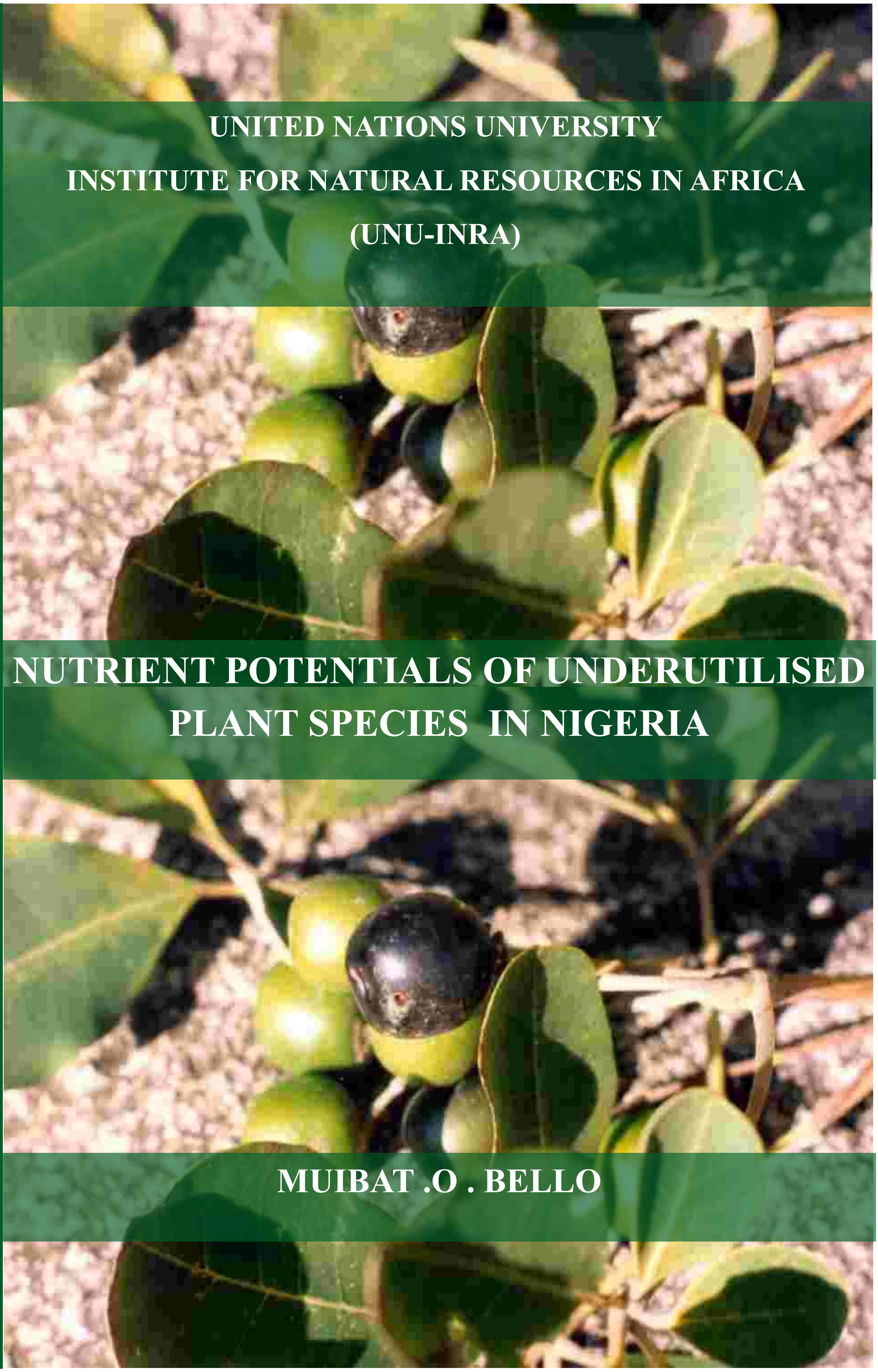

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(UNU-INRA)

NUTRIENT POTENTIALS OF UNDERUTILISED PLANT SPECIES IN NIGERIA

MUIBAT .O . BELLO

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BY

MUIBAT .O. BELLO

UNU-INRA Visiting Scholars Programme

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ABSTRACT

The chemical compositions of some underutilised plants parts (green leafy vegetables, fruits, seed oils and spices) collected from different locations in Oyo and Osun States of Western Nigeria were determined by standard analytical methods in effort to evaluate their nutrient potentials. Among the seven green leafy vegetables, crude fibre, crude fat, crude protein and nutritive calorific values ranged from 2.39 to 6.14 g/100g, 8.75 to 30.19 g/100g, 8.75 to 30.19 g/100g, 261.55 to 373.96 Kcal/g. The vitamin C composition varied from 24.6 to 502.2 mg/100g. Macro and micro elemental analysis in mg/100g dry matter revealed that calcium, potassium, iron and zinc ranged from 286.5 to 3361, 76.4 to 2037, 0.012 to 160 and 11.5 to 63.4 mg/100g. Among the five fruits part, crude fibre, crude fat and crude protein (g/100g) ranged from 7.85 to 16.79, 0.78 to 40.00 and 5.25 to 11.38; vitamin C varied from 156 - 953.33 mg/100g. *Ficus exasperata* fruit contained the highest level of calcium, potassium and iron; *Gardenia erubescens* lowest sodium and manganese, *Cola millenii mesocarp* had highest level of magnesium, sodium, manganese and zinc. The fatty acids profiles of the seed oils revealed that *Telfairia occidentalis* contained more linoleic acids than soybean and only *Cola millenii* contained omega-3 fatty acid, docosahexanoic acid (DHA). Among the spices, onion outer scale peel had highest level of oleic acid, onion top-bottom peels had highest linoleic acid and only *Syzygium aromaticum* had highest level of *linolenic* acid and DHA. The levels of anti-nutrients in the samples were low to be of health threat. The results established a basis for continuous evaluation of the agro-biodiversity to identify food crops with promising nutrient potentials that could complement the commonly consumed ones to enhance sustainable livelihoods.

Key words: *underutilised species, green leafy vegetables, fruits, seed oils, spices, micronutrients; essential fatty acids; nutrient potentials.*

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ACRONYMS

ALA	Alpha linoleic acid
AOAC	Association of Official Analytical Chemists
BAPNA	Benzoyl – DL- arginine –p-*nitroaniline*
CF	Crude fibre
DHA	*Docosahexanoic* acid
EPA	*Eicosapentanoic* acid
FNB	Food and Nutrition Board
GC	Gas chromatography
ICT	Information Communication Technology
LAUTECH	Ladoke Akintola University of Technology
NHMRC	National Health and Medical Research Council
NCD	Non communicable diseases
NV	Nutritive value
RDA	Recommended daily allowance
UNU/INRA	United Nations University Institute for Natural Resources in Africa
USDA	United States Department of Agriculture
WHO	World Health Organization

1.0 INTRODUCTION

Within the plant kingdom, there is a vast repository of hundreds of underutilised food crops that have been grown locally for centuries and which contribute to the food security of the world's poorest people. In human history, 40 – 100,000 plant species have been regularly used for food, fibres, industrial, cultural, and medicinal purposes. At least 7,000 cultivated species are in use today around the world, and over the last five hundred years few of these crop species have neither been intensely or widely used, despite their imperative role as the basis of the world's agriculture (Parvathin and Kumar, 2002). Underutilised plants are those species with under-exploited potential for contributing to food security, health (nutrition/medicine), income generation, and environmental services (Anonymous, 2006). Indeed, there is a high potential for underutilized plants in alleviating poverty and positively contributing towards food security; however, promotion of their use should be done in a sustainable manner (Hoeschle-zeledon and Bordoni, 2003). The range covered by these species is vast, including plants that provide edible fruits, grains, leaves, nuts, oils, roots and tubers, medicines spices, stimulants and other products.

The focus on a few widely used species has helped to sustain the explosion in human population over the last two hundred and fifty years, but it has dramatically narrowed down the number of species upon which global food security, and in general, economic agriculture depend. With over half of humanity's caloric and protein needs being met by three crop species (maize, wheat and rice), humankind faces a highly vulnerable situation. This is why it is imperative for urgent action to promote crop diversification (Saheed and Sumaira, 2007).

Many underutilised species are nutritionally rich and adapted to low input agriculture. They complement significantly the diet based on few staple crops by providing important vitamins and minerals. In fact, many of these species have been implicated in addressing the malnutrition issue of "hidden hunger" characterised by lack of micronutrients, vitamins and other dietary essentials (IPGRI, 1999). So many of these underutilised plant species abound and go to waste season to season constituting environmental nuisance. Recent studies revealed that several of these trees and shrubs abound in Nigeria; most of them produce fruits, which contain various pods and seeds which could be explored to augment available food resources in the provision of food with health benefits (Bello et al., 2008). Thus, promoting the use of underutilised species (vegetables, fruits, starchy crops, medicinal plants and condiments) need to be achieved by highlighting their importance in their current production areas as well as exploiting further opportunities to extend their production and consumption. Promotion of these species, and the development of their value chains, must be based on rigorous scientific methods which will enable us to remove the stigma of ‘food for the poor’ which often hinders their popularisation and new demand creation. More research for development including conservation, selection, breeding, production, nutrition studies, post-harvest value-addition and advocating consumption as part of a balanced diet will facilitate some of these underutilised species transitioning into crops that can better support development and the quality of life.

1.1 Plants of study

Leafy vegetables: the leaf of trees; *Adansonia digitata, Parkia biglobosa* and *Vitex doniana* and shrubs; *Jatropha tanjorensis, Crassocephalum biafrao, Laurea taraxifolia* and *Sesamum indicum*.

Fruits: *Ficus exasperata, Parkia biglobosa, Strychnos spinosa, Gardenia erubescens,*

Seeds: *Artocarpus heterophyllus, Bombax glabra,* Croton *zambesicus.*

Spices: *Eucalyptus citriodora, Eucalyptus camadulensis, Allium cepa* (Onions), onion outer scale peel, onion top-bottom peels, *Croton zambesicus* leaf.

