British Journal of Applied Science & Technology
4(32): 4566-4574, 2014
ISSN: 2231-0843

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Chemical Analysis of Some Wild Underutilized Mucilaginous Vegetables and a Domesticated Vegetable in Benue State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author STU designed the study and wrote the protocol. Author RLT wrote the first draft of the manuscript and managed the literature searches. Authors BAO and QMA managed the laboratory analyses of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2014/12241
Editor(s):
(1) Rui Xiao, School of Energy and Environment, Southeast University, China.
Reviewers:
(1) Anonymous, University of Prihshtina, Kosova.
(2) Charalampos Proestos, Chemistry, National and Kapodistrian University of Athens, Greece.
(3) Dequan Sun, South Subtropical Crop Research Institute, Chinese Academy of Tropical Agricultural Sciences, China.
Peer review History: http://www.sciencedomain.org/review-history.php?iid=659&id=5&aid=6109

Original Research Article

Received 24th June 2014
Accepted 7th August 2014
Published 16th September 2014

ABSTRACT

The chemical analyses of the vegetables; *Abelmoschus esculentus, Ceiba pentandra, Cissus populnea* and *Corchorus oliterious* were investigated to evaluate their nutritional potentials. The edible parts of the fresh and dried vegetables were pretreated and analysed for moisture, ash, crude; fibre, fat and protein as well as carbohydrate content while their energy values were estimated using standard methods. In addition, the mineral content was also evaluated using Atomic Absorption Spectrophotometric technique. The result indicated the following range for nutrients in fresh samples; moisture content

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(86.0to 67.97)%; ash content (2.58 to 0.74)%; crude fibre (15.60 to 2.17)%; crude protein: (0.01 to 0.39)% and carbohydrate (2.53 to 20.90) %. For dried samples the nutrient content in the same order ranges from (17.83 t0 10.39)%; (11.44 to 15.60)%; (39.95 to 25.54)%; (0.04 to 1.37)% and (30.84 to 53.71)% respectively. The energy values ranges from (46.2 to 325.5) kJ/100g and (531.9 to 864.4) kJ/100g in fresh and dried samples respectively. Magnesium was the predominant mineral element among those evaluated while Mn, Ni, Cd, Pb, Zn and Cu were found to be present in relatively low amounts with no clear trend. The wild vegetables were found to be of good nutritional quality having met most of the requirements of regulatory agencies. The values obtained in this study are also in agreement with other studies on vegetables and thus can serve as a source of nutrition therapy for people with certain ailments.

Keywords: Vegetables; proximate; mineral; analyses; energy value; mucilaginous; nutrient; benue state.

1. INTRODUCTION

Certain health challenges; hypertension, diabetes, high cholesterol levels can be reasonably controlled by eating the right kinds of foods. Vegetables make a major group of four kinds of foods regarded as health foods used in nutrition therapy. They may be considered as free foods which are harmless even when they form a large chunk of our daily diet. Furthermore, they are low in saturated fats, trans fats, cholesterol, and have substantial amounts of fibre, vitamins, mineral nutrients; potassium, magnesium and calcium. A diet rich in vegetables can be useful in reducing calories and can be substituted for sweets, pork and whole milk products.

Many native vegetables which may equally savage dietary requirements for managing health challenges are collected from the feral [1]. These non-cultivated plants are utilized in many rural tropical communities for food, fibre, building materials, medicine and several other uses [2]. This wild range of leafy vegetables, roots, tubers, fruits and stems are harvested by rural communities because of their taste, cultural uses, as food supplements or to tide over food shortage [3]. Often referred to as famine or hunger food, wild plants have been acknowledged to be prospective in meeting household food and income security [4,5]. Wild plants become extremely important during certain seasons of the year. Most of them are more available during the dry season when shortage of the commercial vegetable and food condiments runs short of supply.

Okorie and Abiara [6] have reported that most of the indigenous edible plants which could be used as food thickeners and gums in Nigeria and other West African countries have been neglected and have remained relatively unknown and under-utilized.The highly mucilaginous (a thick, gluey substance produced by polar glycol protein) enables them to serve a dual purpose; as thickening agents for dishes and as vegetables [7].

