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COMPOSITION AND FOOD VALUE OF LEAVES OF TWO TROPICAL FOOD THICKENERS – *BOMBAX COSTATUM* AND *CISSUS POPULNEA*

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ABSTRACT

The nutritional, anti-nutritional and mucilage contents of flour of leaves of two vegetables - *Bombax costatum* leaf (BCL) and *Cissus populnea leaf* (CPL) were investigated. Their protein (≈19.0 g/100g in BCL and ≈13.0 g/100g in CPL) and ash (≈6.0 g/100g in BCL and ≈11.0 g/100g in CPL) contents were significantly different at $P < 0.05$. Both leaves were rich in Ca (BCL, 102 ± 2.5 mg/100g; CPL, 113 ± 1.6 mg/100g) and P (BCL, 37.3 ± 2.0 mg/100g and CPL, 21.3 ± 0.2 mg/100g. The metal occurrence in both plant leaves followed the descending order - Ca>K>Mg>Fe>Na>Mn>Zn>Cu. The anti-nutrients (mg/100g) obtained in both plant leaves ranged between 0.07 (Tannin) to 26.3 (Oxalate); they were also very rich in mucilage (BCL, 46.5 g/100g; CPL, 29.8 g/100g). The leaves of both plants have high food values and are exploitable as industrial gums.

Keywords: *Bombax costatum* leaf, *Cissus populnea* leaf, nutritional composition, anti-nutrients, industrial gum.

INTRODUCTION

The gap between the human population and the quantity of the food supply has already become a global threat. According to the Food and Agricultural Organization (FAO), there were about 840 million undernourished people in 1998–2000, of whom 799 million were in developing countries, 30 million in the countries in transition and 11 million in the industrialized countries. In 2010, the number had climbed to 925 million people (FAO, 2010). Therefore, to bridge the gap, efforts are being made to identify and evaluate under exploited food sources (Hussain *et al*., 2010). In particular, leafy greens have been described to be economically affordable and represent an important source of nutrients for people in the lower income sector (Kawashima and Soares, 2003). Consequently, many species of vegetables, especially wild ones have been studied and reported by various scientists - Salazar *et al*. (2006), Ejoh *et al*. (2007), Hussain *et al*. (2010) and Prasad and Bisht (2011).

Bombax costatum and *Cissus populnea* are tropical vegetables whose leaves are used in food preparation. The leaves are used to thicken food because of their high mucilage content. *Bombax costatum Pellegr. (Bombacaceae)* is a common tree in West Africa (Maiga *et al*., 2005). It is a deciduous tree up to 25 m high; its leaves are digitately compound, with 5 - 7 leaflets, 8 - 15 cm long, on long petioles. Its fruit is a dark brown, ellipsoidal capsule, and the calyx of its flowers is used in sauces while the young fruit has been used for preparation of meals (Adewunmi and Sofowora, 1980). *B. costatum* leaves have been reported to be rich in anti oxidants (Atawodi *et al*., 2004); thus, its leaves could be used as antidote to cellular damages arising from reactive oxygen species (ROS).

C. populnea, (Gull and Perr.) is a savannah shrub and a climber which can reach height of three metres, as described by Ibrahim *et al*. (1992). The height could be more than three metres depending on the supporting tree and its age. *C. populnea* is called ‘Daafaraa’ in Hausa, ‘Okoho’ in Idoma and ‘Ogbolo’ in Yoruba languages in Nigeria. In Northern Nigeria, the stem is used as a source of mucilage and the highly viscous extract is employed as thickener in local food preparation (Adebowale *et al*., 2013). There has been great interest in the medicinal application of the mucilage. Versatility of *C. populnea* in tablet binding has been evaluated (Ibrahim *et al*., 1992; Ibrahim and Dawes, 2000) and its efficacy as anti sickling material (Kone *et al*., 2004) has also been reported. In addition, the leaves of *C. populnea* have been reported to be used in tradomedical management of snake envenomation (Edo and Aguiyi, 2008).

