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Influence of cooking method on the nutrients of young *Myrianthus arboreus* leaves

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Abstract

The aim of the study was to evaluate the effect of cooking on the nutritional properties of young leaves of *Myrianthus arboreus* used in the preparation of sauces. The young leaves of *Myrianthus arboreus* cooked with steam and water at different times (10, 20 and 30 minutes) constituted the plant material. The analyzes carried out using standard and referenced methods focused on the biochemical composition. It appears from the results that the parameters studied undergo a significant decrease depending on the time and the cooking method with higher losses for cooking in water. Thus, fresh leaves of *Myrianthus arboreus* with contents of Ca (1203.06), K (1881.30) and Fe (7.55) undergo progressive losses from 16.11 to 39.70% and 8.52 to 29.32%; 36.09 to 61.06% and 18.18 to 46.80%; and 24.50 to 58.01% and 8.21 to 37.35% respectively for cooking with water and steam after 10 and 30 min. Regarding fiber, the results indicate that both cooking methods led to an increase in fiber. However, cooking in water gave a higher fiber rate (57.98%) than steam cooking (53.01%) after 30 min. Also, the amino acid profile shows the presence of 10 amino acids with 7 essential amino acids. These amino acid levels decrease and sometimes disappear with different cooking methods. Except, lysine, glutamic acid and aspartic acid which are present in these young leaves whatever the time and cooking method. To better benefit from the nutrients of the young leaves of *Myrianthus arboreus*, steaming for 10 minutes would be the most appropriate cooking.

Keywords: *Myrianthus arboreus*; Young leaves; Cooking; Biochemical characteristics; Food safety

1. Introduction

Africa has a wide variety of spontaneous plants [1]. Several authors have described plants in relation to the uses made by populations in Côte d'Ivoire [2, 3]. When periods occur when agricultural production cannot meet the needs of populations, wild plant species constitute a food alternative for poor farmers whose average annual income is low [4]. Traditionally, many farmers preserve plants in their fields depending on the interest they give them. Thus, there are wild plants in plantations that can serve as a source of food. This practice shows the interest of these plants among populations [1]. The promotion and consumption of leafy vegetables not only reduces food insecurity but also prevents metabolic diseases associated with oxidative stress [5]. However, the work carried out on spontaneous plants has not yet covered all regions of the country although these plants are used in food in Côte d'Ivoire. Indeed, many local leafy vegetables have not been studied in order to provide information on their nutritional value and appropriate cooking methods to maximize their nutrient supply to consuming populations. This is why the inventory of spontaneous food flora is essential to provide the scientific world with a reliable database as already exists in other countries [6].

Food insecurity remains one of the major problems in many developing countries. The dietary change of urban African populations, greater consumers of animal proteins and cereals, is often accompanied by certain deficiencies [7]. Leafy

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vegetables rich in nutrients essential to improving the nutrition and health of the poorest populations constitute an interesting alternative to solve this problem [8].

Tropical leafy vegetables as opposed to exotic vegetables from temperate countries are generally richer in nutrients (mineral salts, vitamins, antioxidants). These leafy vegetables can therefore contribute to the well-being of the body [9]. There is also a lack of biochemical and nutritional data on spontaneous food plants as indicated by the results of work on nutritional indicators of biodiversity [10]. This could be explained on the one hand by the rarity of food plants, their lack of knowledge and on the other hand, the absence of research on these species [11]. To contribute to improving the diet of populations in Côte d'Ivoire, it would be interesting to promote local plant resources qualified as minor foods [12, 13].

It is in this context that it is appropriate to analyze the nutritional properties of young leaves of *Myrianthus arboreus* and evaluate the effect of cooking on biochemical parameters.

2. Material and methods

2.1. Material

The plant material consists of young leaves of *Myrianthus arboreus* collected in Bayota in the Goh region, a locality located in the Center West of Côte d'Ivoire. After harvest, the young fresh leaves of *Myrianthus arboreus* were sent to the Biocatalysis and Bioprocesses Laboratory at NANGUI ABROGOUA University (Côte d'Ivoire) then were cleared of debris, impurities and stems. These leaves were washed with deionized water and drained at laboratory temperature (20 °C).

