INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 15, No. 5, p. 182-194, 2019

RESEARCH PAPER OPEN ACCESS

Comparison of mineral profile and fiber content of some *Corchorus olitorius* morphotypes for selecting promising varieties in Central Benin

Adjatin Arlette[1*], Bonou-Gbo Zaki[1],Djengue Wilfrid[1], Ewedje Ebenezer[1], Yedomonhan Hounankpon[2], Dansi Alexandre[1], Amouzou Kou'Santa Sabiba[3]

[1]*Ecole Nationale Supérieure des Biosciences et Biotechnologies appliquées, Université Nationale des Sciences, Technologies, Ingénierie et Mathématiques, BP 14 Dassa-Zoumè, Bénin*

[2]*Laboratoire de Botanique et d'Ecologie Végétale, Faculté des Sciences et Techniques, Université d'Abomey-Calavi, 01BP 4521, Cotonou, Bénin*

[3]*Laboratoire de Biochimie et de Nutrition, Faculté des Sciences et Techniques, Université de Kara, BP : 43 Kara, Togo*

Key words: *Corchorus olitorius*, Morphotypes, Mineral composition, Fiber content, Principal Component Analysis, Benin.

http://dx.doi.org/10.12692/ijb/15.5.182-194 Article published on November 15, 2019

Abstract

Corchorus olitorius is an important crop that can ensure food security in Sub-Saharan. In Benin, a lot of plant leaves are widely consumed as vegetables and contribute to the dietary requirements of local people as well as for local economy. The present study is conducted to highlight the mineral composition and fiber content of *C. olitorius* morphotypes consumed in Central Benin. Twelve accessions resulting from germplasm conserved at field collection at the experimental site were evaluated for their mineral composition and fiber content using standard methods. Results showed that all biochemical parameters evaluated varied significantly among accessions ($p < 0.05$). The morphotype Cor6 showed high values for fiber (15.19± 0.3 mg/100g), calcium (1340±11.55 mg/100g), magnesium (323.33 ±14.53 mg/100g), phosphorus (901± 62.084 mg/100g) and manganese (8.261±0.001 mg/kg) while the highest iron value were found in the leaves: 325.63± 0.001mg/kg and 302.63± 0.001mg/kg for Cor9 and Cor12 respectively. In short, the shiny leaves exhibited an appreciable amount of iron. Then, the morphotypes Cor2, Cor9, Cor10 and Cor12 producing shiny leaves may contribute to iron deficiencies alleviation through starchy and soup from *C. olitorius* for children, during the periods of weaning. Also, the morphotype Cor6 could serve as sources of variability in character for *Corchorus* germplasm improvement. Considering the important of fiber and iron in the diet, Cor6, Cor9 and Cor12 had high potentials for all parameters and may be used during breeding for *Corchorus* leafy vegetable. Consequently, biochemical traits could be considered as parameters for defining variability among crop plants.

* **Corresponding Author:** Adjatin Arlette ✉ aarlette2000@yahoo.fr

Introduction

Leafy vegetables play an important role in the diet of people and are affordable with accepted taste and good nutrients content (Choudhary *et al.*, 2013). In Benin, around 18 species of leafy vegetables were considered priorities among which the first four species are *Solanum macrocarpon* L., *Corchorus olitorius* L., *Amaranthus cruentus* L., *Gymnanthemum amygdalina* (Delile) Walp. (Dansi *et al.,* 2008). Thus, *C. olitorius* ranks among the most important traditional leafy vegetable and considered as species known as vegetable by many ethnic groups and highly consumed. It is an important plant food grown throughout the tropics and subtropics countries (Furumuto *et al.,* 2002). This crop is cultivated for the stem bark, which is used in the production of fiber (Jute), and for its mucilaginous leaves, which are also used as food vegetable (Zakaria *et al.,* 2006). Leaves of *C. olitorius* are generally consumed fresh but also in dried form (Adjatin *et al.,* 2017). The sauce is the main mode of preparation where these leaves are washed by rubbing between the hands, sliced and cooked in soups with a little potash to get slimy consistency (Dansi *et al.,* 2008; Adjatin *et al.,* 2017). Moreover, its leaves, roots and fruits are used in traditional medicine to treat various diseases such as gonorrhea, chronic cystitis, pain fever and tumors (Kumawat *et al.,* 2012). Leaf decoction would also treat many diseases such as typhoid fever, anemia, malaria and ulcer (Ndlovu and Afolayan, 2008; Adjatin *et al.,* 2017). The presence of many phytochemical compounds in some morphotype extracts offers supporting evidence for medicinal effective use of *C. olitorius* (Adjatin *et al.,* 2018). From a nutritional point of view, *C. olitorius* like all leafy vegetables are low in calories, very good source of proteins, fiber, vitamins (A,C, E) and they are also rich in mineral nutrients such as calcium and iron (Steyn *et al.*, 2001). Moreover, it is known high levels of iron and folate which are useful for the prevention of anemia (Steyn *et al.,* 2001).It is recognized for its high intra-specific diversity and wide distribution, allowing to identify different morphotypes *C. olitorius* varieties based on the shade (alternate, oval, lance-shade and toothed) and the brilliant aspect (shining and non-shining) of its leaves on one hand and the stem color ranging from green to red in other part (Adebo *et al.,* 2015; Adjatin *et al.,* 2017). Ethnobotanical survey indicated that shiny leaf varieties would be rich in iron and that the iron content is proportional to the leaf trait (Adjatin *et al.,* 2017). According to Van Vuuren (2006), the amount of iron in *C. olitorius* is of particular importance in Africa to cover iron deficiency of children suffering from anemia. In addition, *C. olitorius* is most popular among people as weaning soup for children and good delicacy for adults (Mavengahama and Lewu, 2012).

In Benin, scientific researches undertaken on *C. olitorius* have related to ethnobotanical investigations (Dansi *et al.,* 2008; Adjatin *et al.,* 2017), agro-morphological traits (Adebo *et al.,* 2016), entomological studies (Gbedolo *et al.,* 2018) and phytochemical characterization (Adjatin *et al.,* 2018). Thus, in view of *C. olitorius* food importance knowledge, it imports to define the nutritional composition of the different morphotypes as well as the impact of the phenotype on the nourishing quality therefore.

Materials and methods

Plant material

Twelve accessions from different *C. olitorius* morphotypes conserved on the experimental site of laboratory of Biotechnology, Genetic Resources and Plant and Animal Breeding at National University of Sciences Technologies Engineering and Mathematics of Abomey were collected (Table 1). Morphotypes used here resulted from previous characterizations conducted by Adjatin *et al.,* (2017) on phenotypic diversity of *C. olitorius* in the same region. Leaves collected were first carefully washed 2-3 times with running tap water and once with sterile water to remove the dust particles as recommended by Badau *et al.* (2013) and Adjatin *et al.* (2013). Each sample was then cut into small pieces and dried under shade during two weeks.The dried plant parts were ground using electric blending machine and the powdery samples obtained were sieved using two sieves of 0.2 mm (mesh size) and kept in cool, dark and dry place

for the investigation.