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It is pertinent to state that the results of the past research work that were based, mainly on pharmaceutical applications of these two plants has not led to wide application and increased cultivation of these important plants; they are still grossly underutilised, especially in tropical region of Africa. In addition, there is limited information on the quantitative nutritional and anti-nutritional composition of BCL and CPL. This present work therefore reported nutritional and anti-nutritional composition as well as gum yield of the leaves of these two plants. We therefore envisaged that, the data generated from this study would be a basis that will adequately encourage an increase in their cultivation, consumption and utilization.

MATERIALS AND METHODS

Plant materials and chemical reagents

The leaves of *B. costatum* and *C. populnea* (wild) used in this study were obtained fresh in September, 2010 from farmland at Rounder and Imala respectively, both in Abeokuta North Local Government Area of Ogun State, Nigeria. Three samples were collected from three different locations in each town for each of the two plants (*B. costatum* and *C. populnea*). The leaves were rinsed with deionised water and subsequently oven-dried at 55^oC for 24 h. The dried samples were ground into fine powder using ceramic mortar and pestle and were sieved (250 µm) to obtain dried powder that was stored in air tight plastic containers at 4^oC in a refrigerator prior to analysis. Analysis of the samples commenced immediately after the sample preparation. Leaves of *B. costatum* and *C. populnea* were taken to Herbarium in the Department of Botany, Faculty of Science in the University of Ibadan, Nigeria for identification. All reagents used in the analysis were of laboratory grade. Acetic acid, hydrochloric acid, sulphuric acid, sodium chloride, Kjeldahl catalyst tablets copper were bought from Fisher Scientific (Fair Lawn, NJ, USA). Sodium carbonate, ammonium hydroxide, AGI – X8 chloride anion exchange resin were acquired from Merck (Darmstadt, Germany). Tannic acid, phenolphthalein, calcium chloride, petroleum ether, ammonium molybdate, ammonium metavanadate, tannic acid, dimethyl sulphoxide, D – (+) – Glucose, Anthrone reagent and Phenol were purchased from Sigma Aldrich (St. Louis, MO). Sulphuric acid was obtained from J.T. Baker, USA. Methyl red indicator, tributyl citrate, lysine chloride were bought from Fluka, Germany. Water was purified with a PTL, England.

Proximate analysis and sugar determination

The moisture, protein, total fat, ash and total dietary fibre in the samples were determined by the recommended methods of the Association of Official Analytical Chemists (AOAC, 1990). A certified reference material (CRM) 1570a (spinach leaves) - National Institute of Standard and Technology (NIST), Gaithersburg, MD was used for quality control. All samples and blanks were analyzed similar to procedures reported by AOAC (1990). The reducing sugar in the defatted leaf flour was determined spectrophotometrically at a wavelength of 650 nm using method of Southgate (1976). On the other hand, the total soluble sugars were determined spectrophotometrically at a wavelength of 490 nm using method of Radley (1977).

Analysis of mineral elements

Wet method was employed in the digestion of the pulverized samples (Ajayi *et al*., 2006). Atomic Absorption Spectrophotometer (Perkin-Elmer model 3110, USA) was used to determine magnesium, manganese, iron, zinc copper and calcium while concentrations of sodium and potassium were determined using Jenway Digital Flame Photometer (PFP7 Model) using the filter corresponding to each mineral element. Phosphorus was determined colorimetrically using the vanado molybdate method (AOAC, 1999, AOAC 965.17). A certified reference material (CRM) 1570a (spinach leaves) - National Institute of Standard and Technology (NIST), Gaithersburg, MD was used for quality control. All samples and blanks were analyzed similarly according to procedures reported by Ajayi *et al*. (2006).

Determination of anti-nutrients (tannin, total alkaloid, oxalates, phytate and saponin) and gum extraction

Tannin was estimated by the method of Burns (1971). The determination of total alkaloid was carried out using method of Harborne (1973). Oxalate was determined by the method of Munro and Basir (1969). Method of Latta and Eskin (1980) was employed in phytate content determination. Saponin content was determined by the method of Fenwick *et al*. (1991). Gum was extracted from the flour of the plant leaves using method of Brummer and Wang (2003) as detailed in Adebowale *et al*. (2013).

Statistical analysis

All results were reported as means of triplicate determination. T Test was conducted to compare differences between two (2) independent group means using Statistical Package for Social Science Students (SPSS, 13.0 Version).

