Available online at http://ajol.info/index.php/ijbcs

Int. J. Biol. Chem. Sci. 7(1): 319-331, February 2013

International Journal of Biological and Chemical Sciences

ISSN 1991-8631

Original paper http://indexmedicus.afro.who.int

Proximate, mineral and vitamin C composition of vegetable Gbolo [*Crassocephalum rubens* (Juss. ex Jacq.) S. Moore and *C. crepidioides* (Benth.) S. Moore] in Benin

A. ADJATIN [1], A. DANSI [1*], E. BADOUSSI [2], A. F. SANOUSSI [1], M.DANSI [1], P. AZOKPOTA [2], H. AHISSOU [3], A. AKOUEGNINOU [5], K. AKPAGANA [6] and A. SANNI [3]

[1]*Laboratory of Biotechnology, Genetic Resources and Plant and Animal Breeding (BIORAVE), Faculty of Sciences and Technology of Dassa, University of Abomey-Calavi, 071BP28, Cotonou, Benin.*
[2]*Department of Nutrition and Food Technology, Faculty of Agriculture (FSA), University of Abomey-Calavi, BP 526 Cotonou, Benin.*
[3]*Laboratory of Biochemistry and Molecular Biology, Faculty of Sciences and Technology (FAST), University of Abomey-Calavi (UAC), P.O. Box 526 Cotonou, Benin.*
[4]*Bioversity International, Office of West and Central Africa, 08 BP 0931, Cotonou, Benin.*
[5]*National Herbarium, Department of Botany and Plant Biology, Faculty of Sciences and Technology (FAST), University of Abomey-Calavi (UAC), BP 526, Cotonou, Benin.*
[6]*Laboratoire de Botanique, Faculté des sciences, Université de Lomé, BP 1515, Lomé, Togo.*
[*] *Corresponding author, E-mail: adansi2001@gmail.com*

ABSTRACT

Gbolo (*Crassocephalum crepidioides* and *Crassocephalum rubens*) is a traditional leafy vegetable highly consumed in southern and central Benin, as well as in some part of northern Benin. The nutritional potential of the two species of Gbolo were evaluated through their proximate composition, mineral and vitamin C profile using recommended AOAC method of analysis. The analysis revealed that the contents in raw protein, total lipids, ash and carbohydrates expressed in % of dry matter were 27.13±0.01%,3.45± 0.00%,19.02± 0.01%and 42.22 ± 0.04% for *C. crepidioides*; 26.43± 0.01%, 2.75± 0.01%, 19.76± 0.05% and 43.11±0.10 % for *C. rubens* respectively. The content of vitamin C for 100g of fresh leaf is of 9.17 mg for *C. crepidioides* and 3.60 mg for *C. rubens*. The moisture content (% of cool matter) and the total metabolizable energy (kcal/100 g of dried matter) were respectively 86.79± 0.04 %and 308.45 ± 0.28 for *C. crepidioides* and 87.95% ± 0.07 %and 302.91 ± 0.56 for *C. rubens*. The result of the mineral composition indicated that the sodium (Na), potassium (K), phosphorus (P), magnesium (Mg), calcium (Ca), iron (Fe), Manganese (Mn) and Copper (Cu) contents were higher in *C. rubens*than in *C. crepidioides*. With regard to the obtained values, the Gbolo vegetable showed a satisfactory composition and a significant variability between the mineral salts in its two species and can be valorised for a balanced nutrition of populations. Efforts should be made for the promotion of its wide cultivation and consumption.

Keywords: Benin, *Crassocephalum*, Gbolo, mineral composition, proximate composition, vitamin C.

INTRODUCTION

The health of individuals depends on the quantity and the quality of food they eat (Senga Kitumbe et al., 2013). In tropical countries in general and SSA in particular, the interest of vegetable plants for food for rural communities is recognized (Andzouana and Mombouli, 2012). According to Nair Archana

DOI : http://dx.doi.org/10.4314/ijbcs.v7i1i.27

et al. (2013), vegetables are indispensable constituents of the human diet supplying the body with minerals, vitamins and certain hormone precursors, in addition to proteins and calories (Aja et al., 2010; Olaposi and Adunni, 2010). Throughout the tropical world and particularly in West Africa, a large number of traditional leafy vegetables (TLVs) have long been known and reported to play important roles in food security for people living in both rural and urban areas (Ukpong and Idiong, 2013). TLVs are rich in vitamins (especially A, B and C), minerals, fibres, carbohydrates and proteins and some even possess medicinal properties (Adeoti et al., 2012). They represent affordable but quality nutrition for large proportion of the population and offer an opportunity for improving nutritional status of many families (Olaposi and Adunni, 2010). In many African countries, leafy vegetables account for 50 to 100% of rural households' income and substantially contribute to poverty alleviation (Diouf et al., 2007).

