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Nutritional composition of five food trees species products used in human diet during food shortage period in Burkina Faso

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The proximate compositions, minerals and amino acids contents of *Detarium microcarpum, Gardenia erubescens, Parkia biglobosa, Adansonia digitata* pulp, seeds of *Boscia senegalensis* and leaves of *A. digitata* were studied and quantified in Burkina Faso. Using the conventional procedures described by the Association of Official Analytical Chemists, proximate analysis was done. The minerals were determined by spectrometry and photometry. The profile and total amount of amino acids were determined by reverse phase HPLC using Pico-Tag method. The results showed that the protein content were ranged from 1.10 ± 0.20 to 24.23 ± 0.15%, total carbohydrate varied from 6.7 ± 0.11 to 79.73 ± 1.69%, lipids varied from 1.11 ± 0.08 to 4.65 ± 0.12% and ash from 1.16 ± 0.1 to 11.76 ± 0.10%. These results allowed distinguishing species which are potential sources of protein, calories and micronutrients. Consumption of these tree products can help to overcome nutrients deficiency that is prevalent in poor urban and rural areas of Burkina Faso.

Key words: Food composition, nutrition, food insecure, wild trees, Burkina Faso.

INTRODUCTION

Fruits and leaves from natural forest trees constitute a good food supply for many people during food shortage in Africa (Cook et al., 2000; Kim et al., 1997; Ayessou et al., 2009) and particularly in Burkina Faso

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(Bognounou, 1978; Bergeret and Ribot, 1990; Lamien et al., 1996; Helmfrid, 1998; Thiombiano et al., 2012). In several African countries, natural tree products constitute an important part of human diets and are also an important source of income (Falconer, 1990; Shackleton et al., 1998; Ayessou et al., 2009; Lamien et al., 2009). They are excellent source of minerals and vitamins; and also contain carbohydrates in form of soluble sugars, cellulose and starch (Nahar et al., 1990; Ayessou et al., 2009; Lamien et al., 2009). Mainly crudely consumed, they improve the daily food ration as an energy source and through their content in micronutrients (Parkouda et al., 2007; Ayessou et al., 2009; Kouyaté et al., 2009). Indeed in Africa, they constitute the most affordable and dietary sources of vitamins, trace elements and other bioactive compounds. Thereby, they form common ingredients in a variety of traditional native dishes for the rural population in developing countries (Humphrey et al., 1993). Consumption of indigenous trees products is among strategies to supplement diets (Falconer, 1990; Ayessou et al., 2009; Thiombiano et al., 2012). Several tree products which play pivotal role exist but undervalued and are seasonal (Ambé, 2001; Ayessou et al., 2009). Studies identified some of these food tree species (Arbonnier, 2004; Lamien et al., 2009; Thiombiano et al., 2012) and initiated studies of their nutritional potential (Glew et al., 1997; Parkouda et al., 2007; Ayessou et al., 2009; Kouyaté et al., 2009; Compaoré et al., 2011). However, most of these products have received little research attention, particularly their nutritional compositions. Their contribution to local diets is less understood and quantified. Therefore, the study was done to determine the proximate composition, minerals and amino acids content of five top wild trees products consumed during food shortage by rural population in Burkina Faso.

MATERIALS AND METHODS

Sampling

Samples were taken from edible parts of *Detarium microcarpum*, *Gardenia erubescens*, *Parkia biglobosa*, *Adansonia digitata*, *Lannea microcarpa* and *Vitellaria paradoxa* fruit pulp, *Boscia senegalensis* seeds and from *A. digitata* leaves. Fruits, seeds and leaves were collected from different localities in Burkina Faso including Noumoudara (10 ° 58'60'' N, 4 ° 24'W), Sakoinsé (12 ° 11'N, 1 ° 57'W), Pobé-Mengao (14 ° 3'N, 1 ° 32'W), Kokologho (12 ° 11'N, 1 ° 53'W), Saria (12 ° 16'N, 2 ° 9'W), Tanghin-Dassouri (12 ° 16'10'''N, 1 ° 42'55'' W) and Boulbi (12 ° 14'16'' N, 1 ° 31'33'W). Fruits which are directly consumed without any transformation were directly collected in trees. The products which need transformation and conservation were collected in household in order to identify their effective nutritional value. The fruits of *L. microcarpa*, *G. erubescens*, *V. paradoxa* were collected directly from trees in their predilection area. For each product (fruits, pulp, seed and leaves), three samples from three different trees were collected. The fruits of *D. microcarpum* and *A. digitata* and the pulp of *P. biglobosa* were collected in three households for each. Edible parts of samples were separated and ground using a porcelain mortar and packed in opaque plastic bags in laboratory. Packed samples were kept in cool temperature until required successively for analysis.