RESULTS AND DISCUSSION

Proximate composition

The proximate composition of the flour of *Bombax costatum* leaves (BCL) and *Cissus populnea* leaves (CPL) are presented in table 1. The values of their moisture (fresh sample), protein, ash, soluble sugar and reducing sugar contents were significantly different at $P < 0.05$, while the values of the moisture (flour), total fat, dietary fibre and carbohydrate contents were not. The moisture contents of the fresh leaves - BCL (66.4 ± 0.3 g/100g) and

CPL (69.1 ± 0.3 g/100g) were lower than 82.21% in *Ipomoea batata* leaves (Antia *et al*., 2006), 88.48% in *Amaranthus hybridus* leaves (Akubugwo *et al*., 2007) and 81.40 – 90.30% reported for some Nigerian green leafy vegetables (Akubugwo *et al*., 2007).

Table 1. Proximate composition of *B. costatum* and *C. populnea* leaf flour (per 100g of sample).

Parameter	(BCL)	(CPL)
Fresh samples (wet) Moisture (g)	66.4 ± 0.3[a]	69.1 ± 0.3[b]
Flour (dry basis) Moisture (g)	8.2 ± 0.2 [a]	8.0 ± 0.3[a]
Protein (g)	18.7 ± 0.1 [a]	13.3 ± 0.1 [b]
Ash (g)	6.0 ± 0.1 [a]	11.4 ± 0.4 [b]
Total fat (g)	9.5 ± 0.5 [a]	9.6 ± 0.3 [a]
Dietary fibre (g)	9.1 ± 0.0 [a]	9.0 ± 0.0 [a]
Total Soluble & Reducing Sugars		
Total soluble sugars (g)	17.9 ± 0.0 [a]	17.6 ± 0.0 [a]
Reducing sugar (g)	6.6 ± 0.1 [a]	8.0 ± 0.0 [b]

Results are expressed as the means ± SD for three independent samples (n = 3)
[a-b] Means followed by the same letters on the same row are not significantly different (P < 0.05)
BCL: *Bombax costatum* leaves; CPL: *Cissus populnea* leaves.

The protein contents of BCL and CPL were 18.7 ± 0.1 g/100g and 13.3 ± 0.1 g/100g respectively. These values were higher than 4.60% reported for the leaves of *Momordica foecide* (Hassan and Umar, 2006) and 11.29% in *Momordica balsamia* (Ogle and Grivetti, 1985). Furthermore, the protein content in BCL was comparable with protein content of 17.92% reported for the leaves of *Amaranthus hybridus* (Akubugwo *et al*., 2007). However, the protein contents in the leaves of both plants were lower than 24.85% (*Ipomoea batata* leaves) and 31.0% (*T. triangulare* leaves) as reported by Antia *et al*. (2006) and Etuk *et al*. (1998), respectively. By and large, the protein content in these samples may enhance growth and maintenance of tissue, and will no doubt complement protein from cereals and other plant foods that are known to be low in protein in the diet of the consumers.

The ash contents recorded in BCL and CPL were 6.0 ± 0.1 g/100g and 11.4 ± 0.4 g/100g respectively. Each of these values was lower than 15.09% in *Moringa oleifera* leaves (Lockett *et al*., 2000). However, ash contents of 11.4 ± 0.4 g/100g in CPL compares favourably with 11.10% in *Ipomoea batata* leaves (Antia *et al*., 2006) and higher than 8.00% in *Hibiscus esculentus* leaves (Akindahunsi and Salawu, 2005).

BCL and CPL are rich sources of lipid with concentration of 9.5 ± 0.5 g/100g and 9.6 ± 0.3 g/100g, respectively. These values were higher than lipid content of 4.65% in *A. hybridus* leaf (Akubugwo *et al*., 2007) and 4.20% in *Calchorus africanun* leaf (Agbo, 2004). The values were however within the reported range of 8.30 – 27.00% recorded in some vegetables consumed in West Africa (Ifon and Bassir, 1980).