Cissus populnea (‘Okoho’ or ‘Ager’) is a plant which belongs to the family of Vitaceae or Amphidanceae [8]. It is a dicotyledonous shrub and a woody climber which can reach a height of three (3) meters or more based on its age and the height of the supporting tree [9]. All parts of the plant exude mucilaginous substance that has been in use in Northern Nigeria especially by the Tiv, Idoma and Igala people in Benue and Kogi States respectively as a thickener in the local preparation of soup [8,9]. Gum exudates are mainly obtained from the stem and root of the plant. Young tender leaves are equally mucilaginous and serve as soup thickeners and vegetables [8]. *Corchorus olitorius "L".,* a wild shrub which belongs to the family Tiliaceae, is another plant which exudes mucilage and is consumed as vegetable [10]. Commonly known as wild okra, 'ewedu' (in Yoruba) and 'Atiever' (in Tiv) in Nigeria, is widely consumed in rural communities of Africa [11]. *Ceiba pentandra* commonly called kapok or silk cotton and locally called 'Vambe' by the Tiv tribe in Benue State, Nigeria is another wild vegetable which is consumed in tropical countries [12]. It equally has mucilage and the leaves are consumed as a delicacy during the dry seasons in Middle belt, Nigeria. It belongs to the family *malvaceae* previously separated from the family *Bombacaceae* [13]. *Abelmoschus esculentus "*L*"* also belong to this category of mucilaginous vegetables. Commonly known as okra or okro, is well cultivated domestically.

The nutritional and medicinal uses of these wild vegetables have been reported by several authors. *Cissus populnea* is a plant associated with multitude of medical uses in many countries across the globe. The gum obtained from it has been evaluated for its potential use as a dispersant in pharmaceutical liquid system. It is also widely used as a therapy for the treatment of veneral diseases and ingestion as drug binder. Its extracts have been credited with antibacterial properties; its use to abate hypertension; as a fertility enhancer in males and anti-sickling Nigerian formula [8,10]. *Corchorus olitorius* has been reported to contain high iron and folate content which have been proven positive in the preclusion of anemia [11]. Earlier reports by Zankaria et al. [14] have claimed that *Corchorus olitorius* is useful in the treatment of gonorrhea, chronic cystisis, pain, fever and cancerous tumors. Medicinal uses of wild *Ceiba pentandra* by rural dwellers have been reported in different parts of sub-Saharan Africa. The mucilage from mature leaves have been utilized as a sedative in Gabon and is used in Ivory Coast to eject foreign bodies from the eyes [15]. In Kano-Nigeria, it is used for healing and dressing of sores; whitlows in Congo and massage with leaf- pulp are considered as outstanding measures for the treatment of evening fever especially those presumed to have arisen from evil spirit [16]. *Abelmoschus esculentus* (Okra) has found its use in medicine as a plasma replacement and blood volume expander [17].

It is noteworthy that these wild vegetables are of rich nutritional value and tend to compliment the medical requirement of the body. They are rich sources of carbohydrates which are present in the form of mucilage [18], food fibre and very good source of macro and micro mineral elements required for body metabolism. Interestingly, these wild vegetables are not considered in the core of nutritional sources of people in the study area. The work was carried out to evaluate the chemical composition of three wild underutilized mucilaginous and one cultivated domestic vegetables.

2. MATERIALS AND METHODS

2.1 Sample Collection

Fresh tender leaves of *Ceiba pentandra*, *Corchorus olitorious,* fresh stem of *Cissus populnea* and fresh fruits of *Abelmoscus esculentus* were purchased from local markets; Wurukum, Modern, High-level, Wadata markets in Makurdi and Oturkpo Market all in Benue State. The samples were identified and authenticated by a botanist in the Department of Biological Sciences, Faculty of Science, Benue State University Makurdi-Nigeria. The samples were then taken to the laboratory and stored in a refrigerator.

2.2 Sample Preparation

Each of the fresh samples was divided into two parts. One part was further chopped into smaller pieces and grounded with mortar and pestle and were used as fresh samples for proximate analysis and mineral analysis. The other part was air dried and reduced into fine powder using laboratory mortar and pestle and subsequently sieved.

