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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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An Overview of Nutritive Potential of Leafy Vegetables Consumed in Western Côte d'Ivoire

Armel F. ZORO, Lessoy T. ZOUE, Sévérin A.K. KRA, Arnaud E. YEPIE and Sébastien L. NIAMKE
Laboratoire de Biotechnologies, UFR Biosciences, Université Félix Houphouët-Boigny,
22 BP 582, Abidjan 22, Côte d'Ivoire

Abstract: In tropical Africa, leafy vegetables are traditionally cooked and eaten as a relish together with a starchy staple food. Nevertheless, scientific report on their nutritive potential is scanty. In order to contribute to their wider utilization and valorization, leafy vegetables consumed in Western Côte d'Ivoire (*Abelmoschus esculentus*, *Celosia argentea*, *Ipomea batatas*, *Manihot esculenta* and *Myrianthus arboreus*) have focused our attention. The physicochemical and nutritive properties of these leafy vegetables were investigated and the results obtained were as follow: moisture (66.51-85.40%), crude proteins (9.04-24.10%), crude fibres (11.46-32.44%), ash (6.91-25.69%), carbohydrates (34.92-61.77%), crude lipids (1.45-4.11%) and food energy (159.22-266.95 kcal/100 g). The mineral elements contents were high with remarkable amount of K (516.46-7740.35 mg/100 g), Ca (1249.76-4740 mg/100 g), Mg (564.24-2060.30 mg/100 g), P (718.53-2111.71 mg/100 g) and Fe (30.05-110 mg/100 g). The Ca/P ratio was desirable and ranged from 1.69 to 6.58. These leafy vegetables also contained appreciable levels of vitamin C (43.17-60.00 mg/100 g) and polyphenols (162.72-268.14 mg/100 g). The studied leafy vegetables highlighted antioxidant activity varying from 70.06 to 77.66%. All these results suggest that the studied leafy vegetables if consume in sufficient amount would contribute greatly to the nutritional requirement for human health and to the food security of Ivorian population.

Key words: Leafy vegetables, proximate composition, nutritive value, antioxidant properties

INTRODUCTION

African Leafy Vegetables (ALVs) are considered as valuable sources of nutrients (Nesamvuni *et al*., 2001) with some having important medicinal properties (Hilou *et al*., 2006). Indeed, these plants are valuable sources of nutrients especially in rural areas where they substantially contribute to proteins, minerals, vitamins, fibres and other nutrients which are usually in short supply in daily diets (Mohammed and Sharif, 2011). In view to their nutritive potential, leafy vegetables contribute substantially to food security in sub-Saharan Africa where people's diets based on rice, potato and cassava are high in calories but deficient in essential micronutrients (Yiridoe and Anchirinah, 2005). In these countries, chronic under-nutrition affects about 215 million people representing 43% of the population (FAO, 1996). Inadequate intake of micronutrients known as "hidden hunger" contributes to the increasing rates of illness and death from infectious diseases and disability such as mental impairment (Black, 2003). In addition, epidemiological studies indicate that increased intake of leafy vegetables is associated with decreased risk of cancers, cardiovascular disease, cataract, macular degeneration and other age-related diseases (Tanumihardjo and Yang, 2005).Therefore, leafy vegetables may be used as basic strategy for fighting against poverty, hunger, malnutrition and under nourishment (Barminas *et al*., 1998).

Traditionally, leafy vegetables are cooked and eaten as a relish together with a starchy staple food, usually in the form of porridge (Vainio-Mattila, 2000). Leafy vegetables dishes can be prepared with a single plant species or a combination of different species in order to add flavor, taste, color and aesthetic appeal to diet (Marshall, 2001; Fasuyi, 2006). Despite their availability, the frequency of African leafy vegetables consumption has decreased over the years, probably because they are often considered to be inferior in their taste and nutritional value compared to exotic vegetables such as spinach (*Spinacea oleracea*) and cabbage (*Brassica oleracea*) (Weinberger and Msuya, 2004). In addition, preference of leafy vegetables species depends on the gender and age of consumers, as well as cultural background and geographical location (Jansen-Van-Rensberg *et al*., 2004). However, several studies have indicated that leafy vegetables consumed in Africa contain higher level of micronutrients than those found in most exotic areas (Steyn *et al*., 2001).