The dietary fibre concentrations obtained from BCL and CPL were 9.1 ± 0.0 and 9.0 ± 0.0 g/100g respectively. Each of these values was obviously higher than 6.20% in *T. triangularae* and compared favourably with concentration of 8.61% in *I. batata* (Akindahunsi and Salawu, 2005). Indeed, adequate intake of dietary fibre can lower the serum cholesterol level, risk of coronary heart disease, hypertension, constipation, diabetes, colon and breast cancer (Ishida *et al*., 2000). Based on this report, the studied plants may plausibly be of greater advantage when adequately eaten.

The carbohydrate content in the leaf flour of each of the two plants was about 50 g/100g (48.5 ± 0.9 g/100g in BCL and 48.7 ± 0.5 g/100g in CPL). These values were higher than carbohydrate contents of 20% reported for *Senna obtusfolia* (Faruq *et al*., 2002) and 39.05% in *M. balsamina* leaves (Hassan and Umar, 2006). However, each of these values was lower than the reported (Asibey – Berko and Tayie, 1999) values for *Corchorus tridens* (75.0%), *Amaranthus hybridus* (52.18%) and sweet potatoes leaves (82.80%). Moreover, the results of the sugar analysis of the leaves showed that, each of the leaves contained approximately 18 g/100g of total sugars which was slightly more than twice the concentration of the reducing sugar recorded (6.6 ± 0.1 g/100g in BCL and 8.0 ± 0.0 g/100g). The reducing sugar recorded in this study was about half the values obtained in the leaves of *V. amygdalina* (14.31 ± 0.40%), *V. calvoana* var. bitter (15.79 ± 0.14%), *V. colorata* (14.81 ± 1.53%) and *V. calvoana*, var. non bitter (13.08 ± 1.44%) as reported by Ejoh *et al*. (2007).

Mineral composition

Mineral contents of BCL and CPL are presented in table 2. Calcium was the most abundant of the minerals with concentration of 101 ± 2.5 mg/100g in BCL and 113 ± 1.6 mg/100g in CPL. These values were much higher than 44.15 mg/100g reported for *Amaranthus hybridus* leaves (Akubugwo *et al*., 2007). Phosphorus content in BCL (37.3 ± 2.0 mg/100g) and CPL (21.3 ± 0.2 mg/100g) were significantly different at P < 0.05. Obviously, BCL contained higher concentration of phosphorus when compared with CPL. Nonetheless, these values are lower than 47.3 mg/100g in *Licianthes synanthera* (chomte) leaves (Salazar *et al*., 2006). Furthermore, Akubugwo *et al*. (2007) had earlier reported phosphorus concentration of 34.91 mg/100g in *Amaranthus hybridus* leaves which was slightly lower than the value obtained in BCL. Calcium and phosphorus are associated with each other for growth and maintenance of bones, teeth and muscles (Dosumu, 1997). So, the level of calcium and phosphorus obtained in the leaves of these two plants can alleviate their deficiency in human being when they are adequately eaten.

Table 2. Mineral composition of *B. costatum* and *C. populnea* leaf - flour (mg/100g).

Parameter	Concentration (mg/100g)	
	(BCL)	(CPL)
Calcium	102 ± 2.5 [a]	113 ± 1.6 [b]
Magnesium	37.3 ± 1.4 [a]	45.7 ± 1.4 [b]
Potassium	67.9 ± 1.9 [a]	71.5 ± 1.4 [a]
Sodium	10.7 ± 0.2 [a]	17.1 ± 0.6 [b]
Manganese	4.27 ± 0.01 [a]	5.17 ± 0.01 [b]
Iron	15.2 ± 0.0 [a]	19.6 ± 0.0 [b]
Zinc	1.70 ± 0.01 [a]	2.24 ± 0.02 [b]
Copper	0.44 ± 0.02 [a]	0.60 ± 0.01 [b]
Phosphorus	37.3 ± 2.0 [a]	21.3 ± 0.2 [b]

Results are expressed as the means ± SD for three independent samples (n = 3)
[a-b] Means followed by the same letters on the same row are not significantly different (P < 0.05)
BCL: *Bombax costatum* leaves; CPL: *Cissus populnea* leaves.