Proximate composition

Proximate analysis of samples was conducted using the conventional procedures described by the Association of Official Analytical Chemists (AOAC, 2005): Dry matter by drying at 105°C overnight, ash by incineration at 550°C for 12 h, crude protein (N × 6.25) by the Kjeldahl method and crude fat content by Soxhlet extraction using n-hexane. Metabolizable energy values (kcal/100 g) were calculated by multiplying the grams of protein, fat, and carbohydrate by the factors of 4, 9, and 4 kcal/ g, respectively. The pH was established using HANNA pH-meter (Hanna HI 991300) at 25°C. Titrable acidity was determined by titrating 2.0 g of samples in 100 ml of water with 0.1 M NaOH using phenolphthalein as the indicator and was calculated as percentage citric acid. The total sugars were measured according to the sulfuric orcinol method as described by Montreuil and Spik (1969).

Mineral content

Mineral elements of the samples were determined according to procedures described by Walinga et al. (1989). The sample (1 g) was digested with 4 ml of a mixture (ratio 7:1) of perchloric acid ($HClO_4$, 60%) concentrated sulfuric acid and 15 ml of concentrated nitric acid. After complete digestion, the product was cooled, filtered and the volume adjusted to 50 ml. For determination of calcium, 0.2 ml of the filtered solution was diluted with 4.8 ml of lanthane (La_2O_3, 1%). For the other minerals, the dilutions were made with distilled water. Potassium was measured using a flame photometer (Corning 400, Essex, England); phosphorus was determined with a Skalar auto analyzer (Skalar, Breda, The Netherlands) and all other minerals with an atomic absorption spectrophotometer (Perkin Elmer Analyst 100).

Amino acids

The profile and the amount of total amino acids were determined by reverse phase HPLC, using the Pico-Tag system described by Bidlingmeyer et al. (1984). Samples were first defatted and hydrolyzed. For hydrolysis, 0.4 g of defatted sample placed in a flask and 15 ml of 6 M HCl added and the whole placed in an oven at 110°C for overnight. The sample are subsequently cooled to room temperature and transferred to a 50 ml volumetric flask and filled with Milli-Q water. Approximately, 1 ml of the diluted solution is homogenized and filtered through a filter of 0.45 µm. An aliquot of 10 µl of the solution is placed in reaction tube and dried for 15 min with the Picotag Workstation. The sample was then re-dissolved in 10 µl of re-drying solution (ethanol: water: triethylamine, 2:2:1 volume). They were dried again for 15 min and finally derivatized with 20 µl phenylisothiocyanate reagent (ethanol: water: triethylamine: phenylisothiocyanate, 7:1:1:1) for 20 min at room temperature. Excess reagent was removed with the aid of vacuum for 45 min in Pico-Tag Workstation. Derivatized samples were dissolved in 100 µl PicoTag Sample diluent solution (WAT088119). Analysis (identification and quantification) of amino acids performed using a Waters C18 column under the conditions described by Bidlingmeyer et al. (1984).

Briefly, 40 µl of aliquot was injected onto the column. Quantitation of amino acids was performed using a Waters C18 column (3.9 × 150 mm) with gradient conditions as described elsewhere. Derivatized amino acids were eluted from the column with increasing concentrations of acetonitrile. The eluate was monitored at 254 nm and the areas under the peaks were used to calculate the concen-

Table 1. Proximate composition (g/100 g DM) and energy value (Kcal/100 g DM) of dried products of tree species.