Determination of mineral composition and fiber

Mineral composition of samples was determined according to methods recommended by the Association of Official Analytical Chemists (AOAC, 1990).

Samples were incinerated in the oven at a temperature of 550°C for 3 hours. Each sample was digested using a mixture of concentrated Nitric, perchloric and sulphuric acids in the ratio 9:2:1 (v/v) respectively (Nair *et al.*, 2013). Copper (Cu), iron (Fe), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg) and Manganese (Mn) were determined by Atomic Absorption Spectrophotometer. Phosphorus contents of the samples were measured using Flame photometer as specified in Alinnor and Oze (2011). Fibers content has been determined through the extraction by acidic digestion of the insoluble matters contained in a sample and their incineration according to the AOAC (1990) standard. Concentration of each sample' element was calculated from the dry matter. All analyses were performed with triplicates for the needs of statistical analysis (Pillai and Nair, 2013).

Data analysis

Data were statistically analyzed using XLSTAT and all data analyses were carried out in three replicates. The mean and variance of each parameter was calculated within morphotype and significant differences among morphotypes were assessed using analysis of variance (ANOVA).Critical difference between the means was separated using Turkey's test as packaged by XLSTAT at p = 0.05. Principal Component analysis (PCA) was also performed to examine the relationship between the 12 morphotypes considering as individuals and mineral composition parameters as variables. These analyses were performed using the R software version 3.5.2.

Results and discussion

Table 2 shows mineral composition and fiber content of the leaves from each *C. olitorius* morphotype. Analysis of variance (ANOVA) and Tukey test showed that all these variations were significant ($p < 0.05$) considering used parameters. As a result, all the mineral elements contained and the raw fiber content of leaves (fibers, ash, macro-elements and trace elements) differed significantly (at the risk of 5%) between morphotypes.

Table 1. List of morphotypes sampled and local name.

Accession	Morphotypes/Distinctive traits	Local name
Cor1	Rounded leaves, no-shiny	Ayoyookpolo
Cor2	Elongated leaves, elliptical, shiny	Ayoyoedjo
Cor3	Elongated leaves, no-shiny, red stem	Yoyo olèssèkpikpa
Cor4	Serrated leaves, rounded, shiny	Aladjèlè
Cor5	Rounded leaves, no-shiny	Ninnouwi
Cor6	Elongated leaves, lobed lateral, no-shiny	Afimblikpotoé
Cor7	Elongated leaves, no-shiny	Ninnouwikpahè
Cor8	Elongated leaves, no-shiny	Ninnouwi
Cor9	Rounded leaves, shiny	Yoyo doundoun
Cor10	Elongated leaves, shiny	Yoyo okpolo
Cor11	Serrated leaves, elongated, shiny	Yoyo oyimbo
Cor12	Elongated leaves, shiny	Krimlin

Crude fiber content

The analysis of crude fiber contents of the *C. olitorius* samples revealed that values were particularly high for the elongated leaf morphotypes and varied from 11.41±0.3% for Cor9 to 15.19 ± 0.3% for Cor6. These values are close to those of *Corchorus* accessions

studied in Nigeria (Osawaru *et al.,*2013) for which contents varies from 6.15 ± 2.96% to 11.1% ± 1.19%. They are also similar to those reported in *C. crepidioides* and *C. rubens* (8.18% and 7.95% respectively, Adjatin *et al.,* 2012); and in *Vernonia amygdalina* (10.46%, Sodamade, 2013). They are however lower than in *Gymnanthemum amygdalinum* (25.47%) known as leafy vegetables particularly rich in fiber (Ejoh *et al.,* 2007). So, *C. olitorius* appears as a very good source of dietary fiber and deserves more attention. Fiber is involved in digestion and reduces the risk of cardiovascular disease (Badau *et al.,* 2013). Studies have shown that increasing fiber intake can help reduce incidence of certain diseases such as diabetes, coronary heart disease, colon cancer and various digestive disorders (Badau *et al.,* 2013). Fiber intake also softens feces and lowers blood cholesterol levels in the human body (Pillai and Nair, 2013). Preserving internal distension for normal peristaltic movement of the gastrointestinal tract is a physiological function provided by the raw fibers. However, very high fiber content can cause intestinal irritation and decreased nutrient bioavailability (Pillai and Nair, 2013).

Table 2. Mineral profile and crude fiber content of leaves of twelve selected *Corchorus olitorius* morphotypes.

	Fibers (%)	Ashes (%)	Ca (mg/100g)	Mg (mg/100g)	K (mg/100g)	P (mg/100g)	Na (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)
Cor1	14.61±0.3^{c}	8.41±0.012^{f}	1036.67±8.82^{c}	290±5.77^{b}	2650±5.77^{a}	577.33±32.45^{bc}	413.44±0.01^{d}	5.237±0.001^{h}	2.25±0.001^{e}	165.22±0^{f}
Cor2	14.73±0.3^{b}	8.386±0.009^{f}	886.67±8.82^{e}	273.33±8.82^{bc}	2046.67±8.82^{e}	390±10de	325.39±0.01^{g}	5.671±0.001^{g}	3.15±0.001^{c}	277.47±0.001^{c}
Cor3	13.78±0.3^{h}	8.31±0.006^{g}	960±5.77^{d}	280±5.7^{bc}	2280±5.77^{d}	466.67±3.33^{cde}	300.32±0.01^{h}	4.547±0.001^{i}	1.51±0.001^{i}	128.01±0.001^{g}
Cor4	14.58±0.3^{d}	7.35±0.023^{i}	820±15.28^{f}	210±5.77^{d}	1950±5.77^{f}	333.33±16.67^{e}	429.03±0^{c}	3.839±0^{j}	1.21±0^{j}	103.06±0^{h}
Cor5	12.75±0.3^{j}	9.1±0.006^{d}	1036.67±8.82^{c}	276.67±14.53^{bc}	2356.67±17.64^{c}	546.67±3.33^{cd}	411.16±0.021^{e}	5.237±0.001^{h}	2.25±0.001^{e}	95.82±0^{j}
Cor6	15.19±0.3a	9.703±0.009^{b}	1340±11.55^{a}	323.33±14.53^{a}	2470±11.55^{b}	901±62.084^{a}	445.04±0.01^{b}	8.261±0.001^{a}	2.03±0.001^{g}	207.02±0.001^{e}
Cor7	11.66±0.3^{k}	9.1±0.006^{d}	1036.67±8.82^{c}	290±5.77^{b}	2650±5.77^{a}	497.67±47.43^{cd}	413.44±0.01^{d}	5.237±0.001^{h}	2.25±0.001^{e}	95.82±0^{j}
Cor8	14.52±0.3^{e}	8.41±0.012^{f}	943.33±39.3^{d}	276.67±12.019^{bc}	2300±5.77^{d}	476.67±43.33^{cde}	503.34±0^{a}	8.001±0^{b}	1.69±0^{h}	165.22±0^{f}
Cor9	11.41±0.3^{l}	9.17±0.012^{c}	1046.67±14.53^{c}	276.67±14.53^{bc}	2356.67±17.64^{c}	630±86.22^{bc}	411.16±0.02^{e}	6.149±0^{d}	4.199±0^{a}	325.99±0^{a}
cor10	13.81±0.3^{j}	8.95±0^{e}	1030±0^{c}	230±0^{cd}	2351±0.58^{c}	535±5^{cd}	364.19±0^{f}	5.904±0^{f}	3.791±0^{b}	233.48±0^{d}
cor11	13.83±0.3^{k}	7.73±0.12^{h}	1063.33±20.28^{c}	246.67±20.28^{bcd}	1873.33±8.82^{g}	563.33±20.28^{bc}	290.4467±0.03^{i}	6.137±0.001^{e}	2.219±0.001^{f}	97.92±0.001^{i}
Cor12	13.54±0.3^{l}	10.16±0.008^{a}	1200±5.77^{b}	276.67±8.82^{bc}	2473.33±12.02^{b}	706.67±3.33^{b}	258.69±0.01^{j}	7.535±0.001^{c}	3.13±0.001^{d}	302.63±0.001^{b}
Pr(>F)	<2e-16***	<2e-16 ***	6.54e-16 ***	3.11e-05 ***	<2e-16 ***	2.81e-08 ***	<2e-16 ***	<2e-16 ***	<2e-16 ***	<2e-16 ***