The magnesium contents in the flour of BCL and CPL were 37.3 ± 1.4 mg/100g and 45.7 ± 1.4 mg/100g respectively. Each of these values was lower than 231.22 mg/100g in *A. hybridus* (Akubugwo *et al*., 2007). Magnesium is an important mineral element in connection with ischematic heart disease and calcium metabolism in bones (Ishida *et al*., 2000). Therefore, appreciable Magnesium level in these plant leaves underscore their food values. On the other hand, the potassium content recorded was higher than magnesium with concentrations of 67.9 ± 1.9 mg/100g in BCL and 71.5 ± 1.4 mg/100g in CPL. This range was higher than a value of 54.20 mg/100g in *A. hybridus* (Akubugwo *et al*., 2007). Sodium contents of the two plants were also appreciable with values of 10.7 ± 0.2 mg/100g and 17.1 ± 0.6 mg/100g in BCL and CPL respectively. The Na/K ratio in the body is of great concern for prevention of high blood pressure. Na/K less than one has been recommended (FNB, 2002). From the results of this study, the Na/K ratio less than one (< 1) was recorded in each of the plants; hence, consumption of their leaves would probably reduce high blood pressure disease. This is in addition to some other vital roles they can play in the body.

Manganese contents of 4.27 ± 0.01 mg/100g and 5.17 ± 0.01 mg/100g were obtained in BCL and CPL respectively. These values were higher than 1.51 ± 0.07mg/100g in *Liciathes synanthera* (chomte) leaves (Salazar *et al*., 2006) and lower than 16.4 mg/100g in Canola leaf greens (Miller-Cerbert *et al*., 2009). Zinc contents in BCL (1.70 ± 0.01 mg/100g) and CPL (2.24 ± 0.02 mg/100g) were significantly different at P < 0.05. These values were higher than 0.54 mg/100g in *Licianthes synanthera* (chomte) leaves as reported by Salazar *et al*. (2006) but lower than 3.0 mg/100g in Canola leaf greens (Miller – Cerbert *et al*., 2009) and 3.80 mg/100g in *Amaranthus hybridus* leaves (Akubugwo *et al*., 2007).

The Iron concentration recorded in BCL (15.2 ± 0.0 mg/100g) and CPL (19.6 ± 0.0 mg/100g) were significantly different at P < 0.05. The iron content in the leaf flour of each of the two plants studied was higher than 1.9 ± 0.05 mg/100g in *Licianthes synanthera* (chomte) leaves (Salazar *et al*., 2006) and 13.58 mg/100g in *Amaranthus hybridus* (Akubugwo *et al*., 2007). It is worthy of note that, the iron content of BCL and CPL were lower than 36.8 mg/100g in tomato leaves (certified reference material). Miller – Cerbert *et al*. (2009) has also reported iron content of 24.77 mg/100g in Canola leaf greens which was higher than the values recorded in this study. In both plant leaves, copper had the least concentration among the nine elements investigated in this study with values of 0.44 ± 0.02 mg/100g and 0.60 ± 0.01 mg/100g in BCL and CPL, respectively. Copper content in BCL was comparable with 0.38 ± 0.02 mg/100g in *Licianthes synanthera* (chomte) leaves (Salazar *et al*., 2006). The concentration of copper in CPL was twice the value of 0.30 mg/100g in Canola leaf greens in a study reported by Miller-Cerbert *et al*. (2009).

Comparison of the values of all the mineral composition in BCL and CPL indicated that, all the elements were significantly different (P < 0.05) except potassium. It implies that, apart from potassium, there is variation in the concentrations of these elements in the leaves of these plants. Basically, the soil on which these two plants were grown could have immensely contributed to the level of mineral composition obtained in their leaves.

Anti-nutritional composition

Results of the anti-nutritional composition are presented in table 3. The Values of the anti-nutrients obtained in BCL and CPL were significantly different (P < 0.05) indicating their variation in the two plants. Approximately, tannin concentration of 0.10 mg/100g was obtained in the leaves of each of the two plants. This value was lower than 0.21 ± 0.02 mg/100g in *Ipomoea batata* leaves (Antia *et al*., 2006) and 0.49 mg/100g in *Amaranthus hybridus* leaves (Akubugwo *et al*., 2007).

