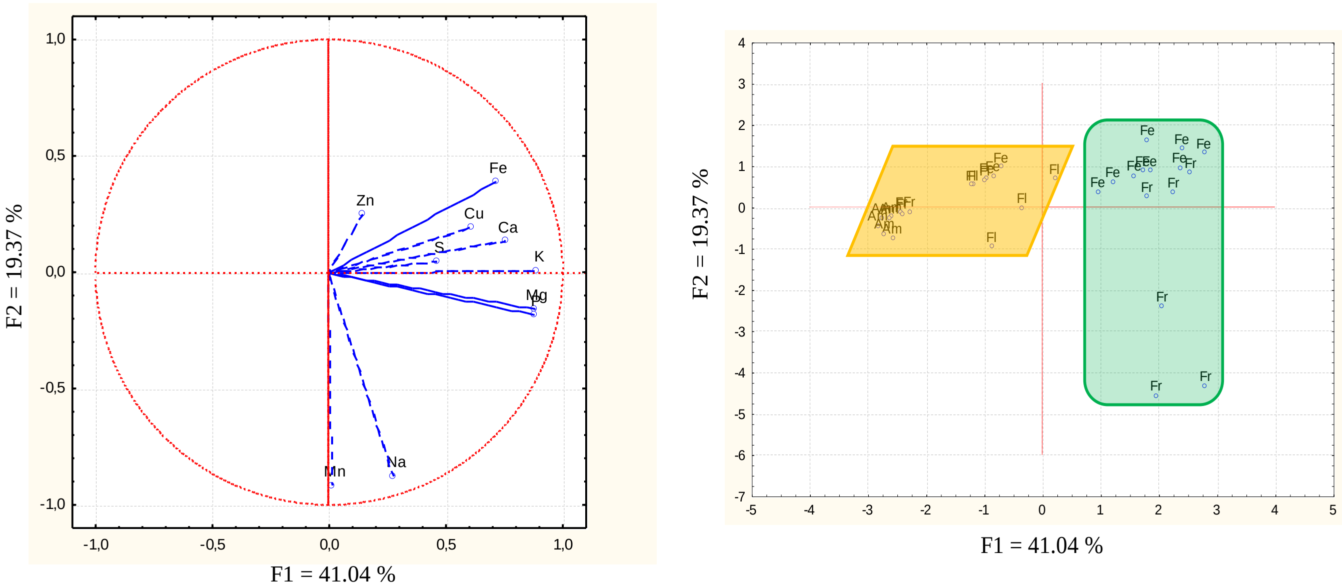

FIGURE 2: REGROUPING OF MINERAL CONTENTS (A) AND EDIBLE PARTS (B) OF THE MUCILAGINOUS PLANTS IN THE PLAN FORMED BY THE FACTORS F1 AND F2 OF THE PRINCIPAL COMPONENTS ANALYSIS.
Fr, fruit ; Fe ,leaves ; Fl, flower; Am, kernels