In Africa, the diversity of the African TLVs is enormous (Senga Kitumbe et al., 2013; Ukpong and Idiong, 2013). Researchers in sub-Saharan Africa have listed and given an account of about 1,000 species (Senga Kitumbe et al., 2013). In Benin, a biodiversity inventory and documentation survey recently conducted on TLVs throughout the country revealed a total of 187 plant species among which the vegetable locally known as Gbolo was found to be of paramount interest (Dansi et al., 2012; Adjatin et al., 2012). Gbolo comprising two species namely *Crassocephalum rubens* (Juss. ex Jacq.) S. Moore and *C. crepidioides* (Benth.) S. Moore is highly consumed throughout Benin (Adjatin et al., 2012). It is used by the local communities as a nutraceutical and locally believed to have antibiotic, anti-helminthic, anti-inflammatory, anti-diabetic, anti-malaria and blood regulation properties and also treats indigestion, liver complaints, colds, intestinal worms, and hepatic insufficiency in addition to its nutritional value (Adjatin et al., 2012). Unlike most leafy vegetables that are seasonal, Gbolo is available all year round because it can be collected during the rainy season, sun dried, stored and further used, when needed, during the long dry season mainly in the arid and semi-arid zones. Despite the crucial role it plays in the food security, nutrition and income generation of the rural poor, the Gbolo vegetable is still among the neglected and underutilized crops species of Benin (Dansi et al., 2012). With the recent wave of economic depression and its attendant effect on the purchasing power of the population of less developed nations, it has become obvious that locally neglected and underutilized (NUS) food crops species will play an increasing role in the food, nutrition and health security of the rural people and the increasing urban poor (Kimbonguila et al., 2010; Ndangui et al., 2010).

As popular as vegetable Gbolo is in Benin, there is still paucity of information on its real nutritional value. We report in this paper a study conducted to determine the proximate, mineral and vitamin C composition of Gbolo (*C. crepidiodes* and *C. rubens*) leaves in order to stimulate interest in its utilisation beyond the traditional localities, through public and dietary awareness of its nutritional status.

MATERIALS AND METHODS

Collection and processing of plant material

Leaves of *C. crepiodiodes* (Figure 1) and *C. rubens* (Figure 2) were collected from the Gbolo vegetable germplasm conserved as field collection at the experimental site of the Faculty of Sciences and Technology of Dassa (University of Abomey-Calavi), in central Benin. The collected leaves were first washed thoroughly 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 Pillai and Nair (2013). The leaves were air-dried at 25 °C for 25 days, milled in powder with a mechanical blender, sieved through 20-mesh and stored at room temperature under dry conditions in an air tight plastic containers for analysis (Nair Archana et al., 2013 ; Senga Kitumbe et al., 2013). Chemical analysis was carried out on both fresh material and powdered leaves of *C. crepiodiodes* and *C. rubens* for the following constituent: water, proteins, lipids, ashes, mineral components (calcium, copper, iron, magnesium, manganese, phosphorus, potassium, and sodium) and vitamin C (Nair Archana et al., 2013; Senga Kitumbe et al., 2013).

Proximate analysis and vitamin C content determination

The sample was analysed for moisture, crude protein, crude fat and ash content. Crude protein was determined by using the Kjeldahl method (Nair et al., 2013). The moisture and crude fat were determined according to the procedure of Association of Official Analytical Chemist (AOAC, 1990). The percentage was calculated based on the dry weigh. Ash was determined after incineration in a muffle furnace following Bangash et al. (2011). Carbohydrates were determined by difference of the sum of all the proximate composition from 100% dry matter (AOAC, 1990; Emebu and Anyika, 2011). Energy values were obtained by multiplying carbohydrate, protein and fat by conversion factors of 17, 17 and 37 respectively (Badau et al., 2013). The vitamin C content was determined using the titrimetry method as described by AOAC (1990). The procedure was performed in the presence of 5% metaphosphoric acid following Bangash et al. (2011) as at 5±6%, metaphosphoric acid is not only a good extractant for vitamin C but also stabilize it for a limited period by complexing metal ions and minimising the rate of oxidation. All the analyses were performed with three replicates.

Determination of mineral composition

Mineral composition of the samples was determined according to methods recommended by Association of Official Analytical Chemists (AOAC, 1990) and Badau et al. (2013). The samples were incineratedin the oven at a temperature of 550 °C for 3 hours. The samples of *C. crepidioides* and *C. rubens* were each digested using a mixture of concentrated Nitric (HNO_3), perchloric ($HClO_4$) and sulphuric (H_2SO_4) acids in the ratio 9:2:1 (v/v) respectively (Nair et al., 2013). Copper (Cu), iron (Fe), zinc (Zn), sodium (Na), potassium (K), calcium (Ca) and magnesium (Mg) and Manganese (Mn) were determined by Atomic Absorption Spectrophotometer (AAS) (PerkinElmer AAnalyst 700, England). Phosphorus contents of the samples were determined using Flame photometer as specified in Alinnor and Oze (2011).

The concentration of each element in the sample was calculated from the dry matter. All the analyses were performed with triplicates for the needs of statistical analysis (Pillai and Nair, 2013).

Data analysis

The data were statistically analysed using Statistical Package for Social Scientists (SPSS) version 17.0. Data were expressed as means ± standard deviations of three replicate determinations (Pillai and Nair, 2013). The data obtained for the two species were evaluated for significant differences in their means with analysis of variance (ANOVA). Critical difference at $p \leq 0.05$ was estimated. Differences between the means were separated using turkey’s test as packaged by SPSS 17.0 software.