The alkaloid contents obtained were 4.25 ± 0.10 mg /100g in BCL and 7.18 ± 0.40 mg/100g in CPL. Each of these values was higher than 3.54 mg/100g in *Amaranthus hybridus* (Akubugwo *et al*., 2007). Alkaloids are known to play some metabolic roles and control development in living system; they also have a protective role in animal (Edeoga *et al*., 2001). However, it has been reported that, the presence of quinolizadine alkaloids in grain legumes, such as lupins (*Lupinus albinos)*, which interfere with nerve functioning, makes them unsuitable for human consumption (George *et al*., 2001). Therefore, the presence of alkaloid in samples may be of advantage to human being or could be anti-nutritional.

Table 3. Anti nutritional composition of *B. costatum* and *C. populnea* leaf - flour (mg/100g).

Parameter	(BCL)	(CPL)
Tannin	0.07 ± 0.00	0.09 ± 0.00
Alkaloid	4.25 ± 0.10 [a]	7.18 ± 0.40 [b]
Oxalate	26.3 ± 0.2 [a]	11.0 ± 0.7 [b]
Phytate	4.33 ± 0.11 [a]	1.90 ± 0.10 [b]
Saponin	1.65 ± 0.04 [a]	2.08 ± 0.10 [b]

Results are expressed as the means ± SD for three independent samples (n = 3)
[a-b] Means followed by the same letters on the same row are not significantly different ($P < 0.05$)
BCL: *Bombax costatum* leaves; CPL: *Cissus populnea* leaves.

The oxalate contents in BCL and CPL were 26.3 ± 0.2 and 11.0 ± 0.7 mg/100g, respectively. It was obvious that, BCL contains more than twice the quantity of oxalate in CPL. However, oxalate content in each sample of BCL and CPL was lower than concentration of 308.00 ± 1.04 mg/100g in *Ipomoea batata* leaves (Antia *et al*., 2006).

The phytate concentration in BCL was much higher than the value obtained in CPL. Phytate contents of 4.33 ± 0.11 mg/100g in BCL and 1.90 ± 0.10 mg/100g in CPL were each lower than 6.00 mg/100g in *Pennisetum purpureum* leaves (Okaraonye and Ikewuchi, 2008). However, the range was higher than values reported for leaves of *I. batata* (1.44 mg/100g) and *Amaranthus hybridus* (1.32 mg/100g) by Antia *et al*. (2006) and Akubugwo *et al*. (2007) respectively. Assessment of phytate contents in the studied plants is necessary because high concentration can cause adverse effects on their digestibility (Nwokolo and Bragg, 1977). Phytate forms stable complexes with Cu^{2+}, Zn^{2+}, Co^{2+}, Mn^{2+}, Fe^{2+} and Ca^{2+}. However, processing such as boiling and fermentation have been reported to reduce the phytate content of cereals, legumes and tubers (Fagbemi *et al*., 2005).

Saponin contents (mg/100g) in BCL and CPL were 1.65 ± 0.04 and 2.08 ± 0.10, respectively. The two values compared favourably with values of 1.68 mg/100g in *Amaranthus hybridus* leaves (Akubugwo *et al*., 2007) and 1.905 mg/100g in *V. calvoana* Var. non bitter (Ejoh *et al*., 2007). Some of the biological effects of saponin in animals include erythrocyte haemolysis, depressed growth, reduced feed intake and effects on nutrient absorption and bile acid metabolism (Cheeke, 1978).

Gum yield

Gum yield of the flour of the two plant leaves were 46.5 g/100g in BCL and 29.8 g/100g in CPL. The values were significantly different ($P < 0.05$) indicating that, BCL was richer in mucilage than CPL. Gum content of CPL was within the range of gum yield of 33 – 50% in seaweeds (Ruperez and Saura-Calixto, 2001) and was slightly higher than value of 40% recorded in green seaweed - *Ulva fasciata* Delile, reported by Carvaho *et al*. (2009).

CONCLUSION

Comparison of the data obtained in this study with values reported in leaves of some other plants showed that, BCL and CPL contained appreciable levels of nutrients and generally, low level of anti nutrients. Therefore, they can contribute significantly to the nutrient requirements of human being and could be used as sources of nutrients to supplement other major ones. In addition, the high gum yield makes the leaves of these plants potential sources of industrial gum with promising applications in food and pharmaceutical industries.

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