

Nutritional Evaluation of Some Nigerian Pumpkins (*Cucurbita* spp.)

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ABSTRACT

Fruits of 10 accessions of *Cucurbita* collected from three agroecological regions of Nigeria were evaluated for their proximate values, phytonutrient and anti-nutrient compositions and mineral content. The results indicated that the moisture content of the accessions was high but did not vary significantly ($P < 0.05$) among the accessions. Protein values were significantly different among accessions and ranged from 8.29 to 12.56%. Crude fat content was low in all the accessions and varied from 1.15 to 2.63%. The genotypes varied significantly ($P < 0.05$) in carbohydrate content. The β -carotene and lycopene values were comparable to values obtained in a popular but more expensive vegetable, tomato. The presence of these phytochemicals explained the medicinal action of the *Cucurbita* fruits encountered in its therapeutic uses. The anti-nutritional factors analysed in the fruits namely, tannins (0.017 to 0.102 mg/100 g dry matter, DM) and phytates (0.002 to 0.021 mg/100 g DM) were lower than the range of values reported for most vegetables. All the minerals evaluated varied significantly among the *Cucurbita* accessions. Potassium, magnesium, and calcium were the most prevalent minerals. The dendrogram on the bases of proximate evaluation grouped the accessions into two clusters with 'Awka-RV' and 'Uvu-watt' forming an outlier. However, only one cluster was formed when the characterization and discrimination among the accessions were considered using the mineral, phytonutrient and anti-nutrient content. These results revealed that *Cucurbita* fruits contain appreciable amount of nutrients and therefore, can be included in diets to supplement our daily nutrient needs.

Keywords: chemical composition, *Cucurbita* accessions, phytochemical, proximate composition, pumpkin

INTRODUCTION

Cucurbita (pumpkin) is one of the underutilized crops which belong to the family, Cucurbitaceae. Its existence is presently been threatened due to neglect in Nigeria. Pumpkin is cultivated in Nigeria in a subsistence level with virtually no commercial importance. Pumpkin is a vine crop and, it plays an important role in the traditional setting as a cover crop and weed control agent (Delahaut and Newenhouse 2006). In Nigeria, it is a traditional vegetable crop, grown mainly for its' leaves, fruits, and seeds and, consumed either by boiling the leaves and fruits, or by roasting or baking the seeds (Facciola 1990). The leaves, fruits, flowers and seeds are health promoting food. Different parts of the plant have been used as medicine in some developed world. The leaves are haematinic, analgesic, and also used externally for treating burns. Traditionally, the pulp is used to relieve intestinal inflammation or enteritis, dyspepsia and stomach disorders (Sentu and Debjani 2007). Pumpkin fruit is an excellent source of vitamin A which the body needs for proper growth, healthy eyes and protection from diseases. It is also rich in vitamin C, vitamin E, lycopene and dietary fiber (Pratt and Matthews 2003; Ward 2007).

In Africa, traditional vegetables are an important source of nutrients and vitamins for the rural population, as many nutritional studies have shown (Mnzava *et al.* 1999; Mosha and Gaga 1999). Farmers have cultivated and collected these vegetables for generations as an additional food source. Natural selection and farmer-based breeding practices have developed the genetic base of the most important vegetables like pumpkin. In recent decades, there has been formal research by national agricultural research programmes and international research organizations on cultivation methods of the vegetables to improve their yield

(Mnzava *et al.* 1999). African leafy vegetables are increasingly recognized as possible contributors of both micronutrients and bio-active compounds to the diets of populations in Africa. Available data on the more commonly consumed varieties point to antioxidants containing leafy vegetables that can also provide significant amounts of beta carotene, iron, calcium and zinc to daily diets (Smith and Eyzaguirre 2007).

The difference between the world's supply of quality foods and the growth of the global population continues to widen and, ways and means of bridging this gap have become a matter requiring an urgent attention. The current surge in the search for nutritious foods is therefore not surprising. The ultimate has not been achieved and this is evidenced by the paucity of literature available on the subject. Several plants exist with very high nutritive value and yet remain unexploited for human and animal benefits (Oladale and Oshodi 2007). Although extensive research efforts have been made on the nutritional composition of *Cucurbita*, the proximate composition, physiochemical properties and mineral contents of Nigerian *Cucurbita* species have not been comprehensively analyzed.

However, in Nigeria, the populace are unaware of the high nutritional and nutraceutical values of *Cucurbita*, rather it is regarded as traditional food mainly for the low income earners, thus has not benefited from the same level of research attention given to other vegetables crops like cucumber, fluted pumpkin, etc. This has created an information gap that may have discouraged high income earners and urban dwellers from making this crop a part of their diet. In order to ascertain the nutritive value of the crop species and thereby stimulate interest in its utilisation beyond the traditional localities, this study was designed to evaluate the nutritional value of the Nigerian pumpkin fruits. This

Table 1 List of *Cucurbita* accessions showing the place of collection.