Many of African leafy vegetables have been identified but lack of scientific data on their chemical composition has limited the prospect of their utilization (Kubmarawa *et al*., 2009). Indeed, their nutritional contribution has not been widely exploited hence nutritional information on these species would be useful for the nutritional education of the public and to improve the nutritional status of the population.

Corresponding Author: Lessoy T. ZOUE, Laboratoire de Biotechnologies, UFR Biosciences, Université Félix Houphouët-Boigny, 22 BP 582, Abidjan 22, Côte d'Ivoire

Ethno-botanical studies have stated that most people in Western Côte d'Ivoire consume indigenous green leafy vegetables such as *Abelmoschus esculentus* "gombo", *Celosia argentea* "soko", *Ipomea batatas* "patate", *Manihot esculenta* "manioc" and *Myrianthus arboreus* "tikliti" through confectionary soups (Kouamé, 2000; N'dri *et al*., 2008). However, there is very little report to the best of our knowledge, on the nutritive potential of these consumed leafy vegetables. This study was therefore under-taken to evaluate the proximate nutrient content, mineral and anti-nutritional factors of leafy vegetables consumed in Western Côte d'Ivoire in order to provide necessary information for their wider utilization and contribution to food security of Ivorian populations.

MATERIALS AND METHODS

Plant materials: Leafy vegetables were collected at maturity from cultivated farmlands located at Dabou (Abidjan District). These plants were authenticated by National Floristic Center (University Felix Houphouët-Boigny, Abidjan-Côte d'Ivoire). The collected plants were destalked, washed with distilled water, drained at ambient temperature and oven-dried (Memmert, Germany) at 60°C for 72 h (Chinma and Igyor, 2007). The dried materials obtained were ground with a laboratory crusher (Culatti, France) equipped with a 10 µm mesh sieve. The dried powdered samples obtained were stored in polythene bags at 4°C until further analyses.

Chemicals: All solvents (n-hexane, petroleum ether, acetone, ethanol and methanol) were purchased from Merck. Standards used (glucose, gallic acid, tannic acid, quercetin, beta-carotene) and reagents (metaphosphoric acid, vanillin, Folin-Ciocalteu, DPPH) were purchased from Sigma-Aldrich. All chemicals used in the study were of analytical grade.

Proximate analysis: Moisture, ash, proteins and lipids were determined using AOAC (1990) official methods. pH was determined as follow: 10 g of dried powdered sample was homogenized with 100 mL of distilled water and then filtered through Whatman No. 4 filter paper. The pH value was recorded after the electrode of pH-meter (Hanna, Spain) was immersed into the filtered solution. For crude fibre, 2 g of dried powdered sample were digested with 0.25 M sulphuric acid and 0.3 M sodium hydroxide solution. The insoluble residue obtained was washed with hot water and dried in an oven (Memmert, Germany) at 100°C until constant weight. The dried residue was then incinerated and weighed for the determination of crude fibres content. Carbohydrates and calorific value were calculated using the following formulas (FAO, 2002):

a) Carbohydrates: 100-(% moisture+% proteins+% lipids+% ash+% fibres)
b) Calorific value: (% proteins x 2.44) + (% carbohydrates x 3.57) + (% lipids x 8.37). The results of ash, fibre, protein, lipid and carbohydrate contents were expressed on dry matter basis

Vitamin C determination: Vitamin C contained in analyzed samples was determined by titration using the method described by Pongracz *et al.* (1971). About 10 g of ground fresh leaves were soaked for 10 min in 40 mL metaphosphoric acid-acetic acid (2%, w/v). The mixture was centrifuged at 3000 rpm for 20 min and the supernatant obtained was diluted and adjusted with 50 mL of bi-distilled water. Ten (10) mL of this mixture was titrated to the end point with dichlorophenol-indophenol (DCPIP) 0.5 g/L.

