

Evaluation of nutritive value of two traditional African vegetables (*Corchorus olitorus* and *Hibiscus sabdariffa*) commonly consumed in Côte d'Ivoire.

ABSTRACT

Aims: Leafy vegetables play an important role as essential components of diet for rural populations in tropical Africa. The aim of this study was to evaluate the nutritive value of two leafy vegetable species (*Corchorus olitorus* and *Hibiscus sabdariffa*) consumed widely as sauces in Côte d'Ivoire.

Methodology: The proximate composition, minerals, nutritive and anti-nutritional components of fresh leafy vegetables were determined according to standard methods for nutritional guidelines.

Results: The results obtained were as follow: moisture (85.75 - 86.29 % Fresh basis), proteins (13.13- 21.00 % Dry basis), ash (7.00 - 9.14 % Dry basis), carbohydrates (26.03 - 42.97 % Dry basis) and lipids (4.35 - 4.75 % Dry basis). The mineral contents were Phosphorus (0.44 – 0.62 g/100 g), Calcium (0.71 – 1.41g/100g), Magnesium (1.31 – 2.00 g/100g) with a high amount of Iron (4.96 – 5.41 g/100g). **Iron and Calcium are bio-available in all the leaves with the ratio of oxalates/iron <1 and oxalates/calcium <2.5 which were under the respective critical value.** These leafy vegetables are good of polyphenols (80.00 - 103.00 mg/100g).

Conclusion: The leaves of *Corchorus olitorus* and *Hibiscus sabdariffa* contain appreciable amount of nutrient and minerals which could participate to the maintenance of a good nutritional status of people in Côte d'Ivoire.

Keywords: African leafy vegetable, physico-chemical composition, nutritional status, food security, Côte d'Ivoire

1. INTRODUCTION

The growing awareness in recent years of the health promoting has directed increased attention to vegetables as vital components of daily diets [1]. Despite this diversity, sub-Saharan Africa has the lowest level of vegetable consumption in the world and the highest level (15%) of malnutrition [2]. The traditional leafy vegetables are rich in micronutrients needed by humans for good health, growth and could contribute significantly to food security, which is a requirement for human development [3,4]. Promotion of traditional vegetables consumption can help to reduce food insecurity and improve nutrition [5]. Traditional African vegetables have values and properties that make them useful for farmers and consumers. Also, leafy vegetables are important sources of minerals, vitamins, fiber, amino acids and health promoting phytochemicals with antioxidant, antibiotic and anticancer and other nutraceutical properties [6]. Green leafy vegetables are not only rich in nutrients but also possess medicinal properties [7]. A fruit and vegetable intake has been associated with a number of health benefits, such as reducing risk of cardiovascular disease and different types of cancer [8]. This association is often attributed to different antioxidant components, such as some vitamins like vitamin C, polyphenols and other phytochemical compounds. Unfortunately, many of these plants have not been put into maximum use except in times of nutritional stress [9]. Among these plants, there are *Corchorus olitorus* and *Hibiscus sabdariffa*, which negligence has been attributed to insufficient information on potential to serve as food security [10]. These vegetables can be used to alleviate micronutrient deficiency if cultivated, popularized and improved [11]. The aim of the present work was to determine the physico- chemical, minerals and anti-nutritional composition of the leaves of *Corchorus olitorus* and *Hibiscus sabdariffa* consumed in Côte d'Ivoire to reveal their nutritional potential.

2. MATERIAL AND METHODS

2.1 Material

These plants were previously authenticated by National Floristic Center (University Felix Houphouët-Boigny, Abidjan-Côte d'Ivoire). The fresh leaves of *Corchorus olitorus* and *Hibiscus sabdariffa* were collected at maturity in the Gagnoa region (West-Central of Côte d'Ivoire).

2.2 Methods

2.2.1 Sample preparation

Leaves were put into clean, dry sample containers and transferred to the Laboratory of Food Biochemical and Tropical Products Technology (Nangui Abrogoua University, Abidjan, Côte d'Ivoire) immediately for the powder preparation. The leafy vegetables were washed in fresh running water to eliminate dust, dirt, possible parasites or their eggs, after, they were again washed with deionized water. Only the edible leaf tissue was used for analyses. The fresh leaves were air dried in the laboratory to remove the surface water, there after oven-dried (Thitec 250, France) at 45°C for 72 h. The leaves were milled into powder using an electric blender (Bimby mod. 2200, Vorwerk, Wuppertal, Germany) and stored in polyethylene bags at room temperature ($21 \pm 01^\circ\text{C}$) prior to analysis.