2.3 Proximate, Mineral Analysis and Energy Values of the Vegetable Samples

The proximate composition (moisture, ash, crude fats, protein, crude fibre) of the vegetable samples were determined by the standard method described by AOAC [19] and ASEAN Manual of Food Analysis [20] while the carbohydrate content was determined by difference method [100 – (crude protein + crude fats + crude fibre + moisture + ash)]. The moisture content was determined by weight loss method after oven-drying 105ºC. Ash content was also determined by the weight loss method after the incineration of each sample in a muffle furnace at 550ºC for three hours. Crude fat determination was achieved after extracting the samples thoroughly with AnaLAR grade petroleum ether. The amount of crude fibre in the samples was estimated from the loss in weight of the crucible after the defatted samples extracted with 10% sulphuric acid and 10% sodium hydroxide were oven dried. The crude protein in the samples was determined by the Kjeldahl method (Cole Parmer D-34530-10). The nitrogen value was multiplied by a factor of 6.25 to obtain the percentage crude protein.

The mineral content of the fresh and dried samples (Mg, Mn, K, Na, Ni, Cd, Pb, Zn and Cu) were measured using an Atomic Absorption Spectrophotometer (PG 990) after digestion with nitric acid. All the samples were analyzed in triplicate and the mean value obtained.

The energy value of the vegetable samples was estimated from their protein, fat and carbohydrate content using energy conversion factors provided by Food and Agricultural Organization (FAO) [21].

3. RESULTS AND DISCUSSION

3.1 Results

The results of proximate composition and mineral content of the studied mucilaginous vegetables are presented in Tables 1 and 2. In the fresh samples, moisture content ranged from 86.0 to 67.97% with the highest and lowest values occurring in *A. esculentus* and *C. populnea* and a similar trend in the dried samples (17.83 to 10.39%). The highest amount of ash content in both fresh and dried samples was found in *C. olitorious* (2.58 and 11.44%) while the lowest amount in the fresh samples was found in *A. esculentus* (0.74%) and (5.59%) in the dried samples. *C. pentandra* recorded the highest amount of crude fibre (15.60%) while the in the dried samples, the highest amount of crude fibre was recorded in the leaves of *C. olitorious* (39.95%). The fat content of all the vegetables was generally low for both fresh and dried samples with values ranging from 0.13% to 1.46% in the fresh samples and 1.67% to 1.84% in the dried samples. Similarly the protein content of the samples was very low with values ranging from 0.39 to 0.01% the fresh samples and 1.37 to 0.04% in the dried samples. The protein content of *C. poplunea* was consistently lowest for both fresh and dried samples. There was also a consistency in the carbohydrate content of *C. populnea* recording the highest amount of carbohydrate (20.90 and 53.71)% for fresh and dried samples. The energy value of the studied vegetable samples in kJ/100g was in the range of 0.365 to 0.054 and 0.970 to 0.601 for fresh and dries samples which was in the order *C. populnea* > *C. olitorious* > *A. esculentus* > *C. pentandra* for fresh samples and *C. populnea* > *C. pentandra* > *C. olitorious* > *A. esculentus* for the dried samples. The energy value of the vegetable samples was in the range of 46.2kJ/100g to 325.5kJ/100g for the fresh samples while the energy value of the dried samples ranged from 531.9kJ/100g to 864.4kJ/100g. *C. populnea* accounted for the highest energy value in both fresh and dried samples. Also, the dried samples of the wild mucilaginous vegetables had higher energy value in comparison with the domesticated *A. esculentus*. Statistical analyses of variance showed no significant difference in the proximate composition of fresh and dry samples with *F-calculated* values of 0.31 and 0.17 which was less than the F- critical values of 3.01 at 0.05 level of significance.

The mineral elements studied in the fresh and dried samples showed that magnesium was predominant in all the samples. The other elements were relatively low with no clear trend for all the samples. The highest amount of Mg was recorded in *C. pentandra* for both fresh and dried samples (71.84 and 1557.31) mg/100g respectively. Mn was recorded in the range of 4.21 to 0.49mg/100g and 11.13 to 73.12mg/100g for fresh and dried samples. The presence of potassium and sodium was not detected in the studied samples using atomic adsorption spectrophotometer. Ni was recorded in all the samples in the range of 0.16 to 1.11mg/100g in fresh samples and 3.62 to 2.15mg/100g in the dried samples. Cd was not detected in *C. pentendra* but its presence was found in the other samples in the range of 0.06 to 0.45mg/100g in fresh samples and 0.62 to 1.51mg/100g in dried samples. The presence of Pb in the fresh samples was found only in *C. populnea* (0.54mg/100g). However, its presence was in the range of 1.95 to 5.24mg/100g in the dried samples with *C. populnea* recording the highest amount. Aside magnesium and manganese, the amount of zinc content of the studied vegetable sample was also appreciable. Its content was in the range of 0.54 to 0.75mg/100g in the fresh samples and 1.71 to 9.29mg/100g in the dried samples with *C. populnea* recording the least concentration of zinc in both cases. The presence of Cu was not detected in the fresh samples of *A. esculentus.* However, Cu was found in the range of 0.11 to 0.18 mg/100g in other fresh samples and 0.39 to 3.3mg/100g in the dry samples. Similarly, statistical analyses of variance showed no significant difference in the mineral composition of fresh and dry samples with F-calculated values of 0.24 and 0.55 which was less than the F- critical values of 3.01 at 0.05 level of significance.

