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Nutritional values of some tropical vegetables

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ABSTRACT
Objective: To investigate nutrition values of fruits of *Lycoperscon esculentum* Mill, *Abelmoschus esculentus L.*Moench, L. *Solanum macrocarpon* Linn. and the seeds of *Vigna unguiculata* (Linn.)Walp. and *Arachis hypogea* Linn.
Methodology and results: The fruits of *L. esculentum*, *A. esculentus S. macrocarpon* and seeds of *V. unguiculata* and *A. hypogea* were bought from a local market in Ibadan. The fruits and seeds were dried and analyzed for proximate, mineral and vitamin contents. *L. esculentum* fruits had the highest total soluble ethanol sugars (15.65g/100g dry matter) and 1.7% crude fibre content. However, the fruits of *A. esculentus* had the highest amount of starch (38.42g/100g dry matter), 2.0% protein while lipid content of 0.2% was recorded in both fruits of *A. esculentus* and L. *esculentum.* The highest moisture content of 18.0% was in fruits of *S. macrocarpon*. The highest glucose (0.03%), arabinose (0.14%), fructose (0.14%), raffinose (0.13%), sucrose (0.11%) and xylose (0. 05%) were in the fruits of *A. esculentus*. The highest mineral element levels were in fruits of *A. esculentus*: Ca 800mg/kg, K 912mg/kg, and Zn 296mg/kg dry matter. *L. esculentum* had 208mg/kg Mn and 76mg/kg Ca. The highest Na (1620), Fe (250) and P contents (1060) mg/kg dry matter were in fruits of *S. macrocarpon*. Highest vitamin A (425mg/100g) and vitamin B12 (0.6mg/100g) levels were in *L. esculentum* while the highest vitamin B6 levels (1.2mg/100g), vit. B2 (1.13mg/100g), vit. D (0.07mg/100g) and vit. K (1.0mg/100g) were in *A. esculentum*. The lowest values of vitamins A, D, and K were in fruits of *S. macrocarpon*. These results revealed that the fruits of *A. esculentum* are more nutritious than *L. esculentum* and *S. macrocarpon*. The proximate analysis of *V.unguiculata and A. hypogeae* seeds showed that the protein contents of the two seeds were similar. However, the lipids content was higher in *A. hypogeae*. Further analysis revealed that *V.unguiculata* was richer in crude fibre, starch and soluble sugars than *A. hypogeae*.
Conclusion and application of findings: The results showed a wide variation in the nutritional values of the fruits and seeds. This indicates that fruits and seeds need to be combined with other foods to make a good diet. This study shows that these local plants are good as food for both man and animals.
Keywords: Nutrient contents, proximate analysis, vegetables, vitamins

INTRODUCTION
Leafy vegetables are generally eaten in many parts of Africa, especially in the Eastern, Central and Southern regions. They are eaten at least once daily in many areas and some of them have been found to have high crude protein content (Imbamba, 1973, Nkafamiya, 2010). Vegetables are good sources of oil, carbohydrates, minerals and vitamins depending on the vegetable consumed (Ihekoronye and Goddy, 1985).
Vegetable fats and oils lower blood lipids thereby reducing the occurrence of disease associated with the damage of the coronary artery and are precursors of prostaglandins which are known to perform the role of vasoconstriction and

vasodilation of the blood vessels. Vegetable fats and oils are known to serve as precursors of thromboxane which facilitate blood clotting in humans (Ononogbu, 2002).They thus provides an important source of protein, minerals, and vitamins for numerous people. Information is therefore needed on their nutritional qualities and the conditions affecting these qualities. Many agricultural and domestic vegetable growers believe that it is a simple matter for anyone to produce vegetables for himself and family use not minding the nutritional qualities of these vegetables.

Vegetables are annual or perennial herbaceous plants whose edible parts are characterized by very high moisture content of least 80%.There are many ways of retaining sufficient moisture for adequate growth for vegetables such as mulching of the soil. The nutritional content of vegetables varies considerably though generally they contain a small proportion of protein and fat and a relatively high proportion of vitamins, provitamins, dietary minerals, fiber and carbohydrates. Many vegetables also contain phytochemicals which may have antioxidant, antibacterial, antifungal, antiviral and anticarcinogenic properties (Steinmetz, 1996).

As a food, groundnut is one of the most concentrated products, since it is rich in calories due to its high fat and protein content. After the extraction of the oil the nut, the residual cake is richer in protein than the whole kernel and it forms one of the most valuable livestock cakes. The proportion of protein in groundnut is higher than that of most of the oil seed cakes and this protein possesses a high biological value. The principal protein of groundnut is arachin and conarchin and they are rich in vitamin B and E (Purseglove, 1974). Groundnut contains about 50% oil from which good quality cooking and salad oil, margarine and peanut butter are obtained. The oil is also used as soaps, lubricant and in pharmaceutical industries.