Results were expressed as mean of three replications ± standard deviation.

Values followed by different letters in the same column are statistically different at probability p = 0.05%.

Ash content

Total ash contents varied from 7.35 ± 0.02 % with Cor 4 to 10.16 ± 0.08% with Cor12 (Table 2). These values are higher than those reported in *Corchorus* accessions from Nigeria (Osawaru *et al.,* 2013) with a content ranging from 4.22 ± 0.91% to 8.82% ± 0.87%. In contrast, these values are lower than those of *C. crepiodioides* (19.02%) *C. rubens*(19.76%) and *Myrianthus arboreus* (36%) reported by Adjatin *et al.* (2012) and Kouamé *et al.*(2015). The high ash content is a reflection of the mineral content in food. It is essential for tissue function and is necessary for daily needs (Iniaghe *et al.,* 2009).

Calcium content

Calcium (Ca) content ranged from 820.00 ± 15.28 for Cor4 to 1340.00 ± 11.55 mg/ 100g for Cor 6 in the leaves of *C. olitorius* morphotypes. These values are similar to that evaluated in *C. crepidioides* (1012 mg / 100 g) but they are lower than that of *C. rubens*

(3845.88 mg / 100 g) and *Crateva adansonii* (2400 mg / 100 g) (Adjatin *et al.*,2012; Agbankpé *et al.*,2015, respectively). Calcium is the most abundant mineral in the human body and is involved in blood coagulation, muscle contraction, neurological function, bone and tooth formation (Senga *et al.*, 2013). It is also an important factor in enzymatic metabolic processes (Mensah *et al.*,2008).

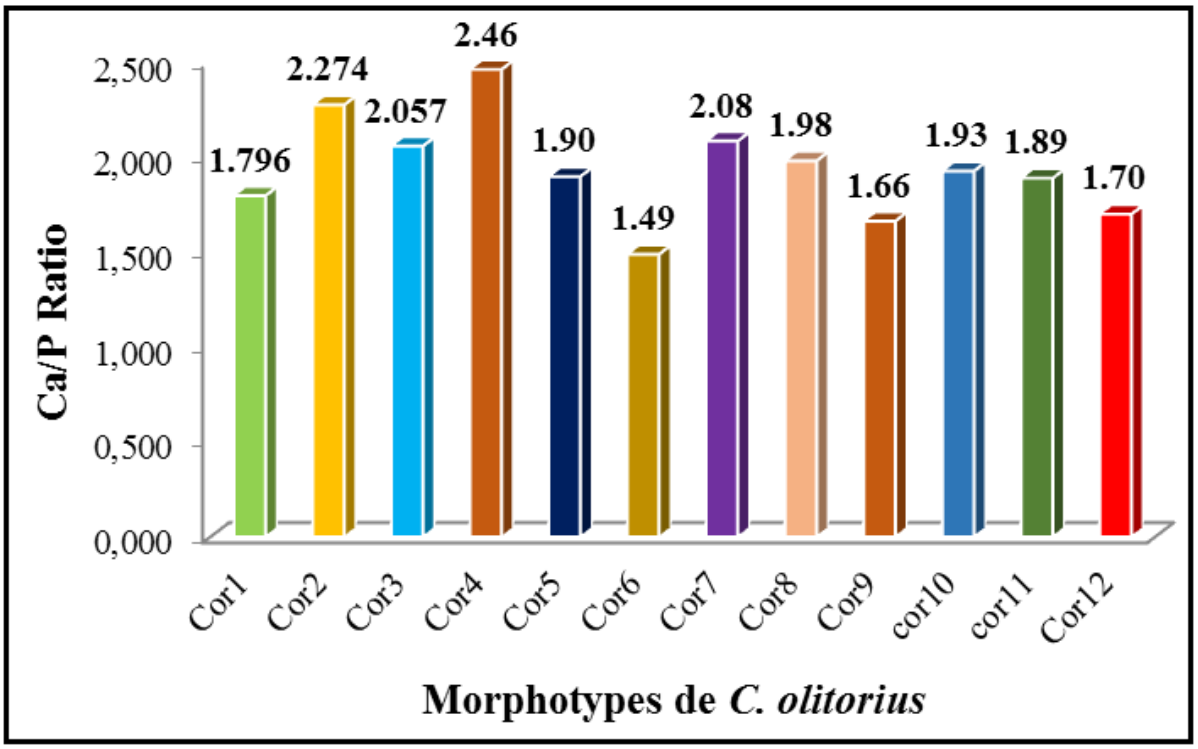

Fig. 1. Ca/P ratio in different *C. olitorius* morphotypes.

Magnesium (Mg) content

Magnesium content of the different morphotypes ranged from 210.00± 5.77 to 323.33 ± 14.53 mg/100g. Cor6, Cor1 and Cor7 exhibited the highest calcium rate than the nine other morphotypes sampled.

