UNITED NATIONS UNIVERSITY

INSTITUTE FOR NATURAL RESOURCES IN AFRICA

(UNU-INRA)

NUTRITIONAL ASSESSMENT OF UNDERUTILISED TRADITIONAL LEAFY VEGETABLES OF SOUTH-EASTERN NIGERIA

BY

CATHERINE V. NNAMANI

UNU-INRA Visiting Scholars Programme
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ISBN: 978-9988-633-61-5

Editorial Team: Kwabena O. Asubonteng, Praise Nutakor and Karamzo Saccoh, UNU-INRA, Accra, Ghana

Published By: United Nations University Institute for Natural Resources in Africa, Accra, Ghana

ABSTRACT

One is hungry when the body takes in less daily nutritional requirements. Currently, global food security has progressively been contingent on a handful of crops and over 50% of the body's requirement of proteins, calories and minerals, are met by few plant genetic resources. These narrowing bases of food security and dietary menu particularly in Nigeria are limiting sources of nutrients for the poor rural and peri-urban communities, thereby snowballing malnutrition. Diversification of dietary menu to include underutilised Traditional Leafy Vegetables (TLVs), which are cheap, readily available and affordable, could contribute to the daily dietary requirements of resource-poor rural and semi-urban dwellers. The proximate and antioxidant values of 13 underutilised TLVs of South-eastern Nigeria were determined. Multidimensional Analysis (MDA) for decision making tool was used to pool the desirable nutrients in each species based on their weighted factors (WF). These were then compared with two most conventional vegetables *Lactuca sativa var*. *longifolia L* and *Allium cepa L*. These TLVs were *Senna occidentalis Linn*, *Newbualdia leavis Seemann* Bureau., *Solanum nigrum L.*, *Ficus capensis Thunb. Ipomoea aquatica Forsk.*, *Synedrella nodiflora Gaertner.*, *Vernonia cinerea (L.) Less.Ageratum conyzoides L*, *Acanthus montanus (Nees) T. Anders.*, *Mucuna flagellipes Hook. F.*, *Zanthoxylum zanthoxyloids Lam.*, *Amaranthus spinosus L*. and *Telfairia. Occidentalis* Hook. Results showed that these TLVs which do not require formal cultivation could contribute to the nutritional requirements of these resource poor communities in Nigeria.

Multidimensional Analysis showed that *S. occidentalis* ranked 1st with a WF of 4.16, *S. nigrum* 2nd with a WF of 3.90, *T. occidentals* is 3rd with WF of 3.75, while *L. sativa* ranked 4th with WF of 3.56; by desirable nutrient values (high moisture, carbohydrate and protein contents, low fat and better energy calorie nutrients) pooled together amongst these TLVs. Similarly in relation to the antioxidant values, *S. nigrum* ranked 1st with WF values of 5.18, *A spinosus* ranking 2nd with WF value of 4.61, while *L sativa* ranked 14th with WF value of 1.21. *S. nigrum* ranked 1st when all the desirable nutrients (Protein-energy calories (kcal) and antioxidants) values are pooled together with 5.18, followed by *A. spinosus* with 4.61 and *L sativa* with 1.21 ranking 14th. It implies that these underutilised TLVs are potentially endowed with some levels of essential nutrients higher than those of the most cherished and expensive species. They could contribute to the daily nutritional requirement and thereby contribute to reducing malnutrition. There is the need for deliberate policy programmes on sustainable enlightenment on their nutritional benefits in order to promote their cultivation and consumption.

Keywords: Evaluation, Nutrient, Underutilised plants, Decision making, Reduction, Malnutrition, South-eastern Nigeria.

ACKNOWLEDGEMENTS

I cannot let this paper go to press without expressing my sincerest appreciation to all those who made it possible for me to conduct this research. First and foremost, I would like to thank the Director of United Nations University Institute for Natural Resources in Africa (UNU-INRA), Dr. Elias T. Ayuk for his exceptional support and constructive feedback on this study, throughout my stay in Accra as a Visiting Scholar of UNU-INRA.

The tremendous support of the UNU-INRA staff and fellow researchers cannot also be forgotten, as your inputs have contributed to the successful completion of this research.

Thanks to my family for showing patience and love during my four months stay in Accra, Ghana. This research would not have been completed without your understanding and support.

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ACRONYMS

ANOVA	Analysis of Variance
AOAC	Association of Agricultural Chemists
BOSON	Botanical Society of Nigeria
DW	Dry Weight
FND	Food and Nutrition Board
GHI	Global Hunger Index
H_2SO4	Sulphuric acid
HCl	Hydrochloric acid
HELP	High Level Panel of Experts
IQ	Intelligent Quiescent
IUCN	International Union for Conservation of Nature
MDA	Multidimensional Analysis
MDGs	Millennium Development Goals
Mm	Millimetre
NCD	Non-Communicable Diseases
NE	Northeast Trades
NFE	Nitrogen-Free Extract
PEM	Protein-energy malnutrition
ROS	Reactive Oxygen Species
SSA	Sub-Saharan Africa
TLVs	Traditional Leafy Vegetables
UN	United Nations
UNIGCM	United Nations Inter-agency Group for Child Mortality
UNU-INRA	United Nations University- Institute for Natural Resources in Africa
UTLVs	Underutilised Traditional Leafy Vegetables
VSP	Visiting Scholar Programme

WAQUA	West African Quaternary Research Association
WHO	World Health Organization
WHPFS	World Hunger and Poverty Facts and Statistics

1.0 INTRODUCTION

The world is insecurely becoming so reliant on a handful of crops, despite the wealth of traditionally cheap and locally-adapted plant genetic resources. Currently, over 50% of the global body requirement for proteins, energy calories and minerals are met by these few crops. Yet, mankind has, for many decades, used more than 7,000 plants for food, watershed management, fuel and medicine and other necessities in life (Odhav *et al.*, 2006). Kiambi and Atta-krah, (2003), reported that more than 115 of plant genetic resources are indigenous to Africa. These narrowing bases of food security and consumption habit are limiting sources of nutrients and livelihood options for the rural-poor and peri-urban communities (Future Harvest, 2007), thereby snowballing malnutrition. The above scenario is compounded by the pressure of climate variability and change on crop productivity and yield, galloping population growth and volatile food prices. The result of all these are high prevalence of abject poverty, translating into increased number of hungry people.

von Grebmer *et al.* (2011) noted in Global Hunger Index (GHI) of 2011 that Sub-Saharan Africa (SSA) and South Asia share the highest regional GHI scores of 21.7 and 22.9, respectively. Evidence from the report shows that out of the 925 million hungry people in the world, Sub-Saharan Africa and South Asia accounted for the greatest proportions of 239 and 578 million, translating to 26% and 62%, respectively (Figure 1).

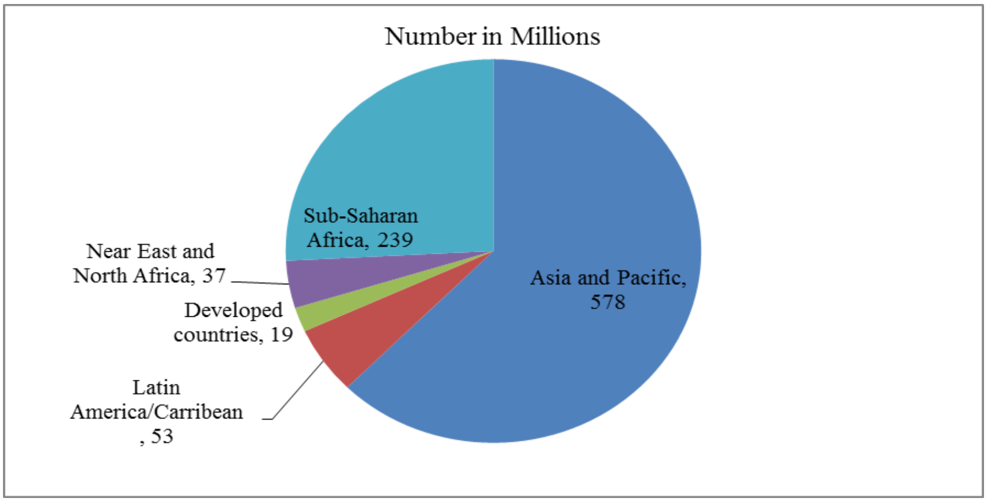

Figure 1: Hungry People in 2010, by Regions (millions) (source: FAO, 2011)

However, von Grebmer *et al.* (2011) stressed that hidden hunger as a result of food insecurity in the two regions has two distinct effects. While in South Asia, the major problem is a high prevalence of underweight children who are under five years, in Sub-Saharan African countries it is rather a high rate of child mortality and morbidity. The nutritional health risk in South Asia is attributed to low nutrition and educational status of women. In SSA however, the high proportion of people who cannot meet their protein-energy calorie requirements is attributed to their low income capacity, bad governance, conflicts and political instability in many of these countries.