Table 1: Proximate composition of leaves of *C. crepidioides* and *C. rubens* in dry matter basis (mg/100g of dry matter).

Parameters	***Crassocephalum crepidioides***	***Crassocephalum rubens***
Moisture	86.79±0.04b	87.95±0.07a
Crude protein (%)	27.13±0.01a	26.43±0.01b
Crude lipid (%)	3.45±0.00a	2.75±0.01b
Total carbohydrate (%)	42.22±0.04b	43.11±0.10a
Total fibre (%)	8.18±0.01a	7.95±0.03 a
Total ash (%)	19.02±0.01b	19.76±0.05a
Calorific value (kcal/100 g)	308.45±0.28a	302.91±0.56b

Results are presented as mean value ± standard deviation, n=3. For the two species and a given parameter, values with different letters are significantly different (p<0.05).

Table 2: Mineral element and vitamin C composition of *C. crepidioides* and *C. rubens* leaves in mg/100 g of dry matter basis.

Composition (mg)	***Crassocephalum crepidioides***	***Crassocephalum rubens***
Phosphorus (P)	1039.2± 1.03a	1409± 0.09b
Calcium (Ca)	1012±0.06a	3845.88±0.20b
Magnesium (Mg)	336.46±0.35b	434.13±0.10a
Potassium (K)	2291.86±0.11a	4469.91±0.11b
Sodium (Na)	2213.45±0.73b	2129.04±0.01a
Iron (Fe)	2.4±0.06b	9.6±0.01a
Copper (Cu)	1.4±0.06a	2.6±0.07b
Manganese (Mn)	7.7±0.26b	8.22±0.20a
Ca / P	0.97	2.73
Na / K	1.03	0.48
Ca / Mg	3.00	8.86
Vitamin C (WL)	9.17	3.60

Results are presented as mean value ± standard deviation, n=3. For the two species and a given parameter, values with different letters are significantly different (p<0.05).

RESULTS AND DISCUSSION

Proximate composition

The proximate composition of the leaves of *Crassocephalum crepidioides* and of *Crassocephalum rubens* are shown in Table 1. From the results, the most abundant composition in fresh leaves of Gbolo was moisture content, followed by total carbohydrate content, crude protein and crude fibre content. The crude fat content was the least abundant in the leaves. Apart from moisture, carbohydrate and ash contents, the protein, dry matter and fat contents and energy values of *C. crepiodiodes*, were statistically higher(p<0.05) than those of *C. rubens*. This means that *C. crepiodiodes* has more organic content and is therefore more nutritious than *C. rubens*. These results are similar to those reported on *Gnetumafricanum* (Ekumankama, 2008), *Brassica oleracea* (Emebu and Anyika, 2011) and *Ochthocharis dicellandroides* (Gilg) (Andzouana and Momboul, 2012) and also on *C. crepidioides* and *Seneciobiafrae* in Nigeria (Dairo and Adanlawo, 2007).

Figure 1: Plant of *Crassocephalum crepidioides.*

Figure 2: Plant of *Crassocephalum rubens.*

The moisture content of *C. crepiodiodes* and *C. rubens* were 86.79% and 87.95% respectively. These values were much higher than those recorded by Omoyeni and Aluko (2010) for *Cissuspetiolata* (6.82%), Adinortey et al. (2012) for *Launaea taraxacifolia* (22.18%), Yameogo et al. (2011) for *Moringa oleifera* (73.90%), Emebu and Anyika, (2011) for *Brassica oleracea* (81.36%) and the values ranged from 7.60-8.55% for some vegetables from Nigeria (Iheanacho and Udebuani, 2009) but similar to those of *Cnidoscolus chayamansa* (82.02%), *Solanium nodiflorum* (85.12%) and *Senecio biafrae* (89.38%) reported by Olaposi and Adunni (2010). They were lower than the recorded 89.00% and 93.40% in *Talinum triangulare* and *Baseila rubra* respectively (Mensah et al., 2008). The differences observed between the result of this study and the report of these authors might be due to experimental methods of analysis, the growing conditions and the level of maturity of the plants and the type of cultivar used. Moisture content is a widely used parameter in the processing and testing of food and is an index of the water activity of many foods (Bangash et al., 2011; Emebu and Anyika, 2011). Badau et al. (2013) reported that high moisture content provides for greater activity of water soluble enzymes and coenzymes needed for the metabolic activities of these leaves. The high moisture content of the leaves of *C. crepiodiodes* and *C. rubens* recorded in the present study indicates that they would be susceptible to microbial attack during storage and would have a short shelf life. It is also indicative of low total solids (Pillaiand Nair, 2013).