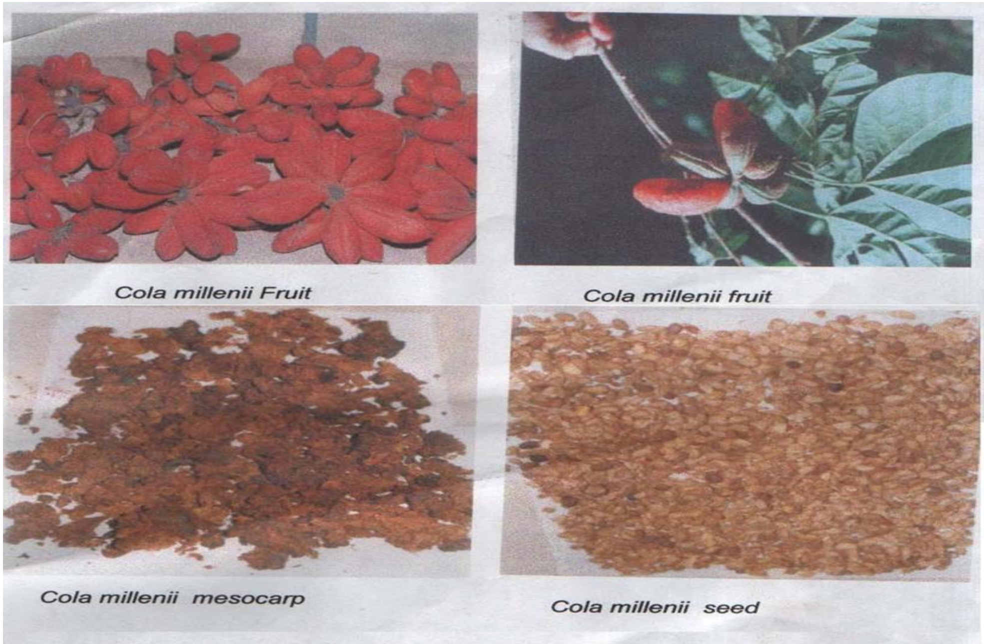

Plate: 1.1 Picture of different parts of *Cola millenii* fruit.

***Telfairia occidentalis* seed pod**

Monodora myristica

Myristica **fragrance**

Syzygium aromaticum

Eucalyptus camadulensis

Eucalyptus citriodora

Figure 1: Picture of some underutilised species

(Source: www.link.springer.com)

1.2 Objectives

The growing interest of consumers for improved diet with health benefits call for exploitation of the plant species that are neglected and underutilised. Most of these plant species grows in the wild and most times are regarded as food of the poor. The reliance on few widely cultivated plant foods has limited the source of calorie for humans and especially the micronutrients, vitamins and essential fatty acids that have to be derived from diet.

In fact, WHO (2002) reported that a low intake of vegetables and fruits does not only put people at the risk of micronutrient deficiencies but that approximately 1.7 million (2.8%) of deaths worldwide are attributable to low fruit and vegetable consumption. The WHO further reiterated that eating a variety of vegetables and fruits clearly ensures an adequate intake of most micronutrients, dietary fibres and a host of essential non-nutrient substances that could help prevent major non communicable diseases (NCD). These assertions are pointers to the fact that there is an urgent need to explore the undervalued, neglected, and underutilised species that habitat in our environment, in order to address the issue of hunger and poverty in relation to malnutrition in Africa and to derive the necessary health benefit from the various plant species with potential *nutraceutical* properties.

It is therefore the objective of this study to determine the chemical constituents of some underutilised indigenous plant species with the aim of generating a list of plant species or agro wastes, which have promising nutrient qualities to complement the commonly consumed plant species to enhance food security. The specific objectives are to determine the proximate constituents of the plants' parts, quantify the level of macro and micro mineral elements, quantify some anti-nutrients phytochemicals and determine the fatty acids profile of the oil.

2.0 MATERIALS AND METHODS

2.1 Collection of samples

2.1.1 Green leafy vegetables

Seven indigenous underutilised leafy vegetables were investigated. These include the leaves of the following trees: *Adansonia digitata, Parkia biglobosa* and *Vitex doniana* and shrubs; *Jatropha tanjorensis, Crassocephalum biafrao, Laurea taraxifolia* and *Sesamum indicum*. Fresh matured leaves were collected at different locations within Ogbomoso at Oyo State in Nigeria.

2.1.2 Fruit samples

Fruit samples were collected from various locations in Oyo and Osun States. *Artocarpus heterophyllus* was collected in front of Agbala compound, beside Olayonu Hospital Ogbomoso, *Strychnos spinosa* was collected around kilometre 10, Igbeti-Igboho road, Gardenia *erubescens* at *Budodera* farm, Ago kere, Igboho, Bombax glabra, in front of Animal Production and Health laboratory, Ladoke Akintola University of Technology (LAUTECH) Ogbomoso, Cola millenii behind Botany Department, Obafemi Awolowo University, Ile-Ife, Parkia biglobosa from LAUTECH staff school compound, Ogbomoso and *Ficus exasperata* was collected in front of Pure and Applied Chemistry Department, LAUTECH.

2.1.3 Spices

Eucalyptus *citriodora* was collected in front of old ICT building, LAUTECH, Eucalyptus *camadulensis* was collected from Ogbomoso Grammar School Compound, Croton zambesicus from no. 6, Segun Adepoju Street, Isale general area, Ogbomoso, *Syzygium aromaticum*, *Monodora myristica* and *Myristica fragrans* were purchased at “Ojagbo” market and Allium cepa were bought at new “waso” market, Ogbomoso, Nigeria.

2.2 Identification of samples

All samples were identified by a Taxonomist, Dr. T. Ogunkunle, Department of Pure and Applied Biology, LAUTECH, Ogbomoso, Nigeria.

2.3 Preparation of samples

2.3.1 Leafy samples

All leafy samples were diced and air –dried at room temperature and ground to powder using Philips food blender. The powdered samples were placed in desiccators and stored in the refrigerator prior to analysis. Fresh samples were used for ascorbic acid assay.

2.3.2 Fruits and seeds

Ficus exasperata fruits were gently ground using laboratory mortar and pestle, *Artocarpus heterophyllus* fruits were removed from the ripe pod and diced into pieces; *Bombax glabra* seeds were removed from the opened pod, shelled and diced into pieces. Cola *millenii* seeds were removed from the pod, shelled and *mesocarp* separated and labelled as Cola *millenii* seed and Cola *millenii mesocarp*. Gardenia *erubescens* coat was peeled from the fruit and cut into pieces, Parkia biglobosa pod was carefully opened and the yellowish pulp was scraped from the seed and labelled Parkia pulp. The ripe hard shell of *Strychnos spinosa* was crushed. The fruit pulp was scrapped inside plastic containers and labelled as *Strychnos spinosa* pulp and kept in a freezer.

All samples were dried separately in oven at 50 0C, ground to powder, kept in airtight containers in refrigerator prior to analyses.

2.4 Data collection/Analysis

The levels of underutilisation or neglect of some Nigerian vegetables were determined using the method of Awoyinka et al., (1995) with some modifications. One hundred and sixty individuals above 20years old within LAUTECH, Ogbomoso were purposefully selected, interviewed and administered with a structured open ended questionnaire. The questionnaire contained important information on the frequency on whether vegetable was 'seen' and or 'eaten'. Both botanical and local names were included for the purpose of easy identification.

Data generated from the questionnaire were expressed as simple percentages of 'seen' and 'eaten'.

2.5 Analytical Procedures

2.5.1 Proximate analysis

The proximate compositions of the samples were determined using the methods of the AOAC (1990). Moisture content was obtained by heating the samples to a constant weight in a thermostatically controlled oven at 105 0C. The ash content was determined by igniting a 0.5g test sample in a muffle furnace at 550 0C until light grey ash is realised and protein was determined using the *Kjedhal* method (Nitrogen x 6.25). The dried pulverised sample was extracted with petroleum ether (boiling point 40-600C) using a *soxhlet* apparatus to obtain the crude lipid content while crude fibre content was estimated by consecutive acid and alkali digestion of the sample followed by washing, drying, ashing at 600 0C. The weight of ash free fibre and carbohydrate were then calculated by difference.

2.5.2 Determination of nutritive values of samples

Nutritive values of dry powder of the leaves were calculated based on the energy value available per kg of the macronutrient. Proteins, carbohydrates and fats yield 4.0, 4.0 and 9.0 Kcal of energy per g respectively. The nutritive value (NV) is calculated as [(4 x % protein) + (4 x % carbohydrate) + (9 x % fat)] (Chinnasammi et al., 2011).

2.5.3 Quantification of ascorbic acid (Vitamin C)

Ascorbic acid was determined colorimetrically using the method described by Falade, et al. (2003), after the formation of the *Osazone* which was dissolved in 85% H2S04 to give an orange-red coloured solution which is measured at 540 nm using a (GENESYS 10 UV spectrophotometer, Thermo Electron Corporation, England) and compared to a standard curve prepared from 0 – 100 mg per litre of ascorbic acid.

2.5.4 Determination of mineral elements

Samples were digested as described by Falade et al., (2003). Each sample (0.5g) was weighed in triplicate into *Kjeldahl* flasks and 10ml of conc. HNO3 was added and allowed to stand overnight. The samples were then heated carefully until the production of brown nitrogen (iv) oxide fume has ceased. The flasks were cooled and (2-4ml) of 70% *perchloric* acid was added. Heating was continued until the solutions turned colourless. The solutions were transferred into 50ml standard flasks and diluted to mark with distilled water. The mineral content was then analysed by Atomic absorption spectrophotometer (ALPHA 4 model, Fisons Chem-Tech, Analytical, UK).

2.5.5 Quantifications of anti-nutrients phytochemicals

Tannin was determined by the modified Vanillin – HCl method using 1.0mg/ml of *Catechin* in 1% HCl - MeOH as standard, the coloured substituted product was measured at 500nm (Price, et al., 1978). Trypsin inhibitor was determined by the method modified by Adewusi and Osuntogun (1991). A synthetic substrate (BAPNA) was subjected to hydrolysis by trypsin to produce yellow coloured *p-nitroanilide*. The degree of inhibition by the extract was measured at 410 nm. *Phytate* was determined by titration method as described by Wheeler and Ferrei (1971), using FeCl3 as standard. Oxalate was determined titrimetrically as described earlier (Falade, et al., 2004) by being precipitated as calcium oxalate and titrated against standard potassium permanganate. The oxalate was calculated as sodium oxalate equivalent.