2.2. Methods

The fresh leaves were randomly subdivided into 3 batches of 500 g each. One of the 500 g batches was used for analyzes requiring fresh material. The other two batches were used for analyzes requiring heat treatment.

2.2.1. Cooking in water

The leaves were cooked in water according to the method described by Randrianatoandro [14]. A quantity of 500 g of fresh leaves was immersed in 3 L of boiling demineralized water. The leaves were cooked for 10, 20 and 30 minutes. After cooking, the leaves were drained and cooled to room temperature. The cooked leaves were divided into two sub-batches of 250 g intended for analysis. A sub-batch was used to carry out the analyzes requiring fresh material and the 2^{nd} sub-batch was dried in an oven at 45°C for 72 hours for the tests requiring dry material. The cooked and dried leaves were then ground using a micro-grinder. The flours obtained were used for the various analyses.

2.2.2. Steam cooking

Steam cooking was carried out according to the method described by Barkat and Kadri [15]. A quantity of 500 grams of fresh leaves vegetables were introduced into a couscous maker connected to a stainless steel pot containing 3mL of demineralized water previously brought to the boil. Then, the leaves were steamed for 10, 20 and 30 minutes. The cooked leaves were divided into two sub-batches of 250 g intended for analysis. A sub-batch was used to carry out the analyzes requiring fresh material and the 2nd sub-batch was dried in the oven at 45°C for 72 hours and was used for the tests requiring dry material. The cooked and dried leaves were then ground using a micro-grinder. The flours obtained were used for the various analyses.

2.2.3. Physicochemical analysis

The determination of humidity and dry matter was carried out according to method of AOAC [16]. This method consists of evaporating the water contained in fresh leaf samples by drying in a ventilated oven at 105°C until a constant mass is obtained. The ash content was also determined according to the method described by AOAC [16] using a muffle furnace. Protein determination was carried out by the Kjeldahl method [16]. As for lipids, that of Soxhlet made it possible to determine them [16]. Crude fiber and assimilable carbohydrates were respectively determined according to the AOAC [16] and FAO method [8].

2.2.4. Mineral analysis

Mineral macroelements (K, Ca, Na, Mg) and microelements (Fe, Mn, Cu) were measured by atomic absorption spectrophotometry according to the AOAC digestion method [16] using strong acids. Concerning the mineral macroelement phosphorus (P), it was determined by direct spectrophotometry according to the method of Taussky & Shorr [17].

2.2.5. Amino acid analysis

Determination of amino acids of leaf powders was carried out by reverse-phase high-performance liquid chromatography (PTC-18 column, 220 mm long, 2.1 mm diameter and precolumn, Applera Corp, Fosters City, CA, USA).

2.2.6. Statistical processing

All measurements were carried out in triplicate and the numerical values obtained were expressed by the arithmetic mean affected by the corresponding statistical standard deviation. One-way analysis of variance (ANOVA) was carried out on all of these results in order to determine the existence of significant differences at the 5% threshold between the values of the calculated means. Significant statistical differences were highlighted by the Duncan test using STATISTICA software.

3. Results

3.1. Physicochemical characteristics

Table 1 presents the physicochemical characteristics of *Myrianthus arboreus* leaves cooked in water and steam at different times (10, 20 and 30 minutes). The different moisture contents of *Myrianthus arboreus* leaves undergo a significant increase at the 5% threshold. These values range between 88.33±0.01 and 93.18±0.07% for cooking in water and between 85.23±0.01 and 88.33±0.01% dry matter (DM) for steam cooking at 10 and 30 min respectively. The results showed that the ash rate of young leaves of *Myrianthus arboreus* suffered a significant decrease at the threshold of 5% with the increase in cooking time. The lowest contents were obtained at 30 minutes, i.e., 6.17±0.01 and 8.52±0.01% DM respectively for cooking in water and steam. The fiber contents of young leaves of *Myrianthus arboreus* increased significantly at the threshold of 5 % with cooking. Indeed, the highest fiber content of the leaves was observed after 30 min of cooking in water with a value of 57.98±0.05% DM while steam cooking recorded a higher content (54.68± 0.01% (DM)) after 10 min. Also, the variations in protein contents of young leaves of *Myrianthus arboreus* depending on cooking and time were analyzed. Overall, it appears that a significant drop at the 5% threshold was observed. The losses are between 11.68 and 26.68% for cooking in water and 8.07 and 23.93% for steam cooking. Regarding lipid contents, they generally experience an increase significant at the 5% threshold. The highest content was recorded in young leaves of *Myrianthus arboreus* cooked in water for 30 min, i.e., 4.02±0.01 (DM) except for leaves steamed for 30 min which suffered a drop with a value of 2.78±0.01% (DM).