The maximum estimates found are similar to 336.46 mg / 100g of *C. crepidioides* reported by Adjatin *et al.,* (2012), but less than 900.00 mg/100g of *Vernonia amygdalina* or 510 mg/100g of *Sesamum radiatum* (Agbankpé *et al.*,2015). Assuming that the recommended dietary allowance is 170 mg/100g for children (FAO, 2004), *C. olitorius* could meet the daily needs of children whose diet consists of jute sauce and starchy foods during weaning periods (Mavengahama and Lewu, 2012).Magnesium is known to prevent cardiomyopathy, growth delay, immune system dysfunction, birth defects and coagulation disorders (Andzouana and Monbouli, 2012). According to Alinor and Oze (2011), magnesium plays a key role in calcium metabolism and bone formation and is also involved in the prevention of circulatory diseases.

Potassium (K) content

The potassium contents of morphotypes varied from 873.33 ± 8.82 to 2650 ± 5.77 mg/100g. These contents are similar to those reported by Sahoré *et al.* (2014) which are between 2593 and 2600 mg/100mg, but they are lower than those found by Soro *et al.* (2012) which are close to various other traditional leafy vegetables from Ivory Coast. These values are however higher than those of *Sesamum radiatum* (1630 mg/100g, Agbankpé *et al.* 2015). Potassium is important in heart rate regulation, body water balance and neurotransmission (Alinor and Oze, 2011). High potassium in the human body increases iron utilization, and is beneficial for people taking diuretics to control high blood pressure (Nair *et al.*, 2013). According to people, a daily recommendation

by WHO is 2000 mg of potassium for adults and 1600 mg for children. This study detected, in Cor1, Cor7, Cor12 and Cor6 morphotypes, the highest potassium values which are above the WHO standards recommended for children and adults. In general, leafy vegetables are a good source of potassium (Mensah *et al.,* 2008); however, potassium is toxic at a concentration greater than 25g. This content of potassium in the blood plasma is called hyperkalemia and is caused the symptoms of vibrating, paralysis, heart palpitations and nausea. A lack of potassium is called hypokalemia and also causes heart disease which symptoms are cramps, hypertension, irritability, digestive disorders. According to Sahoré *et al.* (2014), lack or excess of potassium is revealed during a blood test.

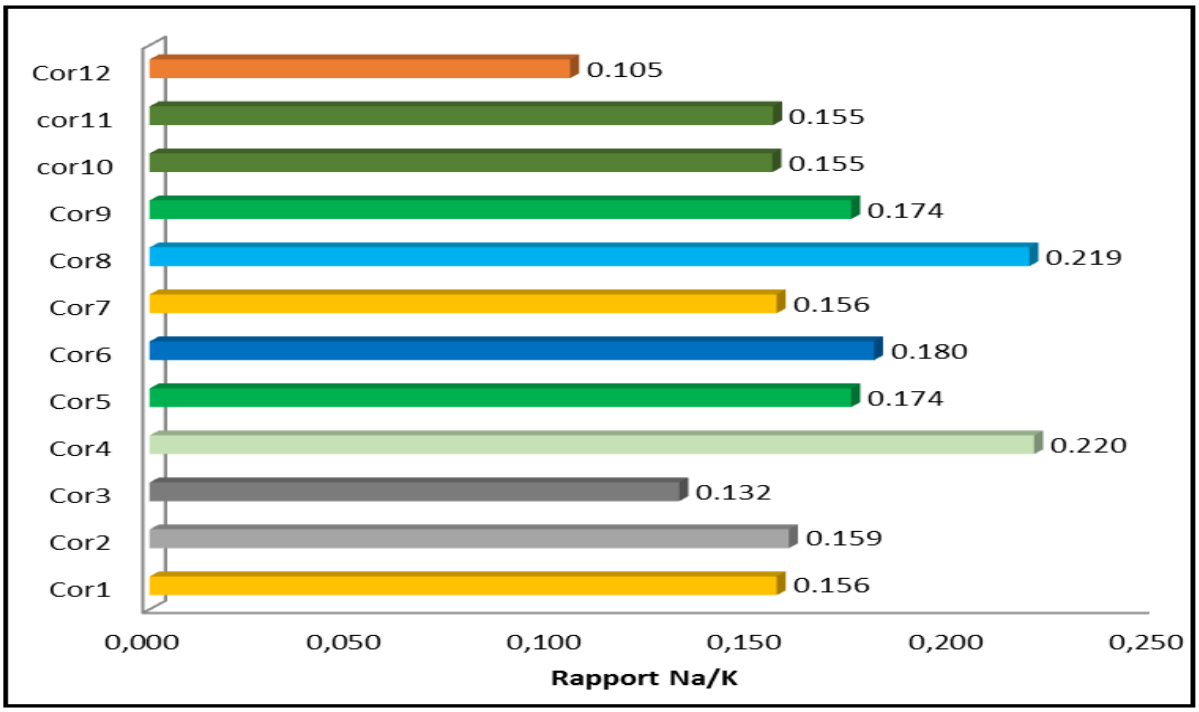

Fig. 2. Na/K ratio in different *C. olitorius* morphotypes.

Phosphorus content (P)

Phosphorus levels were relatively high and varied between 333.33 ± 16.67 mg/100g for Cor4 and 901.00 ± 62.08 mg/100g for Cor6. Thus, these samples with high value of phosphorus are followed by Cor12, Cor9, Cor1 and Cor11 with respectively 706.67 ± 67.00mg / 100g, 630.00 ± 86.22 m/100g, 577.33 ± 32.45 mg / 100g and 563.00 ± 20.28 mg/100g of phosphorus. Analysis of variance showed that means are significantly different within the morphotypes. Phosphorus levels estimates here are higher than those of Abobo station market samples (166.31 ± 6.17 mg/100 g) but they are lower than the ones of vegetable crop site samples (2262.00±1.43 mg/100g) as reported by Soro *et al.* (2012). The phosphorus contents varied either according to morphotype or production zone. The relationship between Ca and P revealed a Ca/P ratio varying between 1.49 and 2.46 (Fig. 1). According to Adeyeye and Aye (2005) and Alinor and Oze (2011), diet is considered nutritionally beneficial and would help increase calcium absorption in the small intestine if the Ca/P ratio is greater than 1 and poor if the ratio is less than 0.5. Thus, all accessions of *C. olitorius* characterized would be a good source of food for its calcium intake for consumers.

Sodium (Na) content

The sodium content of morphotypes ranged from 258.69 ± 0.01mg/100g to 503.34 ± 34 mg/100g. The highest and lowest values were estimated in Cor8 and in Cor12, respectively. Results are similar with that reported in the same plant species (Sahoré *et al.* 2014). Nevertheless, estimates reported here

remained higher than in *V. amygdalina, C. adansonii* and *S. radiatum* (287 ± 2 mg / 100g, 169 ± 2 mg / 100g and 21 ± 2 mg / ml. 100g respectively, Agbankpé *et al.,* 2015). Consequently the samples of *C. olitorius* can be considered as good sources of sodium. According to Alinor and Oze (2011), sodium is an important mineral which assists in the regulation of the body fluids and preservation of electrolyte balance.