Trees specie	Analyses					
	Dry Matter	Ash	Protein	Lipid	Carbohydrate	Energy
Detarium microcarpum (pulp)	95.07±0.1[a]	3.26±0.01[d]	4.65±0.10[c]	1.70±0.01[c]	74.65±0.01[b]	335.5
Boscia senegalensis (seeds)	92.54±0.0[c]	1.16±0.10[f]	24.23±0.1[a]	1.11±0.08[d]	45.29±1.39[e]	288.07
Adansonia digitata (pulp)	91.31±0.14[d]	5.27±0.01[b]	2.00±0.01[e]	1.55±0.40[bdc]	72.30±0.52[c]	311.15
Adansonia digitata (leaves)	93.02±0.8[b]	11.76±0.1[a]	14.80±0.6[b]	4.65±0.12[a]	57.04±1.59[d]	329.21
Gardenia erubescens (pulp)	23.7±0.80[f]	2.54±0.08[e]	1.10±0.20[f]	1.19±0.01[d]	6.70±0.11[f]	41.9
Parkia biglobosa (pulp)	90.06±0.1[e]	4.98±0.01[c]	3.78±0.01[d]	1.99±0.05[b]	79.73±1.69[a]	351.95

Values are Mean ± Standard Deviation for at least 3 samples in triplicate. Values with different letters in the same column are significantly different at $P < 0.05$.

Table 2. Physical parameters of aqueous fruit pulp.

Parameter	*Lannea microcarpa*	*Vitellaria paradoxa*	*Boscia senegalensis*
Acidity (% citric acid equivalent)	0.45± 0.03[a]	0.17± 0.01[b]	1.29±0.03[c]
pH	4.60 ± 0.05[a]	5.85 ± 0.01[b]	2.78±0.02[c]
Degree Brix (°Brix)	23.8±3.7[a]	30.5±1.7[b]	22.58±0.15[a]

Values are Mean ± Standard Deviation for at least 6 samples in duplicate. Values with different letters in the same row are significantly different at $P < 0.05$.

Table 3. Minerals content of samples.

Trees specie	Ca	Mg	K	P	Mn	Fe	Zn	Cu
	Kg DM				Mg/Kg DM			
Parkia biglobosa (pulp)	1.61[a]	1.57[a]	19.24[a]	1.02[a]	96.99[a]	88.83[a]	17.40[a]	3.78[a]
Adansonia digitata (pulp)	2.49[b]	1.48[a]	22.01[b]	0.45[b]	11.79[b]	65.53[b]	19.36[b]	5.16[b]
Adansonia digitata (leaves)	14.34[c]	4.14[b]	16.75[c]	0.37[b]	95.44[a]	401.98[c]	12.22[c]	5.36[c]
Boscia senegalensis (seeds)	0.44[d]	0.08[c]	4.45[d]	1.20[a]	9.59[c]	826.97[d]	25.98[d]	4.32[a]
Detarium microcarpum (pulp)	1.06[e]	0.98[d]	28.80[e]	0.63[c]	39.65[d]	100.72[e]	16.79[a]	3.29[a]
Lannea microcarpa (pulp)	3.56[f]	2.38[e]	11.73[f]	0.30[b]	9.07[c]	91.61[a]	10.57[e]	5.13[b]
Vitellaria paradoxa (pulp)	2.33[b]	0.94[d]	11.73[f]	0.16[d]	3.68[d]	88.10[a]	5.75[f]	2.93[a]

Values are Means for at least 3 samples in triplicate. Values with different letters in the same row are significantly different at $P < 0.05$.

trations of the unknowns using a Pierce Standard H amino acid calibration mixture (Rockford, IL).

Data analysis

Data were computed in Excel and analyzed with XLSTAT version 7.5.2. Statistical analysis was focused on principal component analysis (PCA) and analysis of variance (ANOVA). These analysis were performed with the software "XLSTAT Version 7.5.2" with a risk of error p = 5%.