Table 1 Biochemical composition of young leaves of *Myrianthus arboreus*

	Proteins	**Lipids**	**Moisture**	**Fiber**	**Ash**	**carbohydrate**	**Energetic Value**
	(%)	**(%)**	**(%)**	**(%)**	**(%)**	(%)	(Kcal/100g)
MAF	16.34±0.01^{g}	2.88±0.01^{b}	81.16±0.01^{a}	50.04±0.02^{a}	11 .35 ±0,00 ^{g}	19.39 ± 0.01 ^{c}	133.19 ± 0.03 ^{d}
MAC 10	14.43±0.01^{d}	3. 68± 0.01^{e}	88.33±0.01^{e}	55.05±0.02^{e}	8.96 ±0.01 ^{e}	17.87 ± 0.01 ^{b}	129.81 ± 0.05 ^{b}
MAC20	13.73±0.01^{c}	3.95± 0.01^{f}	90.24± 0.01^{f}	56.16±0.01^{f}	6.42±0 .01 ^{b}	19.73 ± 0.01 ^{d}	136.99 ± 0.03 ^{g}
MAC30	11.98±0.01^{a}	4.02±0.01^{g}	93.18±0,07^{g}	57.98±0.05^{g}	6.17±0.01 ^{a}	19.84 ± 0.01 ^{f}	133.71 ± 0.05 ^{e}
MAS10	15.02±0.01^{f}	3.47± 0.05^{d}	85.23±0.01^{b}	54.68± 0.01^{d}	9.44±0.01 ^{f}	17.38 ± 0.01 ^{a}	127.76 ± 0.05 ^{a}
MAS20	14.74±0.02^{e}	2.98±0.01^{c}	87.98± 0.01^{c}	53.65± 0.01^{c}	8.82±0.01 ^{d}	19.80 ± 0.01 ^{e}	131.60 ± 0.05 ^{c}
MAS30	12.43±0.01^{b}	2.78±0.01^{a}	88.33± 0.01^{d}	53.01± 0.01^{b}	8.52 ±0.01 ^{d}	23.34 ± 0.01 ^{g}	136.92 ± 0.10 ^{f}

MA= *Myrianthus arboreus* ;MAF: MA Fresh ; MAC 10: MA cooked in water for 10 min; MAC 20: MA cooked in water for 20 min; MAC 30: MA cooked in water for 30 min ; MAS 10: MA steamed for 10 min; MAS 20: MA steamed for 20 min; MAS 30: MA steamed 30 min ;The values in the table are averages of three tests, affected by standard deviations. The statistical differences between these average values at 95% confidence level are indicated in the same column by the different letters.

Concerning carbohydrate contents, they generally increase significantly at the 5% threshold. These values range between 17.87 ± 0.01 and 23.34 ± 0.01% (DM). The highest levels were observed after 30 min and the lowest were determined at 10 min of steaming. The energy values of the young leaves of *Myrianthus arboreus* after the different cookings were determined. Generally speaking, energy values vary. Thus, the highest values are between 136.99 ± 0.03 Kcal/100g for cooking in water and 136.92 ± 0.10 Kcal/100 g) for cooking in water. steam after 30min. and the lowest values are between 127.76 ± 0.05 and 129.81 ± 0.05 Kcal/100 g after 10 minutes of cooking with steam and water.

3.2. Mineral composition of young leaves of *Myrianthus arboreus*

The contents of different mineral macroelements (Mg, K, Na, P, Ca) expressed in mg/100 g of DM were estimated for the young leaves of *Myrianthus arboreus*. Generally, cooking in water and steam leads to a reduction in the mineral macroelement contents of the leaves. This significant reduction at the 5% threshold is all the more significant as the cooking time increases with lower contents in the young leaves cooked in water. The results of the mineral composition of young leaves (Table 2) showed high contents of K, Ca, Mg, P. These values decreased with time and the cooking method. After 10 min of cooking with steam and water, the K content of the young leaves decreased respectively from 18.18% to 36.09% to reach losses of 46.80 to 61.06% after 30 min for the different cooking methods. As for Ca, it recorded a drop from 8.52 to 16.11% and 29.32 to 39.70%, respectively for 10 min and 30 min of steam and water cooking.