Carotenoids determination: Carotenoids content was carried out according to Rodriguez-Amaya (2001). Two (2) g of ground fresh leaves were mixed three times with 50 mL of acetone until loss of pigmentation. The mixture obtained was filtered and total carotenoids were extracted with 100 mL of petroleum ether. Absorbance of extracted fraction was then read at 450 nm by using a spectrophotometer (PG Instruments, England). Total carotenoids content was subsequently estimated using a calibration curve of beta-carotene (1 mg/mL) as standard.

Polyphenols determination: Polyphenols content was determined using the method reported by Singleton *et al.* (1999). 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.

Flavonoids determination: The total flavonoids content was evaluated using the method reported by Meda *et al.* (2005). Briefly, 0.5 mL of the methanolic extract was mixed with 0.5 mL methanol, 0.5 mL of $AlCl_3$ (10%, w/v), 0.5 mL of potassium acetate (1 M) and 2 mL of distilled water. The mixture was allowed to incubate at ambient temperature for 30 min. Thereafter, the absorbance was measured at 415 nm by using a spectrophotometer (PG Instruments, England). The total flavonoids were determined using a calibration curve of quercetin (0.1 mg/mL) as standard.

Tannins determination: Tannins of samples were quantified according to Bainbridge *et al.* (1996). For this, 1 mL of the methanolic extract was mixed with 5 mL of vanillin reagent and the mixture was allowed to incubate at ambient temperature for 30 min. Thereafter, the absorbance was read at 500 nm by using a spectrophotometer (PG Instruments, England). Tannins content of samples was estimated using a calibration curve of tannic acid (2 mg/mL) as standard.

Oxalates determination: The titration method as described by Day and Underwood (1986) was performed. One (1) g of dried powdered sample was weighed into 100 mL conical flask. A quantity of 75 mL of sulphuric acid (3 M) was added and stirred for 1 h with a magnetic stirrer. The mixture was filtered and 25 mL of the filtrate was titrated while hot against $KMnO_4$ solution (0.05 M) to the end point.

Phytates determination: The method described by Wheeler and Ferrel (1971) was used for determination of phytates content. A quantity (0.5 g) of dried powdered sample was mixed with 25 mL of trichloroacetic acid (3%, w/v) and centrifuged at 3500 rpm for 15 min. The supernatant obtained was treated with $FeCl_3$ solution and the iron content of the precipitate was determined using spectrophotometric method at 470 nm. A 4:6 Fe/P atomic ratio was used to calculate the phytic acid content.

Antioxidant activity: Antioxidant assay was carried out using the 2,2-diphenyl-1-pycrilhydrazyl (DPPH) spectrophotometric method outlined by Choi *et al.* (2002). About 1 mL of 0.3 mM DPPH solution in ethanol was added to 2.5 mL of sample solution (1 g of dried powdered sample mixed in 10 mL of methanol and filtered through Whatman No. 4 filter paper) and was allowed to react for 30 min at room temperature. Absorbance values were measured with a spectrophotometer (PG Instruments, England) set at 415 nm. The average absorbance values were converted to percentage antioxidant activity using the following formula:

Antioxidant activity (%) = 100 - [(Abs of sample - Abs of blank) x 100/Abs positive control]

Mineral analysis: The mineral content was estimated by dry ashing of dried powdered sample (5 g) in a muffle furnace (Pyrolabo, France). The ash obtained was dissolved in 5 mL of HCl/HNO_3 and analyzed using the atomic absorption spectrophotometer (AAS model, SP9).

Statistical analysis: All the analyses were performed in triplicate and data were analyzed using EXCELL and STATISTICA 7.1 (StatSoft). Differences between means were evaluated by Duncan's test. Statistical significant difference was stated at $p<0.05$.