RESULTS

The proximate composition and Energy value, Physical parameters of aqueous fruit pulp, mineral content and amino acid profile of the sample are shown in Table 1, 2, 3 and 4, respectively. The total carbohydrates content of products ranged from 6.7±0.11 to 79.73±1.69 (Table 1). The lowest value of total carbohydrates was found in *G. erubescens* fruit pulp while the pulp of *P. biglobosa* had shown the highest content. The pulp of *P. biglobosa* (79.73±1.69), *A. digitata* (72.3±0.52) and *D. microcarpum* (74.65±0.01) had the highest content compared to other samples. The leaves of *A. digitata* shown the highest content of lipids (4.65±0.12), while the seeds of *B. senegalensis* shown the lowest content (1.11±0.08). The results of the present study (Table 3) revealed that the studied products are good source of minerals. The amino acids content of *A. digitata* leaves and *B. senegalensis*

Table 4. Amino acids profiles of *Adansonia digitata* leaves and *Boscia senegalensis* seeds (mg/g of proteins).

Amino acid (Mg/g protein)	Seeds of *B. senegalensis*	Leaves of *A. digitata*
Asp	31.03 ± 7.79	24.90 ± 3.61
Glu	33.67 ± 8.36	24.90 ± 3.61
Ser	15.90 ± 3.47	10.27 ± 1.80
Gly	12.47 ± 3.78	11.67 ± 1.14
His	5.27 ± 1.15	5.80 ± 1.97
Arg	43.50 ± 12.24	14.67 ± 1.89
Thr	7.97 ± 1.76	10.27 ± 1.80
Ala	11.37 ± 2.06	14.67 ± 1.89
Pro	42.03 ± 12.62	31.13 ± 4.44
Tyr	7.97 ± 1.76	8.93 ± 1.29
Val	14.37 ± 4.88	11.63 ± 1.10
Met	2.63 ± 0.58	4.47 ± 0.64
Cys	2.63 ± 0.58	-
Ile	7.97 ± 1.76	8.93 ± 1.29
Leu	21.23 ± 5.25	14.67 ± 1.89
Phe	15.17 ± 4.37	11.63 ± 1.10
Lys	7.97 ± 1.76	11.63 ± 1.10

seeds are reported in the Table 4.

DISCUSSION

Proximate composition and energy value of the food tree species

In general, variability in the chemical content are reported to be dependent on soil (habitat), climatic variations, genetic factors, maturity and the storage conditions of the samples as reported elsewhere by Chadare et al. (2009); Diop et al. (2005); Osman (2004). The ash content of the pulp of *A. digitata* in a current study is similar with the 4.97±0.02 reported by Compaoré et al. (2011) in an earlier study in Burkina Faso. For the pulp of *P. biglobosa*, the value found was similar to the value reported by Compaoré et al. (2011). The ash content of the fruits of *D. microcarpum* is fairly similar to 3.04 to 3.1 reported by Parkouda et al. (2007). For *G. erubescens,* the ash content (2.54±0.08) found was lower than that of the value (3.69-4.56) reported by Parkouda et al. (2007). The leaves of *A. digitata* had ash content (11.76±0.1) between the values of 8 and 16 g/100 g reported by Diop et al. (2005).

Statistically, the protein content of the products analyzed was significantly different. Among the studied products, *A. digitata* leaves and *B. senegalensis* seeds had good level of protein (Table 1) and *B. senagalensis* seeds can be considered as potential source of protein. The leaves of *A. digitata* protein content is similar to that value (10.3 to 15 g/100 g) reported by Diop et al. (2005) but higher than the value (10.3 g/100 g) found in an earlier study in Burkina Faso by Glew et al. (1997). The pulp of *A. digitata* has protein content lower than that of the value (5.23±0.03) reported by Compaoré et al. (2011). The protein content of *P. biglobosa* pulp was similar to the result reported by Parkouda et al. (2007) and lower than the value (5.37±0.07) reported by Compaoré et al. (2011). The *B. senegalensis* seeds proteins content is higher than the value (20.62) reported by Parkouda et al. (2007). The protein content of *D. microcarpum* fruits pulp are similar to the value reported by Kouyaté et al. (2009) but higher than the value (2.86) found earlier in Burkina Faso by Parkouda et al. (2007). As shown in Table 1, the lipids content ranged between 1.11±0.08 to 4.65±0.12 with the *B. senegalensis* seeds having the lowest value while the leaves of *A. digitata* had the highest content. Apart from *A. digitata* leaves, all the samples had fairly similar content of lipids. The *P. biglobosa* and *A. digitata* pulps lipids content are similar to the results reported earlier by Compaoré et al. (2011). *D. microcarpum* and *G. erubescens* pulp had lipid levels about ten times higher than previous study (Parkouda et al., 2007) who reported value of 0.1%. Lipid content of *B. senegalensis* seeds is similar to the previous reported by Parkouda et al. (2007) but lower than the value (3.7±0.8 g/100 g) reported in *B. senegalensis* seeds study in Niger by Kim et al. (1997). The leaves of *A. digitata* have a fat content between the values (2.3 to 10 g/100 g) reported by Diop et al. (2005).