Moreover, Na/K ratio of *C. olitorius* morphotypes' leaves is between 0.105 and 0.220 (Fig. 2). Alinor and Oze, (2011) reported that the Na/K ratio promotes blood pressure control while an Na / K ratio of less than 1 allow lowers blood pressure. From these results, regular consumption of *C. olitorius* would prevent treat or prevent blood pressure problems.

Manganèse (Mn) content

Analysis of variance revealed significant differences between some morphotypes ($p < 0.05$). Only Cor1, Cor5 and Cor7 were not different from each other. Manganese content ranged from 3.84 ± 0.001 to 8.26 ± 0.001 for Cor4 and Cor6, respectively. Apart from Cor6 which showed the highest manganese content, samples Cor8 (8.001 mg / 100g) and Cor12 (7.535 mg / 100g) displayed higher manganese contents than that obtained by Sahoré *et al.* (2014) on samples of *C. olitorius* (4 mg/100g).

These values are close to those reported by Adjatin *et al* (2013) on *C. crepidioides* (7.7 mg/100g) and *C. rubens* (8.22 mg/100g). Manganese is a trace element that plays an important role in bone synthesis, amino acids and carbohydrate metabolism.

It contributes to the thyroid gland activity and serves to heal inflammation and sprains (Erikson *et al.,* 2005). Manganese deficiency can lead to problems of infertility, diabetes, joint pain. It is an antioxidant against free radicals and prevents the body from the damage caused by them. Despite its essential character, the accumulation of manganese in the blood is toxic to the central nervous system (Sidoryk and Aschner, 2013).

Copper (Cu) content

Morphotypes Cor1, Cor5 and Cor7had similar content (2.25 ± 0.001mg / 100g). Cor4 contents the content lower in copper (1.21 mg / 100g) while other such as Cor9, Cor10, Cor12 and Cor2 were richer in copper with contents of 4.199 mg/100 g, 3.791 mg/100 g, 3.15 mg/100 g and 3.13 mg/100g respectively and higher copper content of *C. crepidioides* (1.4 mg/100g) and *C. rubens* (2.6 mg / 100 g) (Adjatin *et al.,* 2012) leaves. Copper is needed for enzyme production and electron transport in the body (Alinor and Oze, 2011). The daily recommendation for copper is 3 mg/day in adults and 2 mg/day in children. The leaves' copper content of *C. olitorius* samples is higher than the standard recommended by WHO. These leafy vegetables could therefore cover consumers' copper needs.

Iron (Fe) content

Higher amount of iron content was reported with Cor9 (325.63 ± 0.001mg/kg) while Cor7 showed the low value (95.86 ± 0.001mg/kg) compared to other species. The iron levels found in the present work are higher than those reported by Agbankpé *et al.* (2015) for *Vernonia amygdalina* (49.7 mg/kg) and *Adansonia digitata* (54.1 mg/kg) and significantly higher than those of *C. crepidioides* (2.4 mg/100g) and *C. rubens* (9.6 mg/100g) obtained by Adjatin *et al.* (2013) . In addition, morphotypes studied are much higher than the daily value of 100-150 mg/kg. Iron is known to be an essential part of red blood cells (hemoglobin) and enzymes (cytochromes) and consumption of these leafy vegetables could reduce the risk of anemia (Soetan *et al.,* 2010). Iron deficiency anemia (IDA) is a worldwide health concern and is one of the most prevalent micronutrient deficiencies particularly in the developing countries. About 20-30% of children less than five years of age are malnourished. Malnutrition is normally manifested in various forms in children, such as their being underweight or stunted, or suffering from iron deficiency anemia, normally. The increase in infant malnutrition in sub-Saharan Africa during the weaning period has been attributed to inappropriate complementary feeding practices and is

responsible for half of the child mortality (UNICEF, 2016). In Benin, for 73% children between 6 to 8 months old, having been introduced to solid, semi-solid or soft foods (UNICEF, 2016).

The amount of iron in *C. olitorius* is particularly important to be recommended against iron deficiency considering the fact that 21% of children in South Africa suffer from anemia(Van Vuuren, 2006); for example in West Africa, this vegetable is most popular among people as weaning soup for children (Mavengahama and Lewu, 2012). In addition, leaves' decoction is used to alleviate iron deficiency, folic acid deficiency, and treatment of anemia. Leaves also act as blood purifier (Aiyeloja and Bello, 2006; Handoussa *et al.*, 2013; Adjatin *et al.*, 2017).

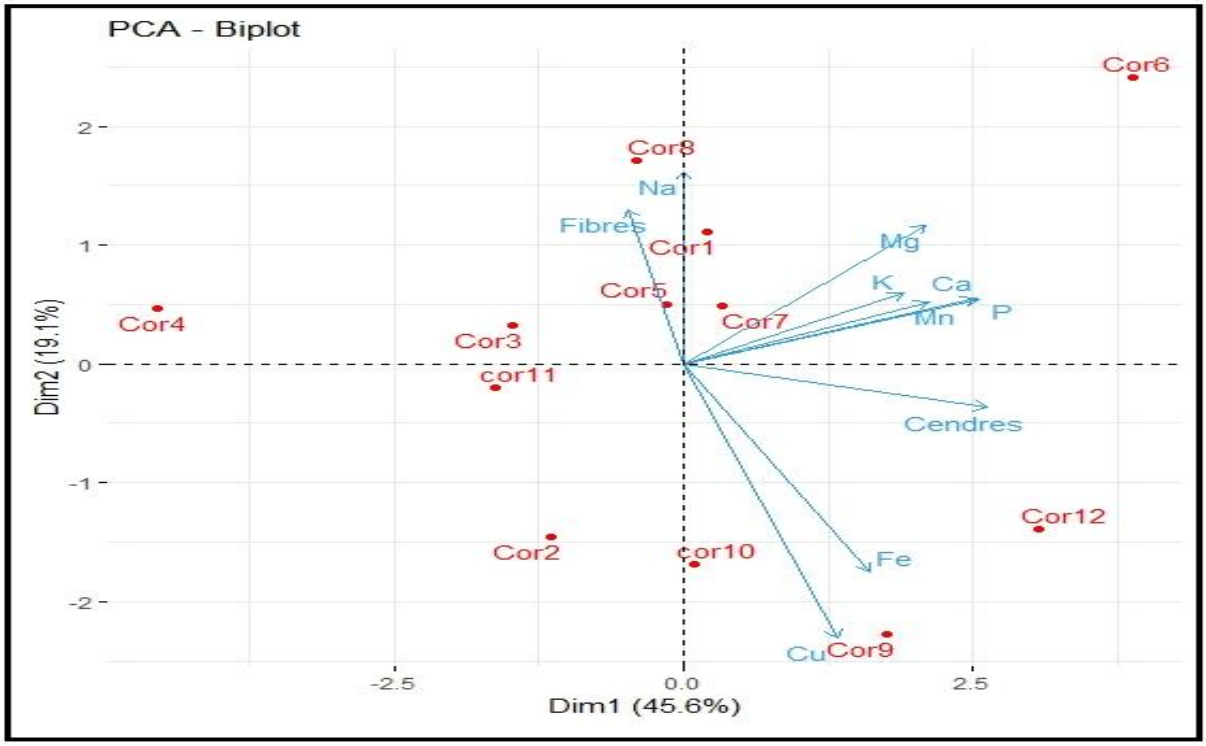

Fig. 3. Samples representation and correlation between the mineral elements.