RESULTS AND DISCUSSION

Physicochemical properties: Proximate composition of the selected leafy vegetables is presented in Table 1. The physicochemical parameters generally differ significantly ($p<0.05$) from a leafy vegetable to another. All samples contained between 68 and 85% moisture. The relatively highest values of moisture obtained in this study corroborated with results (60-90%) of investigated vegetables as indicated by FAO (2006). These results indicate that the studied leafy vegetables would more ability to perish and need appropriate preservation to avoid microbial spoilage (Fennema and Tannenbaum, 1996). In view to their ash contents (9.03±2.12-23.56±2.13%) the selected leafy vegetables may be considered as good sources of minerals when compared to values (2-10%) obtained for cereals and tubers (FAO, 1986). The crude fibres content of the investigated leafy vegetables species ranged from 12.19±0.73% (*M. arboreus*) to 30.83±1.61% (*C. argentea*). These contents are high when compared to *Talinum triangulare* (6.20%), *Corchorus olitorius* (7.0%) and *Vernonia amygdalina* (6.5%) (Antia *et al.*, 2006). Therefore, the consumption of the selected leafy vegetables may be advantageous since high fibres content of foods help in digestion, prevention of colon cancer and in the treatment of diseases such as obesity, diabetes and gastrointestinal disorders (Saldanha, 1995; UICC/WHO, 2005). The lipids content of the remaining species was in the range of 1.45-4.11%. These lowest values of lipids corroborate the findings of many authors which showed that leafy vegetables are poor sources of lipids (Ejoh *et al.*, 1996). In addition, diet providing 1-2% of its caloric energy as fat is said to be sufficient to human beings, as excess fat consumption yields to cardiovascular disorders such as atherosclerosis, cancer and aging (Kris-Etherton *et al.*, 2002). Therefore, the consumption of the studied leaves could be advantageous for individuals suffering from obesity. Proteins content ranged from 9.19±0.15% in *A. esculentus* to 23.39±0.71% in *M. esculenta* leaves. The proteins content of *M. esculenta* was more than that reported for some high value leafy vegetables such as *Momordica balsamina* (11.29%) and *Moringa oleifera* (20.72%) (Asaolu *et al.*, 2012). It's important to note that plant foods which provide more than 12% of their calorific value from proteins have been shown to be good source of proteins (Ali, 2009). This suggests that all the leafy vegetables investigated would be good sources of proteins and could play a significant role in providing cheap and available proteins for rural communities. Assuming complete proteins absorption, 100 g of the studied leaves would respectively contribute for about 12.9 to 32.9% of the daily protein requirement (71 g/day) of pregnant and lactating mothers (FND, 2005). The carbohydrates content (35-60%) determined in this study corroborate the fact that most leafy vegetables are generally not good sources of

Table 1: Physicochemical properties of leafy vegetables consumed in Western Côte d'Ivoire

	Leafy vegetables				
Parameters	*A. esculentus*	*C. argentea*	*I. batatas*	*M. arboreus*	*M. esculenta*
Moisture (%)	83.91±0.08[ab]	84.96±0.44[a]	79.66±3.57[d]	81.30±0.35[c]	68.43±1.92[e]
pH	6.22±0.02[c]	6.37±0.01[b]	6.59±0.02[a]	6.09±0.01[d]	5.88±0.02[e]
Ash (%)	11.90±0.10[c]	22.10±0.75[ab]	23.56±2.13[a]	11.73±0.76[cd]	9.03±2.12[e]
Crude fibres (%)	15.66±0.05[d]	30.83±1.61[a]	21.5±0.82[c]	12.19±0.73[e]	26.23±0.31[b]
Lipids (%)	3.38±1.59[b]	1.79±0.20[d]	2.63±0.06[c]	1.47±0.02[e]	4.09±0.02[a]
Proteins (%)	9.19±0.15[e]	9.77±0.10[d]	15.52±0.40[c]	16.95±0.05[b]	23.39±0.71[a]
Carbohydrates (%)	59.87±1.90[a]	35.52±0.60[e]	36.79±3.41[cd]	56.70±2.71[ab]	37.27±3.16[c]
Calorific energy (kcal/100 g)	264.44±2.51[a]	165.62±6.40[e]	232.91±15.78[c]	259.50±5.26[ab]	224.35±15.67[d]

Data are represented as Means±SD (n = 3). Means in the lines with no common superscript differ significantly (p<0.05)