2.2.2 Chemical composition

The proximate analysis (protein, lipids, fiber, ash, moisture and carbohydrates) of powder of the leaves were determined by Association of Official Analytical Chemist's methods [12]. Moisture was determined by gravimetric method, heating in an oven at $105 \pm 1^\circ\text{C}$ until constant mass; total nitrogen was determined according to the Kjeldahl method and converted into protein, using factor 6.25; total lipids were extracted by the Soxhlet technique with hot solvent (hexane) and afterwards were determined by gravimetry. Ash was determined by gravimetry of incinerated sample, in muffle, at 550°C . The total carbohydrate content was calculated by using the equation: $100 - (\text{moisture} + \text{protein} + \text{lipid} + \text{ash})$ [13]. The pH was measured using a pH meter's calibrated with standard buffers, results are expressed in pH units and are read directly on the pH-meter dial. Total crude fiber was determined according to the technique described by Prosky *et al.* using sulfuric acid [14]. The caloric value of samples was calculated using the Atwater conversion factors: 9 kcal.g^{-1} of lipids, 4 kcal.g^{-1} of carbohydrates and 4 cal.g^{-1} of proteins [15].

2.2.3 Mineral analysis

For mineral determinations were determined by American Association of Cereal chemist's method [16]. Glass and polypropylene materials were soaked in concentrated nitric acid (specific gravity = 1.41 g. cm^{-3}) for 15 min and then rinsed 3 times with distilled deionized water before use. Mineral constituents comprising magnesium (Mg), iron (Fe), calcium (Ca), and phosphorus (P) were determined by atomic absorption spectrophotometry (Unicam Analytical system, Model 919, Cambridge, UK). All samples were previously subjected to dry digestion at 450°C . To dissolve the ashes, 3 mL of concentrated HCl (specific gravity = 1.19 g.cm^{-3}) were added, the vessel was covered with a watch glass and gently warmed ($\sim 70^\circ\text{C}$) for 3.5 h, leaving at the end of heating about 1 mL of liquid. The solution was then transferred to a 10 mL volumetric flask and the volume was completed with water. The solution was then used for individual mineral determination using spectrophotometer and flame photometer. These measurements were carried out in triplicates, with two measurements per analysis. All minerals were expressed in mg/100 g dry weight basis.

2.2.4 The Anti-nutritionals compounds

Corchorus olitorus and *Hibiscus sabdariffa* leaves were analyzed for content of oxalates according to Day and Underwood method [17]. Phytates was extracted and separated by ion-exchange chromatography according to chromophore method of Mohamed *et al.* [18] before being quantified colorimetrically using an Ultraspec 3000 spectrophotometer at 500 nm [19]. Polyphenols content (expressed as gallic acid equivalent, mg/100 g dry weight) was determined by colorimetry, using the Folin-Ciocalteu's method described by Singleton *et al.* [20].

2.2.5 Data Analysis

Data were analyzed using STATA 12 (Stata Corp LP, College Station, and Texa, USA). Student's t-test was used to assess comparisons between both samples at a probability (p) of 0.05.

3. Results and Discussion

3.1 RESULTS

3.1.1. Proximate composition

The physico-chemical content of the leafy vegetables is presented in Table 1. Highly significant ($P = .05$) differences were observed for all the variables between *Corchorus olitorus* and *Hibiscus sabdariffa*, except for moisture. The two leaves were acidic ($\text{pH} = 2.45 - 2.81$) and had good energetic value ($180.62 - 236.00 \text{ kcal/100g}$). The leaves of *Hibiscus sabdariffa* had the highest carbohydrates values content with 42.97%. *C. olitorus* and *H. sabdariffa* had 4.35% and 4.75% respectively as lipid contents. The proteins content was higher in *C. olitorus* (21.00%) than those of 13.15% in *H. sabdariffa* leaves but fibers content was lowest in *H. sabdariffa* (32.01% vs 41.67% for *C. olitorus*). Ash content was lower in *C. olitorus* (7.00%) than *H. sabdariffa* (9.14%).

Table 1. Physico-chemical properties of *Corchorus olitorus* and *Hibiscus sabdariffa* leafy vegetables.