Distribution of variables on the main axes of the main component

A principal component analysis was performed on the different morphotypes (Fig. 4). Axis 1 and axis 2 represent 64.7% of the total variance of trait values.

The first component (F1) characterized morphotypes with high value on ash, calcium (Ca), phosphorus (P), magnesium (Mg), manganese (Mn) and potassium (K) contents.

These parameters are positively correlated with this axis. The second component (F2) is determined on the negative side by the iron (Fe) and copper (Cu) contents and on the positive side by variables such as fiber and sodium contents.

This PCA confirmed results obtained from analysis of variance. Then, Cor6 is different from other samples by the highest levels of fiber, calcium, magnesium, phosphorus and manganese. In contrast, Cor4 is also separated from other samples and is determined by the lowest ash, calcium, magnesium, phosphorus, manganese and copper contents. Also the analysis of Fig. 3 revealed that Cor9 and Cor12 harbored the highest level of iron and copper.

Differentiation between Corchorus olitorius morphotypes

Based on the similarity index and the correlation between variables, the ordination detected five different groups according to their richness (or not) in mineral elements and in raw fibers:

Thus, group I consists of the single variety Cor6 highly rich in fiber, calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P) and manganese (Mn).

Classified in group II, Cor9 and Cor12 are extremely rich in iron (Fe) and copper (Cu).

Group III gathers the varieties Cor1, Cor3, Cor5, Cor7 and Cor8 rich in magnesium (Mg), potassium (K), calcium (Ca), phosphorus (P) and sodium (Na) slightly higher than the average value of all analyzed varieties.

Group IV consists to the single variety Cor4, that displays a low content in ash, calcium (Ca), magnesium (Mg), phosphorus (P), manganese (Mn) and copper (Cu).

Finally, the Group V gathers the varieties Cor2, Cor10 and Cor11 that are more or less rich in fiber and ash but essentially low in sodium (Fig.4).

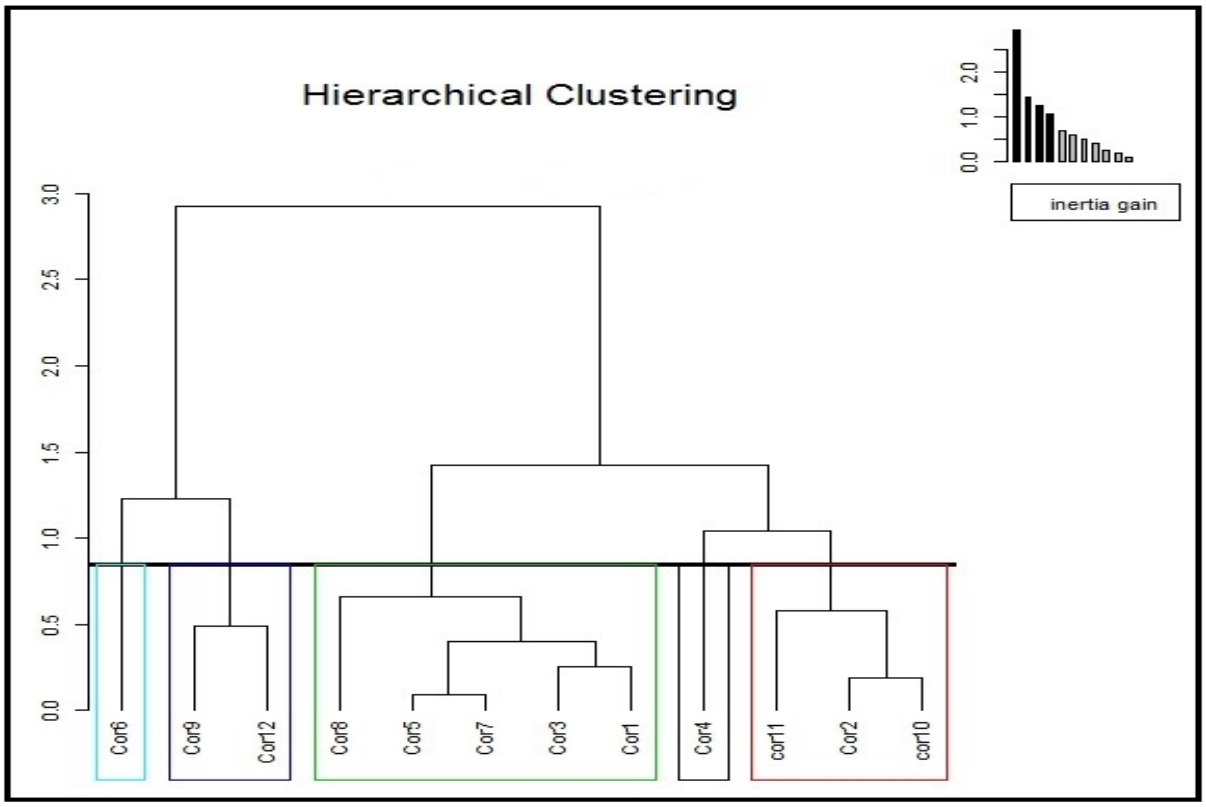

Fig. 4. Ascending hierarchical classification according to K-means method.

Except Cor4, all the morphotypes studied could be directly used by consumers to satisfy their mineral and fiber needs. In addition, each morphotype group has interesting and complementary characteristics which can be used in breeding programs. Indeed, crosses of Cor6 with Cor9 and Cor12 morphotypes from group II could lead to a very rich morphotype as well as in fibers, calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P) and in manganese (Mn) as in iron (iron) and copper (Cu). Our findings are similar to those obtained by Denton and Nwangburuka (2012) on *Corchorus olitorius* and Masuka *et al.* (2012) on *Cleome gynandra*.