WHO (2008) equally reported that globally, under-five mortality has decreased by 35%, from an estimated rate of 88 deaths per 1000 live births in 1990 to 57 deaths per 1000 live births in 2010. This decline translates into an average annual decrease in child mortality of 2.2%. However, these trends which are more pronounced in America, European and the Western Pacific by 50% or more are yet to be scaled up in Sub- Saharan Africa and South-Asian regions, where mortality rate is still high at 3.7 and 2.5 million (31% and 32%), respectively (UNICEF, 2010) (Figure 2).

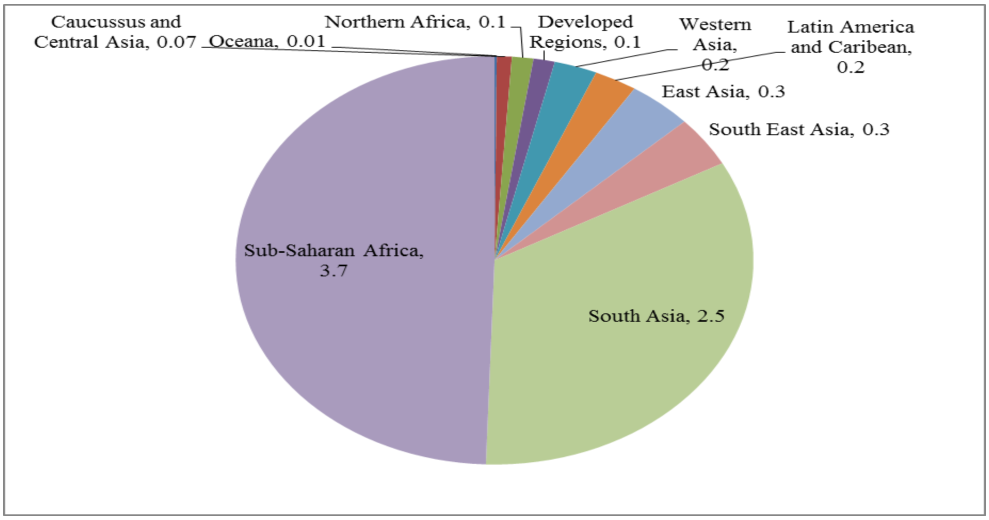

Figure 2: Under-five Child Deaths in 2010 (Millions) (source: UNICEF, 2011)

According to the WHO (2008), about 2 billion people, mostly in developing countries, suffer from micronutrient malnutrition and most of these numbers are clustered in Sub-Saharan Africa and South Asia, who incidentally are the two regions with the highest rates of poverty.

Malnutrition has been noted to be the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth,

maintenance, and other specific functions (Onis et al., 1993). It is systematically interconnected with deficiency of critical micronutrients such as vitamin A, iron, zinc, iodine, protein and dietary calories in daily diet and it is among the world's most serious health risk factors. Lack of these vital elements in diets impairs the mental and physical development of children and adolescents which could result in lower IQ, stunting growth and blindness. The WHO's report (2006) indicated that women, the elderly and children are most vulnerable to malnutrition. These deficiencies arise due to low income capacity, segregation and inequality status which hamper their access to preferences for food that is safe and nutritious enough to meet their dietary needs to enhance active and healthy life (HLPE, 2012). The role of these vital elements in the health of individuals, particularly the poor rural people whose daily staples are basically carbohydrate heavy, has increasingly attracted more attention. Between 100 and 140 million children are vitamins A deficient. Again, it is estimated that between 250,000 to 500 000 of these vitamin A-deficient children become blind every year. In developing countries, half of the children die within 12 months of losing their sight (WHO, 2008). It is postulated that by 2025, hunger would be a daily reality for nearly 42 million children in Africa and this is attributable to micronutrient deficiency, affecting people of all ages in lower socioeconomic groups (Uchendu and Atinmo, 2010).

Ejide (2012) noted that hunger in Sub-Saharan Africa (SSA) dominates African narrative to the neglect of malnutrition, an insidious and lethal offshoot of hunger that should be the focus of sustainable development discourse. Confirming the power of this myriad of inaudible killer of sustainable development in SSA, the Food and Nutrition Board in 2007 reported that malnutrition is the underlying cause of one third of child deaths in SSA- although it may not appear on their death certificates. Instead, secondary illnesses such as diarrhoea, pneumonia and malaria, rather than malnutrition or hidden hunger, are usually put down as the cause of death. However, every available data shows that child death caused by malnutrition are not equally distributed throughout African countries but rather are clustered in poor communities with low income capacity (Onis and Blössner, 2003).

This glaring index of chronic yoke of malnutrition in most African countries cannot be solved by food aid or food trade from the affluent countries, but rather by the adequate and sustainable utilisation of the rich biodiversity endowed by nature within these countries. The diversity of indigenous plant

resources in most African countries can make substantial contribution in meeting the nutritional needs of its populace, especially the low income group in the rural communities. This is more promising now than ever, in the wake of the looming food crisis that threatens to further reduce the already inadequate national food security; occasioned by climate variability and change on crop productivity and yield, currently experienced in many African countries (Emokaro and Ekunwe, 2007).

A cursory look at the diversity of useful plant genetic resources in some African countries shows an estimated density of 2,090; 4,614; 2,200; 1,000; 3,600; 974 and 774 valuable flora in Sierra-Leone, Nigeria, Liberia, Guinea-Bissau, Ghana, Gambia and Cape Verde, respectively (Adebooye and Opabode, 2004) (Figure 3). This can be seen as one of the reasons that have informed the establishment of United Nations University- Institute for Natural Resources (UNU-INRA) in Africa, to strengthen the sustainable development of these natural resources for the benefit of Africa and the world at large. This number is not exhaustive because intensive research works on indigenous knowledge are still going on in this area, discovering many more useful species.

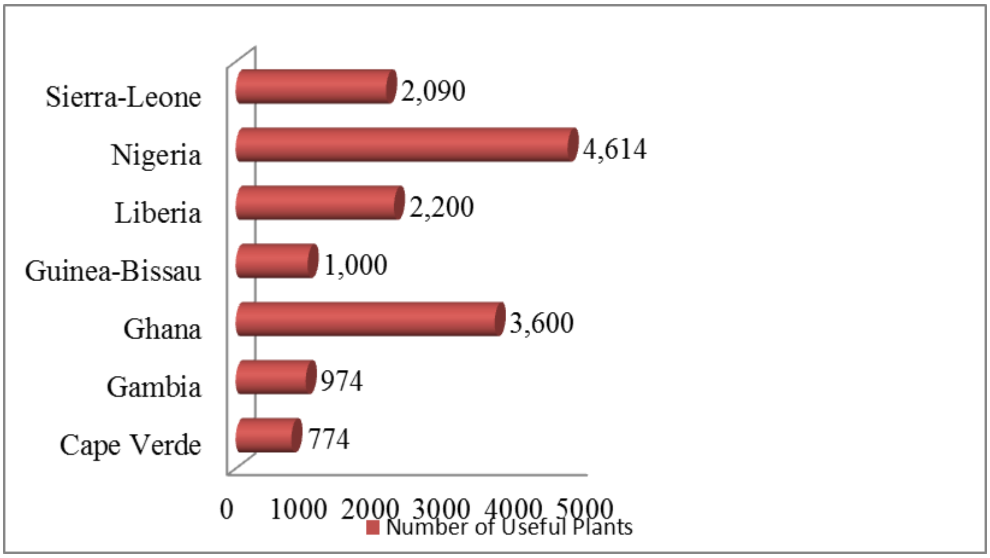

Figure 3: Diversity of useful plants in some African countries (source: Adebooye and Opabode, 2004)

However, this chronic and high prevalence of malnutrition in most African countries with abundant natural resources calls for urgent reappraisal. Diversification of consumption habit to include underutilised TLVs is the most sustainable way of controlling and reducing this menace in resource-poor countries of Africa in general and Nigeria in particular.