Like mineral macroelements, mineral microelements (Fe, Cu, Zn) also decreased with time and cooking method. Indeed, the losses are between 7.77 and 18.76% and between 49.74 and 74.87% after cooking with steam and water respectively at 10 and 30 min for Cu. The highest losses were obtained after 30 min of cooking in water with a loss of 58.01% for iron and 77.08% for zinc. Steam cooking also caused losses but less significant than those linked to cooking in water.

3.3. Amino acid composition

Table 2 Mineral composition (mg/100 g of DM) of young leaves of *Myrianthus arboreus*

	Na	Cu	P	Mg	Fe	Zn	K	Ca
MAF	20.05±0.01^{g}	21.21±0.05^{g}	270.59±0.04^{g}	501.65±0.03^{g}	7.55±0.03^{g}	13.22±0.01^{g}	1881.30±0.04^{g}	1203.06±0.02^{g}
MAC$_{10}$	10.15±0.02^{e}	17.23±0.01^{e}	200.06±0.02^{e}	201.28±0.01^{d}	5.70±0.01^{d}	8.15±0.03^{e}	1202.25±0.02^{e}	1009.20±0.06^{e}
MAC$_{20}$	4.04±0.01^{b}	13.04±0.02^{c}	162.34±0.01^{c}	192.26±0.02^{b}	5.04±0.01^{c}	6.44±0.01^{b}	997.04±0.01^{b}	812.67±0.01^{b}
MAC$_{30}$	2.15±0.01^{a}	5.33±0.01^{a}	111.24±0.03^{a}	146.73±0.01^{a}	3.17±0.01^{a}	3.03±0.03^{a}	732.56±0.07^{a}	725.35±0.01^{a}
MAS$_{10}$	14.23±0.01^{f}	19.56±0.01^{f}	220.06±0.04^{f}	350.21±0.00^{f}	6.93±0.00^{f}	11.62±0.04^{f}	1539.14±0.02^{f}	1100.44±0.01^{f}
MAS$_{20}$	9,17±0.01^{d}	14.02±0.01^{d}	180.02±0.01^{d}	273.06±0.04^{e}	6.28±0.01^{e}	10.02±0.01^{d}	1200.58±0.01^{d}	1000.06±0.01^{d}
MAS$_{30}$	5.06±0.01^{c}	10.66±0.01^{b}	149.15±0.01^{b}	200.23±0.01^{c}	4.73±0.01^{b}	5.63±0.01^{c}	1000.76±0.01^{c}	850.22±0.01^{c}

MA= *Myrianthus arboreus ;* MAF: MA Fresh; MAC 10: MA cooked in water for 10 min; MAC 20: MA cooked in water for 20 min; MAC 30: MA cooked in water for 30 min ; MAS 10: MA steamed for 10 min; MAS 20: MA steamed for 20 min; MAS 30: MA steamed 30 min ; The values in the table are averages of three tests, affected by standard deviations. The statistical differences between these average values at 95% confidence level are indicated in the same column by the different letters.

Table 3 shows the amino acid composition of young leaves of *Myrianthus arboreus*. Among the 20 proteinogenic amino acids, only 10 amino acids were detected in young leaves in the fresh state. Also, the results showed the presence of 7 essential amino acids including histidine. The levels of these amino acids decrease with time and cooking method. Furthermore, certain amino acids are no longer detectable after cooking: leucine, methionine and isoleucine.