2.5.6 Determination of fatty acids profiles of oil

2.5.6.1 Preparation of fatty acid methyl esters

A 50mg of the extracted oil from the sample was esterified for five (5) minutes at 95 0C with 3.4ml of the 0.5M KOH in dry methanol. The mixture was neutralized by using 0.7M HCl and 3ml of 14% boron *triflouride* in methanol. The mixture was heated for 5 minutes at the temperature of 90 0C to achieve complete methylation process. The fatty acid methyl esters were thrice extracted from the mixture with redistilled n-hexane. The content was concentrated to 1ml for gas chromatography analysis and 1µl was injected into the injection port of GC. The fatty acids were identified by comparing their retention times with those of standards and the content of fatty acids was expressed as percentage of total fatty acids.

2.5.6.2 Quantification of fatty acids

The fatty acids profile was determined using gas chromatography equipped with a flame *ionisation* detector and a 30m x 0.25m column coated with a 0.25µm film of HP INNOWAX. Split injection (split ratio 20:1) was performed with nitrogen as carrier gas at a flow rate of 22 psi. The column temperature was maintained at 60 0C for 1 min after injection then programmed at 12 0C min-1 for 20 min to 250 0C, held for 2 min, then at 15 0C min-1 for 3 min held for 8 min. The injection port temperature was 250 0C and detector temperature was 320 0C.

2.6 Statistical analysis

Results were expressed as mean and standard deviation of three determinations using MS Office Excel 2007 (Microsoft, Redmond, Washington, USA). Data were subjected to unpaired t-test to determine the levels of significant difference and considered significance at $p < 0.05$ by using GraphPad Instat version for Windows 2007.

3.0 RESULTS

Table 1: Frequency distribution and percentage of Nigerian vegetables as seen and eaten by 160 Respondents

	Vegetables		Seen		Eaten	
S/N	Botanical name	Common name	No.	Yes	No	Yes
1	*Amaranthus viridis* L.	Tete (Green)	6(3.8)	154(96.3)	9(5.6)	151(94.4)
2	*Celosia trigyna* L.	Sokoyo-koto	35(21.9)	125(78.1)	55(34.4)	105(65.6)
3	*Corchorus estuans* L.	Ewedu	4(2.5)	156(97.5)	8(5)	152(95)
4	*Talinum triangulare* L.	Gbure	15(9.4)	145(90.6)	34(21.2)	126(78.8)
5	*Vernonia amygdalina*	Ewuro	16(10)	144(90)	28(17.5)	132(82.5)
6	*Laurea taraxifolia*	Yanrin	95(59.4)	65(40.6)	130(81.2)	30(18.2)
7	*Crassocephalumbi afrao*	Worowo	76(47.5)	84(52.5)	104(65)	56(35)
8	*Cucurbital pepo*	Elegede	100(62.5)	60(37.5)	129(80.6)	31(19.4)
9	*Gynura cernea* L.	Ebolo	76(47.5)	84(52.5)	124(77.5)	36(22.5)
10	*Telfairia occidentalis*	Ugwu	12(6.3)	148(92.5)	14(8.7)	146(91.3)
11	*Adansonia digitata*	Baobab (kuka)	63(39.4)	97(60.6)	150(93.7)	10(6.3)
12	*Parkia biglobosa*	Ewe Igba	77(48.1)	83(51.9)	124(77.5)	36(22.5)

The levels of awareness concerning the consumption preference of twelve Nigerian vegetables among 160 respondents were reported in Table 1. Frequency of "seen" and "eaten" rated *Corchorus estuans* (Ewedu) highest; 97.5% seen and 95% eaten, followed closely by *Amaranthus viridis*; 96.3% seen and 94.4% eaten. *Talinum triangulare* was also rated high. Most respondents are quite familiar with *Telfaria occidentalis; ugwu*, 92.5% seen and 91.3% eaten. Among the vegetables, *Laurea taraxifolia* and *Cucurbital pepo* are rated high in percentages of not seen. Among the respondents, 39.4% have seen *Adansonia digitata* leaves before but only 6.3% have eaten it amounting to 93.7% of those that has never eaten the vegetable. *P biglobosa* leaves also followed the same trend; 51.9% of respondents have seen the vegetable but only 22.5% have eaten it before. This shows that most of the vegetables are becoming endangered.

Table 2: Proximate composition of some underutilised vegetables compared to a commonly consumed (g/ 100g dry weight)

Samples	Moisture	Crude fibre	Crude fat	Crude protein	Ash	Carbohydrate
Adansonia digitata leaf	86.21± 1.01^{a}	18.78± 1.19^{a}	2.39± 0.21^{d}	28.79± 1.24^{a}	19.51± 0.73^{a}	30.53 ± 1.56^{d}
Parkia biglobosa leaf	85.79± 1.12^{b}	19.35± 0.78^{a}	3.13± 0.02^{c}	30.19± 0.85^{a}	19.42 ± 0.45^{a}	27.73 ± 2.16^{d}
Vitexdoniana leaf	8.04 ± 0.02^{d}	15.58 ± 0.01^{b}	5.10 ± 0.01^{b}	8.75 ± 0.01^{d}	7.92 ± 0.00^{c}	70.20 ± 0.04^{a}
Jatropha tajorensis leaf	80.30 ± 0.90^{c}	9.74 ± 0.34^{d}	4.52 ± 0.28^{b}	24.57 ± 0.18^{b}	8.08 ± 0.01^{c}	58.75 ± 0.35b
Laurea taraxifolia	85.95 ± 1.23^{b}	19.06 ± 0.01^{a}	3.63 ± 0.01^{c}	29.23 ± 2.20^{a}	18.35 ± 1.20^{a}	29.73 ± 0.01^{e}
Crassocephalum biafrao	86.34 ± 1.36^{a}	19.11 ± 0.02^{a}	3.59 ± 0.01^{c}	28.25 ± 1.10^{a}	19.98 ± 1.45^{a}	29.06 ± 0.02^{e}
Sesame indicum	10.26 ± 0.01^{d}	11.75 ± 0.01^{c}	6.14 ± 0.01^{a}	18.37 ± 0.01^{c}	11.04 ± 0.02^{b}	54.21 ± 0.03^{c}
Amaranthus viridis	86.10± 0.4^{a}	7.9 ± 0.20^{d}	3.10 ± 0.50^{c}	26.00 ± 0.40^{a}	11.70 ± 0.80^{b}	52.00 ± 2.30^{c}

Values are means ± standard deviation of triplicate analysis. Values with the same superscripts in the same column are not significantly different at 5 % probability level.

Values are means ± standard deviation of triplicate analysis. Values with the same superscripts in the same column are not significantly different at 5% probability level.

Table 2 presents the results of proximate constituents of some underutilised leafy vegetables. The moisture content was above 80% except for *Sesamum indicum* and *Vitex doniana*. Crude fibre ranged from 7. 9 g/100g in *Amaranthus viridis* to 19.35 g/100g in *Parkia biglobosa*. Crude fat ranged from 2.39 g/100g *Adansonia digitata* to 6.14 g/100g, crude protein ranged from 8.75 g/100g in *Vitex doniana* to 30.19 g/100g in Parkia biglobosa, ash content ranged from 7.92 g/100g in *Vitex doniana* to 19.98 in *Crasocephallum biafrao* and carbohydrate ranged from 27.73 g/100g in *Parkia bigloosa* to 70.20 g/100g in *Vitex doniana*.

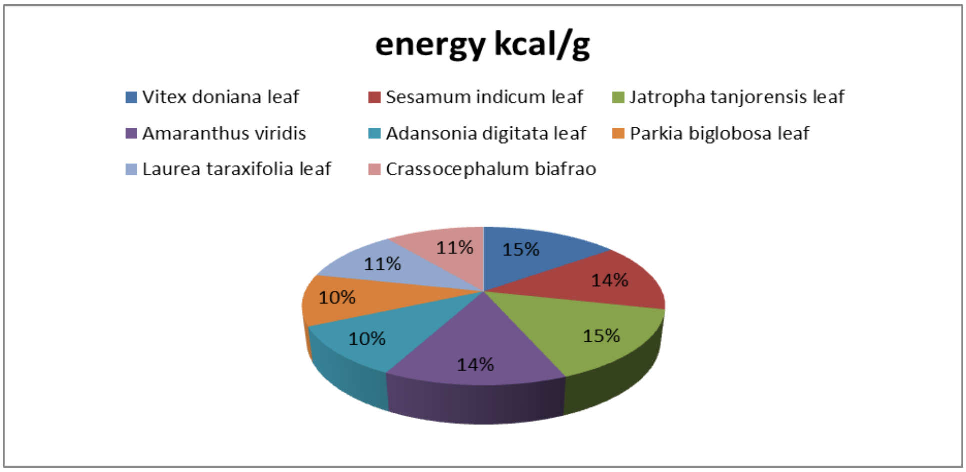

Figure 2: Percentile rating of nutritive energy values of the different leafy

The nutritive energy ranged from 261.55 kcal/g in *Crassocephalum biafrao* to 373.96k cal/g in *Jatropha tanjorensis*.

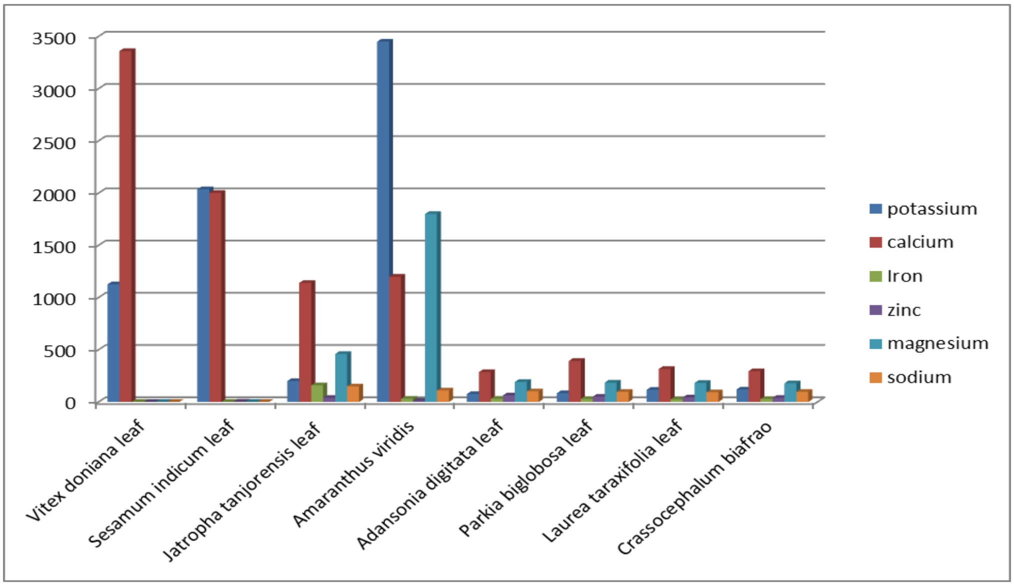

Figure 3: Level of mineral elements in some of the underutilised vegetables (mg/100g)

Results of mineral analysis were presented in Figure 3. Calcium was highest in *Vitex doniana*, potassium and magnesium were highest in *Amaranthus viridis*, iron and sodium were highest in *Jatropha tanjorensis*, zinc was highest in *Adansonia digitata*.