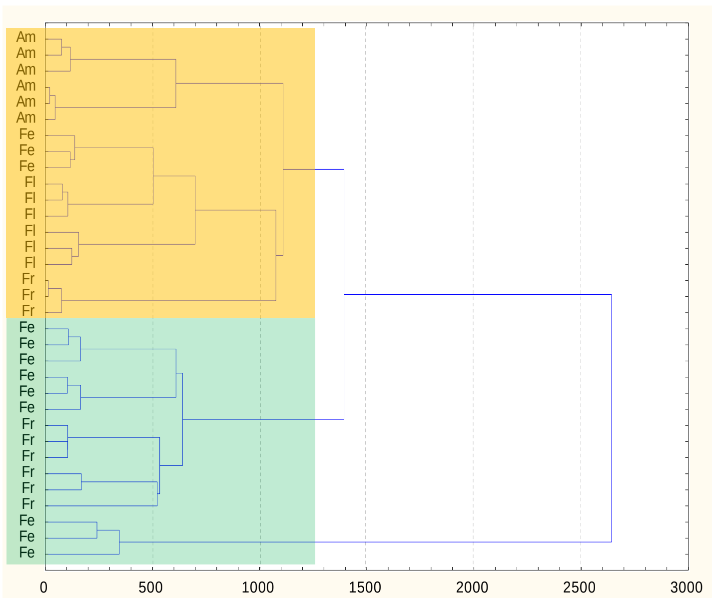

FIGURE 3: DENDROGRAM REPRESENTING ASCENDING HIERARCHICAL CLASSIFICATION OF THE PARTS OF THE MUCILAGINOUS PLANTS ACCORDING TO MINERAL CONTENTS.
Fr, fruit; Fe, leaves; Fl, flowers; Am, kernels

3.4 Estimated contributions in essential mineral at Ivorian adult

3.4.1 Estimated contributions in macroelements

Macroelements quantities brought by the different mucilaginous products for Ivorian adult of 70 kg are presented in the table VI. The daily contribution in potassium is estimated between 1.5 mg/day and 27.70 mg/day. The leaves (*A. digitata*: 22.70 mg/day, *C. olitorius*: 18.20 mg/day, *M. arboreus*: 27.60 mg/day, *B. buonopozense*: 27.70 mg/day) and the flowers of *B. buonopozense* (calyx: 18.50 mg/day, flower: 16.40 mg/day) provided the most elevated quantities. The same organs expressed the best daily contributions to the level of the phosphor, giving thus in the leaves (*A. digitata*: 10.60 mg/day, *C. olitorius*: 5.00 mg/day, *M. arboreus*: 7.10 mg/day, *B. buonopozense*: 7.90 mg/day) and the flowers of *B. buonopozense* (calyx: 3.10 mg/day, flower: 2.80 mg/day). The daily contributions in calcium are consisted between 0.1 mg/day and 31.80 mg/day. Biggest contributions were those of the leaves (AD: 31.80 mg/day, CO: 7.60 mg/day, MA: 10.30 mg/day, BB: 10.90 mg/day) and BB flowers (calyx: 11.70 mg/day, flowers: 8.30 mg/day). Concerning sodium, the daily contributions are consisted between 3.10^{3} mg/day and 0.3 mg/day with the kernels (IG: 0.1 mg/day) and the variety tomi (AE: 0.3 mg/day) providing the best contributions**.**

TABLE 6
ESTIMATED DAILY INTAKE IN MACROELEMENTS FROM THE CONCENTRATIONS RECOVERED IN FOOD

Edible parts		Estimated daily intake in mg/day for adult of 70 kg			
		K	P	Ca	Na
Kernels	IG	2.60	0.80	0.80	0.10
	IW	1.50	1.20	0.50	0.7×10^{-2}
Fruits	AE-*koto*	4.50	1.70	1.80	0.3×10^{-2}
	AE-*tomi*	3.90	1.60	1.90	0.30
	BM	4.90	0.90	0.10	0.7×10^{-2}
Leaves	AD	22.70	10.60	31.80	2.5×10^{-2}
	CO	18.20	5.00	7.60	2.5×10^{-2}
	MA	27.60	7.10	10.30	2.5×10^{-2}
	BB	27.70	7.90	10.90	2.5×10^{-2}
Flowers	BB-*calyx*	18.50	3.10	11.70	2.5×10^{-2}
	BB-*flower*	16.40	2.80	8.30	2.5×10^{-2}

3.4.2 Estimated contributions in microelements

Estimated contributions are presented in the table VII. Magnesium contributions are consisted between 1.1 mg/day and 25.5 mg/day. Iron estimated contributions are consisted between 0.12 mg/day and 1.18 mg/day. Concerning copper and manganese, contributions are consisted respectively between 0.43 mg/day and 1.18 mg/day and between 5.10^{-3} mg/j and 6.10^{-2} mg/day. Finally for zinc, the most elevated valued contributions are gotten for the leaves of *M. arboreus* (0.19 mg/day).