Name of the genotype	Place of collection	Ecological zone
Ogo-mega	Ogoja, Cross River State	Rain forest
Ugwu-Lng	Ugwuoba, Enugu State	Derived savanna
Uvu-Wart	Uvuru, Enugu State	Derived savanna
Jos- Vari	Jos, platuea State	Southern Guinea savanna
Akw-01	Akwanga, Nassarawa State	Southern Guinea savanna
Akw-02	Akwanga, Nassarawa State	Southern Guinea savanna
Akw-03	Akwanga, Nassarawa State	Southern Guinea savanna
Awka-RV	Awka- Anambara State	Derived savanna
Ugwu-Rnd	Ugwuoba, Enugu State	Derived savanna
Ngwo-Wart	Ngwo, Enugu State	Derived savanna

will aid the promotion of the use of pumpkin and the management of nutrition-related problems in Nigeria. It will also help to address the current global food security problems since the crop grows and yields well even with very little attention.

MATERIALS AND METHODS

The experimental materials (**Table 1**) comprised 10 accessions of *Cucurbita* spp. that were collected from three agro-ecological zones of Nigeria namely, rain forest, derived savannah and guinea savannah where the crop is commonly cultivated. The viable seeds of each of the accession were grown in a randomized complete block design (RCBD) with three replications in the research field of the Department of Crop Science, University of Nigeria, Nsukka. For the analyses, fruits were harvested at the fully matured stage, washed and ground into sample pastes. The pastes were put in plastic containers and labelled appropriately.

Analysis of the samples

The sample paste for each *Cucurbita* accession was divided into triplicate and the nutrient composition of the sample paste determined to obtain the values for the moisture content, dry matter, crude protein, crude fiber, ash, crude fat, carbohydrates, lycopene, β -carotene, ascorbic acid, iron (Fe), sodium (Na), potassium (K), phosphorus (P), calcium (Ca), phytate and tannin content.

The proximate analysis was done to obtain values for the moisture content, dry matter, crude protein, crude fiber, crude fat, crude protein and ash following the procedures described by AOAC (1995). The moisture content was determined by air-oven drying as weight difference at 130°C for 1 hr, and the crude protein contents by micro Kjeldahl method (% total nitrogen \times 6.25; AOAC 1990). The crude fiber content was determined using dilute acid and alkali hydrolysis. Crude fat was extracted by exhaustively extracting 10 g of each sample in a Soxhlet apparatus using dimethyl ether (boiling range, 30-60°C) as the solvent. Ash was also determined by the incineration of 10 g of each sample placed in a muffle furnace maintained at 550°C for 5 hrs. The total carbohydrate content (on dry weight basis) was calculated by the difference:

$$100 - (\text{crude protein} + \text{crude fats} + \text{ash} + \text{crude fiber}).$$

Mineral composition

The contents of Fe, Ca, Na and K and P were determined by the procedures outlined by Boehringer (1979) and AOAC (1990). About 2 g of each of the dried samples in a crucible were ashed at 550°C in a Gallenkamp muffle furnace. The ash was later dissolved in 100 ml volumetric flask with de-ionized water. 10 ml of concentrated hydrochloric acid was added and filtered. The filtrate was made up to 50 ml with 0.1M HCl. Iron (Fe) and calcium (Ca) values were determined using Atomic Absorption Spectrophotometer. Na and K were determined by using a flame photometer (model 405, Corning, UK; Mouldin *et al.* 1996). NaCl and KCl were used to prepare the standards. Phosphorus was determined using ammonium vanadate and ammonium molybdate according to Chapman and Pratt (1961).

Phytate and tannin composition determination

The procedure of Young and Greaves (1940) as modified by Igbedion *et al.* (1994) and Abulude (2001) was used for extraction, precipitation and determination of phytate. Quantitative estimate of tannin was carried out using the method described by Makkar and Goodchild (1996) and Hagerman and Ler (1983).

Ascorbic acid, carotenoid and lycopene determination

Fruits were harvested at the fully matured stage for the determination of ascorbic acid, β -carotene and lycopene content. The ascorbic acid (Vitamin C) (mg/100 g) content was estimated titrimetrically using 2, 6-dichlorophenol dye as described by Ranganna (1977). Total carotenoids were extracted and partitioned in acetone and petroleum ether, and estimated spectrophotometrically as described by Gross (1991) and Taungbodhitham *et al.* (1999). Lycopene was extracted and partitioned in acetone and hexene, respectively and estimated spectrophotometrically as described by Taungbodhitham *et al.* (1999) and Britton *et al.* (1996).

Data analyses

Data for all determinations were subjected to analysis of variance (ANOVA) using the using Genstat Discovery Edition 3 (Genstat 2007) software. Fisher's least significant difference (F -LSD_{0.05}) test was used to identify significant differences among treatment means ($P < 0.05$) as outlined by Obi (2002). Prior to analysis, all percentage data were angular (arcsin) transformed (Steel and Torrie 1980). Factor analysis based on principal component analysis (PCA) and cluster analyses were performed (Manly 1994; Johnson 1998) to characterize the accessions in relation to the most discriminating nutrient traits.