The study revealed that, based on the dry weight, *C. crepidiodes* and *C. rubens* leaves contain an appreciably high amount of proteins (27.13% and 26.43% respectively) which are comparable to the amount of protein in dry leaves of *Moringa oleifera* (27.20%) (Yaméogo et al., 2011). These values were high when compared to 11.67% (DM) reported for *B. oleracea* (Emebu and Anyika, 2011), 15.2% (DM) recorded in *G. Africanum* (Mensah et al., 2008), 16.52% in *Afzelia Africana* (Ogunlade et al., 2011) and 8.80% in *Annona senegalensis* (Yisa et al., 2010) and considerably higher than the range of 0.7-5.0 g/100 g reported for selected vegetables grown in Peshawar (Bangash et al., 2011). However, they were lower than 32.95% recorded in undefatted leaves of *A. hybridus* (Iheanacho and Udebuani, 2009). According to Olaposi and Adunni (2010), food plants that provide more than 12% of their calorific value of protein are considered good source of protein. As observed for kale (Emebu and Anyika, 2011), Gbolo is a rich source of vegetable protein and could be used as an alternative source of protein in diet/protein supplement especially in under-developed countries such as Benin where majority of the populace live on starchy food and cereals. The relatively high protein content in Gbolo leaves suggests a high amount of essential amino acids which serve as an alternative source of energy when the carbohydrate metabolism is impaired via gluconeogenesis (Iheanacho and Udebuani, 2009). Due to its protein content and as reported by Andzouana and Momboul (2012), the leaves of Gbolo have numerous benefits such as provision of vital body constituents, maintenance of fluid balance, formation of hormones and enzymes and contribution to the immune function. Lack of protein contributes to low body mass, growth retardation in children and developmental deficiency during pregnancy (Iheanacho and Udebuani, 2009).

The crude fat content in the dried leaves of *C. crepidioides* (3.45%) and *C. rubens* (2.75%) was very low compared to that of the leaves of *Anona senegalensis* (24.0%) by Yisa et al. (2010), *Talinum triangulare* (5.90%), *Baseila alba* (8.71%) and *Amaranthu shybridus* (4.80%) by Mziray et al. (2001) and *Moringa oleifera* (17.1%) by Yaméogo et al. (2011). Dietary fats function to increase the palatability of food by absorbing and retaining flavours (Antia et al., 2006; Bangash et al., 2011). A diet providing 1- 2% of its caloric of energy as fat is said to be sufficient to human beings as excess fat consumption is implicated in certain cardiovascular disorders such as atherosclerosis, cancer and aging (Antia et al., 2006). The low fat content indicated that the leaves of Gbolo can be recommended as a weight reducing diet since low fat food reduces the level of cholesterol and obesity (Badau et al., 2013).

From the result obtained, *C. crepidioides* and *C. rubens* contained 8.18% and 7.95% of total dietary fibre respectively. No significant difference is observed between the two species. These values are similar to those reported by Dairo and Adanlawo (2007) for *C. crepidioides* (8.13%) and *Senecio biafrae* (7.26%). They are lower than that of *Talinum triangulare* (6.20%), *Corchorus alitorius* (7.0%), and *Gymnantheum amygdalinum* (25.47%) know as a vegetable particularly rich in fibre (Ejoh et al., 2007). Due to the increasing awareness of the beneficial effects of dietary fibre towards health optimizing, foods like Gbolo are a source of dietary fibre have been given more attention. Fibre has useful role in providing roughage that aids digestion (Badau et al., 2013). Dietary fibre reduces the risks of cardiovascular diseases. Reports have shown that increase in fibre consumption might have contributed to the reduction in the incidence of certain diseases such as diabetes, coronary heart disease, colon cancer and various digestive disorders (Badau et al., 2013). Fibre consumption also soften stools and lowers plasma cholesterol level in the body (Pillaiand Nair, 2013). Maintenance of internal distension for a normal peristaltic movement of the intestinal tract is a physiological role played by crude fibre. However, it is also reported that when a vegetable has very high fibre content, it may cause intestinal irritation and a decrease of nutrient bioavailability (Pillaiand Nair, 2013). Therefore, both species (*C. crepidioides* and *C. rubens*) of Gbolo could be valuable sources of dietary fibre in human nutrition.

The values of ash content, on dry weight basis, were 19.02% for C*. crepiodides* and 19.76% for *C. rubens*. These values are not significantly different but are higher than that of *Moringa oleifera* (11.10%) and *Ochthocharis dicellandroides* (4.19%) reported by Yaméogo et al. (2011) and Andzouana and Mombouli (2012) respectively. They are also higher than that of some leafy vegetables commonly encountered and consumed in Benin such as *Talinum triangulare*, *Telferia occidentalis*, *Vernonia amygdalina (*syn. *Gymnantheum amygdalinum)* (Andzouana and Mombouli, 2012), *Solanum macrocarpum* and *Amanranthus cruentus* (Aja et al., 2010). The high ash content is a reflection of the mineral contents preserved in the food materials. The result therefore suggests a high deposit of mineral elements in the leaves (Iniaghe et al., 2009). This requires further investigation to ascertain the types of mineral elements as they are essential for tissue functioning and a necessity in daily requirement for human nutrition.