Table 3 Amino acid composition (mg/100 g of protein) of young leaves of *Myrianthus arboreus*

	MAF	MAC_{10}	MAC_{20}	MAC_{30}	MAS_{10}	MAS_{20}	MAS_{30}
Leucine*	$7.13±0.02_g$	Nd	Nd	Nd	Nd	Nd	Nd
Lysine*	$0.87±0.02^g$	$0.65±0.04^a$	$0.56±0.01^c$	$0.24±0.03^a$	$0.80±0.02^e$	$0.86±0.04^f$	$0.14±0.04^a$
Glutamic acid	$5.18±0.02^g$	$4.45±0.04^e$	$3.15±0.03^c$	$0.55±0.04^a$	$4.67±0.02^f$	$3.63±0.06^d$	$0.83±0.04^b$
Aspartic acid	$4.74±0.04^g$	$4.13±0.03^e$	$2.97±0.02^c$	$0.74±0.04^a$	$4.29±0.04^f$	$3.43±0.01^d$	$1.44±0.04^b$
Histidine*	$2.90±0.02^g$	$1.45±0.03^e$	Nd	Nd	$1.78±0.02^f$	$0.06±0.02^d$	Nd
Tyrosine	$2.63±0.02^g$	Nd	Nd	Nd	$2.54±0.03^f$	Nd	Nd
Phenylalanine*	$0.97±0.02^g$	$0.91±0.02^g$	Nd	Nd	$0.97±0.02^g$	$0.95±0.04^g$	Nd
Valine*	$3.65±0.02^g$	Nd	Nd	Nd	$0.97±0.02^f$	Nd	Nd
Methionine*	$0.91±0.02^g$	Nd	Nd	Nd	Nd	Nd	Nd
Isoleucine*	$4.72±0.01^g$	Nd	Nd	Nd	Nd	Nd	Nd

MA= *Myrianthus arboreus ;* MAF: MA Fresh; MAC 10: MA cooked in water for 10 min; MAC 20: MA cooked in water for 20 min; MAC 30: MA cooked in water for 30 min MAS 10: MA steamed for 10 min; MAS 20: MA steamed for 20 min; MAS 30: MA steamed 30 min ; The values in the table are averages of three tests, affected by standard deviations. The statistical differences between these average values at 95% confidence level are indicated in the same column by the different letters; Nd = not defined *= essential amino acids.

4. Discussion

Most leafy vegetables must be cooked before consumption. The aim of this cooking is to soften the vegetables, to make them smoother, which allows a better appreciation of dishes based on them. There are different cooking methods including boiling and steam cooking. These two types of cooking affect the physicochemical properties of the young leaves of Mrianthus arboreus which were analyzed during this study. Thus, the humidity level increases significantly with cooking time. This increase could be caused by the law of osmosis which causes water absorption by leaf cells during cooking. Water migrates from the least concentrated environment to the most concentrated environment [18]. This increase in water content could lead to perishability of leaves due to microbial proliferation and triggering of enzymatic activities.

Regarding the ash rate, it decreases in the young leaves of *Myrianthus arboreus* with cooking time. This loss is more marked for young leaves cooked in water for 30 min. Indeed, this loss of ash would be due to the leaching of minerals in the cooking water after rupture of the cell walls of the leaves. According to Andrée *et al.* [19], this rate provides an idea of the mineral content. These results are consistent with the work carried out by Zoro *et al.* [20] on 5 leafy vegetables consumed in the South of Côte d'Ivoire.

Regarding fiber, the results reveal that cooking has a positive influence on fiber content. This increase in fibers in young leaves of Mrianthus arboreus could be explained by the cooking of plant tissues which alters the physical and chemical properties of plant cell walls, which increases their dietary fiber content. Furthermore, the consumption of these cooked leaves could facilitate intestinal transit but also help prevent 25 to 60% of cancers [21].

As for proteins, cooking leads to a reduction in the protein content of young leaves of Mrianthus arboreus. Indeed, heat treatments lead to rapid protein denaturation which results in conformational changes and an increase in surface hydrophobicity. According to Santé-Lhoutellier [22], proteins are solubilized during cooking which allows them to diffuse into the cooking water, thus leading to their reduction. With contents of 11.98 and 12.43% respectively for cooking with water and steam after 30 minutes. The young leaves of Mrianthus arboreus can be used to combat malnutrition in developing countries. A food with a protein level greater than or equal to 12% DM is said to be rich in protein.

The leaves are generally low in fat. Cooking in water allowed an increase in the lipid content of young leaves for both types of cooking. This observation would be due to the softening of the texture of the cell walls. These young Mrianthus arboreus leaves can be incorporated into the diet of people suffering from overweight or obesity due to their low lipid content as recommended by Maire *et al*. [23] during their work on diet-related chronic non-communicable diseases.