RESULTS

Proximate composition

The proximate analysis of the 10 *Cucurbita* accessions studied is presented in **Table 2**. The table showed significant difference among the accessions ($P < 0.01$) in the crude protein, crude fibre, crude fat, ash and carbohydrate content. Crude protein content was highest in 'Uvu-wart' (12.56%) and lowest in 'Ngwo-wart' (8.29%). The accession, Akw-02 had significantly higher crude fibre content (5.53%) and was followed by 'Ogo-mega' (5.23%), 'Uvu-wart' (5.00%), 'Akw-01' (4.90%) in that order. However, 'Awka-R.V' recorded the lowest crude fibre content. Crude fat was highest in 'Uvu-wart' (2.63%) but did not differ significantly with the values obtained for 'Ugwu-Lng' (2.33%), 'Jos-vari' (2.13%) and 'Akw-02' (2.49%). The accession, 'Ogo-mega' recorded the lowest crude fat value of 1.15%. The ash content was significantly higher in 'Awka-R.V' (7.45%) followed by 'Ugwu-Lng' (6.98%), 'Jos-vari' (6.96%), 'Akw-02' (6.80%) and 'Ngwo-wart' (6.81%) in that order while accession 'Akw-01' gave the lowest (6.48%) ash content value. The result showed that the carbohydrate content varied significantly from 1.79% in 'Uvu-wart' to 4.97% in 'Awka-R.V'. Although accession 'Awka-R.V' recorded significantly higher value of carbohydrate content, it did not differ statistically from 'Ogo-mega' (4.91%), 'Jos-vari' (4.96%), 'Ugwu-Rnd' (4.95%) and 'Ngwo-wart' (4.33%). The result showed that there was no statistical difference among the *Cucurbita* accessions with respect to the fruit moisture content. However, 'Akw-01' (75.53%) had the highest fruit moisture content while 'Akw-02' (71.03%) contained the lowest fruit moisture content.

Table 3 showed the mean performance among the 10 accessions evaluated on the basis of their mineral, anti-nutrient and phytochemical contents. In this table, Fe varied from 0.07 mg/ 100 g dry matter (DM) ('Awka-R.V') to 0.14 mg/100 g DM ('Ogo-mega'), Ca varied from 0.46 mmol l⁻¹ ('Ugwu-Lng') to 0.61 mmol l⁻¹ ('Jos-vari'), K varied from 3.17 mmol l⁻¹ ('Uvu-wart') to 5.57 mmol l⁻¹ ('Akw-02'),

Table 2 Proximate chemical composition of the ten pumpkin accessions evaluated.

Accessions	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate
	Percentage (%)					
Ogo-mega	73.80	8.38	1.15	5.23	6.53	4.91
Ugwu-Lng	74.00	8.67	2.33	3.80	6.98	4.22
Uvu-watt	71.60	12.56	2.63	5.00	6.42	1.79
Jos-vari	73.60	8.38	2.13	3.97	6.96	4.96
Akw-01	75.53	8.64	1.15	4.90	6.48	3.30
Akw-02	71.30	10.13	2.49	5.53	6.8	3.75
Akw-03	71.97	11.46	1.92	4.00	6.75	3.90
Awka-R.V	74.03	9.11	2.01	2.43	7.45	4.97
Ugwu-Rnd	70.30	11.05	2.01	4.97	6.72	4.95
Ngwo-watt	74.94	8.29	1.70	3.93	6.81	4.33
F-LSD _{0.05}	NS	1.553	0.56	0.137	0.06	1.53

Table 3 Mineral, phytochemicals and antinutrient composition of ten pumpkin accessions evaluated.

Genotypes	Fe	Ca	K	Na	P	Phy	Tan	As. Ac.	β-Car	Lyc
	mg/100 g			mmol l ⁻¹				mg/100 g		
Ogo-mega	0.136	0.486	3.233	0.016	1.093	0.013	0.044	3.917	2.477	1.988
Ugwu-Lng	0.132	0.461	3.933	0.020	0.329	0.015	0.034	3.783	1.552	0.98
Uvu-watt	0.115	0.521	3.167	0.022	0.624	0.007	0.102	4.387	1.187	1.307
Jos-vari	0.093	0.610	3.200	0.014	0.386	0.015	0.017	3.62	1.614	0.727
Akw-01	0.115	0.520	4.000	0.022	0.398	0.021	0.025	3.937	0.949	0.979
Akw-02	0.104	0.518	5.567	0.021	0.621	0.003	0.025	3.473	1.32	1.448
Akw-03	0.102	0.477	4.100	0.026	0.567	0.002	0.026	3.773	0.701	0.487
Awka-R.V	0.069	0.467	4.033	0.021	0.145	0.002	0.034	3.867	1.389	1.217
Ugwu-Rnd	0.085	0.477	3.200	0.020	0.259	0.013	0.02	4.203	0.717	0.534
Ngwo-watt	0.127	0.525	4.833	0.018	0.554	0.008	0.051	4.347	1.326	0.501
F-LSD _{0.05}	0.001	0.054	0.120	0.004	0.007	0.02	0.001	0.012	0.001	0.004

Ca: Calcium, Fe: Iron, K: Potassium, Na: Sodium, P: Phosphorus, Phy: Phytate, Tan: Tannin, As. Ac: Ascorbic Acid, β-car: beta carotene, Lyc: Lycopene