TABLE 7
ESTIMATED DAILY INTAKE IN MICROELEMENTS FROM THE CONCENTRATIONS RECOVERED IN FOOD

Edible parts		Estimated daily intake in mg/day for adult of 70 kg				
		Mg	Fe	Cu	Mn	Zn
Kernels	IG	0.40	1.4×10^{-2}	0.01	0.01	0.8×10^{-2}
	IW	0.70	1.2×10^{-2}	2.6×10^{-2}	2.2×10^{-2}	1.4×10^{-2}
Fruits	AE-*koto*	1.25	2.7×10^{-2}	0.03	0.03	0.4×10^{-2}
	AE-*tomi*	1.36	4.4×10^{-2}	0.02	0.5×10^{-2}	0.4×10^{-2}
	BM	0.30	1.8×10^{-2}	0.3×10^{-2}	1.2×10^{-2}	0.8×10^{-2}
Leaves	AD	6.86	0.39	0.29	3.4×10^{-2}	2.7×10^{-2}
	CO	2.94	0.30	0.15	3.4×10^{-2}	2.7×10^{-2}
	MA	7.56	0.28	0.36	3.4×10^{-2}	0.19
	BB	8.12	0.21	0.38	3.4×10^{-2}	2.7×10^{-2}
Flowers	BB-*calyx*	8.12	0.15	0.26	0.06	2.7×10^{-2}
	BB-*flower*	5.39	0.18	0.17	3.4×10^{-2}	2.7×10^{-2}

TABLE 8
CONTRIBUTION (%) OF MACROELEMENTS TO NEEDS SATISFACTION

Edible parts		K		P		Ca		Na	
		DRI	Contr	DRI	Contr	DRI	Contr	DRI	Contr
Kernels	IG	2000	0.13	700	0.11	800	0.1	2500	0.4×10^{-2}
	IW		0.08		0.17		0.06		2.92×10^{-4}
Fruits	AE*koto*		0.22		0.24		0.23		1.44×10^{-4}
	AE*tomi*		0.19		0.22		0.24		1.2×10^{-2}
	BM		0.25		0.13		0.01		2.92×10^{-4}
Leaves	AD		1.14		1.05		3.97		1.02×10^{-3}
	CO		0.91		0.71		0.95		1.02×10^{-3}
	MA		1.38		1.01		1.29		1.02×10^{-3}
	BB		1.39		1.13		1.36		1.02×10^{-3}
Flowers	BB-*calyx*		0.93		0.44		1.46		1.02×10^{-3}
	BB*flower*		0.82		0.40		1.03		1.02×10^{-3}

***DRI**, Daily recommended intake; **contr**, contribution*

TABLE 9
CONTRIBUTION (%) OF FOOD MICROELEMENTS TO NEEDS SATISFACTION

Edible parts				Fe		Cu					
		DRI	Contr	DRI	Contr	DRI	Contr	DRI	Contr	DRI	Contr
Kernels	IG	375	0.10	14	0.10	1	1	2	0.5	10	7.9×10^{-2}
	IW		0.19		0.09		2.6		1.1		0.14
Fruits	AE-*koto*		0.33		0.19		3		1.5		3.9×10^{-2}
	AE-*tomi*		0.36		0.31		2		0.24		3.9×10^{-2}
	BM		0.08		0.12		0.29		0.6		7.9×10^{-2}
Leaves	AD		1.83		2.78		29		1.70		0.27
	CO		0.78		2.14		15		1.70		0.27
	MA		2.01		2.00		36		1.70		1.9
	BB		2.16		1.50		38		1.70		0.27
Flowers	BB-*calyx*		2.16		1.07		26		3		0.27
	BB-*flower*		1.44		1.29		17		1.70		0.27

***DRI**, Daily recommended intake; **contr**, contribution*

IV. DISCUSSION

The mucilaginous food plants make parts of the food habits of Ivorian populations in different regions. Origin specificity exists and the consumption of some dishes is tributary of these plants presence in a given region. The results of the study reveal concentrations variability in minerals according to the parts of mucilaginous plants consumed. On the whole, measured minerals concentrations are in conformity with data of the literature **[22].**