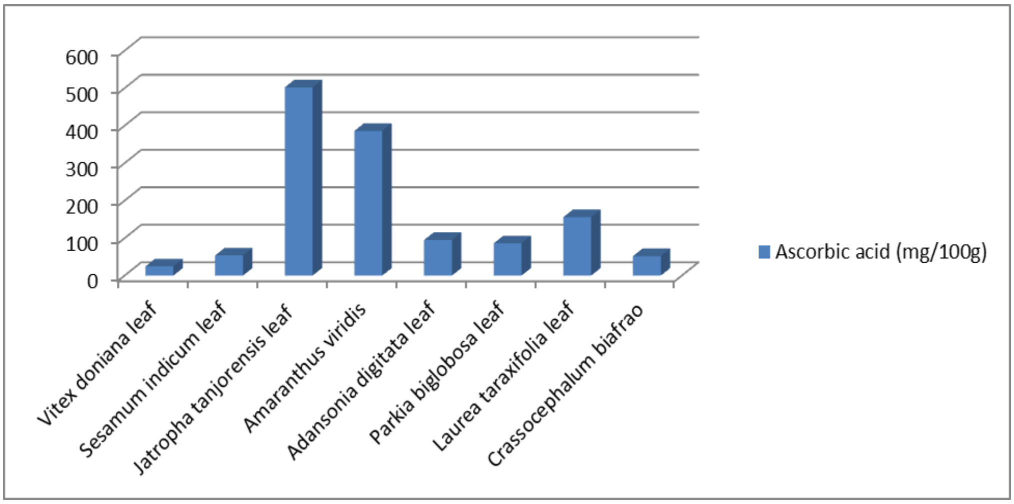

Figure 4: Level of Vitamin C in underutilised vegetables and Amaranthus viridis (mg/100g)

The level of ascorbic acid (vitamin C) was reported in Figure 4. Ascorbic acid was highest (502.2 mg/100g) in *Jatropha tanjorensis* followed by *Amaranthus* *viridis* (386 mg/100g), *Laurea taraxifolia* (156 mg/100g), *Adansonia digitata* (95 mg/100g). The lowest quantity of ascorbic acid (24.6 mg/100g) was observed in *Vitex doniana*.

Table 3: Proximate composition of some underutilised fruits (g/100g)

	Moisture	**Crude fat**	**Crude fibre**	**Crude protein**	**Ash**	**Carbohydr-ate**
Arthocarpusheter ophyllus seed	8.25 ± 0.10^{d}	6.10± 0.14^{d}	1.23 ± 0.03^{e}	14.02 ± 0.50^{c}	3.60 ± 0.06^{c}	68.03 ± 0.27^{b}
Bombaxglabra seed	23.00 ± 0.22^{a}	48.78± 0.21^{a}	12.01 ± 0.11^{c}	34.09 ± 0.94^{a}	7.86 ± 0.62^{a}	15.92 ± 0.92^{e}
Cola millenii seed	10.00 $±0.01^{b}$	40.0 $±1.16^{b}$	4.03 $±0.01^{d}$	9.19 ± 0.62^{e}	3.00 ± 1.41^{d}	37.81 ± 0.71^{d}
Strychnos spinosa seed flour	8.93 ± 0.97^{c}	1.67 ± 0.01^{e}	13.39 ± 0.86^{b}	15.67 ± 2.42^{b}	1.79 ± 0.15^{e}	71.94 ± 2.25^{a}
Croton zambesicus	7.94 ± 0.11^{e}	26.73±0 $.32^{c}$	15.45 ± 0.01^{a}	9.64 ± 0.02^{d}	4.15 ± 0.01^{b}	67.09 ± 2.07^{c}

Values are means ± standard deviation of triplicate analysis. Values with the same superscripts in the same column are not significantly different at 5% probability level.

The results of proximate constituents of some underutilised fruits are reported in Table 4. The moisture content ranged from 4.0 g/100g in *Parkia* pulp to 90.96 g/100g in *Strychnos spinosa* pulp. Crude fat was lowest in S. *spinosa* pulp, 0.78 g/100g, followed by G. *erubescens* 1.54 g/100g then *Ficus exasperata* fruit; 4.28 g/100g, the highest oil content was observed in Cola *millenii mesocarp*. *S. spinosa* had the lowest crude fibre (7.85 g/100g), the highest fibre was observed in F. *exasperata* fruit (16.79 g/100g). The crude protein ranged from 5.25 g/100g in *P. biglobosa* pulp to 11.38 g/100g in *F. exasperata*. Ash content ranged from 2.0 g/100g in Cola *millenii mesocarp* to 9.68 g/100g in *F. exasperata* and carbohydrate ranged from 7.88 g/100g in S. *spinosa* to 70.69 in Gardenia *erubescens.*

Table 4: Proximate compositions of some underutilised seeds (g/100g) dry weight

	Moisture	Crude fat	Crude fibre	Crude protein	Ash	Carbohydrate
Arthocarpusheterophyllus seed	8.25± 10^{d}	6.10 ± 0.14^{d}	1.23 ± 0.03^{e}	14.02 ± 0.50^{c}	3.60 ± 0.06^{c}	68.03 ± 0.27^{b}
Bombaxglabra seed	23.00± 0.2^{a}	48.78 ± 0.21^{a}	12.01 ± 0.11^{c}	34.09 ± 0.94^{a}	7.86 ± 0.62^{a}	15.92 ± 0.92^{e}
Cola millenii seed	10.00 ±0.01^{b}	40.0 ± 1.16^{b}	4.03 ± 0.01^{d}	9.19 ± 0.62^{e}	3.00 ± 1.41^{d}	37.81 ± 0.71^{d}
Strychnos spinosa seed flour	8.93± 0.97^{c}	1.67 ± 0.01^{e}	13.39 ± 0.86^{b}	15.67 ± 2.42^{b}	1.79 ± 0.15^{e}	71.94 ± 2.25^{a}
Croton zambesicus	7.94± 0.11^{e}	26.73 ± 0.32^{c}	15.45 ± 0.01^{a}	9.64 ± 0.02^{d}	4.15 ± 0.01^{b}	67.09 ± 2.07^{c}

The results of proximate constituents of the seed part of the underutilised species are reported in Table 5. Moisture content ranged from 7.94 g/100g in Croton *zambesicus* to 23.20 in *Bombax glabra*. Crude fat ranged from 1.67 in *Strychnos spinosa* seed to 48.78 in *Bombax glabra*. Crude fibre ranged from 4.03 in Cola *millenii* seed to 15.45 in Croton *zambesicus.* Crude protein 9.19g/100g in Cola *millenii* seed to 34.09 g/100g in *Bombax glabra*, ash from 1.79 in S. spinosa to 7.68 g/100g in *Bombax glabra* and carbohydrate 15.92 in *Bombax glabra* to 71.94 in *S. spinosa*. Among the seeds, Croton *zambesicus* had the lowest moisture and highest fibre; *Bombax glabra* highest moisture, fat content, protein and lowest carbohydrate. *S. spinosa* had the lowest fat and ash content but the highest content of carbohydrate among the studied seeds.

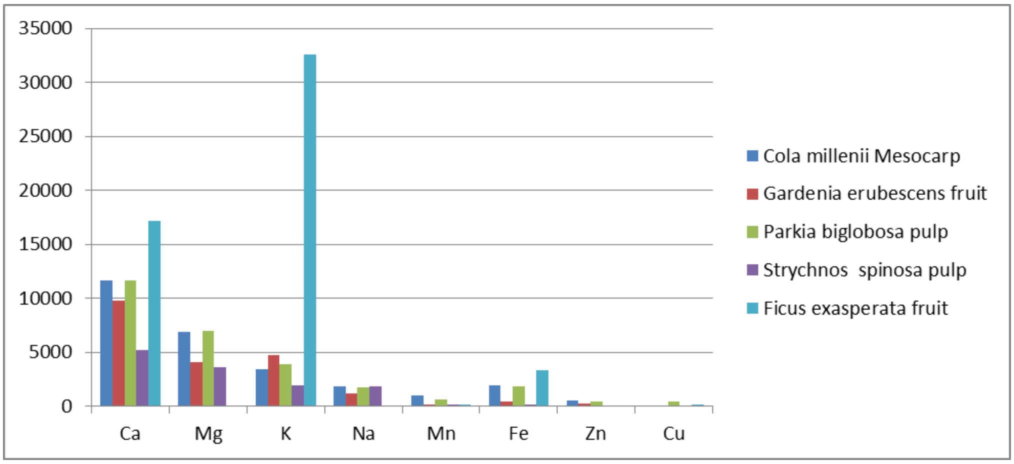

Figure 5: Levels of some macro and micro mineral elements in some fruit parts (mg/kg)

The levels of macro and micro nutrients in some fruit parts are reported in Figure 5. Among the macro nutrients, calcium ranged between 5.22 g/kg in *S. spinosa* to 17.21 g/kg in *F. exasperata*. Magnesium was not detected in *F. exasperata*, among other fruits; 3.62 g/kg was reported in *S. spinosa*, *C. millenii mesocarp* contained 6.9 g/kg. Potassium ranged from 1.9 g/kg in *S.spinosa*to 32 g/kg in *F. exasperata*. Sodium ranged from 1.2 g/kg in *G. erubescens* to 1.83 g/kg in *C.millenii mesocarp*, sodium was not detected in *F. exasperata* fruit. Among the micro nutrients; manganese was lowest in *G. erubescens* fruit (123.7 mg/kg) but highest in *C. millenii mesocarp*; 973.48 mg/kg. Iron was lowest in *S. spinosa* pulp (158.73mg/kg), highest in F. exasperata fruit (3.31 g/kg). Zinc ranged between 119 mg/kg in *S. spinosa* and 559.74 mg/kg in *C. millenii mesocarp* and copper ranged from 45.35 mg/kg in S. *spinosa* to 447.48 mg/kg *in P. biglobosa* pulp. *Ficus exasperata* fruit contained highest level of calcium, potassium and iron; *Gardenia erubescens* lowest sodium and manganese, *Cola millenii mesocarp* had

highest level of magnesium, sodium, manganese and zinc while*Parkia biglobosa* had highest level of copper.