Furthermore, this study revealed a relationship between biochemical traits, in particular iron (Fe) content and the phenotype, especially the glossy appearance of *C. olitorius* leaves. Indeed, among the morphotypes studied, four samples namely Cor2 (elongated leaves and shiny appearance), Cor9 (rounded leaves and shiny appearance), Cor10

(elongated leaves and shiny appearance) and Cor12 (elongated leaves and glossy aspect) present relatively high iron content respectively 277.47 mg/kg, 325.99 mg/kg, 233.48 mg/kg, 302.63 mg/kg. These results confirm those of Adjatin *et al.* (2017) who have reported that 87% of respondents thought that varieties' leaf would be rich in iron; then the iron is proportional to the brightness of the leaves. These results clearly show that the local communities surveyed have a good knowledge of their used plant species. In terms of classification, identification and use, their endogenous knowledge should be capitalized by geneticists and breeders (Dansi *et al.,* 2010). The morphotypes Cor4 (shiny toothed leaves) and Cor11 (shiny toothed leaves) have low iron content despite their shiny appearance. These low values could be explained by the fact that they are not only the varieties introduced but hybrids whose crossings did not consider the correlations between phenotypes and biochemical compositions. According to Muhammad *et al.* (2009), the success of a crop improvement program requires a good knowledge of agromorphological, molecular and biochemical characterization which is used to assess genetic diversity in germplasm collection. Previous researches have revealed variability in *C. olitorius* using biochemical characterization (Choudhary *et al.,* 2013; Osawaru *et al.,* 2013). Biochemical characterization is important to identify varieties with desirable traits to establish their nutritional composition and to find out possible ways for their improvement (Choudhary *et al.,* 2013).

Conclusion

Significant differences were observed between biochemical parameters of analyzed morphotypes. While combining biochemical traits and the phenotype, the most promising varieties were those with leaves brightness. Therefore, the shiny leaves can be used as a primary indicator to identify varieties with good biochemical traits. Considering the importance of fiber and iron in the diet, morphotypes Cor6, Cor9 and Cor12 showed high potentials for all parameters and might has good parental stock material for *Corchorus* leafy vegetable breeding. Morphotypes Cor9 and Cor12 with elevated iron levels could be used directly in food to fill the iron deficits causing anemia in both children of weaning age, pregnant women and vulnerable adults.

References

Adebo HO, Ahoton LE, Quenum F, Ezin V. 2015. Agro-morphological Characterization of *Corchorus olitorius* Cultivars of Benin. Annual Research and Review in Biology **7(4),** 229-240. http://dx.doi.org/10.9734/ARRB/2015/17642 http://sciencedomain.org/review-history/9825

Adeyeye EI, Aye PA. 2005. Chemical composition and the effect of salts on the food properties of Triticum durum whole meal flour. Pakistan Journal of Nutrition **4**, 187-196.

Adjatin A, Dansi A, Eze CS, Assogba P, Dossou-Aminon I, Akpagana K, Akoègninou A, Sanni A. 2012. Ethnobotanical investigation and diversity of Gbolo [*Crassocephalum rubens* (Juss. ex Jacq.) S. Moore and *C. crepidioides* (Benth.) S. Moore], a traditional leafy vegetable under domestication in Benin. Genetic Resources and Crop Evolution **59(8)**, 1867-1881. http://dx.doi.org/10.1007/s10722-012-9901-z

Adjatin A, Balogoun D, Loko L, Djengue W, Bonou-gbo Z, Yedomonhan H, Dansi A, Akoégninou A, Akpagana K. 2017. Phenotypic diversity, uses and management of local varieties of *Corchorus olitorius* L. from central Benin. Journal of Biodiversity and Environmental Sciences **11(1),** 81-96. http://www.innspub.net

Adjatin A, Dansi A, Badoussi E, Sanoussi AF, Dansi M, Azokpota P, Ahissou Y, Akouegninou A, Akpagana K, Sanni A. 2013. Proximale, mineral and vitamine C composition of vegetable Gbolo (*Crassocephalum rubens* and *C. crepidioides*) in Benin. International Journal of Chemical Sciences **7(1),** 319-331. http://ajol.info/index.php/ijbcs

Adjatin A, Hounkpatin A, Assogba F, Djengue W, Agbotta P, Bénindicte H, Dansi A, Gbenou J, Amouzou KS. 2018. Phytochemical screening, antioxidant and cytotoxic activity of different morphotypes of *Corchorus olitorius* L. leaves in the central region of Benin Republic (West Africa). Pharmacognosy and Phytotherapy **10(12),** 195-203. http://dx.doi.org/10.5897/JPP2018.0525 http://www.academicjournals.org/JPP

Agbankpé AJ, Bankolé SH, Dougnon TJ, Yèhouénou B, Hounmanou YMG, Baba-Moussa LS. 2015. Comparison of Nutritional Values of *Vernonia amygdalina*, *Crateva adansonii* and *Sesamum radiatum*: Three Main Vegetables Used in Traditional Medicine for the Treatment of Bacterial Diarrhoea in Southern Benin (West Africa). Food and Public Health **5(4),** 144-149. http://dx.doi.org/10.5923/j.fph.20150504.07 http://dx.doi.org/10.5923/j.fph.20150504.07

Aiyeloja AA, Bello OA. 2006. Ethnobotanical potentials of common herbs in Nigeria: A case study of Enugu state. Educational Research Review **1(1),** 16-22. http://www.academicjounals.org/ERR

Alinnor IJ, Oze R. 2011. Chemical evaluation of the nutritive value of *Pentaclethra macrophylla benth* (African Oil Bean) Seeds. Pakistan Journal of Nutrition **10(4),** 355-359.

Andzouana M, Mombouli JB. 2012. Assessment of the Chemical and Phytochemical Constituents of the Leaves of a Wild Vegetable *Ochthocharis dicellandroides* (Gilg). Pakistan Journal of Nutrition, **11(1),** 94-99.

AOAC. 1990. Official methods of Analysis (15th Edition): Helrich, K. Ed.; Association of Official Analytical Chemists, Washington D.C.

Badau MH, Abba HZ, Agbara GI, Yusuf AA. 2013. Proximate composition, mineral content and acceptability of granulated maize dumpling (Dambu Masara) with varying proportions of ingredients. Global Advanced Research Journal of Agricultural Science **2(1),** 320-329. http://garj.org/garjas/index.htm

Choudhary SB, Sharma HK, Karmakar PG, Saha AR, Hazra P, Mahapatra BS. 2013. Nutritional profile of cultivated and wild jute (*Corchorus*) species. Australian Journal of Crop Science **7(13),** 1973-1982.

Dansi A, Adjatin A, Adoukonou-Sagbadja H, Akpagana K. 2008. Production and traditional seeds conservation of leafy vegetables in Benin rural areas. Bulletin de la Recherche Agronomique du Benin **59,** 59-70.