Some ailments such as diabetes, heart related diseases and obesity among the people in the tropics are diet related. There is contrasting information on some nutritional status of many vegetables in the tropics (Ladeji et al. 2004; Nkafamiya, 2010). Therefore the objective of this study was to determine the nutritive values of some tropical vegetables to provide more authentic information.

MATERIALS AND METHODS

Plant materials: The fruits of *Lycopersicon esculentum* (common tomato*)*, *Hibiscus esculentus* syn. *Abelmoschus esculentus* (okra) and *Solanum macrocarpon* (African eggplant*)* and the dry seeds of *Vigna unguiculata* (cowpea) and *Arachis hypogaea* (groundnut) were bought from Bodija market Ibadan, Nigeria.

Preparation of samples: Fruit samples were sliced into small pieces and sun-dried for eight (8) days. They were subsequently dried in oven at 70^0C for 48h. When completely dried, the samples were milled to powder using a milling machine. The dry seeds samples were washed to remove the seed coat, sun-dried for about a week, and dried in the oven at 70^0C for 48h. Thereafter, the seeds were milled into powder using a milling machine and sieved, and samples were kept in dessicator at 28 $\pm 0^o$ C pending analysis.

Proximate and quantitative analysis:

Each sample was analyzed proximately and quantitatively to determine their total soluble sugar, starch/glycogen, crude protein, lipid, crude fibre, moisture content, dry matter, mineral elements; calcium, potassium, sodium, manganese, zinc, iron, phosphorus, and copper contents as described by A.O.A.C (2003), vitamin A, B_1, B_2, B_{12}, D and K were determined using the method of Harold *et al.* (1987).

Reducing Sugar: The phenol-sulphuric acid method of Dubois *et al.* (1956) was used.

Starch/Glycogen: The diastase hydrolysis method of Shriner (1932) and Barnell (1936) was adopted for starch analysis with some modification. One hundred grammes of sample of the dried ethanol insoluble residue of each sample were weighed into separate sterilized McCartney bottles followed by the addition of 5ml distilled water. The bottles were then covered with lids and heated in a boiling water bath for about an hour to gelatinize the starch. The bottles were allowed to cool before 5ml of 1% (w/v) diastase in phosphate buffer solution (pH 6.2) was added into each bottle and the bottles incubated at 37^0C for 24 h. The blank was

prepared using 5ml of 1% (w/v) diastase in phosphate buffer solution (pH 6.2). After incubation, the mixture was heated to boiling in water bath and was centrifuged. The insoluble materials were washed with hot distilled water. The two filtrates were then cleared with 1% (w/v) basic acetate method of Eastham (1949) and Bacon and Edelman (1951). The excess lead ions were removed with methanol. The same treatment was applied to the blank. The quantity of hydrolyzed starch was determined using phenol-sulphuric method of Dubois *et al.* (1951). The amount of starch was estimated from the calibration curve prepared from glucose. The starch value obtained was multiplied by 0.9 according to the method of Hassid & Neufield (1964). Each sample was replicated.

Crude Protein: The crude proteins in the residue were determined using Kjeldahl's method (1968). This consists of 3 techniques of analysis namely digestion, distillation and titration.

Crude Fibre, Moisture Content and Dry Matter: These were determined using the method of Akpapunam and Markakis (1981).

***Phosphorus*:** A 0.2g portion of each sample was weighed into a dried crucible, put inside a furnace set at 600^0C and allowed to ash for 2h. The ash was washed by pipetting 10ml of 1N HCl into the ash sample and placed on a hot place. It was evaporated to dryness, then added 10ml more of 1N HCl and removed from hot plate. This was then cooled, and washed into a 100ml volumetric flask using filter paper and funnel then made to 60 – 100ml level with diet water. Into a 500ml volumetric flask, 10ml from 100ml was pipetted and 10ml of vandate yellow was added made up with distilled water. It developed for 15, and the absorbance was read at 170nm. Standard phosphorus was prepared and read first before the sample. Phosphorus level was determined using vanadate-molybdate colorimeter.

Calcium (Ca), Potassium (K) and Sodium (Na): From the washed sample (100ml), flame photometer was used to read the level of Calcium (Ca), Potassium (K) and Sodium (Na), after been standardized with respective minerals.