3.2 Discussion

Vegetables provide good source of nutrients and supplements for food especially as the challenges of food scarcity are on the increase in developing nations. The amount of food nutrients and mineral composition was increased upon drying as shown in Tables 1 and 2. This increase is attributed to the concentration of the nutrients upon drying which reduces the moisture content of the vegetables. The values of moisture content in the studied vegetables was high in the fresh samples with all the mucilaginous vegetables having their moisture content within the 60 to 83g/100g recommended by Food and Agricultural Organization(FAO) for vegetables and fruits [22]. Fresh fruits of *A. esculentus* had its moisture content above this range. However, the moisture content of *A. esculentus* was lower than the range of 87.5 to 90.15% reported by Adetuyi et al. [23] for local varieties in western Nigeria. High moisture increases perishability as the vegetables become more susceptible to microbial degradation [24]. Ash content is a measure of the elemental constituents in a sample. The high ash content of *C. olitorious* indicates that it will be a good source of mineral nutrient. Ash content of *C. olitorious* and *C. populnea* in the present study is lower than the 18.38% and 12.97% reported by Idris*et al* and Agbo et al. [25,26]. The ash content of *A. esculentus* is in agreement with the 7.19 to 9.16% reported by Adetuyi et al. [23]. While the ash content of *C. pentandra* leaves is above the 7.54% reported by Friday et al*.* [27] for dried samples.

Table 1. Proximate composition of the studied mucilaginous vegetables

Parameter (%)	*Abelmoschus esculentus* (fruits)		*Ceiba pentandra* (leaves)		*Cissus populnea* (stem)		*Corchorus olitorious* (leaves)	
	Fresh	**Dried**	**Fresh**	**Dried**	**Fresh**	**Dried**	**Fresh**	**Dried**
Moisture	86.00±0.79	17.83±0.01	79.99±0.89	13.76±0.68	67.97±0.01	10.39±0.01	77.00±1.98	13.92±0.06
Ash Content	0.74±0.05	9.87±0.40	1.48±0.60	10.24±0.39	1.64±0.00	5.59±0.00	2.58±0.04	11.44±0.18
Crude Fibre	2.35±0.14	38.43±2.97	15.60±0.00	25.54±0 .49	9.08±0.02	28.45±0.01	2.17±0.24	39.95±0.64
Crude Fat	0.24±0.01	1.67±0.64	0.13±0.14	1.84±0.00	0 .40±0.03	1.82±0.04	1.46±0.45	1.73±0.01
Crude Protein	0.12±0.01	1.37±0.11	0.39±0.02	0.40±0. 26	0.01±0.02	0.04±0.00	0.33±0.04	0.65±0.49
Carbohydrat	9.83±0.65	30.84±2.04	2.53±0.29	48.22±0. 46	20.90±0.01	53.71±0.03	16.47±0.47	32.30±1.25
Energy value (kJ/100g)	156.1	531.9	46.2	787.0	325.5	864.4	299.9	548.5