Olaiya and Adebisi. (2010) stated that vegetables are important protective foods, which are highly beneficial for the maintenance of good health and prevention of diseases. It has been reported that increasing colon and stomach cancers correlate with low vegetable meals intake. It is suggested that the incorporation of vegetables in our diet may help reduce the incidence of these types of cancers (Gropper *et al*., 2005). It is highly valuable in maintaining alkaline reserve in the body due to their high vitamin, dietary fibre and mineral contents (Ball, 2006).

The dark green leaves and deep yellow fruits provide a high amount of *carotene, ascorbic* acid and micro minerals which play important roles in nutrient metabolism and thereby slowing down degenerative diseases (Yi-Fang *et al*., 2002, Olaiya *et al*., 2010). TLVs also make food more palatable, appetising and digestible. In support of these facts, Ogunlesi *et al* (2010) stated that the consumption of fruits and vegetables in diet has been reported to protect the human body from degenerative diseases. It is very essential in the diet of postpartum women as they aid the contraction of the uterus.

The main protective action of vegetables has been attributed to the *antioxidants* present in them, which act as scavengers to Reactive Oxygen Species (ROS) on stressed tissues, organs and organelles. In so doing, they maintain the balance between the production and removal of potentially damaging radicals generated by a variety of sources including pesticides, tobacco smoke, exhaust fumes, certain pollutants and organic solvents in the body (Szeto *et al* ., 2002). Apart from all these vital benefits, TLVs are cheap and readily affordable to many resource- poor people in rural, semi-urban and urban areas (**Plate1**). Because they are accessible to low-income groups, they play a crucial role in improving their food security, nutritional statuses and livelihood options (Nnamani *et al*., 2009, 2010). They can help to meet the increasing demand for food security in this era of price volatility, mitigate climate change and be beneficial to the health needs of rural populations.

Though it is argued that vegetables products have lower food value and heat than foods from animal origin, they have vital nutrition. Koudela and Petříková, (2008) reported that many species of vegetables contain high amounts of digestible carbohydrates (starch, sucrose, glucose, and fructose) and non-digestible carbohydrates (cellulose, hemicellulose, pectin). Consumption of fresh vegetables enables full assimilation of vitamins in the

human body with their high content of numerous minerals such as: Ca, Fe, Cu, P, Zn, Cl, and Na amongst others. They provide alkalising effects thereby neutralising the acidity produced by other foods, especially those of animal origin.

Plate 1: Traditional leafy vegetables are readily accessible, cheap, and affordable to many resource- poor people in rural areas.

1.1 General Background of Nigeria

Nigeria is located in West Africa and it is bordered by the Gulf of Guinea to the south, Benin on the west and Cameroon on the east. It has a compact land area of 923,768 square kilometres (356,376 square miles) (Ofomata, 1985) with a population of 170,123,740 (US Census Bureau 2011). However, UN World Population Prospects (2010) reported that Nigeria has experienced population explosion during the last 50 years due to high fertility rates which resulted in the quadrupling of its population. It further projected that the population of Nigeria will reach 402 million by 2050 and may get to 730 million by 2100 (US Census Bureau, 2011).

1.2 Status of Malnutrition in Nigeria

A nippy look at the socio-economic implication of these projections indicates that more than half (53%) of the population are between 15 and 64 years old. The second segment (44%) includes children between 0 and 14 years old who are helpless and vulnerable to food insecurity, while the last segment of (3%) comprises individuals above 65 years. This latter segment comprises people who are naturally above productivity age. High mortality due to non-communicable diseases (NCD), lower life expectancy, and high infant mortality and morbidity, occasioned by hidden hunger (micronutrient deficiency) will definitely be the characteristic phenomenon in a country with so many mouths to feed and low agricultural output to balance this number.

The UN Inter-agency Group for Child Mortality (2011) estimated that about half of all under-five years' deaths occur in five countries- namely, India, Nigeria, Democratic Republic of the Congo, Pakistan and China. It noted further that 22% is recorded in India while Nigeria accounted for 11%. It is significant to note that the two countries accounted for a third of all under-five deaths (Figure 4).

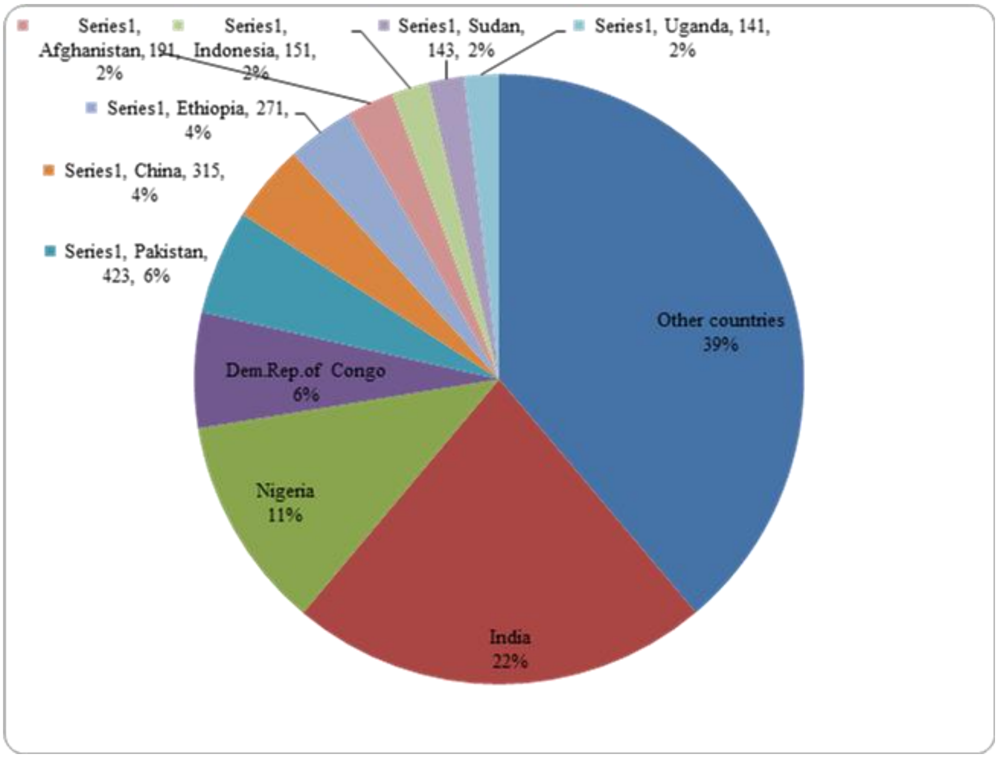

Figure 4: Top ten countries with the most under- five deaths in 2010 (Source: UN Inter-agency Group for Child Mortality, 2011)

Similarly, the GHI (2011) ranked Nigeria 40th out of 80 countries with high proportion of hungry people. Statistics have shown that these numbers are concentrated in the local communities where subsistence farming and extraction of resources from the immediate ecosystem are the only options of livelihood.