Table 2: Nutritive and antioxidant properties of leafy vegetables consumed in Western Côte d'Ivoire

	Leafy vegetables				
Parameters (mg/100 g)	*A. esculentus*	*C. argentea*	*I. batatas*	*M. arboreus*	*M. esculenta*
Vitamin C	52.50±0.00[b]	30.00±0.00[e]	60.00±0.00[a]	47.50±4.33[d]	48.00±0.01[c]
Carotenoids	1.44±0.08[e]	2.45±0.01[d]	3.26±0.02[c]	4.36±0.00[a]	3.56±0.00[b]
Polyphenols	246.97±0.10[b]	264.64±3.50[a]	164.47±1.75[e]	169.93±2.29[cd]	170.65±3.50[c]
Tannins	185.09±6.81[a]	165.36±1.50[b]	52.81±1.50[e]	114.28±1.50[c]	66.00±0.00[d]
Flavonoids	41.19±0.64[c]	57.02±0.64[b]	69.00±0.80[a]	28.60±0.00[e]	35.00±0.00[d]
Oxalates	780.00±39.00[c]	800.00±78.00[a]	78.00±0.00[e]	520.00±0.00[d]	800.00±78.00[ab]
Phytates	36.90±0.10[ab]	24.41±0.00[cd]	16.69±0.24[e]	24.80±0.02[c]	37.00±0.00[a]

Data are represented as Means±SD (n = 3). Means in the lines with no common superscript differ significantly (p<0.05)

carbohydrates (Emebu and Anyika, 2011). Except for *C. argentea* (165.62±6.40 kcal/100 g), the estimated calorific values of the studied plants were compared favourably to 248.8-307.1 kcal/100 g reported in some Nigerian leafy vegetables (Antia *et al*., 2006). Furthermore, Asibey-Berko and Tayie (1999) also reported comparable energy values in some Ghanaian green leafy vegetables. Thus, the calorific value agree with general observation that vegetables have low energy values (Lintas, 1992) due to their low fat content and relatively high level of moisture (Sobowale *et al*., 2011).

Nutritive and antioxidant properties: Nutritive and antioxidant properties of the selected leafy vegetables are shown in Table 2. There was a significant difference (p<0.05) between most of these parameters. Vitamin C content ranged from 30.00±0.00 mg/100 g for *C. argentea* to 60.00±0.00 mg/100 g for I. batatas. With regard to the standard value (40 mg/day) recommended by FAO (2004), the consumption in sufficient amount of the studied leaves could cover the dietary allowance for vitamin C. It's worth precising that ascorbic acid is a water-soluble antioxidant that promotes absorption of soluble iron by chelating or by maintaining the iron in the reduced form (FAO, 2004). Besides its ability to scavenge free radicals, ascorbic acid can regenerate other antioxidants such as tocopheroxyl from their radical species (Halliwell and Gutteridge, 1999). The carotenoids content depends on the leafy vegetables species and varied from 1.44±0.08 mg/100 g for *A. esculentus* to 4.36±0.00 mg/100 g for *M. arboreus* (Table 2). In plants, vitamin A occurs in the form of provitamin A carotenoids which amount determines their bioavailability in human diet (Rodriguez-Amaya, 2001; West *et al*., 2002). Furthermore, carotenoids contents of *M. arboreus* and *M. esculenta* could cover the standard values (3.6-4.8 mg/day) recommended by FAO (2004). Analysis of polyphenols has revealed that *C. argentea* and *A. esculentus* are major sources with contents of 264.64±3.50 and 246.97±0.10 mg/100 g, respectively. Polyphenols are the main dietary antioxidants which have higher *in vitro* antioxidant capacity than vitamins and carotenoids (Gardner *et al*., 2000). Plant phenolics include phenolic acids, coumarins, flavonoids, stilbenes, hydrolysable and condensed tannins, lignans and lignins (Naczk and Shahidi, 2004). Flavonoids such as myricetin, quercetin, kaempferol, isorhamnetin and luteolin have been reported in leafy vegetables by Trichopoulou *et al*. (2000). These polyphenols levels may explain the antioxidant activity values (70-80%) of the studied leafy vegetables (Fig. 1). Indeed, plant extracts that contain appreciable amount of polyphenols also exhibit high antioxidant activity and contribute to their medicinal properties (Wong *et al*., 2006). The consumption in high amount of these plants could therefore lower cellular oxidative stress, which has been implicated in the pathogenesis of various neurodegenerative diseases, including Alzheimer's disease, Parkinson's disease and amyotrophic lateral sclerosis (Rice-Evans and Miller, 1995; Amic *et al*., 2003). The selected leafy vegetables used in this study contained anti-nutrients which amounts vary from 78.00±0.00 to 800±78.00 mg/100 g for oxalates and