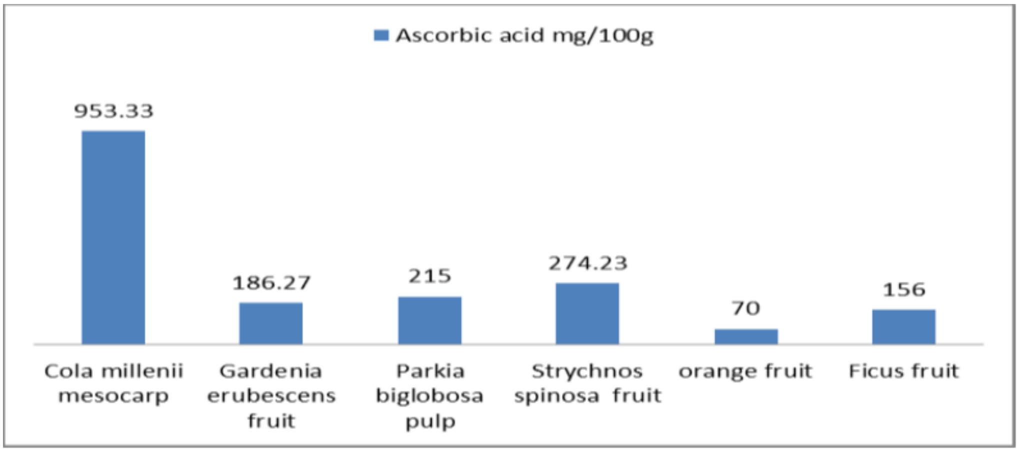

Figure 6: Level of Ascorbic acid (Vitamin C mg/100g) in underutilised fruit compared to orange fruit

The levels of vitamin C in the fruits expressed in mg/100g dry matter are expressed in Figure 6. *Cola millenii mesocarp* had the highest level of vitamin C, followed by *Strychnos spinosa* fruit. The least amount of vitamin C was quantified in commonly consumed orange fruit.

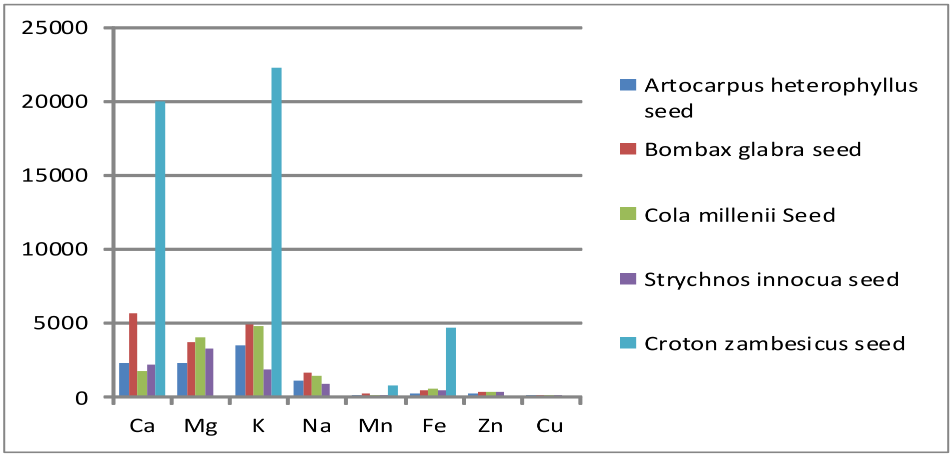

Figure 7: Levels of macro and micro elements in some underutilised seeds (mg/kg)

The macro and micro mineral elements in the seed are reported in Figure7. Calcium ranged from 1.6 g/100g in *C. millenii* seed to 19.9 g/100g in *Croton zambesicus*. Magnesium ranged from 2.2 g/100g in *A. hererophyllus* seed to 3.9 g/100g in *C. millenii*. Potassium ranged from 1.8 g/100g in *S. innocua* seed to 22.2g/100g in *C. zambesicus*. Sodium ranged from 0.7 g/100g in *S. innocua* seed to 1.0 g/100g *A. heterophyllus*. Manganese ranged from 9.86mg to 71.6 mg/100g, iron ranged from 19.80mg to 467.5 mg/100g, zinc ranged from 20.10mg to 31.91 mg/100g and copper from 7.29mg in *Artocarpus heterophyllus* to 9.65 mg/100g in *Cola millenii* seed.

Table 5: Proximate constituents of some herbs / spices (g/100g dry weight)

Samples	Moisture	Crude fat	Crude fibre	Crude protein	Ash content	Carbohydr-ate
Allium cepa (Onion) bulb	8.78 ± 0.01[c]	14.98 ± 0.05[b]	6.05 ± 0.01[e]	8.75 ± 0.07[b]	2.32 ± 0.07[e]	65.16± 0.05[c]
Onion (outer scale peel)	8.02 ± 0.00[c]	15.13 ± 0.03[b]	26.84 ± 0.02[a]	2.64 ± 0.01[e]	11.46 ± 0.01[a]	66.12± 0.02[b]
Onion (top-bottom peel)	9.21 ± 0.01[b]	15.71 ± 0.04[b]	15.68 ± 0.01[c]	8.76 ± 0.01[b]	8.06 ± 0.01[c]	54.88± 0.02[e]
Croton zambesicus leaf	7.88 ± 0.01[d]	15.42± 1.49[b]	16.63 ± 0.01[b]	13.13 ± 0.01[a]	9.28 ± 0.01[b]	55.35± 0.02[d]
Eucalyptus camadulensis leaf	4.32 ± 0.01[e]	3.87 ± 0.01[c]	16.74 ± 0.03[b]	5.26 ± 0.01[d]	2.26 ± 0.01[e]	84.29± 1.89[a]
Eucalyptus citriodora	4.11 ± 0.01[e]	3.96 ± 0.01[c]	16.55 ± 0.02[b]	7.13 ± 0.02[c]	4.15 ± 0.04[d]	80.64± 3.66[a]

leaf						
Syzygium aromaticum (clove seed)	23.35 ± 0.02^{a}	18.90± 0.04^{a}	10.65 ± 0.03^{d}	7.00 ± 0.01^{c}	9.10 ± 0.05^{b}	30.95± 0.17^{f}

Values are means ± standard deviation of triplicate analysis. Values with the same superscripts in the same column are not significantly different at 5% probability level (Source: Fieldwork)

The proximate constituents of some herbs/ spices parts were reported in Table 6. Moisture contents ranged from 4.11g/100g in *E. citriodora* to 23.35 g/100g in *S. aromaticum*, while crude fat contents ranged from 3.87 g/100g in *E. camadulensis* leaf to 18.9 g/100g in *S. aromaticum*, crude fibre contents ranged from 6.05 g/100g in *A. cepa* (onion bulb) to 26.84 g/100g in onion outer scale peel. It was equally observed that crude protein contents ranged from 2.64 g/100g in onion outer scale peel to 13.13 g/100g in *C. zambesicus*. Ash content ranged from 2.26 g/100g in *E .camadulensis* to 9.28 in *C. zambesicus* leaf. Carbohydrate contents also ranged from 30.95 g/100g in *S.aromaticum* to 84.29 g/100g in *E. camadulensis*. The part of onion discarded as waste compared favourably with the bulb consumed in most of the nutrients.

Table 6: Levels of mineral elements in herbs/spices

Samples	Calcium g/100g	Potassium g/100g	Manganese (mg/100g)	Iron(mg/100g)	Zinc (mg/100g)	Copper (mg/100g)
Allium cepa (Onion) bulb	1.22± 0.05^{d}	2.98 ± 0.08^{a}	50.0 ± 1.01^{b}	40.0 ± 1.00^{e}	ND	130.0± 1.10^{a}
Onion (outer scale peel)	3.05 ± 0.05^{a}	1.02 ± 0.03^{d}	80.0 ± 1.05^{a}	1000.0 ± 9.01^{b}	30.0 ± 0.08^{b}	40.0 ± 1.0^{b}
Onion (top-bottom peel)	2.08 ± 0.05^{c}	1.52 ± 0.03^{b}	60.0 ± 1.21^{b}	1330.0 ± 12.1^{a}	90.0± 2.35^{a}	10.0 ± 0.01^{c}
Croton zambesicus leaf	3.04 ± 0.04^{a}	1.68 ± 0.03^{b}	71.21± 2.35^{a}	275.03 ± 4.77^{c}	ND	ND
Eucalyptus camadulensis leaf	2.73 ± 0.05^{b}	1.43 ± 0.04^{c}	0.24 ± 0.01^{c}	0.81 ± 0.01^{f}	ND	ND

Eucalyptus citriodora leaf	2.86 ± 0.05^{b}	1.53 ± 0.04^{b}	0.26 ± 0.01^{c}	0.43 ± 0.01^{f}	0.05± 0.00^{c}	0.03 ± 0.00^{d}
Syzygium aromaticum (clove seed)	0.78 ± 0.01^{e}	0.01 ± 0.00^{e}	ND	71.0 ± 0.12^{d}	0.00	0.00 ± 0.00

Values are means ± standard deviation of triplicate analysis. Values with the same superscripts in the same column are not significantly different at 5% probability level.

The levels of micro and macro elements in some herb spices were reported in Figure 7. Calcium concentrations varied from 0.78 g/100g to 3.05 g/100g in *S. aromaticum* and onion outer scale peel respectively. The potassium contents ranged from 0.01 g/100g in *S. aromaticum* to 2.98 g/100g in *Allium cepa*. Highest concentration of manganese of 80.0 mg/100g was equally observed in onion outer scale peel and lowest concentration of 0.24 mg/100g in *E. camadulensis*. While 1 g/100g concentration of iron was found in onion outer scale peel, *E. Citriodora* had 0.05 mg/100g of iron.