According to the World Bank's Poverty Assessment country report on Nigeria, 62.60% of Nigeria's population lived below national poverty line in 2010. The percentage of people below the National Poverty Line in rural areas is higher than the national average. While in the rural areas 69.00% of people were below the poverty line, the figure for urban areas was 51.20%. Source: (http://data.worldbank.org/topic/poverty,http://povertydata.worldbank.org/poverty/home/).

Uchendu and Atinmo (2011) in confirming the above facts reported that WHO in its performance rating for health system ranked Nigeria 187th of the

200 member states of the WHO nations, where majority of the populace are experiencing excruciating pains of malnutrition and poverty accompanied by huge unemployment and poor social infrastructures. These scenarios are compounded by neglected and dilapidated health care system, low agricultural productivity and low industrial investment. All these result in high inflation thereby making the little food products available so expensive and unaffordable to the greater number of the population who are usually poor (Enogholase, 2010).

UNICEF (2011) reported that more than one-quarter of all children less than five years in developing countries and mostly in Sub-Saharan Africa, were underweight. More than one-third (8,819) representing 11% of all these underweight children were found in Nigeria alone.

Table 1: Nutritional Indices of Nigeria from 2007-2011

Nutritional Indices	Percentage
Low birth weight (2007-2011)	12
Underweight (2007-2011), moderate and severe	23
Underweight (2007-2011) Severe	9
Stunting (2007-2011), moderate and severe	41
Wasting (2007-2011) moderate and severe	14
Overweight (2007-2011), moderate and severe	11

Source, UNICEF, 2011

(http://www.unicef.org/infobycountry/nigeria_statistics.html,accessed, viewed, 12/07/2013).

South-eastern Nigeria has six geo-political zones consisting of Abia, Anambra, Ebonyi, Enugu and Imo States. It is located within longitudes 5° 30' and 9° 30' E and latitudes 4° 30' and 7° 00' N, occupying a land area of about 75,488 km^2 and bordered by Cameroon to the east, Cross River State to the south, the River Niger to the west, Kogi and Benue States to the north (figure 5) (Ofomata, 1975).

Broadly speaking, temperature in the South-eastern Nigeria is marked by two distinct alternating seasons of uniformly high temperature of 37° C. The aridity of the dry season is accentuated by the dust laden harmattan winds (NorthEast Trades). The mean monthly temperatures oscillate between 23.3°C and 27.7° C with a seasonal bimodal annual rainfall of (1500-2500mm). Vegetation is essentially a response to the climate associated with the long anthropogenic activities which has given rise to a derived mosaic of the Lowland Rainforest vegetation type that houses a relic of Tropical rainforest vegetation belt (Ofomata, 1975).

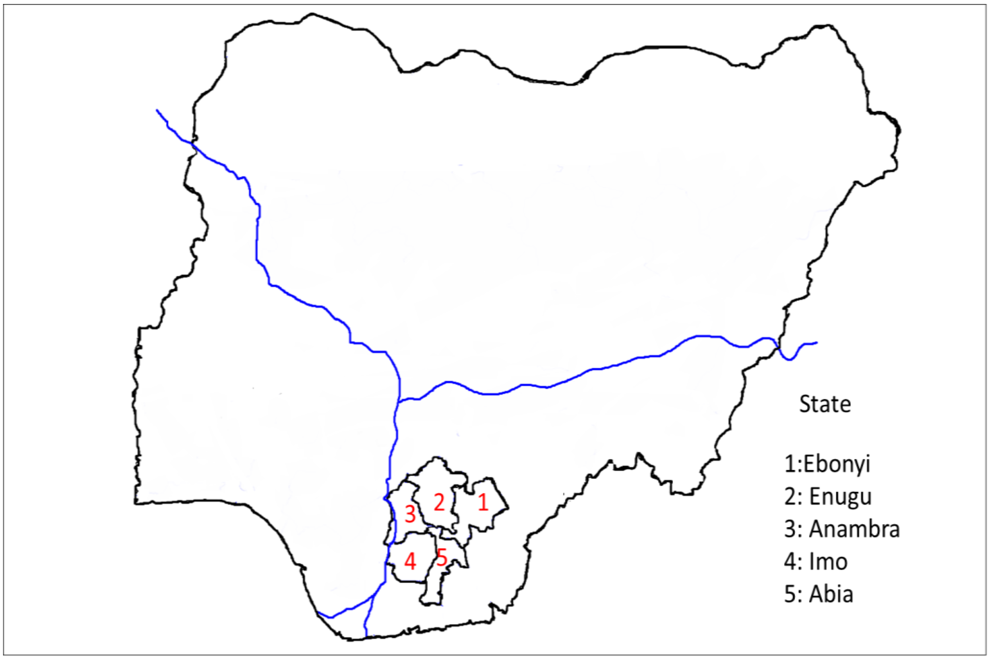

Figure 5: Map of Nigeria, showing South-eastern Nigeria. Source: Ofomata, 1975 (modified)

The 2006 World Population Revision Database gave South-eastern Nigeria population to be 16,381,729. This shows that the population in 2012 must be far more above the stated figure considering high fertility rate which is synonymous with the country in general (World Population Prospects, 2010).

According to Madu (2005), population pressure is the most important problem of rural development in this region, recognisable from a broad spectrum of livelihood activities such as rigorous agriculture, engagement in non-farm activities like extraction of flora and fauna from their immediate ecosystem as a means of survival and migration into urban cities. Majority of these people have access to the minimum amount of calories derivable from their habitual carbohydrate staple of yam, rice and cassava. Most

communities in South-eastern Nigeria depend on starch-based foods as the main staple, for their supply of both energy and protein. This accounts in parts for the high prevalence of malnutrition among the populace (Akinyele, 2005).

Documentation of the wild and cultivated TLVs in many parts of Nigeria on their identification, preparation, utilisation and nutritional values have been conducted (Okafor, 1983; Okigbo, 1977; Dania-Ogbe *et al*., 1992; Chweya, 1999; Dania-Ogbe *et al.,* 2001; Chweya and Eyzaguirre, 2002; Adebooye, 2001; 2002; 2004; PROTA; 2004; Nnamani *et al.,* 2009, 2011).

The above works were notable, because they opened up more frontiers for greater research on underutilised plant genetic resources in Nigeria. However, there are some glaring gaps on data for their nutritional values, especially with the increasing number of useful plants from indigenous knowledge. Secondly, these TLVs are rich in nutrients as noted by some of the researchers cited earlier. Nevertheless, these species are not equally endowed with these bioactive compounds; some may be rich in one nutrient and deficient in another. Using the conventional tool of Analysis of Variance (ANOVA) to show which of the nutrient was significantly higher or lower in these TLVs is quiet good, but it does not allow us to make a decisive decision on each of the most desirable nutrient for a particular species when the need arises.

This current work sought to use Multidimensional Analysis (MDA) for Decision Making by Akoroda (2004), to rank and classify these TLVs based on their most desirable nutrients. This decision making tool will identify, pin and incorporate all the desirable weighted factors (WF) per nutrients as contributed by each species, to enable a final decision on these TLVs. To the best knowledge of the researcher, this is the first innovative step in this direction for UTLVs in Nigeria in general and South-eastern Nigeria in particular.

The major aims of this research work were to assess the proximate values of these TLVs; evaluate their antioxidant compositions and use Multi-dimensional Analysis for decision making to identify, capture and rank these TLVs. This will enable the summation of all the desirable nutrients and finally make decision on them. The findings will also enhance their selection as components of dietary menu, thereby improve the nutritional status of the rural communities in South-eastern Nigeria.

2.0 MATERIALS AND METHODS

2.1 Plant Collection and Identification

Freshly harvested TLVs were collected from farms, markets and home gardens in some local communities in Ebonyi, Enugu and Anambra states of South-eastern Nigeria. Details of each plant species with respect to their scientific names, family, common name and local name are elaborated in Table 2. Two conventional species *Lactuca sativa var. longifolia* L (exotic) and *Allium cepa* L were used in comparison. Identification of plants was done in the fields by the taxonomist and authenticated with monographs and textbooks by Keay, (1989); Akobundu and Agyakwa (1998), and Inyang (2003). Vouched specimens were deposited in the herbarium of Department of Applied Biology, Ebonyi State University Abakaliki, Nigeria.