The carbohydrate content of the vegetable Gbolo was 42.22% for *C. crepidiodes* and 43.11% for C*. rubens*. These values are higher when compared to the 10.87% recorded in *Talinum triangulare* (Aja et al., 2010), 11.73% recorded in *Ochthocharis dicellandroides* (Andzouana and Mombouli, 2012) and 3.6 g/100 g in *Celosia argentea* (Mensah et al., 2008). However, these values were lower than the 52.32% reported for *Pachira glabra* and 45.92% for *A. Africana* seed flowers (Ogunlade et al., 2011), and 52.18% for *Amaranthu shybridus* (Akubugwo et al., 2007). According to Emebu and Anyika (2011) most vegetables are generally not good sources of carbohydrate. Some of them are rich sources while others contain traces of the nutrients (Andzouana and Momboul, 2012). The relatively high carbohydrate content can be used as energy source and also it is necessary in the digestion and assimilation of other foods. Carbohydrate supplies energy to cells such as brain, muscles and blood. It contributes to fat metabolism and spares proteins as energy sources. It also acts as a mild natural laxative for human beings and generally adds to the bulk of the diet (Gordon, 2002). They provide the body with a source of fuel and energy that is required to carry out daily activities (Yisa et al., 2010).

The energy value of dried leaves of *C. crepidiodes* (308.45 kcal /100 g) and *C. rubens* (302.91 kcal/ 100 g) was significantly higher than the 593.15 kj /100g recorded in *Ochthocharis dicellandroides* (Andzouana and Mombouli, 2012), the 39.56 kcal /100 g reported for *Tridax procumbens* leaves (Ikewuchi et al., 2009), the 58.46 kcal/100g reported for *B. oleracea* (Emebu and Anyika, 2011) but lower than 339.1 kcal/100g reported for *M. oleifera* (Yaméogo et al., 2011). The energy value of the sample suggested that consumption of this edible vegetable could assure energy security for the Beninese population.

Vitamin C content

The vitamin C content in fresh Gbolo was determined to be 9.17 mg /100g sample for *C. crepidioides* and 3.60 mg/100g sample for *C. rubens*. *C. crepidiodes* therefore contains about three times more vitamin C than *C. rubens*. In Nigeria, Odukoya et al. (2007) reported 122.95 mg /100g as the vitamin C content in *C. crepidioides*. The difference is high and might be due to the possible variation of ascorbic acid content between cultivars (Pillai and Nair, 2013). Mziray et al. (2001) reported values ranging from 455 to 535 mg /100g in a single variety of *Amaranthus cruentus* planted at different locations in Dar es Salaam. In the same *Amaranthus cruentus,* Kadam et al. (2011) reported a variation within a range of 69 to 288 mg/100 g. Based on the report of Olayinka et al. (2012), the values obtained are lower when compared to the most consumed leafy vegetables in Benin (Dansi et al., 2008) such as *vernonia amygdalina* (13.41mg/100g), *Cleome gynandra* (14 mg/100g), *Solanum macrocarpum* (38.11mg / 100g), *Adansonia digitata* (55 mg/100 g), *Bidens pilosa* (63 mg/100 g), *Corchorus tridens* (78 mg/100 g) and *Talinum triangulare* (116.35 mg / 100g). Vitamin C plays a huge role in maintaining a healthy lifestyle, and preventing diseases. It has immune-stimulating, anti-allergic and antioxidant effects and preserves the cardiovascular system and the eye. Vitamin C is required for the synthesis of collagen, the intercellular "cement" substance which gives structure to muscles, vascular tissues, bones, tendons and ligaments (Olayinka et al., 2012). With regards to the importance of vitamin C for human health it will be important to study the variation of its content between varieties within the germplasm gathered from different localities across Benin in order to identify those having the highest content in vitamin C for direct utilization and breeding purposes.

Mineral composition

Minerals are important component of diet because of their physiological and metabolic function in the body. The result presented in Table 2 shows that Gbolo (*C. crepiodiodes* and *C. rubens*) is a rich mineral leafy vegetable. The major elements present in the leaves were sodium (Na), potassium (K), phosphorus (P), magnesium (Mg) and calcium (Ca). Iron (Fe), Manganese (Mn) and copper (Cu) were found in low amounts. Distorted enzymatic activity and poor electrolyte balance of the blood fluid are related to inadequate Na, K and Mg as they are the most required elements of living cells.

C. crepidiodes and *C. rubens* sample have calcium contents of 1012 mg/100 g and 3845.88 mg/100 g respectively. The recommended daily intake of calcium by The World Health Organization’s (WHO) is 800 mg for both adult and children. This study shows that the calcium content of Gbolo species was above the WHO recommended standard. The sauce made from these leafy vegetable can be considered as good source of calcium. Calcium is the most abundant mineral in humans existing as hydroxyapatite (hard mineral which provides strength to the bone and teeth) and very important to humans for it role in blood clotting, muscle contraction, neurological function, bone and teeth formation/repairs and also an important factor in enzymatic metabolic processes (Senga Kitumbe et al., 2013) and in the preservation of the integrity of the intracellular cement substances (Karau et al., 2012)

The phosphorus content in the dried leaves of the Gbolo vegetable was 1039.2 mg / 100g for *C. crepidiodes* and 1409 mg/100g for *C. rubens*. The recommended daily intake for phosphorus in adult and children is 800 mg/day (Pillaiand Nair, 2013). Phosphorus in conjunction with calcium, contribute to strengthening the bones and teeth especially in children and lactating mothers (Andzouana and Mombouli, 2012). The value of phosphorus obtained from the analysis of the sample was higher than the recommended standard. Therefore the Gbolo vegetable meets human phosphorus nutritional requirement if it is consumed in good proportion.