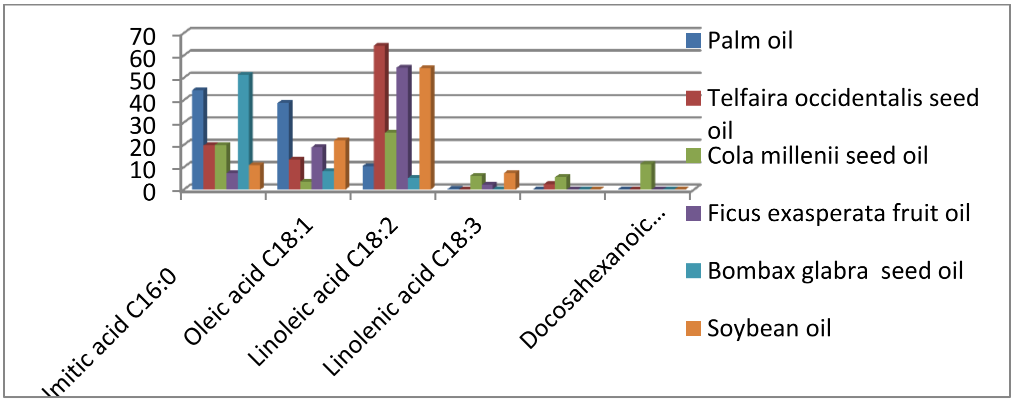

Figure 8: Comparison of fatty acids in underutilised oils to two commonly used

(Source: Fieldwork)

Some fatty acids in some unconventional seed oils were compared to two commonly consumed oils; palm oil and soybean oil. All the oils have lower palmitic acid than palm oil with exception of *Bombax glabra*. Oleic acid content is lowest in *Cola millenii* seed and highest in palm oil. The level in *Ficus exasperata* fruit compared favourably with that of soybean oil. Linoleic acid is lowest in *Bombax glabra* seed oil followed by palm oil but highest in

Telfaira occidentalis seed oil. Linolenic acid was not detected in *Telfaira occidentalis*. All the oils have low linolenic acid except *cola millenii* seed oil and soya oil. The polyunsaturated fatty acid, eicosapentanoic (EPA) was only present in *Telfaira* oil and *Cola milleni*, it was absent in palm oil and soybean. Only *cola millenii* seed oil contained the omega-3 fatty acid, docosahexanoic acid (DHA).

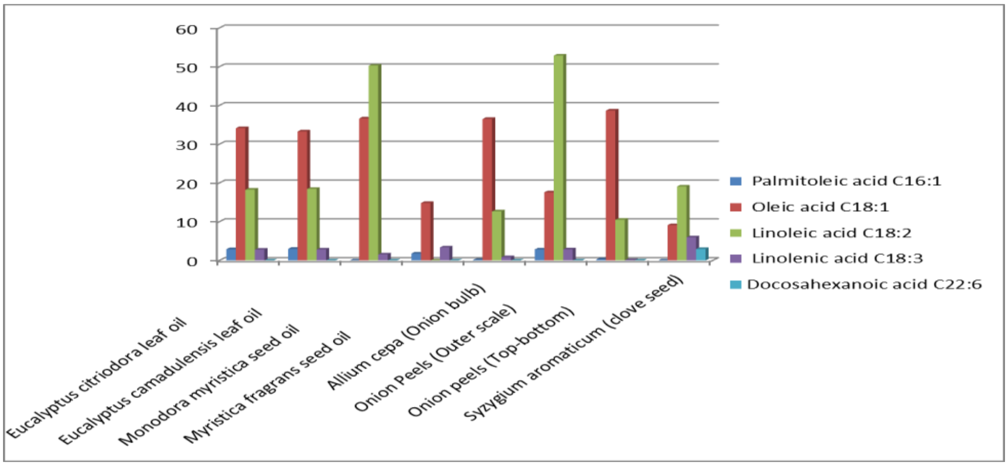

Figure 9: Comparison of fatty acids in underutilised oils to two commonly used

(Source: Fieldwork)

The levels of health benefiting unsaturated fatty acids in herbs/ spices are reported in Figure 9.

Palmitoleic acid was not detected in both *Monodora myristica* oil and *Syzygium aromaticum* seed oil. *E camadulensis* recorded the highest percentage of palmitoleic acid. Oleic acid was detected in all samples, the concentration varied from 9.11 g/100g in Syzygium aromaticum to 36.65 g/100g in *Monodora myristica* seed oil. Linoleic acid was not detected in *Myristica fragrans*, *Monodora myristica* contained 50.27% linoleic acid. Linoleic acid was detected in all samples; *Syzygium aromaticum* contained the highest proportion. *Docosahexanoic* acid was only detected in *Syzygium aromaticum* among all spices studied.

Table 7: Level of anti -nutrients in some of the underutilised species

	Tannin (mg/g)	Trypsin (TIU/g)	Phytate (mg/g)	Oxalate (mg/g)
Leafy vegetables				
Jatropha tanjorensis	1.47 ± 0.45[c]	57.14 ± 2.75[a]	0.43 ± 0.10[a]	2.46 ± 0.01[b]
Sesamum indicum	0.91 ± 0.10[d]	ND	0.29 ± 0.04[b]	0.95 ± 0.14[c]
Vitexdoniana	2.34 ± 0.20[b]	ND	0.18 ± 0.01[c]	0.39 ± 0.10[c]
*Amaranthus viridis	3.0 ± 0.1[a]	-	-	8.7 ± 0.8[a]
Fruits				
Cola millenii mesocarp	1.33 ± 0.06[b]	9.64 ± 0.32[c]	0.38 ± 0.02[b]	0.25± 0.10[b]
Parkia biglobosa pulp	1.08 ± 0.20[c]	15.55 ± 1.10[b]	0.20 ± 0.05[c]	0.93 ± 0.10[b]
Strychnos spinosa pulp	1.01 ± 0.01[c]	10.12 ± 0.22[c]	0.72 ± 0.02[a]	1.17 ± 0.10[a]
Gardenia erubescens fruit	7.50 ± 0.71[a]	16.5 ± 0.54[a]	0.24 ± 0.02[c]	1.10 ± 0.10[a]
Seeds				
Artocarpus heterophyllus seed	1.08 ± 0.03[b]	44.17 ± 1.26[b]	0.55 ± 0.10[c]	0.23 ± 0.01[b]
Bombax glabra seed	1.20 ± 0.01[a]	17.86 ± 0.57[c]	0.54 ± 0.04[c]	0.46 ± 0.01[a]
Cola millenii seed	1.27 ± 0.06[a]	14.86 ± 0.12[d]	3.90 ± 0.30[b]	0.56 ± 0.14[a]
Strychnos spinosa seed	1.12 ± 0.05[b]	58.2 ± 1.60[a]	6.65 ± 0.60[a]	0.31 ± 0.01[b]

*commonly consumed. ND – not determined. Values are means ± SD.

Values with the same superscript within a group in column are not statistically different at $P < 0.05$. (**Source: Fieldwork**)

The anti-nutrient phytochemicals in some of the underutilised species are reported in Table 8. Tannin ranged from 0.91 in *Sesamum indicum* to 3.0 mg/g in *Amaranthus* leafy vegetables; 1.08 in *Parkia biglobosa* pulp to 7.50 mg/g in *Gardenia erubescens* fruit and 1.08 in *Artocarpus heterophyllus* to 1.27 mg/g in *Cola millenii* seed. Trypsin inhibitor ranged from 9.64 TIU/g in C*ola* *millenii mesocarp* fruits to 58.2 TIU/g in *Strychnos spinosa* seed. Level of 57.14 TIU/g was observed in *Jatropha tanjorensis* leaf.*Phytate* ranged from 0.18mg/g in *Vitex doniana* leaf to 6.65 mg/g in *Strychnos spinosa* seed. Oxalate ranged from 0.23 mg/g in *Artocarpus heterophyllus* to 8.7 mg/g in commonly consumed *Amaranthus* vegetables.

4.0 DISCUSSION

4.1 The level of awareness and frequency of 'seen' and 'eaten' of vegetables

The extent of neglect/underutilisation of some vegetables in terms of frequency of ''seen'' and eaten have been summarised in Table 1. The study revealed that only few of the species were in regular use for consumption and most are underutilised. The frequency of ''seen'' ranged from 1.9% in *Parkia biglobosa* leaf to 97.5% in *Cochorus olitorius* while the frequency of eaten ranged from 6.3% in *Adansonia digitata* leaf to 9.5% in *Cochorous olitorius*. This finding was also corroborated by other *ethnobotanical* surveys that showed that several plants' food are available in the wild but only few species were consumed by humans (Saheed and Sumaira, 2007). Among the vegetables, the leaves of trees are mostly underutilised as sources of vegetables; this might be as a result of the fact that trees are generally considered important only as sources of fruit. The nutritional values of three leaves of trees, *A. digitata*, *P.biglobosa* and *V. doniana* and four other shrubs were thus reported and compared to *Amaranthus viridis* which is widely seen and eaten by many respondents. The proximate constituents, level of mineral elements, nutritive energy value and level of macro and micro mineral elements were thus reported in Table 2 and Figures 2 and 3.

4.2 The proximate constituents of the vegetables

The proximate constituents of the vegetables were reported in Table 2. This revealed the level of moisture, crude fat, crude fibre, crude protein, ash and carbohydrate. The moisture content is the amount of water present in a sample; it makes an important contribution to the texture of the leaves and helps in maintaining the protoplasmic content of the cells. It also makes them perishable and susceptible to spoilage by micro-organism during storage. Most of the vegetables studied have high moisture contents which fell within the range of 55.76 ± 0.05 to 91.83 ± 0.04 g/100g reported for some commonly consumed conventional leafy vegetables (Kwenni et al., 2011). However, *Vitex doniana* and *Sesamum indicum* leaves have low moisture contents which could enhance a prolonged shelf life if properly kept from other external conditions.