2.2 Sample Preparation

The TLVs were taken to the laboratory where unhealthy and infected ones were carefully removed. They were washed, cut and oven dried at 40°C for 2 hours. The dried leaves were pulverised, packaged in airtight sterile bottles, labelled and stored in a refrigerator until used.

2.3 Proximate Analysis

The chemical analysis of percentage crude protein, crude fibre, moisture, ash, fat and carbohydrate were carried out using methods described by Pearson, (1976). The crude protein was obtained by determining the organic nitrogen content of the sample using micro- Kjeldah method and multiplying the nitrogen by a protein conversion of 6.25. The ash content of the leaves was estimated by igniting the weighed sample in the weighed crucible at a temperature of 500°C for about 3 hours in a muffle furnace, while the moisture content was determined using oven method. The crude fibre and fat determinations were done by hydrolysing the sample with 0.128ml of H2SO4 and 0.223ml of KOH and *Soxhlet* extraction method, respectively. Carbohydrates are not measured directly, but were estimated by calculating the “nitrogen-free extract” (NFE) in the product. This is determined simply by subtracting the average of each of the other components (percentage crude protein, crude fat, crude fibre, moisture and ash) from 100.

2.4 Physiochemical Analysis

The mineral contents were determined using dry ashing procedure as

described by Association of Agricultural Chemists (AOAC, 1990). About 2g of each sample was pre-ashed in a crucible for 1-2 hours until the sample is completely charred on a hot plate. The pre-ashed sample was then placed on a muffle furnace and ashed at 500°C for about 3 hours or until the ash is white. After ashing, the sample was cooled and weighed. This was transferred into a 50ml volumetric flask by carefully washing the crucible with 5ml of 30% HCl. The solution was diluted to volume with iodized water and was then used for individual mineral determination using Spectrophotometer and flame photometer.

2.5 Calculate the Energy Calorie Content

The proximate content of these TLVs were worked out to determine their energy calories (kcal) values, this involves the amounts of crude protein, crude fat, and carbohydrate in the product multiply by the appropriate “modified Atwater” values of 3.5 for protein and carbohydrate with 8.5 for fat (Jones, 1941). The results of the three calculations are added and multiplied by 10.

2.6 Statistical Analysis

Three replications were made for each of the sample. Data were analysed using a number of statistical techniques, specifically percentages, charts, means and standard deviation. Akoroda’s (2004) Multidimensional Analysis (MDA) for decision making was used to rank and classify the summation of all the desirable nutrients including (moisture, Protein, carbohydrate, fibre, low fat values, energy values, Vitamin A, B1, B2, B3, Vitamin C, and E) in all the TLVs plus the two conventional species in order to make a decision on them.

Table 2: List of TLVs of South- eastern Nigeria used for the analysis (scientific names family and common name)

S/N	Scientific Name	Family	English Name	Local Name
1	*Senna occidentalis* Linn	Fabaceae	Negro Coffee	Oshigbuomma
2	*Newbualdia leavis* Seemann Bureau	Bignoniaceae	Boundary tree	Omirima
3	*Solanum nigrum* Linn	Solanaceae	Black nightshade	Ewa
4	*Ficus capensis* Thunb.	Moraceae	Hedge fig	Ekwuakpuru
5	*Ipomoea aquatica* Forsk.	Convolvulaceae	Swamp morning glory	Ekwuuda
6	*Synedrella nodiflora* Gaertner.	Asteraceae	Node weed, Cinderella Weed	Ekwu ewu
7	*Vernonia cinerea* (L.) Less.	Asteraceae	Little ironweed	Orubu egu
8	*Ageratum conyzoides* L	Asteraceae	Goat-weed	Ekwu eyu
9	*Acanthus montanus* (Nees) T. Anders.	Acanthaceae	Leopard/False thistle	Ezi Agu
10	*Mucuna flagellipes*Hook. F.	Fabaceae		Egbara
11	*Zanthoxylum zanthoxyloids* Lam	Rutaceae	Candlewood, Senegal prickly-ash	Nkaa
12	*Amaranthus spinosus* L.	Amaranthaceae	Spiny amaranth	Enene ogwu
13	*Lactuca sativa var. longifolia* L	Asteraceae	Lettuce	Lettuce
14	*Telfairia. occidentalis* Hook	Cucurbitaceae	Fluted pumpkin	Ugu
15	*A. cepa* L	Alliaceae	Onions	Alibasa

Source: Fieldwork, 2012

3.0 RESULTS AND DISCUSSION

The result as presented in Table 2 shows the mean values of the proximate analysis for the TLVs including *L. sativa*. Considering the overall moisture content, it showed that *L. sativa* had the highest moisture content of 95.60%, followed by *S. occidentalis* with 95.19±1.26% (4.81% DW), *Z. zanthoxyloides*with 90.4±1.05%; others had comparatively moderate values ranging from 88.50±1.21% - 81.05±1.0.04.% as compared with *A. cepa* 76.32±0.07%. The least was recorded from *M. flagellipes* with 69.3±50.18% (Table 2). It is interesting to note that, in view of these analyses, the moisture contents of *S. occidentalis* with 95.19±1.26% (4.81% DW), *Z. zanthoxyloides* 90.4±1.05%; of these underutilised TLVs were comparable with the value of the most cherished and highly priced *L. sativa* with 95.60% (4.4% DW) (Latham**,** 2000). The result is equally comparable with 94.91% *L. sativa* by (Caunii *et al.*, 2012).

However, this result was greater than the 84.00% reported for African spinach by Mohammed and Mann (2012) and Chionyedua *et al.* (2009) in *Amaranthus cruentus* (23.57% DW), *Celosia argenta* (15.58% DW), and *C. olitorius* (30.90%). George (2003) and Nnamani *et al.*, (2009) noted that although moisture content makes an important contribution to the texture of the leaves and helps in maintaining the protoplasmic content of the cells, it also makes vegetables perishable and susceptible to spoilage by micro-organism during storage. This underpins their vulnerability to decay and hence their low shelf life. The above facts notwithstanding, Lussier (2010) reiterated that the levels of moisture in some TLVs will help the body to use less energy and resources to digest and assimilate the nutrients in them thereby exerting less pressure on the digestive system.

The results equally showed variations in the level of protein, ash, fat, fibre and carbohydrate (Table 2). Significant differences were observed practically in protein contents, with the highest values recorded from *S. nigrum* 26.49±2.07; this was followed by *T. occidentalis* with 24.67±1.90 and *Z. zanthoxyloides* having the least value of 6.12±0.43 (Table 2). In the same line, a brief look at this table shows a “breath ceasing” low content of protein for *L. sativa* with 1.4±0.0 as reported by (Latham**,** 2000 and United States Department of Agriculture, 2012). The above results were equally higher than the value for *Gnetum africanum* (utazi) 6.40±0.25 as reported by (Agbaire and Emoyan, 2012)**.** It is worthy to note that these TLVs have

crude protein values exceeding the Minimum Daily Protein Requirement (MDPR) of 0.45grams of protein per kilogram, for ideal body weight per day as recommended by WHO (2002).

Similarly Pearson (1976) reported that, plant product that contains more than 12% of its calorific value from protein is considered good source of protein. It implies therefore, that *S. occidentalis, N. leavis S. nigrum F. capensis I. aquatic, S. nodiflora V. cinerea A. conyzoides A. montanus M. flagellipes A. spinosus and T. occidentals* with crude protein values of 20.58 ± 0.10, 17.58 ± 1.02, 26.49 ± 2.07, 17.88 ± 1.08, 15.99 ± 0.01, 16.51 ± 0.15, 15.92 ± 0.04, 18.98 ± 1.21, 19.1 ± 1.05, 17.41 ± 0.71, 22.11 ± 1.84 and 24.67 ± 1.90, respectively are good sources of plant protein (Table 2). The above results were higher than 1.01 ± 0.02 % and 1.30 ± 0.05 % reported for *Brassica capitata* (Red cabbage) and *Daucus carota* with 1.03 ± 0.06 % from Netherlands and France, respectively (Algirdas *et al*., 2012). FND (2002) and Mohammed and Mann, (2012) noted that adults, children, pregnant and lactating mothers require 34 to 50, 13 to 19, and 17 to 71 g of protein daily, respectively.