The study showed that the potassium content of *C. crepidiodes* and *C. rubens* was 2291.86 mg/100 g and 4469.91 mg/ 100 g respectively. Therefore, Potassium appeared as the most abundant mineral in the Gbolo vegetable. This observation is in agreement with the report of Alinor and Oze (2011) according to which potassium is the most abundant in agricultural products. Potassium is important in the regulation of heart beat, neurotransmission and water balance of the body (Alinor and Oze, 2011). High amount of potassium in the body was reported to increase iron utilization (Nair et al., 2013) and beneficial to people taking diuretics to control hypertension and suffer from excessive excretion of potassium through the body fluid (Nair et al., 2013). The WHO recommended intake of potassium per day is 2000 mg for adult and 1600 mg for children. This study revealed that potassium content of *Crassocephalum* species sample was far above WHO recommended standard for children and adult.

Magnesium was determined to be 336.46 mg/100g for *C. crepiodides* and 434.13 mg/100g for *C. rubens*. The Recommended Dietary Allowance (RDA) for magnesium is 350 mg/100g for adult and 170 mg/100g in children. Taken into account the existence of variation between varieties (Alinor and Oze, 2011), it can be concluded that both species of the Gbolo vegetable have the minimum required magnesium content to fulfil adults and children daily needs. Magnesium is known to prevent cardiomyopathy, muscle degeneration, growth retardation, alopecia, dermatitis, immunologic dysfunction, gonadal atrophy, impaired spermatogenesis, congenital malformations and bleeding disorders (Andzouana and Monbouli, 2012). According to Alinor and Oze (2011), magnesium plays an essential role in calcium metabolism in bones and is also involved in the prevention of circulatory diseases. It helps in regulating blood pressure and insulin releases.

According to Alinor and Oze (2011), sodium is an important mineral that assists in the regulation of body fluid and in the maintenance of electrical potential in the body tissue. *C. crepiodides* and *C. rubens* sodium content were respectively 2291.86 mg/100 g and 2921.04 mg/100 g. The World Health Organization's (WHO) recommended intake of sodium per day is 500 mg for adult and 400 mg for children. The result indicates that sodium content of *C. crepiodides* and *C. rubens* leaves represent at least four times the WHO recommended standard daily intake, therefore *C. crepiodides* and *C. rubens* are good sources of sodium and could be recommended to pregnant women and to those suffering from hypertension and renal diseases whose direct salt intake should be at minimal (Emebu and Anyika, 2011).

The iron content of the leaves of *C. crepidiodes* and *C. rubens* found in this study

(Table 2) was slightly lower than the WHO recommended dietary allowance of 10-15 mg/day (Senga Kitumbe et al., 2013). According to Andzouana and Monbouli (2012), iron as an essential trace metal plays numerous biochemical roles in the body and is a key element in the metabolism of almost all living organisms. In humans, iron is an essential component of hundreds of proteins and enzymes (Andzouana and Monbouli, 2012). It is important for normal functioning of the central nervous system (Alinor and Oze, 2011) and facilitates the oxidation of carbohydrate, protein and fats. Iron is required for blood formation and is said to be an important element in the diet of pregnant women, nursing mothers, infants convulsing patients and elderly to prevent anaemia and other related diseases (Alinor and Oze, 2011).

Copper is required in the body for enzyme production and biological electron transport (Alinor and Oze, 2011). The copper content, in dry weight basis, was 1.4 mg/100 g and 2.6 mg/100 g for *C. crepidiodes* and *C. rubens* respectively. The RDA for copper is 3mg/day in adult and 2 mg/day in children. The result indicates that only *C. rubens* copper content was higher than the recommended standard for children but still slightly below the recommended standard for adult. *C. rubens* can be considered as an acceptable copper source for both children and adults.

Table 2 also shows that the Ca/P ratio value was 0.97 and 2.73 for *C. crepidiodes* and *C. rubens* respectively. According to Adeyeye and Aye (2005) and Alinor and Oze (2011), Ca/P ratio higher than two helps to increase the absorption of calcium in the small intestine. Food is considered good if the ratio Ca/P is higher than1 and poor if the ratio is less than 0.5. Consequently, the Gbolo vegetable and particularly the species *C. rubens* appears as a good food (Ca/P >0.5 and above 1). For instance calcium helps in bone formation and blood coagulation.

The Na/K ratio of *C. crepidiodes* and *C. rubens* in this study were 1.13 and 0.48 respectively. Alinor and Oze (2011) reported that the Na/K ratio in the body help in controlling high blood pressure and a food source having Na/K ratio of less than1 has impact in lowering blood pressure. Among the two species of Gbolo studied, only *C. rubens* leaves having Na/K ratio of 0.48 are useful as nutraceutical for treating or preventing blood pressure problems.