The pulp of *P. biglobosa* and *A. digitata* from this study had higher levels than those reported by Compaoré et al. (2011) who found respectively 67.66±0.05 and 67.8±2.1. The pulp of *D. microcarpum* and *G. erubescens* had total carbohydrates content lower than those reported by Parkouda et al. (2007) while the *B. senegalensis* seeds had total carbohydrates content similar to that found by Parkouda et al. (2007). The total carbohydrates content of the *A. digitata* leave found (57.04±1.59) between the values (13.8 to 70) reported by Diop et al. (2005). The value of calculated metabolizable energy was comprised between 41.9 to 351.9 kcal/100 g. The metabolizable energy found in *A. digitata* pulp is lower than the value (320.3±4.4 kcal/100 g) reported by Osman (2004)

Physical parameters of aqueous fruit pulp

The most acidic was *S. senegalensis* and this may be responsible for the sour taste of this pulpy fruit. The low level of acidity in the *V. paradoxa* pulp can be explained by the fact that they do not contain enough free organic acids. Organic acids play an important role in the sensorial quality of product because the flavor is essentially a balance between sugar content and acidity (Neta et al., 2007). Indeed sugars and organic acids are two parameters used as indicators of maturity or ripeness of the fruit

(Mahmood et al., 2012).

Mineral content of food tree species

The wide differences found in the chemical content of the current study can be attributed to soil (habitat), climatic variations, genetic factors, maturity and the storage conditions of the samples as reported by Chadare et al. (2009); Diop et al. (2005); Osman (2004). The pulp of *A. digitata* and *P. biglobosa* had higher levels of manganese compared to the report of Compaoré et al. (2011) who reported 0.6 and 78.5 mg/kg, respectively. The manganese content of the leaves of *A. digitata* is higher than the value 31 to 89 mg/kg and 31 mg/kg, respectively, reported by Diop et al. (2005); Glew et al. (1997). The iron content of the *A. digitata* pulp and *P. biglobosa* pulp are lower than those (149 mg/kg and 1030 mg/kg) respectively reported by Compaoré et al. (2011). The Iron content of the leaves of *A. digitata* was between the values (150 to 490 mg/kg) reported by Diop et al. (2005). The iron content of *V. paradoxa* pulp and *D. microcarpum* pulp are higher than those reported by Parkouda et al. (2007) respectively 45.8 and 61.5 mg/kg. The iron content of seeds of *B. senegalensis* was much higher that the values of 31.2 and 44.1 to 61.1 mg/kg reported respectively by Parkouda et al. (2007); Kim et al. (1997). This difference may be due to the processing methods applied by processors before storage; indeed collected seeds are generally extracted exhaustively with water to remove bitter components and possible toxic substances (Kim et al., 1997).