Magnesium (Mg), Zinc (Zn), Iron (Fe) and Copper (Cu): Dilution 1:25 were made for Mg level determination from the washed sample. After dilution, it was then read on atomic absorption spectrophotometer (ASS), after standardizing it with Mg standard. Zn, Fe and Cu were read from the solution that remained in the 100ml flask, also read on AAS after standardizing with respective mineral elements. The percentage individual elements were calculated in parts per million (ppm) using the formula:

$$ppm = \frac{\text{Meter reading X Average gradient X dilution factor}}{\text{Weight of sample}}$$

Determination of Vitamins: Vitamins were determined using the method of Harold *et al* (1987).

***Vitamin A*:** Five gram samples were weighed into a 250ml volumetric flask. Fifty ml of 3N alcohol and 5ml of 75% potassium hydroxide solution was added. A standard taper reflux condenser was placed on the flask and saponified on a steam bath for 30 minutes. The flask was occasionally swirled to prevent sticking. After saponification, the flask was cooled to room temperature and using the condenser pipette, 100ml of this mixture was pipette into the flask, and placed on a mechanical shaker at 200 rpm for 15 minutes. The flask was allowed to stand so as to allow four-layer separation. A portion of the upper layer (hexane) was pipetted into a 50ml volumetric flask; the absorbance of the sample was read at 325nm, 310nm, and 334nm using Isopropanol as reference solution. The vitamin A value was determined spectrophotometrically by saponification extraction and measuring the absorption of an Isopropyl extraneous material which absorbs within this region. Readings were done at 310nm and 334nm and the Mortions-stubbs mathematical correction applied.

Vitamin B_6: Two gram of the sample was weighed into 250ml flask, 5ml of 2N acetic acid was added, 5ml of dichloroethane was also added and 90ml of distilled water was added. This mixture was put in water bath for 20 minutes, cooled, and centrifuged; the first 10ml of the aliquot was discarded. Two ml was pipetted into 200ml volumetric flask and made up to mark with distilled water. Standards were prepared by dissolving 20g into 100ml of distilled water and preparation of 1.5ppm; 2.0ppm, 2.5ppm, and 3.00ppm were prepared from stock solution. The standards were first read on the spectrophotometer at 575nm wavelength before the sample.

***Vitamin B_2*:** 0.5 (half) gram of the sample was weighed into 200ml flask, 5ml of dichloromethane was added and 90ml of deionized water was added, put on the steam bath for 20 minute, so that all the vitamins go into solution. It was cooled and made up with water. Five ml of this was pipette into hot 250ml volumetric flask and made up to mark with water. Standard solution was prepared by dissolving 50g of vitamin B_2 into 500ml of distilled water and further dilution of

2ppm, 4ppm, 6ppm, 8ppm, and 10ppm. They were read on spectrophotometer at 520nm wavelength.
Calculations were done using the formula:
Meter reading X Dilution factor X Standard reading

***Vitamin B_{12}*:** Two gram of sample was weighed into a 150ml flask. Five ml of 5N HCl, 5ml of dichloroethane and 90ml of deionized water were added. Put on the steam bath for 30 minutes so that all vitamin B_{12} goes into solution. It was then cooled and made up with water, filtered, discarding the first 20ml of the aliquot, 2ml of it was pipetted into a 200ml volumetric flask and made up to mark with water. Standard solution was prepared with dissolved 50g of B_{12} in 500ml of distilled water, a further dilution of 5ml into 150ml and 5ml into 100ml followed.
Readings were taken on spectrophotometer at 520nm wavelength and calculated follows:
Mg of Vitamin B_{12} =
Sample reading X Standard weight X Dilution factor
Standard reading Sample weight

***Vitamin D*:** Five gram of sample was dissolved in 5ml of chloroform, 0.31ml of acetic anhydride added, followed by 0.01ml of concentrated H_2SO_4 and shaken vigorously. A red coloration through violet to blue to green indicated the presence of vitamin D.

Vitamin K: Five gram of sample was weighed into 200ml flask and 5g of menadione and 50ml of (methanol) MeOH were added and mixed gently for 10 minutes and let to stand for 5 minutes. The mixture was diluted with 5ml aliquot and 5ml MeOH, mixed and centrifuged for premixes with different menadione levels. The reaction was read on spectrophotometer at 575nm wavelength using Vitamin K standards after the calibration of the machine.

Data analysis: The data were subjected to ANOVA using SAS package (SAS Institute, 1996). Least significant differences were determined and t-tests were performed to separate the means of the measured parameters.