Conclusion

This study highlighted the nutritious potential of vegetable Gbolo (*C. crepiodides* and *C. rubens*) in Benin. The study revealed that *C. crepidoides* has more organic content and is more nutritious than *C. rubens* while *C. rubens* is richer in mineral element than *C. crepidoides.* Moreover *C. crepidoides* is a better source of vitamin than *C. rubens*. Based on the results obtained the Gbolo vegetable was found to be a good food and its two species, when regularly used can assist in meeting the daily recommendations of important nutrients and enhance the nutritional status of both rural and urban populations. Therefore, it is important to stimulate interest in its cultivation (in homes and in market gardens) and utilisation beyond the traditional localities, through public and dietary awareness of its nutritional status. For further promotion of the crop, the following research actions are suggested:

(i) Assessment of the vitamin A and B content of the leaves of the two species;

(ii) Analysis of the variation of the proximate, mineral and vitamin content between varieties in order to identify the most nutritive varieties for direct promotion and breeding purposes;

(iii) Determination of the phytochemical composition of the leaves of the species for a better knowledge of their medicinal importance;

(iv) Validation of antimicrobial, anti-diabetic, anti-inflammatory and blood pressure regulation properties attributed by the local communities to the leaf of the two species.

ACKNOWLEDGMENTS

This research was sponsored by the government of Benin through the Scientific Council of the University of Abomey-Calavi (UAC) and the analyses were conducted at the Laboratory of Applied Chemistry of the Benin Centre of Scientific research (CBRST, Porto-Novo). We express our sincere thanks to all the technicians for their technical assistance. Special thanks are also due to the anonymous reviewers for their suggestions and constructive criticisms. We express our gratitude to Dr. K. Adeoti (University of Abomey-Calavi) who, in one way or the other, lent us his support during the entire study.

REFERENCES

Adéoti K, Dansi A, Ahoton L, Vodouhè R, Ahohuendo BC, Rival A, Sanni A. 2012. Agromorphological characterization of *Sesamum radiatum* (Schum. and Thonn.), a neglected and underutilized species of traditional leafy vegetable of great importancein Benin. *African Journal of Agricultural Research*, **7**(24): 3569-3578.

Adeyeye EI, Aye PA. 2005. Chemical composition and the effect of salts on the food properties of *Triticum durum* whole meal flour. *Pak. J. Nutr.*, **4**: 187-196.

Adinortey MB, Sarfo JK, Quayson ET, Weremfo A, Adinortey CA, Ekloh W, Ocran J. 2012. Phytochemical Screening, Proximate and Mineral Composition of *Launaea taraxacifolia* Leaves. *Research Journal of Medicinal Plant*, **6**(2): 171-179.

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. *Genet. Resour. Crop. Evol.*, DOI 10.1007/s10722-012-9901-z (online first).

Aja PM, Okaka ANC, Onu PN, Ibiam U, Urako AJ. 2010. Phytochemical composition of *Talinum triangulare* (Water Leaf) Leaves. *Pakistan Journal of Nutrition*, **9**(6): 527-530.

Akubugwo IE, Obasi NA, Chinyere GC, Ugbogu AE. 2007. Nutritional and chemical value of *Amaranthus hybridus* L. leaves from Afikpo, Nigeria. *Afr. J. Biotechnol.*, **6**: 2833-2839.

Alinnor IJ, Oze R. 2011. Chemical evaluation of the nutritive value of *Pentaclethra macrophyllabenth* (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.

Antia BS, Akpan EJ, Okon PA, Umoren IU. 2006. Nutritive and Anti-Nutritive Evaluation of Sweet Potatoes (*Ipomoea batatas*) Leaves. *Pak. J. Nutr.*, **5**: 166-168.

AOAC. 1990. *Official Methods of Analysis.* (13th edn). Association of Official Analytical Chemists: Washington DC.

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.

Bangash JA, Arif M, Khan F, Khan F, Rahman A-U, Iqbal H. 2011. Proximate composition, mineral and vitamin content of selected vegetables grown in Peshawar. *J. Chem. Soc.Pak.*, **33**: 118-122.

Dairo FAS, Adanlawo IG. 2007. Nutritional quality of *Crassocephalum crepidiodes* and *Senecio biafrae*. *Pak. J. Nutr.*, **6**: 35-39.

Dansi A, Adjatin A, Adoukonou-Sagbadja H, Faladé V, Yedomonhan H, Odou D, Dossou B. 2008. Traditional leafy vegetables and their use in the Benin Republic. *Genet. Resour. Crop Evol.*, **55**: 1239-1256.

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. *Sci. World J.*, ID 932947, DOI 10.1100/2012/932947. p. 19.

Diouf M, Lo C, Gueye M, Mbengue NB. 2007. Sélection participative de nouveaux cultivars de quatre (4) espèces de légumes-feuilles (*Hibiscus sabdariffa* L., *Amaranthus* L. spp, *Vignaunguiculata* (L.) WALP et *Moringa oleifera* Lam) au Sénégal. *Afri. J. Food Agric. Nutr. Dev.*, **7**(3): 17.