Studied mucilaginous food plants reveal that leaves and fruits seem to be the more provided in nutritive elements. The contents in potassium, phosphor and calcium are the most elevated; it could explain itself by the fact that the terminal parts of the plants, notably the leaves and the fruits, are preferential zones of mineral accumulation **[23].** So potassium contents in the leaves of *C. olitorius* (2.6 g/100g DM) are in the same tendencies (2.292 g/100g DM) that these gotten **[24].** To the level of *M. arboreus* leaves, the concentrations in this mineral (3.95 g/100g DM) showed to be bigger than these found **[25].** The contents (1.3 g/100 g DM) observed in kernels remain superior to these gotten (0.68 g/100 g DM) **[26].** The phosphor contents in the leaves of *M. arboreus* (1.02 g/100g DM) makes the double of the results **[25]** and the fruits of *A. esculentus* (1.7 g/100g DM), displayed some concentrations (403.69 mg/100g DM) superior **[22].** In the same way, *A. digitata* leaves presented some concentrations in calcium (4.54 g/100 DM) similar **[27].** In the organism, the quasi-totality (99%) of Ca is in the skeleton, of which it's the constituent principal. it's indispensable to a good growth and muscles and teeth maintenance **[28,29].** So, *A. digitata* leaves, seen their elevated contents, could be beneficial in the food of young children in growth. They could also contribute to fight against the osteoporosis often bound to the insufficiency of the food contribution in calcium and phosphorus **[30,31,32].** The valorization of the consumption of mucilaginous food plants could decrease the risks of cardiac illnesses and cerebral vascular accidents **[33,34]**. The concentrations in sulphur are less elevated in relation to potassium and phosphorus, the gotten maximal concentration is 0.75 g/100g DM. Sulfur enters in the composition of some amino acids, whose assembly drives to the proteins. It also plays an essential role in the processes of tissue synthesis (for example, cartilages) but also in the phenomena of elimination of the harmful substances, produced by the organism or come from an outside contamination **[35].** Sulphur deficiencies don't observe themselves truly, because the needs are covered in general in the food by the sulphurated amino acids **[36].** The concentrations in Na are on the whole very weak of studied parts. It's underlined by the works **[37]** but also **[38]** which the contents (0.06 g/100g DM) in kernels of *I. gabonensis* are similar to ours. In spite of weak content, Na has an important nutritional interest because it intervenes in the hydroelectric balance and the working of the systems nervous and muscular **[39].**

Magnesium has been displayed as the most abundant microelement in the mucilaginous food plants. The results of the analysis of the fruits of *A. esculentus* (1.25 g/100g and 1.35 g/100g DM) are raised more than (0.54 g/100g) **[40]** and (51.18 mg/100g DM) **[41]**. Recognized like a co-factor in the membrane stabilization, Mg is also implied in the oxidatives phosphorylations , the glycolyse, DNA transcription and the proteinic synthesis **[42].** Iron and zinc are so important for the working of the organism that their deficit poses real problems of public health. Indeed, anemia made of iron is responsible of 10% of the maternal mortality or 800 000 deaths, representing 2,4% of mortality yearly caused by illnesses **[43].** Zinc stimulates the immune system, intervenes in the metabolism of the proteins necessary to the normal development of the fœtus, intervenes in the synthesis of the insulin, the production of the spermatozoids and is an antioxidant **[31,44,45].** The works **[22]** showed quantities of iron similar to ours, in the fruits of *A. esculentus*. To the level of the leaves of *C. olitorius*, **[46]** showed iron contents (47mg/100g DM) similar to ours (43.05 mg/100g DM), on the other hand, zinc concentrations are bigger (5 mg/100g). The copper contents are high in the leaves of *C. olitorius* (0.041 g/100 g DM), *M. arboreus* (0.051 g/100 g DM) and of *B. buonopozense* (0.054 g/100 g DM), while manganese contents stay very weak. In the variety koto of *A. esculentus*, the Cu contents (30.10 mg/100 g DM) and Mn (27.69 mg/100 g DM) are raised more than the results of Cu (3 mg/100 g DM) and Mn (19.6 mg/100 g DM) **[47]**. Indeed, the copper intervenes notably in the bony mineralization, the regulation of the neurotransmitters, immunity, iron metabolism and in oxidative metabolism of the glucose **[48,49,50].** Manganese participates in the regulation of different ways of control of the homeostasy of the glucose **[51]** and is implied also in the insulin metabolism **[52].** We can deduce that MFPs stay non negligible sources of microelements.