Table 3: Mineral composition of leafy vegetables consumed in Western Côte d'Ivoire

	Leafy vegetables				
Minerals (mg/100 g)	*A. esculentus*	*C. argentea*	*I. batatas*	*M. arboreus*	*M. esculenta*
Calcium (Ca)	2659.14 ± 13.00^{c}	4620 ± 120^{a}	3501.02 ± 40.00^{b}	1313.76 ± 64.00^{e}	1439.08 ± 30.00^{d}
Magnesium (Mg)	872.16 ± 26.00^{d}	1070 ± 30.00^{c}	2040.30 ± 20.00^{a}	1191.77 ± 58.00^{b}	584.24 ± 20.00^{e}
Phosphorus (P)	403.69 ± 10.00^{e}	1090 ± 20.00^{b}	2071.71 ± 40.00^{a}	727.26 ± 8.73^{d}	781.40 ± 20.00^{c}
Potassium (K)	532.46 ± 16.00^{e}	6590 ± 90.00^{b}	7670.35 ± 70.00^{a}	3116.66 ± 23.00^{c}	2472.72 ± 70.00^{d}
Sodium (Na)	ND	300 ± 20.00^{a}	ND	ND	ND
Iron (Fe)	42.66 ± 0.12^{c}	100 ± 10.00^{a}	30.25 ± 0.20^{d}	ND	57.79 ± 0.00^{b}
Zinc (Zn)	ND	ND	ND	ND	ND
Ca/P	6.58	4.24	1.69	1.81	1.84
Na/K	-	0.045	-	-	-
Oxalates/Ca	0.29	0.17	0.02	0.39	0.55
Phytates/Ca	0.01	0.005	0.004	0.058	0.02
Phytates/Fe	0.86	0.24	0.55	-	0.6

Data are represented as Means±SD (n = 3). Means in the lines with no common superscript differ significantly (p<0.05). ND: non detected

16.69±0.24 to 37.00±0.00 mg/100 g for phytates. Oxalates contents in this study were in the range of those (0.6-15.1%) reported in some edible leafy vegetables (Badifu, 2001).Toxicity of oxalates for humans was set as 2-5 g/day and the consumption of diet high in these anti-nutrients may result in kidney disease (Hassan and Umar, 2004; Hassan *et al.*, 2007). Phytates are the principal storage form of phosphorus and are particularly abundant in cereals and legumes (Champ, 2002). These anti-nutrients chelate divalent cations such as calcium, magnesium, zinc and iron, thereby reducing their bioavailability (Sandberg, 2002). These results indicate that the consumption in large amounts of fresh studied leaves may have adverse effects on human health. Moreover, the anti-nutrients present in these plants could easily be detoxified by soaking, boiling or frying (Ekop and Eddy, 2005).