As for the energy value, these leafy vegetables are not excellent sources of energy because they provide few calories because they are rich in water and have a low lipid content. The energy values obtained are between 127.76 ± 0.05 and 136.99 ± 0.03 Kcal/100g. Leafy vegetables must therefore be accompanied by starchy foods. Furthermore, according to Vainio-Mattila [24] it will be necessary to add fat to make up for this calorific deficit during preparation.

Concerning minerals, a significant drop was recorded. Indeed, during cooking, these micronutrients are dissolved in the cooking water. These results obtained are in agreement with those of Vadouhe *et al.* [18] who showed the influence of the cooking method on the mineral composition of leafy vegetables. Minerals play a considerable role in all biochemical exchanges in the body. They are essential for the activity of hormones and enzymes essential to the body [25]. In addition, they contribute to maintaining heart rate, muscle contraction and acid-base balance. Thus, their deficit or deficiency in nutrition can be the cause of several pathologies such as infections, cardiovascular diseases and cancers. Although the body is able to store minerals, it cannot make them itself. These minerals come exclusively from food intake. The major minerals in the young leaves of *Myrianthus arboreus* are potassium, calcium, magnesium and phosphorus. Potassium is a mineral that prevents an increase in blood pressure and mainly helps maintain ionic balance throughout the body [26]. Phosphorus is important in the synthesis of nucleic acids and certain proteins. It is also involved in cell permeability. Calcium is important for maintaining normal excitability of the heart, muscles and nerves. Calcium also acts as a cofactor for several enzymes and is essential in blood clotting and the maintenance of blood pressure. Adequate consumption of calcium and phosphorus is important for overall health and well-being [27]. Concerning magnesium, it is a mineral which is involved in the body's mechanism against bacterial and viral attacks and in maintaining the normal functioning of muscle and nerve [28]. The mineral composition of samples could significantly contribute to the improvement of certain nutritional deficiencies [29].

Regarding amino acids, they occupy an essential function in an organism and they are the most important components of human tissues, enzymes and hormones [30].

The quantity of amino acids decreases with cooking ; it should be noted that studies carried out by numerous authors have shown that the content of amino acids can increase or decrease after cooking depending on the species [31]. Aspartic acid, glutamic acid and leucine are the main amino acids present in cooked leaves. A similar finding was also reported by Ogunwa *et al.* [32] for Marugbo leaves grown in Nigeria. Glutamic acid, leucine are important for health, growth, development and lactation [33].

Methionine, lysine, phenylalanine are the amino acids which have the lowest contents and are therefore the limiting amino acids. These results are in agreement with those reported by Ndomou et al. [34] who found that sulfur amino acids were the most limiting in *G. africanum* leaves. The total loss of methionine after the different cooking is an interesting result because it is considered a bitter amino acid [35].

5. Conclusion

The young leaves of *Myrianthus arboreus* analyzed in this study are rich in nutrients that can ensure well-being. These leaves are cooked before being consumed, which influences their nutrient composition. Thus, the composition of amino acids, biochemical compounds and minerals decreases significantly with time (10, 20, 30 min) and the cooking method (cooking in water and steam). There was more loss with boiling compared to steam cooking. However, steaming for 10 minutes would be the most appropriate cooking because it would better preserve the nutrients. A study of phytochemical compounds may prove necessary for the continuation of this work.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Shumsky SA, Hickey GM, Pelletier B, Johns T. Understanding the contribution of wild edible plants to rural social-ecological resilience in semi-arid Kenya. Ecology and Society, 2014; 19(4) : 34-21.

[2] Kouakou, K A, Barima Y S S, Kouakou ATM, Sangne YC, Bamba I et Kouamé NF. Diversité végétale postconflits armés de la Forêt Classée du Haut Sassandra (Centre-Ouest de la Côte d'Ivoire). Journal of Animal and Plant Sciences, 2015; 26 (2) : 4058 – 4071.

[3] Ta Bi IH. N'guessan K, Bomisso EL, Assa RR & Aké S. Etude ethnobotanique de quelques espèces du genre Corchorus rencontrées en Côte d'Ivoire. European Scientific Journal, 2016; 12 (24): 415-431.