Na varied from 0.016 mmol l⁻¹ ('Ogo-mega') to 0.026 mmol l⁻¹ ('Akw-03') and P varied from 0.145 mmol l⁻¹ ('Awka-R.V') to 1.093 mmol l⁻¹ ('Ogo-mega'). The anti-nutrient screening revealed that *Cucurbita* fruits evaluated contain generally low values of phytates and tannins. The phytate content was significantly highest in 'Akw-01' (0.021 mg/100 g DM) and lowest in 'Akw-03' and 'Awka-R.V' (0.002 mg/100 g DM), respectively. The genotypes, 'Uvu-watt' (0.102 mg/100 g DM) and 'Jos-vari' (0.017 mg/100 g DM) recorded the highest and lowest tannin content, respectively. With respect to phytochemical content, the results (Table 3) showed that 'Uvu-watt' produced significantly highest (4.39 mg/100 g) Vitamin C content while 'Akw-02' gave the least value of 3.47 mg/100 g. The variation in β-carotenoids content revealed that 'Ogo-mega' (2.48 mg/100 g) was the highest followed by 'Jos-vari' (1.61 mg/100 g), and 'Ugwu Lng' (1.55 mg/100 g) while 'Akw-03' (0.701 mg/100 g) gave the lowest value. The highest lycopene content was recorded in 'Ogo-mega' (1.99 mg/100 g) followed by 'Akw-02' (1.45 mg/100 g), 'Uvu-watt' (1.31 mg/100 g), 'Awka-R.V' (1.22 mg/100 g) and the lowest was 'Akw-03' (0.49 mg/100 g).

Factor analyses

The results of the PCA of the six proximate values measured were presented in Table 4. The results showed that the first three components contributed 93.15% of the variability among the 10 accessions evaluated. The PC1, PC2 and PC3 accounted for 49.49, 30.07 and 13.59% of the total variation, respectively. The first principal component axis had high positive loading for ash, carbohydrate and moisture content. The second principal component axis weighed highest and positive crude fibre and ash content while carbohydrate had high positive loadings in the PC3 axis. The intra-population variability evaluated by UPGMA dendrogram using the Euclidean distance (Fig. 1) on the proximate values grouped the accessions into two clusters at about 0.90 similarity coefficient. However, 'Awka-RV' and 'Uvu-watt' were an outlier and, therefore did not belong to any of the clusters. Cluster I comprised the accessions, 'Ugwu-Lng', 'Jos-vari', 'Ngwo-watt', 'Ogo-mega' and 'Akw-01'

Table 4 Eigenvector values for principal components using six proximate nutrient traits of the *Cucurbita* accessions.

Nutrient parameters	PC 1	PC 2	PC 3
Ash	0.38029	0.54770	0.00856
Carbohydrate	0.42236	0.11880	0.73252
Crude fat	-0.27823	0.57484	-0.17663
Crude fibre	-0.39595	-0.43020	-0.03968
Crude protein	-0.50396	0.25079	-0.03968
Moisture	0.43453	-0.32788	-0.54324
Percentage variation	49.49	30.07	13.59

Table 5 Clusters means for the six proximate nutrient traits of the 10 *Cucurbita* accessions evaluated

Nutrient parameters	Clusters		Awka-R.V	Uvu-watt
	I	II		
Moisture (%)	74.37	71.19	74.03	71.60
Crude protein (%)	8.47	10.88	9.11	12.56
Crude fibre (%)	4.37	4.83	2.43	5.00
Crude fat (%)	1.69	2.14	2.01	2.63
Ash (%)	6.75	6.76	7.45	6.42
Carbohydrate (%)	4.34	4.20	4.97	1.79

while cluster II consist of 'Akw-02', 'Akw-03' and 'Ugwu-Lng'. Although, 'Ugwu-Lng', 'Jos-vari', 'Ngwo-watt', 'Ogo-mega' and 'Akw-01' were clustered together in cluster I, 'Ugwu-Lng', 'Jos-vari' and 'Ngwo-watt' had minimal differences with similarity coefficient of about 0.925. The similarity coefficient of about 0.935 was observed among the accessions in cluster II. Fig. 2 showed the distribution of the accessions in the cluster analysis plot of first two principal components. The cluster means (Table 5) shows that cluster I comprise of accessions with high moisture and carbohydrate content but low in crude fat. The accessions in cluster II performed comparably low in most of the proximate traits evaluated. The accession, 'Awka-R.V' was characterized with high ash and carbohydrate content while 'Uvu-watt' was found to be high and low in crude fat and carbohydrate, respectively.

The result of the principal components analysis (PCA) of the mineral, anti-nutrients and phytochemical nutrient