Mineral composition: Mean values for mineral content of the selected leafy vegetables are presented in Table 3. The species analyzed in this study contained relatively high amounts of calcium (1250-4740 mg/100 g), potassium (516-7740 mg/100 g), phosphorus (397-2110 mg/100 g), magnesium (564-2060 mg/100 g) and iron (30-110 mg/100 g). The relationship between Ca and P revealed ratio varying from 1.69 to 6.58. Only *C. argentea* contained sodium (Na) with value of 300±20.00 mg/100 g. In view to the recommended dietary allowance (RDA) for minerals: calcium (1000 mg/day); phosphorus (800 mg/day); magnesium (400 mg/day) and iron (8 mg/day), these leafy vegetables could cover RDA and contribute substantially for improving human diet (FND, 2005). Calcium and phosphorus are associated for growth and maintenance of bones, teeth and muscles (Turan *et al.*, 2003). However, the Ca/P ratio higher than 1 may be advantageous for consumption of the studied leaves because diet is considered good if the ratio Ca/P is >1 and as poor if <0.5 (Adeyeye and Aye, 2005). In addition, consumption of *C. argentea* leaves would probably

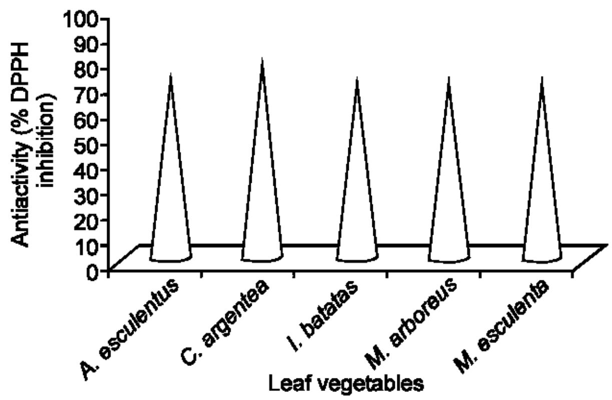

Fig. 1: Antioxidant activity of leafy vegetables consumed in Western Côte d'Ivoire

reduce high blood pressure diseases because its ratio Na/K is less than one (FND, 2005). Sodium and potassium are important intracellular and extracellular cations respectively, which are involved in the regulation of plasma volume, acid-base balance, nerve and muscle contraction (Akpanyung, 2005). As concern magnesium, this mineral is known to prevent cardiomyopathy, muscle degeneration, growth retardation, alopecia, dermatitis, immunologic dysfunction, gonadal atrophy, impaired spermatogenesis, congenital malformations and bleeding disorders (Chaturvedi *et al.*, 2004). The iron contents of the studied leafy vegetables leaves were higher than recommended dietary allowance for males (1.37 mg/day) and females (2.94 mg/day) (FAO/WHO, 1988). According to Geissler and Powers (2005), iron plays numerous biochemical roles in the body, including oxygen blinding in hemoglobin and acting as an important catalytic center in many enzymes as the cytochrome oxidase. Thus, the selected leaves of this study could be recommended in diets for reducing anemia which affects more than one million people worldwide (Trowbridge and Martorell, 2002). To predict the bioavailability of calcium and iron, anti-nutrients to nutrients ratios were calculated. The calculated [oxalates] / [Ca] and [phytates] / [Ca] ratios in all the species were below the critical level of 2.5 known to impair calcium bioavailability (Hassan *et al.*, 2007). It was also observed that the calculated [phytates]/[Fe] ratios of *A. esculentus* and *I. batatas* were above the critical level of 0.4. This implies that the phytates of these leafy vegetables may hinder iron bioavailability (Umar *et al.*, 2007). However, the [phytates]/[Fe] ratios could be considerably reduced after processing such as soaking, boiling or frying (Ekop and Eddy, 2005).

Conclusion: From the results above, the leaves of *Abelmoschus esculentus*, *Celosia argentea*, *Ipomea batatas*, *Manihot esculenta* and *Myrianthus arboreus* could serve as a supplementary diet for the Ivorian population, supplying the body with nutrients such as fibres, proteins, minerals and vitamins (vitamin C and provitamin A). The presence of secondary metabolites (polyphenols, flavonoids, tannins) in appreciable amounts in the plant leaves contribute to their medicinal value. These species also contain some anti-nutritional factors such as oxalates and phytates which are required to be removed to improve their nutritional quality. Hence, the studied leafy vegetables could contribute to the alleviation of protein-energy malnutrition and micronutrient deficiencies if they are consume in sufficient amount. However, it is necessary to consider other aspects such as the effects of processing on the chemical and nutritive value of these leafy vegetables.

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