Parameters (% Dry basis)	<i>H. sabdariffa</i>	<i>C. olitorus</i>
pH	2.81 ± 0.00^a	2.45 ± 0.00^b
Moisture (% Fresh matter)	85.75 ± 0.76^a	86.29 ± 0.85^a
Carbohydrates	42.97 ± 0.00^a	26.03 ± 0.03^b
Proteins	13.15 ± 0.00^b	21.00 ± 0.88^a
Lipids	4.74 ± 0.07^a	4.35 ± 0.00^b
Fibers	30.01 ± 0.84^b	41.67 ± 0.00^a
Ash	9.14 ± 0.02^a	7.00 ± 0.00^b
Energetic value (kcal/100g)	236.00 ± 0.00^a	180.62 ± 0.00^b

Data are expressed as Means $\pm$ Standard Deviation ($n=3$). Means in the same line with no common superscript differ significantly ($P = .05$)

3.1.2. Minerals compound

The mineral content of the leafy vegetables is presented in Table 2. and differed significantly ($P = .05$) between *Corchorus olitorus* and *Hibiscus sabdariffa*. The leaves are very important source of minerals. Calcium in *H. sabdariffa* leaves (1.41%) was higher than the one of *C. olitorus* (0.71%) and iron content in *C. olitorus* (4.96%) was lower than *H. sabdariffa* (5.41%). Besides magnesium content in *H. sabdariffa* 2.00% was more than those of *C. olitorus* (1.31%). The leaves of *Hibiscus sabdariffa* had the highest phosphorus value content with (0.62%) vs 0.44% *C. olitorus*.

Table 2: Mineral composition of *Corchorus olitorus* and *Hibiscus sabdariffa* leafy vegetables.

Minerals composition (% Dry basis)	<i>H. sabdariffa</i>	<i>C. olitorus</i>
Calcium	1.41 ± 0.06^a	0.71 ± 0.00^b
Iron	5.41 ± 0.40^a	4.96 ± 0.03^b
Magnesium	2.00 ± 0.00^a	1.31 ± 0.00^b
Phosphorus	0.62 ± 0.01^a	0.44 ± 0.00^b

Data are expressed as Means $\pm$ Standard Deviation ($n=3$). Means in the same line with no common superscript differ significantly ($P = .05$)

3.1.3. Anti-nutritionals compounds

The antinutrients of *Corchorus olitorus* and *Hibiscus sabdariffa* are shown in Table 3. They differed significantly ($P = .05$). Phytates and Polyphenols content were higher in the leaves of *C. olitorus* than in *H. sabdariffa* with the values of 0.05 g/100 g and 1.40 g/100 g respectively while oxalates were abundant in the leaves of *H. sabdariffa* (1.23 g/100 g). The different ratio of oxalate/calcium and the

phytates/calcium ratios were lower than 2.5. All the samples analyzed had their oxalates/iron and phytates/iron ratio less than 1.

Table 3: Anti-nutritional factors/mineral ratios of *Corchorus olitorus* and *Hibiscus sabdariffa* leafy vegetables.

Parameters	<i>H. sabdariffa</i>	<i>C. olitorus</i>
Phytates (%)	0.01 ± 0.00 ^b	0.05 ± 0.00 ^a
Polyphenols (%)	1.03 ± 0.00 ^b	1.40 ± 0.00 ^a
Oxalates (%)	1.23 ± 0.00 ^a	0.80 ± 0.00 ^b
Oxalates /Ca	0.87 ± 0.00	1.12 ± 0.00
Oxalates / Fe	0.16 ± 0.00	0.13 ± 0.00
Phytates/Ca	0.07 ± 0.00	0.00 ± 0.00
Phytates/Fe	0.01± 0.00	0.00 ± 0.00

Data are expressed as Means ± Standard Deviation (n=3). Means in the same line with no common superscript differ significantly (P = .05)