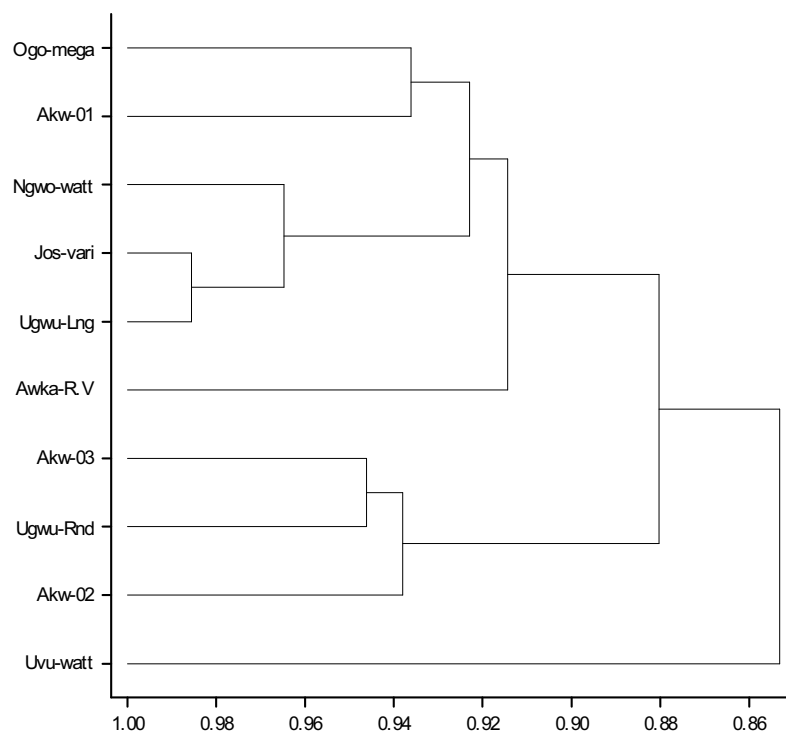


Fig. 1 Dendrogram of 10 cucurbita accessions based on proximate composition.

Table 6 Eigenvector values for the principal components based on the minerals, phytochemicals and anti-nutrient traits of the *Cucurbita* accessions.

Nutrient parameters	PC 1	PC 2	PC 3
β -carotene	0.49899	-0.11607	-0.19075
Ascorbic acid	0.03525	0.38234	0.56080
Iron (Fe)	0.38974	0.18749	0.02936
Calcium (Ca)	0.11977	-0.40585	0.16449
Potassium (k)	-0.15662	0.08427	-0.50882
Lycopene	0.40066	0.14091	-0.31737
Sodium (Na)	-0.35589	0.43206	-0.12087
Phosphorus (P)	0.43777	0.21492	-0.18200
Phytate	0.19472	-0.34967	0.37762
Tannin	0.20556	0.50832	0.26691
Percentage variation	31.35	20.56	17.94

Table 7 Clusters means for minerals, phytochemicals and anti-nutrient traits of the 10 *Cucurbita* accessions evaluated.

Nutrient parameters	Cluster I	Ogo-mega	Jos-vari	Uvu-watt
Calcium (Ca)	0.492	0.486	0.610	0.521
Iron (Fe)	0.105	0.136	0.093	0.115
Potassium (K)	4.238	3.233	3.200	3.167
Sodium (Na)	0.021	0.016	0.014	0.022
Phosphorus (P)	0.410	1.093	0.386	0.624
Phytate	0.009	0.013	0.015	0.007
Tannin	0.031	0.044	0.017	0.102
Ascorbic acid	3.912	3.917	3.620	4.387
β -Carotene	1.136	2.477	1.614	1.187
Lycopene	0.878	1.988	0.727	1.307

traits of the cucurbita accessions was presented in **Table 6**. The PCA showed that three eigen vectors were required for reaching a total variance of 70.09% among the 10 *Cucurbita* accessions evaluated. The PC 1, PC 2 and PC 3 accounted for 33.98, 20.75 and 16.17% of the total variation, respectively. The nutrient traits affecting the PC1 were β -carotene and phosphorus content while tannin and Na content affected the PC 2. The PC 3 had high loading for ascorbic acid content. The scatter plot of the first two principal components revealed that the accessions were grouped into one major cluster of seven accessions (**Fig. 3**), with 'Ogo-

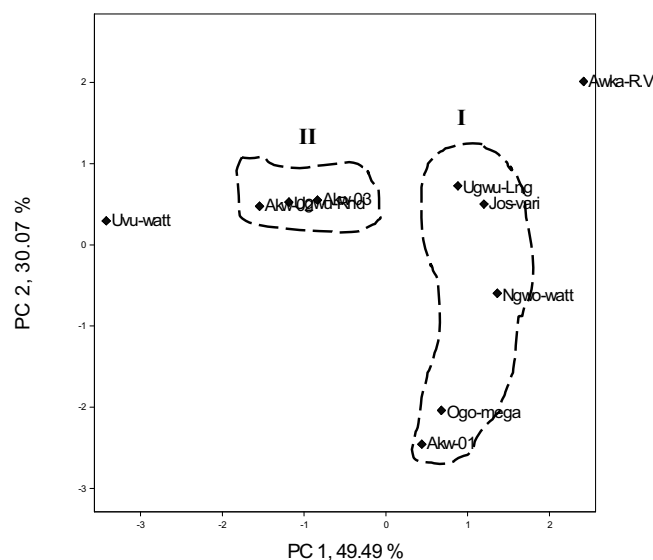


Fig. 2 Scatter plot showing the clustering of the *Cucurbita* spp. on the basis of their proximate values.

mega', 'Uvu-watt' and 'Jos-vari' as an outlier that did not belong to the cluster. The cluster and outlier mean values were presented in **Table 7**. It showed that the clustered accessions were relatively high in K and phytate content when compared with the remaining accessions. The accession, 'Ogo-mega' was rich in Fe, P, β -carotene and lycopene content. However, the accession, 'Jos-vari' was found to be high in Ca and low in Na and phytate content. The Vitamin C and tannin content of 'Uvu-watt' were high.