[4] Eyog MO, Ndoye O, Kengue J, Awono A. Les fruitiers forestiers comestibles du Cameroun. Cotonou, Benin, International Plant Genetic Resources Institute (IPGRI) Regional Office for West and Central Africa. (2006) 203p. ISBN: 978-92-9043-707-9 and 92-9043-707-3.

[5] Agbo AE, Méité S, Traoré S, Koffi AH, Assemand EF, Djaman AJ. Antioxidant Potentialities of Black Nightshade and Sweet Potatoes Leaves Consumed in Côte d'Ivoire. American Journal of Food Nutrition, 2018 ; 6 (1), 28-32. https://doi.org/10.12691/ajfn-6-1-5

[6] Itumba OM. Contribution à étude des plantes alimentaires sauvages de yasikia (Pk 31 route Opala, Po, RDC), 2014 ; 36 p.

[7] Kahane R, Temple L, Brat P, De Bon H . Les légumes feuilles des pays tropicaux : diversité, richesse économique et valeur santé dans un contexte très fragile. Colloque Angers , 2005 ; 7-9 septembre, 9 p.

[8] FAO. Food energy-methods of analysis and conversion factors. FAO Ed, Rome. 2002 ; 97 p.

[9] Bailey JM. Aliments du Pacifique: les feuilles vertes que nous mangeons. Service de publication du Secrétariat général de la Communauté du Pacifique (CPS), Graphoprint, Nouméa, 2003 ; 97p.

[10] FAO. FAO Statistical Databases. Food and agriculture organization of the United Nations. 2013. http://faostat.fao.org.

[11] Mangambu MJD, Diggelen RV, Mwanga MJC, Ntahobavuka H, Malaisse F, Robbrecht E. Étude ethnoptéridologique, évaluation des risques d'extinction et stratégies de conservation aux alentours du Parc National de Kahuzi Biega (RD Congo). Geo-Eco-Trop. 2012 ; 36: 137-158.

[12] Atchibri LA, Soro LC, Kouamé C, Agbo EA, Kouadio KKA. Valeur nutritionnelle des légumes-feuilles consommés en Côte d'Ivoire. International Journal of Biological and Chemical Sciences. 2012 ; 6(1): 128-135. DOI : http://dx.doi.org/10.4314/ijbcs.v6i1.12

[13] Acho CF., Lessoy T, Zoue LT, Apka EE, Yapo VG, Niamké SLL. Leafy vegetables consumed in Southern Côte d'Ivoire: a source of high value nutrients. Journal of Animal and Plant Sciences. 2014; 20: 3159-3170.

[14] Randrianatoandro VA. Identification et caractérisation des plats sources en micronutriments consommés en milieu urbain (Manjakaray, Madagascar) : étude de plats à base de légumes-feuilles. Thèse de doctorat en Sciences de la Vie, Option : Biochimie appliquée aux Sciences de l'Alimentation et à la Nutrition, Université d'Anatananarivo, Madagascar; 2010.

[15] Barkat M & Kadri F. Impact de deux modes de cuisson sur la teneur en polyphenols solubles de six légumes. Revue de Génie Industriel. 2011; 6: 41-45.

[16] AOAC. Official methods of Analysis. Association of Official Analytical Chemists (15th Ed.). Washington DC. 1990.

[17] Taussky HH & Shorr E. A microcolorimetric method for the determination of inorganic phosphate. Journal of Biological Chemistry.1953 ; 202 : 675-685.

[18] Vodouhe S, Dovoedo A, Anihouvi VB, Tossou, Soumanou MM. Influence du mode de cuisson sur la valeur nutritionnelle de *Solanum macrocarpum*, *Amaranthus hybridus* et *Ocimum gratissimum*, trois légumes-feuilles traditionnels acclimatés au Bénin. International Journal of Biological Chemical Sciences, 2012. 6(5): 1926-1937.

[19] Andrée ES, Kadji BRL, Dje KM, Kone KTM,Dabonne S, Koffi-Nevry AR. Qualité nutritionnelle, microbiologique et organoleptique de farines composés à base de maïs (Zea mays) et safou (Dacryodes edulis) produites en Côte d'Ivoire. International journal of biological and chemical sciences, 2019 ; 13 (1) : 325-337.