The vegetables contained high crude fibre (CF) which could be of health benefit. High dietary fibre confer laxative effect in the gastrointestinal tract, thereby shortening transit time of food in the tract, and increasing waterholding capacity of faeces. As a result, the likely incidence of the disorders such as constipation, *diverticulatics*, irritability bowel syndrome, gall stone and colorectal cancer is prohibited. Fibres are known to slow down glucose absorption and reduce insulin secretion which is of great importance to diabetic patients (Ijeomah et al., 2012).

The crude fibre content in the leaves is higher compared to 1.60 ± 0.02 to 4.5 ± 0.14% crude fibre reported for some Nigerian vegetables (Agbaire and Emoyan, 2012). They could supply 19-25%, 21-38%, 28% and 29% recommended daily allowance of fibres for children, adults, pregnant and lactating mothers respectively (Javid et al., 2010).

Thus, these vegetables could be valuable sources of fibre in human nutrition better than the commonly consumed *Amaranthus viridis.* In fact the consumption of these neglected vegetables for their higher crude fibre could also complement the CF of some commonly consumed vegetables which are lower in CF; Talinum triangulare (6.20%), Piper guineeses (6.40%), Cochorus olitorius (7.0%) and bitter leaves, Vernonia amygdalina (6.5%) (Akindahunsi and Salawu, 2005).

The fat contents of the vegetables are low and comparable to that of *Amaranthus viridis*. The crude fat in *V. doniana* is lower than that of *S. indicum*, most often leafy vegetables are poor sources of fat and this is beneficial for individual requiring less fat in their diet as high amount of fat has been implicated in several health related diseases like obesity and cardiovascular disorders (Antia et al., 2006). However, *Vitex doniana* and *S. indicum* have higher fat content when compared to 4.2% in Jatropha curcas and 4.6% in *Celosia argentea* (Agbaire and Emoyan, 2012). They could be good sources of fat soluble vitamins and good substitutes for soup from groundnut which could have more than 50% oil (Asibuo et al., 2008).

All the undervalued vegetables contained high protein except *Vitex doniana* with 8.75g/100g, the level of protein compared favourably with the 26 g/100g in *Amaranthus viridis.* The level in *Vitex doniana* rated low in protein content is higher when compared to that of some commonly consumed vegetables such as lettuce, spinach, parsley and cabbage which contain protein of 1-3% range (Chinnasammi et al., 2011). The vegetables contain more than 12% protein recommended for a food to be considered as a protein source (FNB, 2002). Thus, they could be dietary sources of protein for the alleviation of Protein Energy Malnutrition (PEM). Koval et al.. (1999), have documented the acceleration of fracture healing with a modest of 10 to 20 gram increase in protein intake among elderly hip fracture patients, poor protein status at the time of fracture predicts fracture outcome, those with low protein status take longer to heal and have more complications, including death. Consumption of these vegetables could increase dietary protein need of man.

The ash content which is a measure of inorganic matter in samples is high in all the vegetable samples. The low levels of ash in *Jatropha tanjorensis* and *Vitex doniana* were higher compared to 7.64% ash content in dry leaf of *Moringa oleifera* (Moyo et al., 2011). This indicated that these vegetables could be good sources of mineral elements.

The carbohydrate content and nutritive values of the vegetables were high (Table 2 and Fig.2), the values compared favourably with a range of 58.9% to 66.20% reported for some indigenous vegetables (Nnamani et al., 2009). This could be an indication that the samples could provide energy to power the cells and tissues of the body on consumption. They could therefore be recommended as source of energy for vegetarians.

4.3. Level of mineral elements

Minerals are important in the diet because they serve as cofactors for many physiologic and metabolic functions; they are of interest due to their *pro-oxidant* activities and health benefits (Alphan *et al*., 1996).

The level of calcium is high in most of the samples, the level of calcium compared favourably to the calcium content in *Brassica oleraceae* leaf (4.05 mg/100g Ca) consumed in Asaba, Delta state, Nigeria (Emebu and Anyika, 2011). In fact, the level of calcium in the leaves compared favourably with 3.65 g/100g in *Moringa oleifera* (Moyo et al., 2011). Thus, the calcium in the leaves might be beneficial in preventing calcium deficiency related diseases like osteoporosis. In fact, *Sesamum indicum* leaf could be a better source of calcium than some conventional vegetables. The recommended dietary allowance (RDA) for calcium is 800mg per day (FNB, 2002), this means that about 24g dry weight of this vegetable alone could provide the RDA for calcium. The level of potassium is high in the vegetables and compared to a range of 0.08 to 6.10 mg/100g in some leafy vegetables. Potassium plays a role in controlling skeletal muscle contraction and nerve impulse transmission (Mensah et al., 2008). The vegetables could therefore be recommended to patient with soft bone problems.

Iron were detected in all samples, iron is needed in haemoglobin formation and normal functioning of the central nervous system and in the oxidation of carbohydrates, proteins and fats (Adeyeye and Otokiti, 1999). From the results, the iron content of some of the vegetables were low compared to 1.2 mg/100g in lettuce and 2.7 mg/100g in spinach and cannot solely supply the 7mg RDA of iron for men and 12-16mg per day for women (USDA, 2005).Thus, these leaves should be supplemented with other food sources of iron. However, *Jatropha tanjorensis* contained very high level of iron, more than 0.013 g/100g reported for *amaranthus* (Adewusi et al. 1999) but within the range of 0.14 - 0.17 g/100g reported for *Hibiscus esculentus*, *Baselia alba* and *Celocia argentia* (Akindahunsi and Salawu, 2005).

The vegetable would conveniently provide the RDA of iron for all groups of people. This finding supports the indigenous knowledge and assertion that the vegetable has a potential for the enhancement of blood. It is therefore recommended that the domestication and cultivation of *Jatropha tanjorensis* should be promoted. Zinc was present at micro level in most of the vegetables. It was not detected in *Vitex doniana* leaf. Zinc deficiency has been reported to be associated with dermatitis, poor wound healing, retarded growth and sexual development, reduced taste acuity; apoptosis or programmed cell death is also potentiated by zinc deficiency (Erukainure et al., 2010).

The level of zinc in some of the vegetables was within the range reported for some tropical leafy vegetables and higher than 0.002 g/100g reported for *amaranthus* (Adewusi et al., 1999). These vegetables could complement other food sources because 19g of *Adansonia digitata*, 24g of *Parkia biglobosa* and about 30g of *Jatropha tanjorensis* would provide the 12mg per day RDA for men aged 19-64 years and woman 19-54 years age (NHMRC, 1991). They could be good food sources in effecting positive impact of zinc supplementation on the growth of stunted children and on the prevalence of selected childhood diseases such as diarrhoea (Hussain et al., 2009).

Ascorbic acid (vitamin C) is an antioxidant which strengthens the immune system and helps to protect the body against cancer and other degenerative diseases such as arthritis and type II diabetes mellitus (Mensah et al., 2008). The studied underutilised vegetables contained high levels of vitamin C (Figure 4). The highest quantity was reported in *Jatropha tanjorensis* and lowest in *Vitex doniana*. However, the quantity in *Vitex doniana* was higher in comparison to some leafy vegetables consumed by Edo people of Nigeria; 12.50 ± 0.82mg, 14.61 ± 1.30mg and 21.03 ± 1.15mg/100g in *Pterocarpies soyauxii, Piper guinenses* and *Gnetum ofericanum* respectively. Therefore the consumption of these vegetables would provide the 40mg daily requirement of vitamin C as reported by Chinma and Igyor (2007).

4.4 The constituents of the underutilised fruits and seeds

The proximate constituents of some underutilised fruits and seeds were reported in Tables 4 and 5. Some of the fruits parts have low moisture content which can enhance longer shelf life, those with higher moisture have to be properly preserved and consumed within shortest period to prevent microbial attack. The protein contents of the fruits were higher than 3.2% in fruit pulp of baobab (Osman, 2004). However, fruits generally are not very good sources of fats and are usually recommended as part of weight reducing diets. Low levels of fat contents were recorded in the fruits except in *Cola millenii mesocarp*. A diet providing 1-2% of its caloric of energy as fat is said to be sufficient to human beings as excess fat consumption is implicated in some cardiovascular disorders (Antia et al., 2006). Consumption of these fruits could reduce the intake of fat by individual requiring low fat diet.

Dietary fibre is an important factor in diet as it provides many physiological functions in human beings such as the regulation of intestinal motility, prevention of constipation and regulation of glucose and blood lipids levels (Ijeomah et al., 2012). The crude fibre (CF) in the fruits may prove useful as a good source of dietary fibre. Their levels were higher than the CF in guava (5.2%), pineapple (0.5%), mango (0.7%), papaya (0.8%) and apple (1.0%) (Nazarudeeen, 2010).

The seeds however, are very important as a source of protein, oil and carbohydrate. Some of the seeds contain more than 12 g/100g recommended for a food to be considered as source of protein (FNB, 2002). The protein content in *Bombax glabra* seed compared favourably with 31.65 g/100g in *Moringa oleifera*seed (Anwar and Rashid, 2007). The high protein content may enhance growth and maintenance of tissue and will complement protein from cereals and other plant foods that are known to be low in protein. Some of the seeds like, *Croton zambescus, Cola millenii* and *Bombax glabra* had oil contents which were higher than 14 g/100g in wheat germ, 20 g/100g in soya bean, 23 g/100g in rice bran and 25 g/100g in cotton seed (www.chempro).

These seeds could be good sources of fixed oil thus complementing the conventional sources; they could also be a good source of essential fatty acids and fat soluble vitamins.

4.5 Mineral elements of fruits and seeds

Mineral elements of fruits and seeds reported in Figures 4 and 6 showed that they are good sources of these macro and micro elements. Less than 50g of *Ficus exasperata* fruit, 70g of both *Colamillenii mesocarp* and *Parkia* pulp and 40g of *Croton zambesicus* seed could provide the recommended daily allowance of 800mg of calcium, in fact, less than 10g of *Cola milleniimesocarp*, *Ficus exasperata* fruit, P*arkia* pulp and *Croton zambesicus* seed could provide the 12mg per day RDA for adults. The fruits are therefore good sources of calcium; an increasing calcium intake throughout the life span has been reported to be beneficial to the skeleton (Nieves, 1998). Other macro nutrients and micro nutrients were also detected in both the fruits and the seeds. Potassium is a nutritional metal element that is required in diets, the intake has been reported to show positive association with bone density in elderly women and thus suggested that increasing consumption of food rich in potassium may play a role in osteoporosis prevention (Zhu et al., 2009). The level of potassium in the fruit could be of great physiological significance if included in feed formulations especially in parts of the world where muscle weakness and increased neurons are relatively rampant (Iqhodaro et al., 2012).