DISCUSSION

The potential of a particular food is determined primarily by its nutrient composition. Leafy vegetables are known to add taste and flavour, as well as substantial amounts of protein, fiber, minerals, and vitamins to the diet (Oyenuga and Fetuga 1975). Sheela *et al.* (2004) and Kubmarawa *et al.* (2009) reported that leafy vegetables are generally good sources of nutrients and, are highly beneficial for the main-

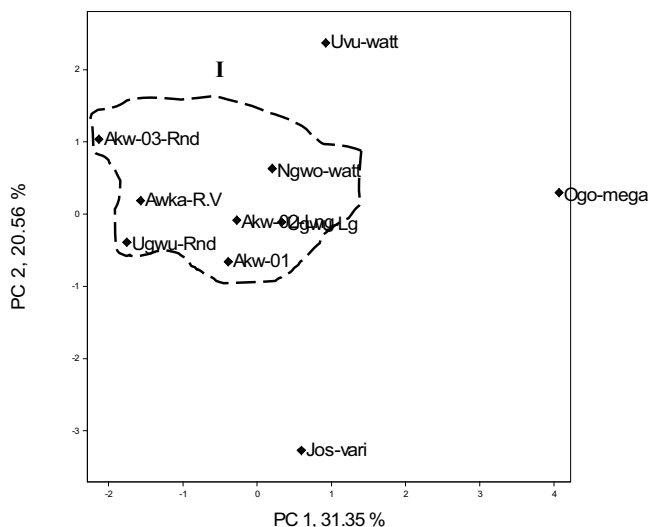


Fig. 3 Scatter plot showing the clustering of the *Cucurbita* spp. on the basis of their mineral, phytochemicals and antinutrient nutrient values.

tenance of good health and prevention of diseases. They further opined that leafy vegetables are rich in carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorous.

Although the moisture content were not significant among the *Cucurbita* accessions evaluated, the accessions had high moisture content (70.30 to 75.54%) and this could imply short fruit shelf-life. High amount of moisture in leafy vegetables makes them vulnerable to microbial attack, hence, spoilage (Desai and Salunkhe 1991). The moisture content of any food is an index of its water activity (Frazier and Westoff 1978) and is used as a measure of stability and the susceptibility to microbial contamination (Scott 1957; Davey 1989). This high moisture content also means that dehydration would increase the relative concentrations of other food nutrient and therefore improve the shelf-life/preservation of the fruits. There is also need to stored the fruit in cool condition if they are to be kept for a long period without spoilage especially, in the tropics were wastage of vegetable crops is estimated to be around 50% due to high moisture content (Thompson 1996). The relative high moisture content observed in this study is in line with the report by Umoh (1998) who said that high moisture content is typical of fresh fruits at maturity. Thomas and Oyediran (2008) had reported 82.8% moisture content for *C. esculenta* which is comparable with the range of moisture content obtained in this study. A moisture content of 61.40% had been reported earlier in African pear (*Dacryodes edulis*) fruit (Ibanga and Okon 2009).

The observed crude protein (CP) content was between 8.29% in 'Ngwo-watt' and 12.56% in 'Uvu-watt'. This values compares favourably with the crude protein values reported for yam (7.31 to 9.67%) (Behera 2009) and *Zanthoxylum zanthoxyloides* (Hercules club, 'Nka') (8.74%) (Nnamani *et al.* 2009) indicating that the pumpkin may be another cheap source of plant protein for the marginal resource communities of Nigeria. Ene-obong (1992) reported that diet is nutritionally satisfactory, if it contains high caloric value and a sufficient amount of protein. Ali (2010) and Effiong *et al.* (2009) also stated that any plant foods that provide about 12% of their calorific value from protein are considered good source of protein. Some of the cucurbita fruits evaluated, therefore meet this requirement with percent CP contents of 12.56, 10.13, 11.46 and 11.05% for 'Uvu-watt', 'Akw-02', 'Akw-03' and 'Uguwu-Rnd', respectively.

The value of the crude fat for the fruits of the *Cucurbita* accessions were low (varied from 1.15% in 'Ogo-mega' and 'Akw-01' to 2.63% 'Uvu-watt') when compared to those of *Talinum triangulare* (5.90%), *Amaranthus hybridus* (4.80%)

and *Calchorus africanum* (4.20%) (Ifon and Bassir 1979; Akindahunsi and Salawu 2005). These results are in the lower range when compared with reported values (8.3-27.0%) in some vegetables consumed in Nigeria and Republic of Niger (Sena *et al.* 1998). This showed that evaluated fruits of the *Cucurbita* accessions have moderate crude fat contents, which further agrees with the findings that leafy vegetables are low lipid containing food, and this may be an advantage for people suffering from obesity (Lintas 1992). Dietary fats function in the increase of palatability of food by absorbing and retaining flavours (Antia *et al.* 2006). A diet providing 1-2% of its caloric of energy as fat is said to be sufficient to human beings. Excess consumption of fat have been implicated in certain cardiovascular disorders such as atherosclerosis, cancer and aging (Antia *et al.* 2006). Therefore, pumpkin diet should therefore be encouraged to reduce the risk of above diseases in man.