Consequently, these results show that some of these TLVs could supply the 13-19 g of daily protein requirement, which satisfies the recommended daily allowance of protein for children (FAO, 1986), who are the most vulnerable to malnutrition in Nigeria.

The carbohydrate content was highest in *Z. zanthoxyloides* 66.2 ± 1.84, followed by *S. occidentalis* 58.48 ± 2.05 with *I. aquatica* recording the least value of 8.72 ± 0.02. Even with this low values as inferred for *I. aquatica*, their values for this indispensable nutrients were all higher than that of the highly esteemed *L. sativa* with 2.2 0 ± 0.01. Others ranged from 58.48 ± 2.05 to10.01 ± 0.13.

Crude fat content was highest in *A. spinosus* 9.50 ± 1.25 as compared to other species with lower fat value. This value deviated so much with the result reported from another genus of *Amaranth* with 3.00 + 0.01 by (Kwenin *et al.*, 2011). The interesting aspect of this work is the revelation on the high lipid contents of some of these TLVs such as *A. spinosus, Z. zanthoxyloides* and *S. nigrum* recording 9.50 ± 1.25, 3.5 ± 0.02 and 1.8 ± 0.52, respectively as against 0.2 ± 0.01 for *L. sativa* (United States

Department of Agriculture, 2012, Caunii *et al*, 2011). This low fat value of *L. sativa* makes it the best in this respect. Incidentally, *Z. zanthoxyloides* and *S. nigrum* are two of the most highly sought for among these TLVs and in high demand in South-eastern Nigeria. Nonetheless, some of these TLVs have low fat contents to make them desirable as component of dietary menu as against the recommended value Daily carbohydrate– fat-protein ratio of 20 to 30% energy source for a meal. Those with low fat contents were *S. occidentalis, I. aquatic, S. nodiflora, V. cinerea, A. montanus and M. flagellipes with* 0.35 ± 0.02, 0.35 ± 0.02, 0.25 ± 0.01, 0.3 ± 0.01, 0.5 ± 0.03and 0.3 ± 0.01, respectively (Table 2). The above results were comparable with *A. cruentus* (0.45%), *C. argenta* (0.21%), and *C. olitorius* (0.32%) as reported by (Chionyedua *et al*., 2009).

Table 3: Nutritional values of the underutilised traditional leafy vegetables of South-eastern Nigeria (%/2g)

	S/N	Moisture	Protein	Ash	C2HO	Fat	Fibre
1	*S. occidentalis*	95.19±1.26	20.58 ± 0.10	14.1 ± 2.11	58.48±2.05	0.35 ±0.02	2.40 ±1.16
2	*N. leavis*	81.10±1.03	17.58 ±1.02	6.2 0± 0.02	58.27±1.28	0.95 ±0.06	2.5 0±1.09
3	*S. nigrum*	88.50±1.21	26.49 ± 2.07	15.15±2.53	33.65±0.84	1.8 0±0.52	3.01±1.14
4	*F. capensis*	81.09±0.04	17.88 ±1.08	2.65 ±0.06	12.45±0.18	0.67 ±0.03	1.75±0.82
5	*I. aquatic*	87.15±0.72	15.99 ± 0.01	1.05 ± 0.01	8.72 ±0.02	0.35 ±0.02	1.05 ±0.51
6	*S. nodiflora*	81.05±1.04	16.51± 0.15	3.10 ± 1.06	10.01±0.13	0.25 ±0.01	1.20 ±0.03
7	*V. cinerea*	82.65±0.23	15.92± 0.04	1.50 ± 0.02	9.62±0.28	0.30 ±0.01	1.85 ±1.05
8	*A. conyzoides*	83.20±0.51	18.98 ±1. 21	2.90 ± 0.11	12.15±0.16	0.80 ±0.04	2.30 ±1.06
9	*A. montanus*	82.80±0.38	19.10 ± 1.05	2.70 ± 0.02	11.12±0.09	0.50±0.03	1.89 ±0.91
10	*M. flagellipes*	69.35±0.18	17.41 ± 0.71	1.75 ± 0.04	24.01±0.18	0.30 ±0.01	2.01 ±1.03
11	*Z. zanthoxyloides*	90.40±1.05	6.12 ±0. 43	8.10 ± 1.07	66.2 ±1.84	3.50 ±0.02	2.35 ±1.23
12	*A. spinosus*	81.05±0.06	22.11± 1.84	14.95 ±1.49	33.05 ±0.81	9.50 ±1.25	1.44 ±0.39
13	*L. sativa**	95.60±1.19	1.40 ±0.01	-	2.2 0± 0.01	0.20 ± 0.01	1.16 ±0.02
14	*T. occidentals*	80.03± 0.14	24.67±1.90	10.63± 1.08	42.28 ±2.07	1.20 ±0.03	2.30 ±1.05
15	*A. cepa*	76.32±0.07	11.53 ± 0.53	-	78.36± 4.13	0.97 ±0.05	0.07 ±0.01

Source: Field work. Legend:* Data from Latham, (2000), Caunii *et al*., (2012)

With regard to the fibre contents of all the studied TLVs, results show that they are potentially high for this food nutrient. *S. occidentalis* had 2.4 ± 1.16, *S. nigrum* 3.01 ± 1.14, *N. leavis* 2.5 ± 1.09, *A. conyzoides* 2.3 ± 1.06 and *Z. zanthoxyloides* 2.35 ± 1.23. Others are relatively low, ranging from 2.01 ± 1.03 to 1.05 ± 0.51 (Table 3). In view of the vital role of high fibre content in

a diet, Yekeen *et al* (2011), reiterated that high fibre rich food usually produces loose stool, reduces stool transit time in the intestine and prevents colon cancer. This implies that these TLVs could contribute to colon cancer reduction, if incorporated into the daily meals of these resource- poor communities in Nigeria.

Results in figure 6, shows the protein-energy calorie (kcal) values of these TLVs, with *T. Occidentalis* having the highest, followed by *S. occidentalis* and *S. nigrum* with 674.33, 668.02 and 653.37 kcal, respectively. The least was recorded from *I. batata* with 213.68. However, this energy calorie content was still higher than that of 83.73 for *L. Sativa (*Latham**,** 2000). This implies that these TLVs as potential sources of energy could contribute to the daily allowance of protein-energy calories.

The vitamin (antioxidant) analysis indicated that these TLVs were potentially high in vitamin A with *S. nigrum* having the highest value of 1517.73 ± 0.20, followed by *N. leavis* and *T. occidentalis* with 1276.60 ± 0.01 and 1177.31 ± 0.21, respectively (Table 5). The lowest content was recorded from *F. capensis* with 312.06 ± 1.10. Mircea (1995) reported that, although Vitamin A is not found in plants, its major precursor beta-carotene can only be accessed in plants and considering its importance to human health, its deficiency leads to night blindness and failure of normal bone and tooth development (FAO, 1998). The Vitamin C contents of the TLVs showed variable trends and considerable high values with the highest coming from *S. nigrum* 14.99 ± 0.4 followed by *A. conyzoides, Z. zanthoxyloides, T. occidentalis* with 12.65 + .02, 10.59 ± 1.03 and 10.59±0.40, respectively (Table 5). Across other species, antioxidant potentials were relatively high.

These results cannot compare favourably with 67.2% (*L. taracifolia*) to 91.8% (*B. pilosa*) TLVs from South-western Nigeria (Oloyede *et al*., 2011) and those of amaranth globe (97.49), bitter leaf (32.15), cabbage (23.05), ginger (11.50) and honey (27.78) (Ogunlesi, 2010).