Iron has been reported as an essential trace metal which plays numerous biochemical roles in the body, including oxygen binding in haemoglobin and acting as an important catalytic centre in many enzymes (Geisslar and Powers, 2005). It is estimated that two billion of the World's population; largely in developing countries have marked iron deficiency anaemia (WHO, 1997). This in turn limits work performance and leads to impaired performance in mental and motor test in children (Lockeett et al., 2000). The iron content in the fruit is much higher compared to the level in most of the popular fruits such as pineapple (2.42 mg/100g), mango (1.3 mg/100g), apple (0.66 mg/100g) and jackfruit (0.56 mg/100g) (Nazarudeen, 2010). Thus, the level of iron in the fruit could provide the FAO/WHO recommended dietary allowance for males (1.37 mg/day) and females (2.94 mg/day) (WHO, 1997).

4.6 The content of ascorbic acid (vitamin C) in the fruits

The different quantities of ascorbic acid (vitamin C) in the fruits were reported in Figure 6. Ascorbic acid is an important water soluble vitamin implicated in most of the life processes as an antioxidant. It is present abundantly in fruits and vegetables where the common man in the developing countries receives most of their daily intake. The quantities of ascorbic acid in the underutilised fruits are comparatively higher than that in commonly consumed orange. These are higher than 46.5 mg/100g edible portion of lime (*Citrus aurantifolia*), 43.2 mg/100g in pawpaw, 35.2 mg/100g in lemon and 25.2mg/100g in pineapple (Okegbile et al. 1990). The findings was in line with the report of Eromosele et al (1991), a range of 60.3 to 403.3 mg/100g ascorbic acid were reported for some wild fruits. Less than 20g of the fruits could supply the recommended daily intake of 30 mg/day for healthy women and 40 mg/day for men (NHMRC, 1991).

4.7 Nutrient constituents of herbs/ spices

Another class of undervalued species is the spices. They could be used as an aromatic and stimulating addition to medicines and snuff, ground to powder, they may be taken as a stimulant or stomachic or to relieve constipation, thus most times ameliorate food and health problems. Several of these plants parts are used in various concoctions in folk medicine but most of the time they have not been valued for their nutrient potentials. Examples are the eucalyptus species. They have been severally characterised for their essential oils and various biological activities (Ogunwande et al., 2003). Onions (*Allium cepa L.*) is another spice of interest. They are the second most important horticultural crop worldwide, after tomatoes, with current annual production around 66 million tonnes. Over the past 10 years, onion production has increased by more than 25% (Benitezet et al., 2011).

While raw and cooked onions are consumed as young green plants or as bulbs, valued for their distinctive pungency and flavour which improve the taste of other foods, onion peels are usually discarded thus, contributing to environmental pollution. The nutrient contents of the various spices were reported in Table 6. The low moisture in *Eucalyptus citriodora* is a good property for long shelf life, *Syzygium aromaticum* has to be properly dried to prevent microbiological spoilage. *Eucalyptus camadulensis* has low fat and thus could be packaged as beverage for people requiring low fat diet. Most of the spices have high fibre content; this might justify some of their uses as anti-constipation ingredient in folkloric medicine. The outer peel of onion has the highest crude fibre and thus it could complement the dietary fibre needs of people if consumed as ingredient in soup.

The high level of protein and ash in *Croton zambesicus* leaves are an indication that it could assist in body building processes and serve as a source of mineral elements. The spices also contain higher level of mineral elements (Table 7), 27g of *Syzygium aromaticum* alone could provide the 800mg RDA of calcium and less than 1g of onion top-bottom peel and outer scale could provide the 7mg RDA of iron and unfortunately these are the parts thrown away as waste. The levels of iron in these parts are 25% higher than the concentration in the main bulb consumed. Thus, these parts of onion are recommended for consumption as part of food ingredient, Benitez et al. (2011) also reported many nutritive components in the parts of onion.

4.8 Health benefitting Fatty acids

The levels of various health benefitting fatty acids in seeds and spices oils were reported in Figures 8 and 9. The underutilised oils compared favourably with the commonly consumed oils. Oleic acid (omega-9) is a monounsaturated fatty acid with many health benefits. These include ensuring free flow of blood without forming plaques that could block arteries and provision of rich *antioxidants* that help in fighting the devastating effects of free radicals in the body and lowering the level of cholesterol in the body thereby reducing the risk of cardiovascular diseases such as stroke, high blood pressure, angina pectoris (chest pain) and heart failure (Marlene, 2012). Thus, these fruits and spices could be good source of *nutraceutical* for the high level of oleic acid.

Linoleic acid (LA) and *α-linolenic* acid (ALA) present in the fruits and spices are very essential fatty acids that are vital in the maintenance of some key physiological functions of the animal body. The nutritional value of linoleic acid is due to its metabolism at tissue levels which produce the hormone like *prostaglandins* that assists in lowering of blood pressure and constriction of smooth muscle (Aurand et al., 1987).

Linoleic acid was above 50% in the oils of *Telfairia occidentalis seed, Ficus exasperata fruit, Monodora myristica seed* and outer scale of onion. The oils due to the expressed high levels of LA could be valuable as a dietary supplement for the synthesis of *icosanoids* which assists in prevention of cardiovascular, renal, reproductive, gastro intestinal and immune systems dysfunction (Dupont and White, 1990). Also, ALA which was present in the oils is the parent molecule of the omega-3 essential fatty acid family and is converted in the body to other members of the omega-3 group; *docosahexanoic* acid, DHA, C22: 6n-3 and *eicosapentanoic* acid EPA, C20:

5n-3. Adequate intake of EPA and DHA is essential to prevent depression and the ALA in the seed and spice oil could be useful as a dietary supplement to arrest the development and progression of DHA deficiency triggered depression (Chivandi et al., 2009).

4.9 Levels of anti-nutrient phytochemicals

The levels of anti-nutrient phytochemicals in different underutilised species were reported in Table 8. Tannins are water soluble phenolic compounds with a molecular weight greater than 500 and with the ability to precipitate proteins from aqueous solution (Agbaire and Emoyan, 2012). They bind to proteins making them bio unavailable (Bello et al., 2008). Tannin content in the species were low compared to 46.89 ± 0.02mg/g reported for *Melocia corchorfolia* leaves) and 152.5 ± 0.1 mg/g for Cleome *rutidosperma,* an unconventional vegetable commonly consumed in Adamawa state (Hassan et al., 2011). Therefore, the levels of tannin in the species will not pose any toxicity threat.

Phytate is another phytochemical quantified in the species. *Phytate* is known to decrease the bioavailability of minerals, especially Ca, Mg, Fe and Zn (Bello et al., 2008; Hassan et al., 2011). Hurrel et al (1992) reported that a phytic acid intake of 4-9 mg/100g dry matter decreases iron absorption by 45 folds in human. On the other hand, phytate was an *anti-carcinogen* that protects against colon cancer and it is known to be a potent *antioxidant* that inhibits Fenton reactions leading to lipid *peroxidation* and inhibition of *polyphenol* oxidase (Hassan et al., 2011). The levels of phytate compared favourably with 0.20 ± 0.02 mg/g in *Hibiscus cannabinus* and 0.18 ± 0.02 mg/g in *Haematostaphis* b*arteri;* two unconventional vegetables consumed in Adamawa State of Nigeria mostly by the rural dwellers (Kubmarawa et al., 2009). High levels of oxalate have long been known to inhibit the absorption and utilisation of minerals.

It has also been implicated as a source of kidney stones (Bello et al., 2008). Oxalate contents of the different species were low compared to a range of 2.88 ± 0.37% to 3.78 ± 0.28% reported in some edible leafy vegetables (Nkafamiya et al., 2010). This compound is not likely to pose any danger in the species compared to 8.7 per 100g reported for *Amaranthus viridis* among the vegetables and to 10.2 and 32.6g per 100g levels reported for cabbage and sweet potato respectively, (Santamaria et al., 1999). The highest level of trypsin inhibitor in *Strychnos spinosa* fruit pulp was low when compared with a range of 6,700 – 23,300 TIU/g reported for cowpea (Adewusi and

Osuntogun, 1991). This factor is not likely to affect the utilization of the underutilised species for consumption.

5.0 CONCLUSION

The nutrients and health benefitting potentials of some leafy vegetables, fruits, seed oils and herbs/spices were reported. The list to underutilised species is by no means exhaustive, and undervalued plants are diverse in different regions of the world. Nutrient analyses showed that the underutilised leaves of trees are good sources of green vegetables; they have low moisture content, higher fibres and are good sources of zinc and magnesium. Leaves of *Sesamum indicum*are a very good source of potassium and calcium while that of *Jatropha tanjorensis*are a very good source of protein and iron. *Cola millenii mesocarp* is an excellent source of vitamin C more than most commonly consumed fruits, *Cola millenii* seed oil is a very good source of omega-3 fatty acids. The fixed oil in *Syzygium aromaticum* contained a very good ratio of linoleic and linolenic acids which is of health benefit. The promotion, conservation and domestication of these species would not only bring good health benefit but also be of economic importance.

6.0 POLICY IMPLICATIONS AND RECOMMENDATIONS

Nutritional food insecurity in the form of micro nutrient deficiencies remains a key issue in many parts of the world today. Although the different global approaches are in order, efforts should however be geared towards exploring various cheap indigenous species that abound in the immediate environment. The study has shown that underutilised plant species contain more micro-nutrients than the conventional fruits and vegetables and are therefore potential food sources for minimising malnutrition especially among poor populations.

Based on the findings of the study, the following recommendations are drawn:

i. Non-Governmental Organisations, health institutions and dieticians should increase public awareness of the importance of underutilised species for nutrition, with emphasis on the low cost and easy availability of nutrient-rich but underexploited plant species.
ii. Policies on public health and nutrition should also incorporate locally available but underutilised plant species as an alternative nutritional supplement among poor and food insecure households.
iii. Government should also provide enabling environment for commercialisation of these underutilised plant species.
iv. Further research work might also be required to determine the cultural acceptability of these underutilised plants.

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