The crude fiber contents of 2.43-6% that were recorded among the cucurbita accessions were high when compared with soybean (0.2%), (Suarez *et al.* 1999), Berlandier Nettle Spurge seed (*Jatropha cathartica*) (1.6%) (Oladele and Oshodi 2007) but relatively low when compared with *Talinum triangulare* (6.2%), *Piper guineenses* (6.4%), *Corchorus olitorius* (7%) and bitter leaves (*Vernonia amygdalina*) (6.5%) (Akindahunsi and Salawu 2005). The fiber content of 3.6% for cowpea (Suarez *et al.* 1999) and 6.31% for pumpkin leaf extract have been reported by Nworgu *et al.* (2007). Agostoni *et al.* (1995) reported that non-starchy vegetables are the richest sources of dietary fiber. Crude fiber is the part of food that is not digested by human beings but the normal functioning of the intestinal tract depends upon the the presence of adequate fiber. It increases stool bulk and decreases the time that waste materials spend in the gastrointestinal tract. Fiber helps in the maintenance of human health and has been known to reduce cholesterol level in the body (Bello *et al.* 2008). A low fiber diet has been associated with heart diseases, cancer of the colon and rectum, varicose veins, phlebitis, obesity, appendicitis, diabetes and even constipation (Saldanha 1995; Lajide *et al.* 2008). Therefore, the 'Ogo-mega' (5.23%), 'Uvu-watt' (5%), 'Akw-01' (4.90%), 'Akw-02' (5.53%) and 'Uguwu-Rnd' (4.97%) could be recommended as crude fiber source in the diet as a result of their relative high crude fiber content.

The ash content of the cucurbita fruits ranges from 6.42% and 7.45%. It is slightly higher than the values reported for *C. pepo* seeds (5.1-6.3%) (Idonraine *et al.* 1996; Alfawaz 2004) but lower than the ash content of the pumpkin leaf extract (10.92%) (Nworgu *et al.* 2007). The proportion of ash content is a reflection of the mineral contents preserved in the food materials (Omotoso 2005; Nnamani *et al.* 2009). The result could suggest a high deposit of mineral elements in the pumpkin fruits. Ash content of 1.5-2.50% for nut has been recommended for suitability as animal feeds (Pomeranz and Clifton 1981).

The result showed that the carbohydrate content varied significantly from 1.79% in 'Uvu-watt' to 4.97% in 'Awka-R.V'. The carbohydrate values obtained for accessions, 'Awka-R.V' (4.97%), 'Ogo-mega' (4.91%), 'Jos-vari' (4.96%), 'Uguwu-Rnd' (4.95%) and 'Ngwo-watt' (4.33%) were comparable with the value of $6.39 \pm 2.66\%$ reported by Loukou *et al.* (2007) for *Arachis hypogaea*. The results obtained for the carbohydrate content of all the 10 *Cucurbita* accession establishes that 'Awka-R.V', 'Ogo-mega', 'Jos-vari', 'Uguwu-Rnd' and 'Ngwo-watt' can be ranked as carbohydrate-rich fruits due to their relatively high carbohydrate content when compared with the remaining accessions. The high carbohydrate content of *Cucurbita* fruits makes it a good quality food. The low value of carbohydrate in 'Uvu-watt' is attributed to the high value of its crude protein content.

The values obtained for Ca (0.461 to 0.61 mmol l⁻¹), P (0.145 to 1.093 mmol l⁻¹), K (3.167 to 5.567 mmol l⁻¹) and Na (0.014 to 0.026 mmol l⁻¹) were comparable with the

values reported on the pumpkin leaf extract by Nworgu *et al.* (2007). However, the Fe content (0.093-0.136 mg/100 g DM) was observed to be low when compared to the values obtained by Nworgu *et al.* (2007) for the pumpkin leaf extract. The low values obtained for iron is desirable because large quantity of iron in the food have been reported to have destructive effect on the ascorbic acid (Lajide *et al.* 2008). Minerals are considered to be essential in human nutrition (White and Broadly 2005; Ibanga and Okon 2009). These minerals are vital for the overall mental physical well being and are important constituent of bones, teeth, tissues, muscles, blood and nerve cells (Soetan *et al.* 2010). They generally help in maintenance of acid-base balance, response of nerves to physiological stimulation and blood clotting (Hanif *et al.* 2006).

The phytate content of the evaluated cucurbita fruits was between 0.002-0.015 mg/100 g DM. These amounts are very low when compared with those reported for some commonly consumed tropical legumes, cowpea, *Vigna unguiculata* (2.0-2.9%): pigeon pea, *Cajanus cajan* (2.0-2.4%) and African yam beans, *Sphenostylis stenocarpa* (2.4%) (Obboh 2006). Obboh *et al.* (2003) reported that phytate has the ability to chelate divalent minerals and prevent their absorption. Phytic acid has complicated effect in human system including indigestion of food and flatulence (Maynard 1997). The tannin content of the cucurbita fruits is considered low (0.017-0.103%) when compared with the value (2.56%) reported for Cuban Boa (*Epicrates anquifer*) (Ogunkoya *et al.* 2006). According to Enujiugha and Agbede (2000), tannin usually forms insoluble complexes with proteins, thereby interfering with their bioavailability. Poor palatability is generally attributed to high tannin diets (Mehansho *et al.* 1987). Tannins are capable of lowering available protein by antagonistic competition and can therefore elicit protein deficiency syndrome, 'kwashiorkor'. The result revealed that the anti-nutrients composition of the cucurbita accessions were generally low such that none of the anti-nutrient were above the lethal dosage approved by standard bodies like National Agency for Food and Drugs Administration and Control (NAFDAC) in Nigeria. The amounts of phytates and tannins reported in this study were well below the range of values that would adversely affect their nutritional values or cause any of the toxic effects associated with the anti-nutrients. This could mean that the pumpkin fruit will not affect human nutrition if consumed in a large quantity and is therefore an advantage to the consumers of pumpkin.