Dansi A, Adoukonou-Sagbadja H, Vodouhè R. 2010. Diversity, conservation and related wild species of Fonio millet (Digitaria spp.) in the northwest of Benin. Genetic Resources and Crop Evolution **57(6),** 827–839. http://dx.doi.org/10.1007/s10722-009-9522-3

Dansi A, Vodouhè R, Azokpota P, Yedomonhan H, Assogba P, Adjatin A, Loko YL, Dossou-Aminon I, Akpagana K. 2012. Diversity of the Neglected and Underutilized Crop species of importance in Benin. Scientific World Journal 1-19. http://dx.doi.org/10.1100/2012/932947.

Ejoh RA, Nkonga DV, Innocent G, Moses MC. 2007. Nutritional Components of Some Non-Conventional Leafy Vegetables Consumed in Cameroon. Pakistan Journal of Nutrition **6,** 712-717.

Erikson KM, Syversen T, Aschner JL, Aschner M. 2005. Interactions between excessive manganese exposures and dietary iron-deficiency in neurodegeneration. Environmental Toxicology and Pharmacology **19(6),** 415–421. https://doi.org/10.1016/j.etap.2004.12.053

Furumuto T, Wang R, Okazaki K, Hasan FA, Ali IM. 2002. Antitumour promoters in leaves of jute (*Corchoruscapsularis* and *Corchorus olitorius*). Food Science and Technology Research **8,** 239-243.

Gbèdolo AE, Dassou AG, Dassou Hospice G, Dossou Aminon I, Omondi AB, Dansi A. 2018. Morphotype diversity of Corchorus olitorius and influence of agricultural practices on its potential major pest insects. Scientia Horticulturae, **239,** 234-241.

Iniaghe OM, Malomo SO, Adebayo JO. 2009. Proximate Composition and Phytochemical Constituents of Leaves of Some Acalypha Species. Pakistan Journal of Nutrition **8(3),** 256-258.

Kouame NMT, Soro K, Mangara A, Diarrassouba N, Koulibaly AV,Boraud NKM. 2015. Étude physico-chimique de sept (7) plantes spontanées alimentaires du centre-ouest de la Côte d'Ivoire. Journal of Applied Biosciences **90,** 8450– 8463.
http://dx.doi.org/10.4314/jab.v90i1.12

Kumawat BK, Gupta M, Singh TY. 2012. Free radical scavenging effect of various extracts of leaves of *Balanites aegyptiaca* (L.) Delile by DPPH method. Asian Journal of Plant Science and Research **2(3),** 323-329.

Masuka A, Goss M, Mazarura U. 2012. Morphological Characterization of Four Selected Spider Plant (*Cleome Gynandra* L.) Morphs from Zimbabwe and Kenya. Asian Journal of Agriculture and Rural Development **4(2),** 646-657.
https://ageconsearch.umn.edu/record/198011

Mavengahama S, Lewu FB. 2012. Comparative evaluation of the germination capability of three morphologically different wildge no types of *Corchorus olitorius* L. from Northern, Kwa ZuluNatal, South Africa. African Journal of Biotechnology **11(22),** 6050-6054.
http://dx.doi.org/10.5897/AJB11.3480

Mensah JK, Okoli RI, Ohaju-Obodo JO, Eifidiyi K. 2008. Phytochemical, nutritional and medicinal properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnological **7,** 2305- 2308.

Nair AG, Pradeesh S, Devi CM, Mini I, Swapna TS. 2013. *Diplazium esculentum*: A Wild Nutrient-Rich Leafy Vegetable from Western Ghats. Prospects in Bioscience **1,** 293-301.

Ndlovu J, Afolayan AJ. 2008. Nutritional analysis of the South African Wild Vegetable *Corchorus olitorius* L. Asian Journal of Plant Sciences **7(6),** 615-618.
http://ansinet.com

Osawaru ME, Ogwu MC, Imarhiagbe O. 2013. Biochemical Characterization of Some Nigerian Corchorus L. Species. Journal of Pure and Applied Sciences **6(2),** 69 – 75.
http://dx.doi.org/10.4314/bajopas.v6i2.15

Pillai LS, Nair BR. 2013. Proximate composition, Mineral elements and Anti-nutritional factors in *Cleome viscosa* L. and *Cleome burmanni* W. & A. (Cleomaceae). International Journal of Pharmacy and Pharmaceutical Sciences **5(1),** 384-387.

Sahoré AD, Abouattier L, Gbogouri FG. 2013. Assessment of Some Mineral Elements (Ca, Na, K, Mg, Fe, Mn Cu and Zn) and their Nutritional Intake of Two Traditional Leafy Vegetables: Leaves of *Corchorus olitorius (Tiliaceae)* and *Hibiscus Sabdariffa (Malvaceae)*. International Journal of Agriculture Innovations and Research **3(3),** 2319-1473.

Senga Kitumbe P, Opota Onya D, Tamba Vemba A, Tona Lutete G, Kambu Kabangu O, Covaci A, Apers S, Pieters L, Cimanga K. 2013. Chemical composition and nutritive value study of the seed oil of *Adenanthera pavonina* L. (Fabaceae) growing in Democratic Republic of Congo.

International journal of Pharmtech Research **5(1),** 205-216.
http://wwwsphinxsai.com

Sidoryk-Wegrzynowicz M, Aschner M. 2013. Manganese toxicity in the central nervous system: the glutamine/glutamate-γ-aminobutyric acid cycle. Journal of internal medicine **273 (5),** 466-477.
https://doi.org/10.1111/joim.12040

Sodamade A. 2013. Proximate Analysis, Mineral Content, Amino Acid Composition and Functional Properties of Vernonia amygdalina Vegetable Leaf Protein Concentrates. Greener Journal of Agricultural Sciences **3(3),** 204-210.

Soetan KO, Olaiya CO, Oyewole OE. 2010. The importance of mineral elements for humans, domestic animals and plants: A review. African Journal of Food Science **4(5),** 200-222.

http://academicjournals.org/ajfs

Soro LC, Ocho-Anin Atchibri AL, Kouadio Kouakou KA, Kouamé C. 2012. Evaluation de la composition nutritionnelle des légumes feuilles. Journal of Applied Biosciences **51,** 3567– 3573.
http://dx.doi.org/10.4314/ijbcs.v6i1.12

Steyn NP, Olivier J, Winter P, Burger S, Nesamvuni S. 2001. A survey of wild, green, leafy vegetables and their potential in combating micronutrient deficiencies in rural populations. African Journal of Sciences **97,** 276-279.

UNICEF. 2016. One is too many: ending child deaths from pneumonia and diarrhea Van Vuuren, I., 2006. Wild vegetables tamed to decrease hunger: emerging agriculture. Water Wheel **5,** 22-25.

Zakaria ZA, Somchit MN, Zaiton H, MatJais AM, Suleiman MR, Farah W, Nazaratul-Marawana R, Fatimah CA. 2006. The in vitro antibacterial activity of *Corchorus olitorius* extracts. International Journal of Pharmacology **2(2),** 213-215.