Results are mean values of triplicate determinations

Table 2. Mineral content (mg/100g) of studied mucilaginous vegetable samples

Element	*Abelmoschus esculentus* (fruits)		*Ceiba pentandra* (leaves)		*Cissus populnea* (stem)		*Corchorus olitorious* (leaves)	
	Fresh	**Dried**	**Fresh**	**Dried**	**Fresh**	**Dried**	**Fresh**	**Dried**
Mg	22.14±0.005	414.16±0.002	71.84±0.005	1557.31±0.01	63.89±0.00	250.28±0.01	28.63±0.005	346..36±0.01
Mn	0.49±0.004	73.12±0.00	0.66±0.001	22.33±0.006	4.21±0.001	11.13±0.001	2.92±0.001	11.38±0.002
K	ND	ND	ND	ND	ND	ND	ND	ND
Na	ND	ND	ND	ND	ND	ND	ND	ND
Ni	0.94±0.002	2.94±0.004	0.61±0.003	3.62±0.003	1.11±0.001	3.61±0.004	0.71±0.002	2.15±0.002
Cd	0.45±0.003	0.62±0.003	ND	ND	0.23±0.001	1.49±0.001	0.06±0.000	1.51±0.006
Pb	ND	2.75±0.002	ND	2.64±0.003	0.54±0.003	5.24±0.005	ND	1.95±0.001
Zn	0.74±.002	3.91±0.001	0.73±0.003	9.29±0.001	0.54± 0.002	1.71±0.002	0.75±0.001	3.30±0.002
Cu	ND	0.39±0.00	0.11±0.002	3.36±0.001	0.16±0.001	0. 59±0.001	0.18±0.000	1.34±0.003

Results are mean values of triplicate determinations **ND: Not detected*

Fibre is valuable for the maintenance of mass, motility and increasing intestinal peristalsis by extending the surface area of food in the intestine [28]. The values of crude fibre content of all the dried samples in the present study are above the 6g/100g recommended by NAFDAC [29] for nutritional claim for food with high fibre and also above the 8g/300g reported by EU/WHO [30] for vegetable groups. The crude fibre content of *A. esculentus, C. pentandra* and *C. olitorious* are well above the values reported in similar studies [23,27,25] while the crude fibre content of *C. populnea* is in agreement with the 29.37% reported by Agbo et al. [26]. The fat content of the vegetables investigated in the present study are below the 2g/300g reported by EU/WHO for vegetable groups except for *C.olitorious* which its value of crude fat in its fresh sample (1.46g/100g) is above those reported by EU/WHO for vegetable groups. All the dried samples had fat content higher than the report of EU/WHO. It is worthy of note that the fat content of all the samples meets the NAFDAC claim of less than 3g/100g for low fat foods. Low fat diets, rich in fibre containing grain products, fruits and vegetables may reduce the risk of some types of cancer [29].

The studied vegetable samples are not rich in protein from the result presented. They protein content of the vegetable samples did not account for up to 12% of their energy values as recommended by NAFDAC. The protein content of these samples is also far less in comparison with results from similar studies [23,25,26,27]. The protein content of the samples was also found to be below the 14g/300g recommended by EU/WHO for vegetable groups. The mucilaginous vegetables are a very good source of carbohydrate. The mucilaginous nature of vegetables is a function of their carbohydrate content [31,32]. The carbohydrate content of *C. populnea* and *C. olitorious* determined in the present study was found to be higher than the values reported in similar studies [23,25] while carbohydrate content of *C. pentandra* was found to be lower than the 52.06% reported by Friday et al. [27] for its dried leaves. The highly mucilaginous nature of *C. populnea* is reflected here in its dominant carbohydrate content. Comparatively, the carbohydrate content and energy values of the wild vegetables were higher than the domesticated *A. esculentus* in the dried samples but not as high as the carbohydrate content of *Irivingia gabonensis* (“Ogbono”), another domesticated mucilaginous plant used as soup thickener.

The mineral content of this vegetables indicate that dry samples of *A. esculentus* and *C. pentandra* had values of Mg and Mnabove the NAFDAC recommended Daily Intake (RDI) of 375mg/100g and 2mg/100g respectively. Also, the amount of Mn in the fresh and dried samples of *C. populnea* and *C. olitorious* was found to be above the RDI by NAFDAC. In addition, the presence of Cu in the dried samples of *C. pentandra* and *C. olitorious* were present in amounts higher than the RDI of 1 mg/100 g. Trace elements are essential for metabolic processes but if consumed in excess may become toxic to the body. The below detection limit of potassium and sodium in the samples does not necessitate their absolute absence but may be as a result of the method used which is likely to have caused their volatility and subsequently led to their being not detectable.

4. CONCLUSION

The crude ash, crude fibre, carbohydrate content and energy value of most of the wild vegetable types studied are higher than the analogous types reported in literature. However, there was no significant difference in both the proximate and mineral content of the studied vegetables. They are also a good source of mineral nutrients especially magnesium. Based on the acceptable limits provided by regulation bodies; NAFDAC and EU/WHO, the wild vegetables found in the study area are a good source of dietary requirement for people needing low fat and rich in fibre food but should be complemented with rich in protein foods.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=659&id=5&aid=6109