The physiochemical screening showed that the fruits of the pumpkin accessions contain ascorbic acid (3.473 mg/100 g in 'Akwa-02' to 4.387 mg/100 g in 'Uvu-watt'), β -carotene (0.701 mg/100 g in 'Akwa-03' to 2.477 mg/100 g in 'Ogo-mega') and lycopene (0.487 mg/100 g in 'Akwa-03' to 1.988 mg/100 g in 'Ogo-mega') content in a relatively high quantity. The levels of the lycopene found in the studied accessions of cucurbita were within the range reported for some of the tomato samples (*S. lycopersicon*), (1.78 \pm 0.12 mg/100 g, 0.65 \pm 0.04 mg/100 g) and *S. lycopersicon* var *cerasiforme* (2.56 \pm 0.22 mg/100 g) but lower when compared with *S. pimpinellifolium* (22.12 \pm 1.24 mg/100 g) (Adalid *et al.* 2007). They also reported lycopene values of 0.72 \pm 0.06 mg/100 g and 1.66 \pm 0.21 mg/100 g for *S. lycopersicon* and *S. lycopersicon* var. *cerasiforme*, respectively. Pumpkin provides a valuable source of carotenoids and ascorbic acid that have a major role in nutrition in the form of provitamin A and vitamin C (Pandey *et al.* 2003). These are known to exhibit medicinal activity as well as physiological activity (Pandey *et al.* 2003). They reported that pumpkin provides a valuable source of carotenoids and ascorbic acid that have a major role in nutrition in the form of provitamin A and vitamin C as antioxidants, when used at ripening stage or after storage.

The PCA conducted on the proximate data indicated that the ash, carbohydrate, moisture and crude fibre content were the distinguishing characters among the accessions (Table 4). The above nutrient traits except crude fibre had

positive eigen values indicating that they contributed maximum to the discriminations among the accessions observed in the proximate characters. These nutrient traits could therefore be considered during the crop improvement through selection. Prasad *et al.* (2010) reported that PCA helps to identify traits that have substantive and meaningful contribution towards the observed variations. The dendrogram (Fig. 1), on the basis of the proximate characteristics, grouped the accessions into two clusters at about 0.90 similarity coefficient. The accessions, 'Akwa-RV', and 'Uvu-watt' were an outlier and therefore considered genetically different. The accessions in Cluster I include: 'Ugwu-Lng', 'Jos-vari', 'Ngwo-watt', 'Ogo-mega', and 'Akwa-01' (Fig. 2). These accessions were characterized with high moisture and carbohydrate content with low crude fat content. The accessions in Cluster II included: 'Akwa-02', 'Akwa-03', and 'Ugwu-Rnd'. They performed comparably low in most of the proximate characters evaluated. The accession, 'Akwa-RV' had high ash and carbohydrate content while 'Uvu-watt' was found to be high in crude fat and low carbohydrate content.

With respect to the mineral, phytochemicals and anti-nutrient nutrients of the cucurbita fruits (Table 6), the contribution of the characters towards the discrimination of the accessions revealed that in PC 1, the important characters responsible for differentiation were β -carotene and phosphorus content. In PC 2, differentiation was mainly by the Tanin and sodium content. The principal component analysis revealed that the eigen values for the above nutrient characters in the PC 1 and 2 are positive indicating that the five nutrient characters contributed to the maximum discrimination observed among the *Cucurbita*. However, the dendrogram showed that the accessions were grouped together in one major cluster except for the accessions, 'Ogo-mega', 'Uvu-watt' and 'Jos-vari' which were outliers. On the basis of the cluster means (Fig. 3), the cluster comprises accessions with high K and phytate content. The accession, 'Ogo-mega' is very rich in Fe, P, β -carotene and lycopene content. The accession, 'Jos-vari' was rich in Ca and low in Na and phytate content while 'Uvu-watt' recorded high values in ascorbic acid, Vitamin C and tannin content.

The multivariate statistical procedures (cluster analysis and principal component) helps to understanding the inter-relationships existing among several variables (Quinn and Keough 2002; Raubenheimer 2004). It has been effectively and extensively exploited in the characterization and discrimination of genotypes like buckthorn (fruits), *Rhamnus alaternus* (Izhaki *et al.* 2002); St Lucie cherry, *Prunus mahaleb* (Alonso and Herrera 2001); Lucerne plants (Alfalfa), *Medicago sativa* (Farshadfer and Farshadfar 2008); lentil, *Lens culinaris* (Karadavut and Genç 2010) and some traditional medicinal plants (Prasad *et al.* 2010) on the bases of their nutrient and chemical compositions.

In conclusion, the study revealed that *Cucurbita* fruits, consumed in the three agroecological zones of Nigeria contribute useful amount of nutrients including amino acids to human diet. It contains high levels of protein, carbohydrates and minerals good for human and animal health. Interestingly, the anti-nutritional contents of the fruits were low, much lower than is obtainable in most other Nigerian vegetables. Pumpkin is as good as the most promoted and commonly consumed fruits in the tropics and should be consumed, especially for people with heart diseases as a result of its haematinic and analgesic properties.

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