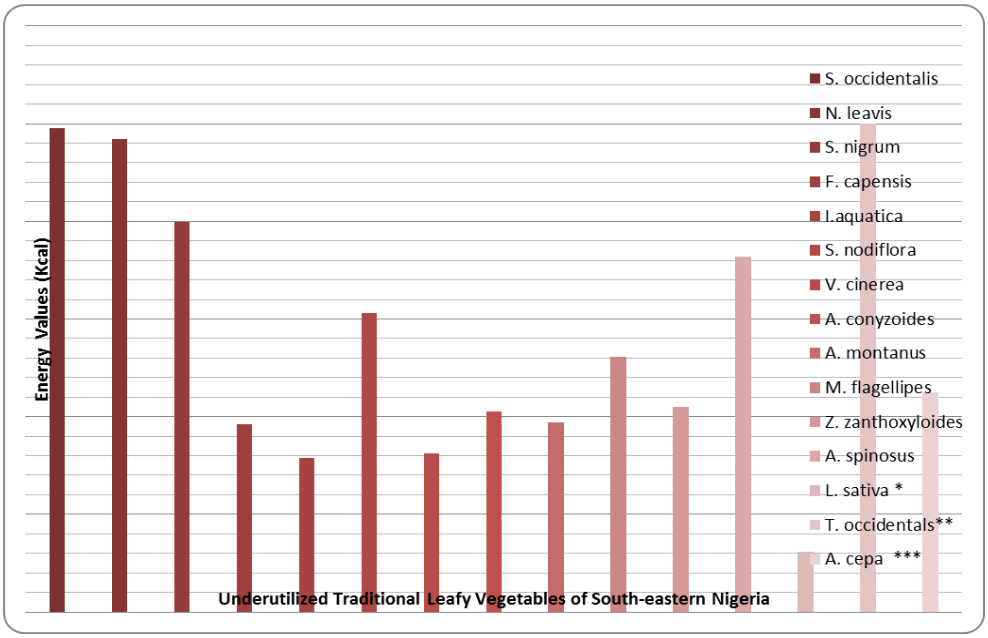

Figure 6: Energy Values (Kcal) of the Traditional Leafy Vegetables of South-eastern Nigeria, (Source: Fieldwork, 2012)

3.1 Multi-Dimensional Analysis (MDA)

Table 3, presents the nutritional and energy calories contents and their weighted factors for the individual TLVs. It also showed the total weighted factors when the different single nutrients were pooled together. The columns 2, 4, 6, 8, 10, and 12, show the weighted factors with the desirable nutrient values weighted as unity or 100%. The column 13 gives the grand weighted totals when columns 2, 4, 6, 8, 10 and 12 were summed together. Whereas, column 14 gives the ranking in ascending order with the TLVs having the highest WF ranked number one. *S. occidentalis* was ranked 1st with a WF of 4.16, followed by *S. nigrum* 2nd with 3.90, *T. occidentals* 3rd with 3.75) while *L. sativa* ranked 4th 3.56 (Table 4). Others equally ranked were *N. leavis, M. flagellipes,V. cinerea, S. nodiflora,A. montanus,A. conyzoides, I.aquatica, A. spinosus, F. capensis, S. nigrum, Z. zanthoxyloides and A. cepa* with 3.55, 3.32, 3.29, 3.28, 3.20, 3.19, 3.00, 2.97, 2.96, 2.46 and 1.93, respectively in that ascending order.

Table 4: Nutritional values of the underutilised traditional leafy vegetables of South-eastern Nigeria (%/2g)

S/N	Moist	WF	Protein	WF	Carb	WF	Fat	WF	Fibre	WF	Energy (Kcal)	WF	Total	Ranking
S. occidentalis	95.19	0.995	20.58	0.776	58.48	0.037	0.35	0.571	2.40	0.797	668.02	0.990	4.166	1*
S. nigrum	88.50	0.925	26.49	1.000	33.65	0.065	1.80	0.111	3.01	1.000	539.11	0.799	3.900	2
T. occidentals	80.03	0.837	24.67	0.931	42.28	0.052	1.20	0.166	2.30	0.764	674.33	1.000	3.750	3
L. sativa	95.60	1.000	1.400	0.052	2.200	1.000	0.20	1.000	1.16	0.385	83.710	0.124	3.561	4
N. leavis	81.10	0.840	17.58	0.663	58.27	0.037	0.95	0.210	2.50	0.835	653.37	0.968	3.553	5
M. flagellipes	69.35	0.725	17.41	0.657	24.01	0.091	0.30	0.666	2.01	0.667	352.36	0.522	3.328	6
V. cinerea	82.65	0.864	15.92	0.600	9.620	0.228	0.30	0.666	1.85	0.614	219.59	0.325	3.297	7
S. nodiflora	81.05	0.847	16.51	0.623	10.01	0.219	0.25	0.800	1.20	0.398	413.60	0.613	3.285	8
A. montanus	82.80	0.866	19.10	0.721	11.12	0.197	0.50	0.400	1.89	0.627	262.77	0.389	3.200	9
A. conyzoides	83.20	0.870	18.98	0.716	12.15	0.181	0.80	0.250	2.30	0.764	276.55	0.410	3.191	10
I.aquatica	87.15	0.911	15.99	0.603	8.720	0.252	0.35	0.571	1.05	0.348	213.68	0.316	3.001	11
A. spinosus	81.05	0.847	22.11	0.834	33.05	0.066	9.50	0.021	1.44	0.478	490.44	0.727	2.973	12
F. capensis	81.09	0.848	17.88	0.674	12.45	0.176	0.67	0.298	1.75	0.581	259.26	0.384	2.961	13
Z. zanthoxyloides	90.40	0.945	6.120	0.231	66.20	0.033	3.50	0.057	2.35	0.780	282.72	0.419	2.465	14
A. cepa	76.32	0.798	11.53	0.435	78.36	0.028	0.97	0.206	0.07	0.023	303.23	0.449	1.939	15

Source: Fieldwork (2012)

Table 5: Vitamin Content of the TLVs of South- eastern Nigeria

S/N	Vit A (iu)	WF	Vit B1 (mg)	WF	Vit B2 (mg)	WF	Vit B3 (mg)	WF	Vit C (%)	WF	Vit E (mg)	WF	Total	Rank
S. nigrum	1517.73±0.20	0.71	29.00± 0.23	0.87	20.00±1.01	0.64	2.00±0.03	0.94	14.99± 0.4	1.00	26.60±0.23	1.00	5.183	1*
A. spinosus	1078.01±0.04	0.50	33.00± 0.01	1.00	31.00± 3.02	1.00	1.44±0.01	0.68	7.84± 0.01	0.52	24.00±0.04	0.90	4.613	2
Z. zanthoxyloides	978.72± 0.04	0.45	16.00± 0.10	0.48	14.00± 1.06	0.45	1.11±0.03	0.52	10.59±1.03	0.70	17.60±0.30	0.66	3.287	3
N. leavis	1276.60±0.01	0.60	29.00±0.04	0.87	20.00± 0.06	0.64	0.56±0.01	0.26	3.03± 0.02	0.20	17.70± 0.02	0.66	3.255	4
S. nodiflora	2127.66±0.04	1.00	16.00± 0.76	0.48	14.00± 2.04	0.45	1.81±0.01	0.85	2.20 ±0.12	0.14	6.00±0.010	0.22	3.163	5
S. occidentalis	723.40±1.01	0.33	13.00±1.02	0.39	11.00± 0.03	0.35	2.11± 0.01	1.00	1.10±0.01	0.07	19.60± 0.20	0.73	2.895	6
F. capensis	312.06 ± 1.10	0.14	20.00± 1.07	0.60	17.00± 0.04	0.54	1.78± 1.02	0.84	6.26 ± 1.6	0.41	8.80 ± 0.02	0.33	2.890	7
V. cinerea	936.17 ± 0.50	0.43	20.00± 0.98	0.60	17.00±1.02	0.54	1.42±0.02	0.67	4.81±0.04	0.32	6.40± 0.04	0.24	2.825	8
T. occidentalis	1177.31± 0.21	0.53	10.00± 0.01	0.30	1.00± 0.01	0.03	1.11±0.01	0.47	10.59±0.40	0.70	18.60±0.03	0.69	2.751	9
I .aquatica	921.99 ± 0.02	0.43	20.00± 0.24	0.60	1.50±0.010	0.04	1.22±0.01	0.57	0.41±0.03	0.02	5.00±0.010	0.18	1.879	10
A. montanus	340.43 ± 0.02	0.16	16.00± 0.24	0.48	14.00± 2.01	0.45	1.06±0.03	0.50	1.24+.02±	0.08	4.40+ 0.20	0.16	1.844	11
A. conyzoides	226.9 ± 2. 020	0.10	12.00± 0.10	0.36	1.50± 0.03	0.04	0.14±0.01	0.06	12.65+.02	0.84	9.80+ 0.20	0.36	1.794	12
M. flagellipes	695.40± 0 .02	0.23	17.31± 1.01	0.52	0.35± 0.02	0.01	1.01±0.01	0.47	1.65+.020	0.11	5.80+ 0.20	0.21	1.577	13
L. sativa *	180.02 ± 0.10	0.08	0.1± 0.300	0.00	0.1± 1.010	0.00	0.4± .020	0.18	10.25± 2.01	0.68	6.73± 1.02	0.25	1.215	14
A. cepa ***	0.010±0.001	0.00	0.02± 0.01	0.00	0.04± 0.00	0.00	0.2 ± 0.01	0.09	11.35± 0.04	0.75	9.1± 0.100	0.34	1.194	15