RESULTS

The results showed that the fruits of *L. esculentum* had the highest total soluble sugar, while the lowest total soluble sugar was in *S. macrocarpon*. The starch/glycogen content was highest in *A. esculentus* and lowest in *L. esculentum* (Table 1). The fruit of *A. esculentus* contained the highest amount of crude protein, crude fibre and dry matter, while *S. macrocarpon* contained the lowest amount of crude fibre. The lipid contents of the fruits of *L. esculentum* and *A. esculentus* were similar. Moisture content was higher in *S. macrocarpon*, while *A. esculentus* had the least.

Table 1: Proximate Analysis of Fruit and Seed Samples

	g/100g dry matter							% dry matter
	Samples	Total Soluble Sugar	Starch/ Glycogen	Crude Protein	Lipids	Crude Fibre	Moisture Content	Dry Matter
Fruits	L.E	15.63a	10.36b	1.00b	0.20a	0.60c	6.00b	94.00a
	A.E	11.25b	38.42a	2.00a	0.20a	1.70a	2.00b	98.00a
	SM	10.63b	14.50b	0.95b	0.18a	1.20b	18.00a	82.00b
Seeds	V.U	36.25a	45.10a	23.00a	1.40b	3.20a	2.00a	98.00a
	A.H	21.88b	25.30b	24.94a	43.00a	2.80a	0.99b	99.01a

The values were means of ten replicates. The means with the same letter in the same column in each sample are not significantly different at $P \leq 0.05$. The means were separated using the t-test.L.E – *Lycopersicon esculentum,* A.E – *Abelmoschus esculentus,* S.M – *Solanum macrocarpon*, V.U – *Vigna unguiculata,* A.H – *Arachis hypogea*

Other sugars, glucose, arabinose, fructose, raffinose, sucrose and xylose were present in all the three fruits, although *A. esculentus* tend to have contained higher amounts of these sugars, but had the same amount of raffinose with *S. macrocarpon*. *L. esculentus* had the lowest in all the sugar except for glucose which was higher than that of *S. macrocarpon*. Xylose contents of *L. esculentum* and *S. macrocarpon* fruits were similar (Table 2).

Table 2: Sugar Contents (mg/100g dry matter) of the Fruit and Seed Samples

	Samples	Glucose	Arabinose	Fructose	Raffinose	Sucrose	Xylose
Fruits	L.E	0.03b	0.01b	0.03b	0.02b	0.08a	0.04a
	A.E	0.10a	0.14a	0.14a	0.13a	0.11a	0.05a
	SM	0.02b	0.04c	0.11a	0.13a	0.10a	0.04a
Seeds	V.U	0.14b	0.08b	1.40a	2.50a	0.48a	0.35a
	A.H	0.20a	0.20a	0.13b	0.15b	0.10b	0.18b

The values were means of ten replicates. The means with the same letter in the same column in each sample are not significantly different at P≤0.05. The means were separated using the t-test. L.E – *Lycopersicon esculentum,* A.E – *Abelmoschus esculentus,* S.M – *Solanum macrocarpon*, V.U – *Vigna unguiculata,* A.H – *Arachis hypogeal*

The mineral element analysis of the fruits showed that the highest amount of Calcium, Potassium and Zinc were in *A. esculentus* and lowest in *S. macrocarpon*. Manganese and Copper were highest in *L. esculentus* and lowest in *S. macrocarpon*, but Iron and Phosphorus were highest in *S. macrocarpon* and lowest in *L. esculentum*, while Sodium was highest in *S. macrocarpon* and lowest in *A. esculentus* (Table 3).

Table 3: Mineral Elements contents (mg/kg) of the Fruit and Seed Samples

	Samples	Ca	K	Na	Mn	Zn	Fe	P	Cu
Fruits	L.E	2200b	836ab	1548a	208a	256b	120b	760b	76a
	A.E	8000a	912a	1368b	196a	296a	220a	960a	30b
	SM	2000b	798b	1620a	76b	240b	250a	1060a	24b
Seeds	V.U	8800a	1064a	1548b	116a	226a	1000a	1760a	20a
	A.H	8600b	874b	2016a	150a	300a	820a	1260b	36a

The values were means of ten replicates. The means with the same letter in the same column in each sample are not significantly different at P≤0.05. The means were separated using the t-test. L.E – *Lycopersicon esculentum,* A.E – *Abelmoschus esculentus,* S.M – *Solanum macrocarpon*, V.U – *Vigna unguiculata,* A.H – *Arachis hypogea*

Vitamin A was highest in *L. esculentum* and lowest in *S. macrocarpon*; Vitamins B_6 and B_2 were highest in *A. esculentus* and lowest in *L. esculentum*; Vitamin B_{12} was highest in *L. esculentum* and lowest in *A. esculentus*; Vitamin D and K were highest in *A. esculentus* and lowest in *S. macrocarpon* (Table 4).