[20] Zoro AF. Effets de différents modes de traitements technologiques sur les propriétés physico-chimiques et nutritives de 5 légumes-feuilles consommés à l'Ouest de la Côte d'Ivoire. Thèse de Doctorat, UFR Biosciences, Biotechnologie-Agroalimentaire,Université Félix Houphouët- Boigny, Abidjan (Côte d'Ivoire) ; 2016.

[21] Afolayan AJ & Jimoh FO. . Nutritional quality of some wild leafy vegetables in South Africa. International Journal of Food Science and Nutrition. 2009 ; 60(5): 424–431.

[22] Santé-Lhoutellier V, Astruc T, Daudin JD, Kondjoyan A, Scislowski V, Gaudichon C, Rémond D. Influence des modes de cuisson sur la digestion des protéines : approches in vitro et in vivo, Innovations Agronomiques. 2013 ; 33: 69-79.

[23] Maire B, Lioret S, Gartner A, Delpeuch F. Transition nutritionnelle et maladies chroniques non transmissibles liées à l'alimentation dans les pays en développement. Cahiers Santé. 2002 ; 12 : 45- 55.

[24] Vainio-Mattila K. Wild vegetables used by the Sambaa in the Usambara Mountains, North-East Tanzania. Annales Botanici Fennici. 2000 ;37 : 57-67.

[25] De Fremicourt I. Alimentation et santé: Manger des fruits et des légumes c'est préserver sa santé. Cahier Agriculture Environnement. 2006; 17-19.

[26] Tettey-Larbi L, Poku O, Darko EO, Faanu A, Appiah AA, Baidoo IK. Determination of the concentration of potassium in Lippia multiflora and Bridelia ferruginea for the treatment of high blood pression (hypertension). International Journal of Science and Technology. 2015 ; 5(1):24-27.

[27] Ijarotimi OS. Influence of germination and fermentation on chemical composition, protein quality and physical properties of wheat flour (Triticum aestivum). Journal of Cereals and oils seeds. 2012 ; 3(3):35-47.

[28] Mebdoua S. Caractérisation physico-chimique de quelques populations de niébé (Vigna unguiculata L. Walp.) influence des traitements. Mémoire de Magister en Phytotechnie, Ecole Nationale Supérieure Agronomique, Algérie. 2011.

[29] Ngo BMN, Ngwa FA, Manga GA. Evaluation nutritionnelle de la morelle africaine au Cameroun. International Journal of Biological and Chemical Sciences. 2018 ;12(1): 62-74. DOI: https://dx.doi.org/10.4314/ijbcs.v12i1.5

[30] Sá AGA, Moreno YMF, Carciofi BAM. Plant proteins as high-quality nutritional source for human diet. Trends Food Science &Technology. 2020 ; 97 : 170–184.

[31] Titi Mutiara K, Harijono, Teti E, Sriwahyuni E. Effect of Blanching treatments against protein content and amino acid of Drumstick leaves (Moringa oleifera). Journal of Food Research. 2013 ; 1: 101-108.

[32] Ogunwa TH, Ajiboye SA, Sholanke DR, Awe OB, Ademoye TA, Oloye OB, Ilesanmi OC. Nutritional evaluation of Cleroden¬drum volubile (Marugbo) leaves. Asian Journal of Plant Science Research. 2015 ; 5: 26-31.

[33] Siahbalaei R, Kavoosi G, Noroozi MM. Protein nutritional quality, amino acid profile, anti-amylase and anti-glucosidase properties of microalgae: Inhibition and mechanisms of action through in vitro and in silico studies. LWT. 2021 ; 150 (112023):1-7.

[34] Ndomou M, Mezajoug KLB, Tchiegang C. Physico-chemical properties of leaves of Gnetum africanum (L.) and Gnetum bucholzianum(L.) (Gnetaceae) from Cameroon. American Journal of Research Communication. 2014 ; 2(12) : 101-112.

[35] Dullius, A.; Fassina, P.; Giroldi, M.; Goettert, M.I.; Volken de Souza, C.F. A biotechnological approach for the production of branched chain amino acid containing bioactive peptides to improve human health: A review. Food Research International. 2020, 131 (109002): 1-16.