The zinc content of the leaves of *A. digitata* is lower than that reported by Glew et al. (1997); Diop et al. (2005) who found respectively 18.7 and 19 mg/kg. The pulp of *P. biglobosa* had a zinc content lower than that of (30.1 mg/kg) reported by Compaoré et al. (2011) while the zinc content of *A. digitata* was higher than that of the value (15.4 mg/kg) reported by Compaoré et al. (2011) and 18 mg/kg reported by Osman (2004). The zinc content of seeds of *B. senegalensis* and pulp of *V. paradoxa* are lower than those reported by Parkouda et al. (2007) respectively 33.5 and 22.3 mg/kg. The pulp of *A. digitata* and *P. biglobosa* had copper contents much lower than those values (67.3 and 252 mg/kg) reported by Compaoré et al. (2011). Osman (2004) reported value of 18 mg/kg for the *A. digitata* pulp. The copper content of the leaves of *A. digitata* was between the value (1 to 12 mg/kg) reported by Diop et al. (2005). The calcium content of *P. biglobosa* pulp are similar to the value (1.1 g/kg) reported by Compaoré et al. (2011). The calcium content (2.49 g/kg) of the pulp of *A. digitata* is similar to the value (2.9 g/kg) reported by Osman (2004) but lower than the values (3.1 g/kg) reported by Compaoré et al. (2011). For the leaves of *A. digitata* the value found (14.34 g/kg) is comprised between the values (3.1 to 40.2 g/kg) reported by Diop et al. (2005). The calcium content of *B. senegalensis* seeds was similar to the values (0.17 to 0.5 g/kg) found by Kim et al. (1997).

The *A. digitata* pulp had value (1.48 g/kg) similar to the value (1.55 g/kg) reported by Compaoré et al. (2011) but lower than the value (2.1 g/kg) reported by Glew et al. (1997) and higher than the value (0.9 g/kg) reported by Osman (2004). For the leaves of *A. digitata* the content is between the values (3.1 to 5.5 g/kg) reported by Diop et al. (2005). The magnesium content of seeds of *B. senegalensis* (0.08 g/kg) is lower than the value (0.6 g/kg) reported by Parkouda et al. (2007). The seeds of *B. senegalensis* showed a value 4.45 g/kg which is lower than the value (5.0 to 8.9 g/kg) found by Kim et al. (1997). The potassium content of the leaves of *A. digitata* is similar to that reported by Diop et al. (2005). The pulp of *A. digitata* and *P. biglobosa* had potassium contents higher than values reported by Compaoré et al. (2011). Earlier study in Saudi Arabia, Osman (2004) reported potassium value of 12.4 g/kg for *A. digitata* pulp. The pulp of *A. digitata* and *P. biglobosa* have phosphorus levels lower than those reported by Compaoré et al. (2011). The leaves of *A. digitata* phosphorus content was between the values (0.3 to 6.7 g/kg) reported by Diop et al. (2005).

As reported by Elinge et al. (2012), minerals contribute to diverse functions of human body such as blood pressure, fluid balance and blood volume regulation (sodium); nutrients passage through cell walls and muscle contraction (calcium); releasing of parathyroid hormone and tissue respiration (magnesium); buffering of the human body fluid for metabolism and facilitation of the nutrient crossing other cell membrane (phosphorus); formation of blood and transfer of oxygen and carbon dioxide from one tissue to another (iron); important role in all mental functions and transfer of oxygen from lungs to cells (manganese); boosting the health of hair and playing sensorial such as ability to tastes, sense and smell (zinc). Based on the results obtained, these products consumed during the shortage periods have potential to contribute to alleviate the malnutrition during this period if they are available in quantity and quality.

Amino acids of *A. digitata* leaves and *B. senegalensis* seeds

The results showed that the leaves of *A. digitata* and seeds of *B. senegalensis* had a good profile of amino acids. However, cysteine is the limiting amino acid in the leaves of *A. digitata*. The values of the amino acids obtained from the leaves of *A. digitata* in a current study are higher than those reported by Glew et *al.* (1997).

Conclusion

The present study distinguished some wild tree species which can be used as source of protein (seeds of *B.*

senegalensis), as a source of metabolizable energy (*D. microcarpum*, pulp of *P. biglobosa* and *A. digitata*) or minerals. Nutritionally, these products could contribute positively to the minerals intake. Most of the minerals determined are essential elements for normal body functioning. During food shortage period, consumption of these products will help to overcome nutrients deficiency in urban and rural areas.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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