Ejoh RA, Nkonga DV, Inocent G, Moses MC. 2007. Nutritional Components of Some Non-Conventional Leafy Vegetables Consumed in Cameroon. *Pak. J. Nutr.*, **6**: 712-717.

Ekumankama IO. 2008. Nutrient composition of indigenous vegetables (*Pterocarpus soyanxii*, *Pterocarpus santalicides* and *Gnetum africanum*). *Nig. J. Nutr. Sci.*, 29: 195-200.

Emebu, P.K. and J.U. Anyika. 2011. Proximate and mineral composition of kale (*Brassica oleracea*) grownin Delta State, Nigeria. *Pak. J. Nutr.*, **10**: 190-194.

Gordon MN, Kessel M. 2002. *Perspective in Nutrition* (5th edn). McGraw Hill Company: Ohio, New York; 257-281.

Iheanacho KME, Udebuani AC. 2009. Nutritional composition of some leafy vegetables consumed in Imo State Nigeria. *J. Appl. Sci. Environ. Manage*, **13**: 35-38.

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.

Kadam SD, ShuklaYM, Patel NJ. 2011. Variability in Proximate Composition of Elite Genotypes of *Amaranthus* (*Amaranthus* spp.). *Indian Journal of Agricultural Biochemistry*, **24**(1): 77-79

Karau GM, Njagi NM, Machocho AK, Wangai LN. 2012. Phytonutrient, mineral composition and *In vitro* antioxidant activity of leaf and stem bark powders of *Pappeacapensis* (L.). *Pakistan Journal of Nutrition*, **11**(2): 123-132.

Kimbonguila A, Nzikou JM, Matos L, Loumouamou B, Ndangui CB, Pambou-Tobi NPG, Abena AA, Silou T, Scher J, Desobry S. 2010. Proximate composition and physicochemical properties on the seeds and oil of *Annona muricata* grown in Congo- Brazzaville. *Res. J. Environ. Earth Sci.*, 2: 13-18.

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. *Afr. J. Biotechnol.*, **7**: 2305- 2308.

Mziray RS, Imungi JK, Karuri EG. 2001. Nutrient and antinutrient in contents of raw and cooked *Amaranthus hybridus*. *Ecology of food and nutrition*, **40**(1): 53-65.

Nair Archana G, Pradeesh S, Devi Chinmayee M, Mini I, Swapna TS. 2013. Diplaziumesculentum: A Wild Nutrient-Rich Leafy Vegetable from Western Ghats. *Prospects in Bioscience*, **1**: 293-301.

Ndangui CB, Kimbonguila A, Nzikou JM, Matos L, Pambou-Tobi NPG, Abena AA, SilouTh, Scher J, Desobry S. 2010. Nutritive composition and properties physico-chemical of gumbo (*AbelmoschusesculentusL.*) seed and oil. *Res. J. Environ. Earth Sci.*, **2**: 49-54.

Odukoya OA, Inya-Agha SI, Segun FI, Sofidiya MO, Ilori OO. 2007. Antioxidant activity of selected Nigerian Green Leafy Vegetables. *American Journal of Food Technology*, **2**(3): 169-175.

Ogunlade I, Ilugbiyin A, Osasona AI. 2011. A comparative study of proximate composition, anti- nutrient composition and functional properties of *Pachira glabra* and *Afzelia Africana* seed flours. *Afr. J. Food Sci.*, **5**: 32-35.

Olaposi AR, Adunni AO. 2010. Chemical composition of three traditional vegetables in Nigeria. *Pakistan Journal of Nutrition*, **9**(9): 858-860.

Olayinka OO, Kareem AM, Ariyo IB, Omotugba SK, Oyebanji AO. 2012. Antioxidant Contents (Vitamin C) of Raw and Blanched Different Fresh Vegetable Samples. *Food and Nutrition Sciences*, 3:18-21.

Omoyeni AO, Aluko BT. 2010. Qualitative determination of chemical and nutritional composition of *Cissus petiolata* leaves. Electron. *J. Environ. Agric. Food Chem.*, **9**: 436-440.

PillaiLS, Nair BR. 2013. Proximate composition, Mineral elements and Anti-nutritional factors in *Cleome viscose* L. and *Cleome burmanni* W. & A. (Cleomaceae). *Int. J. Pharm. Pharm. Sci*., **5**(1): 384-387.

Senga Kitumbe P, OpotaOnya 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.

Ukpong IG, Idiong IC. 2013. Maximum likelihood estimates and determinants of technical efficiency of leafy vegetable producers in Akwa Ibom State, Nigeria. *Journal of Agricultural Science;* doi:10.5539/jas.v5n3p139 (online first)

Yaméogo CW, Bengaly MD, Savadogo A, Nikiema PA, Traore SA. 2011. Determination of chemical composition and nutritional values of *Moringa oleifera* leaves. *Pakistan Journal of Nutrition*, **10** (3): 264-268.

Yisa J, Egila JN, Darlinton AO. 2010. Chemical composition of *Annona senegalensis* from Nupe land, Nigeria. *Afr. J. Biotechnol.*, **9**: 4106-4109.