Source: Fieldwork (2012)

Multidimensional Analysis shows that with respect to total nutritive elements including their energy calorie status, *S. occidentalis* stands to be the best with a MDA value of 4.16, while *A. cepa* had the least value of 1.93 (Table 4). It implies that *S. occidentalis* with highest summation values of 4.16 is recommended as the best amongst these TLVs, having all the desirable nutritional values (high moisture, carbohydrate, protein contents with low fat and better energy calorie values) pooled together. Similarly, in relation to the antioxidant values total summation in Table 4 shows that *S. nigrum* ranked 1st with WF values of 5.18 with *A spinosus* ranking 2nd with WF value of 4.61, while *L sativa* ranked 14th with 1.21 (Table 5).

Finally, when the total decision on the best choice is to be made on which of these TLVs has all the indicators of good and high nutritive bioactive elements, energy calories and enhanced concentration of vitamins pooled together, *S. nigrum ranked* 1st with a summation of 9.08 WF, followed by *A. spinosus*. The least with regards to total MDA ranking was *A. cepa* with 3.13 (Figure 7). This ranking of *S. nigrum* as the 1st among the 15 TLVs is an

indication that these underutilised traditional leafy vegetables among others and even when compared with the exotic species *L sativa* could contribute to the daily required nutritional and energy needs of these resource- poor people in Nigeria.

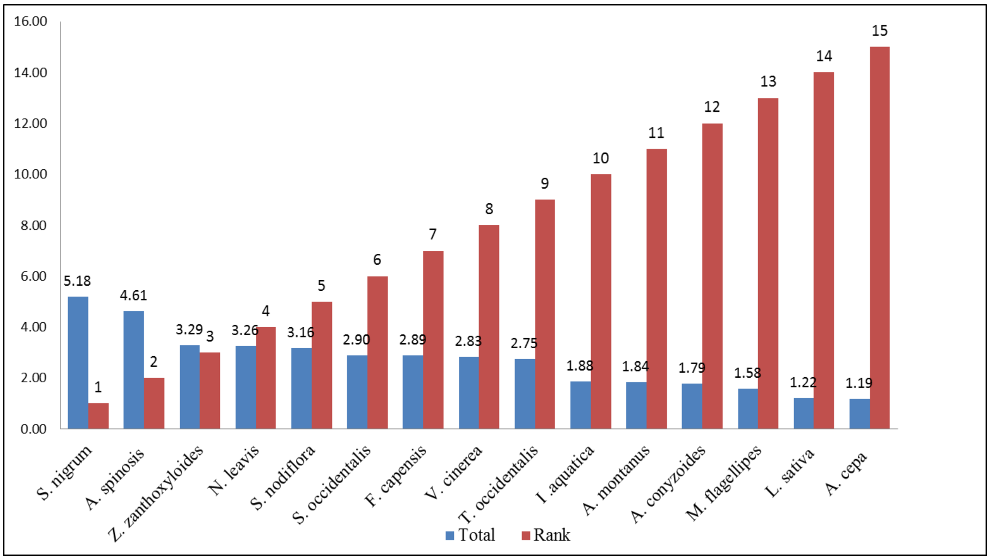

Figure 7: Ranks for all the desirable nutrient (Protein- energy calories- antioxidants) values of the TLVs of South-eastern Nigeria (Source: Fieldwork (2012)

4.0 CONCLUSION

It has been established from this work, that these underutilised TLVs identified in South-eastern Nigeria are potentially endowed with high levels of essential nutritive and antioxidant compounds which could contribute to the daily requirement and maintenance of good health. They are capable of reducing malnutrition and hidden hunger in resource- poor communities in Nigeria.

Banking on the nutritional potentials of *S. occidentalis* (Negro coffee) and *Solanum nigrum* (Black nightshade) rich in high crude protein, carbohydrate, fat and energy calories values against the highly cherished and very expensive exotic species like *Lactuca sativa* var. *longifolia* L (Lettuce) with low nutrient value could contribute to protein-energy needs of these malnutrition-threatened communities in South-eastern Nigeria.

MDA summation of combined protein-energy calories and antioxidant contents of *S. nigrum* and *Amaranthus spinosus* (Spiny amaranth) which are higher than that of the conventional species *Telfairia occidentalis* (Fluted pumpkin) and Lettuce is an indication of the nutritional potencies of these TLVs. It has equally shown that, some of these neglected TLVs have good qualitative and quantitative macro and micro nutrients which could be accessed to improve the nutritional dietary menu of the resource-poor groups in Nigeria. Adequate consumption of the TLVs with higher ranks of MDA could result in improved good health thereby reducing malnutrition related diseases (cardiovascular diseases, diabetes, Goitre, Colon and Stomach Cancer, Lower IQ, Stunting, Blindness, Kwashiorkor, Marasmus and High Blood Pressure) in South-eastern Nigeria.

Climate variability and change carry with it new and enhanced pressure on plant genetic resources, particularly in Nigeria, where environmental degradation and prolonged anthropogenic activities are impacting on crop production and yield. National and international breeding programs for a number of crops are already targeting new varieties with substantive traits adaptation to future climatic hassles. The strength and successes in this innovative strategy is dependent on knowing their wild relatives. African tropical ecosystem and indeed Nigerian eco-zone serve as a good repository for many of these indigenous TLVs. It becomes imperative to put proper

policy programs for their sustainable utilisation and conservation. The findings from the study have further enlarged the database of nutrition and antioxidant values of some underutilised plant genetic resources of Africa in particular and the world in general.

5.0 RECOMMENDATIONS

This significant paradigm made using MADM to assess the nutritional and antioxidant compositions of Traditional Leafy Vegetables (TLVs) and to rank them in their order of nutritional importance is an important addition to the already existing data on TLVs in the literature. It has just opened up a new frontier for further research. Thus more research is needed on the level of toxicity compounds in these TLVs and on the presence of heavy metals.

There must be emphasis on policy interventions on cultivation, utilisation and sustainable conservation of these TLVs to avoid their genetic erosion. Advocacy and nutritional education as well as deliberate policy programmes should be adopted to enlighten their consumption not only among the resource-poor communities in Nigeria, but also in countries where malnutrition is a health risk. This will reduce malnutrition as entrenched in the MDGs benchmark of 2015.

Finally, more programmes on their commercialisation are needed; while greater work is recommended on mechanism of scaling up their shelf life.

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