MFPs are appreciated by Ivorian populations; however the quantities consumed per day stay very weak in a general way opposite to total quantity (1018.1g/day) of foods consumed. They oscillate between 0.1 g/day and 0.7 g/day **[20].** During the consumption, the daily intake of adult was more important in the leaves and the flowers contrary to the kernels and fruits. This distribution could first explain itself by the mineral concentrations contained in these parts and then by the quantities of leaves (0,7 g/day) and of flowers (0,7 g/day) consumed. Contrary to our data, **[53]** showed that the fruits (38%) and the leaves (33%) were the organs more consumed. To the level of these organs, the daily intake estimated in potassium (16.40 mg/day to 27.70 mg/day), phosphorus (2.80 mg/day to 10.60 mg/day) and calcium (7.60 mg/day to 31.80 mg/day) contributed to the daily recommended intake (2000 mg/day; 700 mg/day; 800mg/day) between 0,4% and 4% **[21].** The contributions in calcium of the leaves of *A. digitata* could help to fill the needs constantly increasing at pregnant women and aged people. For sodium, the daily intake is very weak; that contributed to 0.01% of the needs (2500 mg/day).

To the level of microelements, 3 tendencies have been observed. The weak needs of Cu (1 mg/day) of the organism **[21]** permit good satisfactions between 15% and 38% of the daily recommended intake (0.17 mg/day to 0.38 mg/day) by leaves and flowers. Then, the minerals (Mg, Fe and Mn) that permitted to cover between 1% and 3% of the needs. Contrary to the subjects, that consider a good source of iron, plants that the contribution would be necessary superior to 10% **[54]**, to the look of the quantities consumed (0.7 g/day) and of the contributions (1.07% to 2.78%), MFPs in general and leaves in particular will be consider a good source of iron. The iron contents of these plants could be valorized in the hospitals in order to fight against the anemia of the women in pregnancy and children, but also by the farming populations very often distant of the health centers. And according to **[55]**, *C. olitorius* would often be recommended to the women enclosed by the traditional midwives for iron richness. It could be the case also for the vegetarians whose, the iron need is 1.8 times more elevated because of their weak biodisponibility in their diets **[36].** And **[56],** also recall that only 3 to 4% of the Mn absorbed come from foods.

Finally, the daily intake of *M. arboreus* leaves contributed to 1,9% to the needs in Zn. The diet influences the use of zinc by the organism, presenting some factors activators (iron) and of other inhibitors (calcium, phytates) to his absorption **[57,58,59].** *M. arboreus* leaves could be recommended briskly to the vegetarians, of which the needs made of zinc can be until 50% more elevated, especially among the strict vegetarians that eat mainly cereals and legumes **[34,60].** The same recommendation could be made to people affected by the HIV because of the important deficiencies in this mineral **[55,61].**

V. CONCLUSION

This study showed that the mucilaginous food plants are rich in essential minerals to the organism. It showed also that the leaves and the fruits generally have more elevated contents than kernels and flowers. We notice that the quantities of mucilaginous food plants ingested per day were very weak (0.1g/day to 0.7g/day) when we take the total daily quantities ingested by Ivorian populations (1018.1 g/day). The parts of mucilaginous plants provided substantial daily contributions in some minerals, contributory thus of efficient manner to the needs of the consumers. The evaluation of the contributions showed that leaves and flowers had the biggest contributions to the needs in relation to kernels and fruits. The studies of variability divided the mucilaginous plants relatively in two groups to the mineral contribution. This classification orients the populations better on plants and specific parts to consume for an optimization of the contributions in mineral elements. Mucilaginous food plants especially present themselves like an asset in the struggle against the malnutrition and its perverse effects in the farming zones.

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