Table 4: Vitamins Contents (mg/100g dry matter) of Fruit and Seed Samples

	Samples	A	B_6	B_2	B_{12}	D	K
Fruits	L.E	425a	0.06b	0.04b	0.60a	0.06a	0.17b
	A.E	83b	1.20a	1.13a	0.13b	0.07a	1.00a
	SM	25b	0.08ab	0.05b	0.50a	0.03b	0.02c
Seeds	V.U	18a	1.05a	2.20a	0.21a	0.14b	0.31a
	A.H	21a	0.87b	0.25b	0.17b	0.31a	0.12b

The values were means of ten replicates. The means with the same letter in the same column in each sample are not significantly different at P≤0.05. The means were separated using the t-test. L.E – *Lycopersicon esculentum,* A.E – *Abelmoschus esculentus,* S.M – *Solanum macrocarpon*, V.U – *Vigna unguiculata,* A.H – *Arachis hypogea*

The proximate analysis of seeds showed that total soluble sugar, starch, crude fibre and moisture contents were higher in *V. unguiculata* while crude protein, lipids, and dry matter were higher in *A. hypogea* (Table 1). Glucose and arabinose were higher in *A. hypogaea,* while fructose, sucrose, raffinose and xylose were higher in *V. unguiculata* (Table 2).The mineral elements Calcium, Potassium, Iron, and Phosphorus contents were higher in *V. unguiculata*, while Sodium, Manganese, Zinc, and Copper were higher in *A. hypogaea* (Table 3). Vitamins A and D contents were higher in *A. hypogaea*, while Vitamins B_6, B_2, B_{12}, and K were higher in *V. unguiculata* (Table 4).

DISCUSSION

These results revealed that the amount of lipid content in *A. esculentus* and *L. esculentum* were similar to 1.60±0.02 % crude lipids recorded in undefatted *A.hybridus* (Ihenacho and Udebani, 2009).The amount of crude protein found in *A. esculentus* compared favorably Shukla and Naik 1993.

Sugars such as glucose, fructose, arabinose, raffinose, sucrose and xylose were present in all the fruits. The main sugars obtained from the fruits samples were raffinose in *S. macrocarpon*; fructose, arabinose, sucrose, glucose and xylose in *A. esculentus*. This differed from the findings of Horbowicz *et al.* (1980) who reported that the main sugars in most vegetables are fructose, glucose, and sucrose. The higher starch content in *A. esculentus* could be attributed to the mucilage made up of d-galactose, l- rhamnose and d-galactose that abounds in this vegetable (Burkill, 1997). Ifon and Bassir (1987) reported that the mineral contents of some Nigerian vegetables were adversely affected by high content of phythates, oxalates and cyanogenic glycosides. This reason may be responsible for the low values of mineral elements recorded in the fruits of *S. macrocarpon*. *L. esculentum* contained the highest amount of vit. A among the three fruits. This could be due to high level of β-carotene in tomato which is a precursor of Vitamin .A. George (1985) reported that sun-drying as a form of preservation, particularly in the fruits of okra caused over 80% loss in the ascorbate and β-carotene content. It however had only negligible effect on thiamine, riboflavin and pyridoxine contents. This corroborated our findings where *A. esculentus* contained the highest amount of vitamins B_2 and B_6. The lipid content was low in the three fruits. This makes them suitable for obese and diabetic people.

The proximate analysis of the seeds of *V. unguiculata* and *A. hypogea*, showed that there was little variation in their crude protein contents (23.00 and 24.94%, respectively), which compared favorably with the result obtained from the work of Ogunsua and Adebona (1983) on *Tetracarpidium conophorum* nuts protein (23.5%). The seeds of *V. unguiculata* contained less lipid content (1.40%) and this is an implication that the two seeds can be interchanged in the diet of the people of the tropics to lower the blood cholesterol level.

From the results obtained in the investigation, *V. unguiculata* fruit was found to be rich in crude fibre, starch, moisture content and soluble sugars while A. *hypogea* is richer in protein and lipids contents. These results indicate that *V. unguiculata* and *A. hypogea* are good sources of protein and carbohydrate for man and animals particularly in the dry season. *V. unguiculata* could be recommended for diabetic patients.

This study shows that there is a wide variation in the levels of the chemicals investigated in those seeds and fruits. The values are high enough and are either close or above the recommended levels needed in the body.

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