3.2. Discussion

The specific nutrients that are close to reported value by Korotimi *et al.* [21]. These authors reported a higher moisture content for *C. olitorus* leaves compared to values in the present study. The relatively high moisture contents reveal that the studied leafy vegetables need care for appropriate preservation as they would be prone to deterioration [22]. Indeed, the high moisture content may induce a greater activity of water soluble enzymes and co-enzymes involved in metabolic activities of these leafy vegetables [23]. The results of lipids contents are in conformity with similar studies on leafy vegetables with range of 0.5-7.62 % [23]. The values of the fat (in %) for the leaves of *C. olitorus*, and *H. sabdariffa* were 4.35 and 4.74 respectively which were moderate in amount when compared to those of *Talinum triangulare* (5.09), *Amarantus hybridus* (4.80) [25]. However high contents of lipid in human diet are principal sources of obesity and other related diseases. Dietary fat composition can interfere in the development of obesity due to the specific roles of some fatty acids that have different metabolic activities, which can alter both fat oxidation and deposition rates, resulting in changes in body weight and/or composition [26]. A diet providing 1.20% of its caloric of energy as fat is said to be deficient for human being as excess fat consumption is implicated in certain cardiovascular disorders [23, 27]. The leaves of *Corchorus olitorus* and *Hibiscus sabdariffa* have higher level in protein. These leaves could be used as food protein supplement. The fiber and carbohydrate contents of both the leaves of *Corchorus olitorus* and *Hibiscus sabdariffa* observed in this study are lower than reported values for a number of tropical plants [28]. It reported that carbohydrate provides energy to the cells in the body, particularly the brain, which is the only carbohydrate-dependent organ in the body [29]. It is necessary for maintenance of the plasma level, it spares the body protein from being easily digested and helps to prevent the using up of protein. [30] The consumption of selected leafy vegetables could be beneficial for populations because the high fiber content of foods facilitates digestion by increasing gastrointestinal function and preventing constipation, thereby, reducing the incidence of metabolic diseases such as diabetes mellitus and hypercholesterolemia. It also contributes to the prevention of colon cancer by binding to carcinogenic chemicals away from the cells that cover the colon [31].

The content in minerals of this study defers the one of [32]. The differences in minerals content may be due to leaf age at harvest, or the mineral fertilizer used in culture soil mineral composition and the proportion of individual mineral absorption by each plant and cultural practices [32-33]. The leaves vegetables may be considered as good sources of bioavailable minerals such as calcium (Ca), iron (Fe), magnesium (Mg) and phosphorus (P) [34]. These micro-nutrients are very important in the body. Calcium is important for construction and maintenance of bone and normal function of nerves and muscles [34]. Iron plays a role in the production of hemoglobin, myelin, melanin and it also keeps thyroid gland functioning normally [35]. Iron is essential for haemoglobin formation, normal functioning of central nervous system and in the oxidation of carbohydrates, protein and fats [36]. The deficiencies of magnesium are unusual but may lead to bone deformities, rashes, reduced hair growth [37].

Phenolic compounds concentration may vary with cultivar, agronomic conditions, maturity stage, variety, environmental conditions, fruit season, light exposure and storage conditions [38]. The phytochemical screening of *Corchorus olitorus* and *Hibiscus sabdariffa* leaves revealed presence of

polyphenols. Consumption of polyphenols has been linked to lowered risks of many chronic diseases including cancer, cardiovascular diseases, chronic inflammation and many degeneration diseases [39]. Polyphenolic antioxidants from dietary sources are frequently a topic of interest due to widespread scientific agreement that they may help lower the incidence of certain cancers, cardiovascular and neurodegenerative diseases, and DNA damage and even may have antiaging properties [40]. Phytochemicals in fruits can have complementary and overlapping mechanisms of action, acting as antioxidant agents, stimulants of the immune system, regulators of gene expression in cell proliferation and apoptosis, intermediaries in hormone metabolism, as well as antibacterial and antiviral agents. They play a role in prevention of degenerative diseases, particularly cardiovascular diseases and cancers [41]. The reductions in oxalates and phytates contents could improve the health status of consumers. Indeed, oxalates and phytates chelate divalent cations such as calcium, magnesium, zinc and iron, thereby reducing their bioavailability [42]. **In view of the highest oxalates and phytates of *Hibiscus sabdariffa* leaves, may appear as a detoxification procedure by removing these anti-nutritional factors.** 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 [43]. It was also observed that the calculated phytates/Fe **ratios of samples were above** the critical level of 1. This implies that the phytates of these leafy vegetables **may hinder** iron bioavailability [44]. However, the phytates/Fe ratios could be considerably reduced after processing such as soaking, boiling or frying [45].

4. CONCLUSION

The leaves of *Corchorus olitorus* and *Hibiscus sabdariffa* contain significant levels of nutrients and polyphenols that are essential for human health. The result of this study revealed **the** the bioavailability of minerals like calcium, iron and zinc. Thus, the leafy vegetables studied could significantly contribute to human health and could play a major role to combat micronutrient deficiency, also called “hidden hunger”, a main cause of health problems and high mortality for groups at risk, mainly children and pregnant women in tropical Africa (Côte d'Ivoire).

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