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Nutritional Significance of Cowpea Leaves for Human Consumption

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ABSTRACT

Cowpea is a legume whose grains are widely consumed as rich sources of protein and other nutrients in some parts of the continent. Recent surveys have also shown that cowpea leaves are relished as vegetable in Southern and Eastern Africa as well as Middle belt areas of Nigeria. Protein, calorie and mineral deficiencies such as marasmus, kwashiorkor and anaemia are reported to characterize malnutrition in many parts of Africa. For instance, amongst the health benefits of cowpea leaves, low glycemic index carbohydrates and vegetable-derived nutrients are known to prevent or combat cancer, hypertension, stroke, diabetes, insomnia, osteomalacia, osteoporosis, anencephaly, rickets and could enhance cardiac health and metabolic wellbeing. However, in eastern Nigeria, consumption of cowpea as leafy vegetable is largely non-existent probably due to dearth of information on its nutrients composition and possible health benefits amongst other factors. As part of efforts to create awareness to stimulate and warrant its adoption, utilization and consumption as leafy vegetable in eastern Nigeria, this study aims to document the nutrient composition of cowpea leaves grown in the area; and to highlight the potential human health benefits attendant from consumption of these nutrients. The study was carried out in the University greenhouse, with cowpea variety IAR-48 grown in heat sterilized topsoil contained in 20 cm pots arranged in completely randomized design replicated four times. The whole experiment was repeated twice. At 8 weeks after planting, tender leaves of the crop were harvested from the mid section of the crop, enveloped and later used for nutrient analyses. Chemical and nutrient profiling of the cowpea leaves tissues were done based on analytical and standard spectrometric methods and was carried out in triplicate determinations. Findings from this study indicated that cowpea leaves contained protein (34.91%), low glycemic index carbohydrates (31.11 %), prebiotics (19.46 %), fat (5.42 %), iron (65.21 mg), calcium (1.62 g), phosphorus (0.56g), magnesium (1.66 g), potassium (13.445 g) and sodium (2.22 g). Based on literature, these amounts of nutrients were sufficient to offset most of the recommended daily intakes (RDIs) of these nutrients in human diets. Though the anti-nutrient factors were not conducted in this study, previous investigators have shown that cowpea leaves contain low amounts of anti-nutrient factors, hence, findings from this study therefore support the adoption, utilization and consumption of cowpea leaves as vegetable in eastern parts of Nigeria.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) a member of the family fabaceae, is an annual legume thought to have originated in Africa (Davis *et al*., 2007). The crop which may be trailing, erect or bushy in growth habit is widely cultivated in Africa, Asia and the Americas (Awurum and Enyiukwu, 2013a). Cowpea is drought and salinity tolerant. It is an excellent intercrop in tuber and cereal-based farming systems where it is reported to improve yield of the component crops by 30 %. In addition to lowering aluminum ion toxicity in tropical soils, it controls erosion and plays an important role in soil fertility restoration fixing by symbiosis with nodular *Bradyrhizobia spp.* up to 200 kgN/ha per annum (source: www.leafforlife.org>VIGNAUNG; Enyiukwu and Awurum, 2013a; 2013b). It also functions in sinking greenhouse gases (GHGs) and ameliorating climate change effects (FAO, 2016).

Cowpea is used as medicine, fodder, feed and food (Awurum, 2000; Okwu and Njoku, 2009). In ethno-botany, the root is prepared as an antidote against snake bite; its clustered porridge for treating chest pain, epilepsy and dysmenorrhea, infusion of the seed for amenorrhea, while that of the whole plant for fever and schistosomiasis (HBT, 2016). In addition, the role of pulses and pulse-derived vegetables as tonics, appetizers, stimulants, aphrodisiacs and anthelmintics are well documented in literature (FAO, 2016). Preparations from cowpea also play important roles in reducing the risk of lymphoblastic leukemia and aberrant foci cyst development (Campos-Vega *et al*., 2010). As food, the protein-rich grains provide cheap sources of protein for millions of consumers of the crop in meat-scarce communities of the tropics (Aveling, 2007). Besides contributing valuable grains for human consumption, the mild-flavoured leaves are veritable sources of nutrient-rich edible vegetable which could play significant roles in fighting malnutrition (Alemu *et al*., 2016; FAO, 2016). In a trial on displaced people it was found that six (6) tonnes of fresh leaf (1 tonne dried leaf) of cowpea could supply about 800 children 4-6 years old with 10 g leaf concentrate and provide them 7.75 mg of iron per week year round (source: www.leafforlife.org>VIGNAUNG, 2016).

Fig. 1: Leaves of cowpea (Var. IAR-48) growing in the greenhouse

Nielsen *et al*. (1997) reported that compared to the grains, the leaves of the crop contain amino acids such as isoleucine, leucine, lysine, methionine, cysteine, phenylalaminine, valine, tryptophan and histidine in significantly higher amounts which are able to meet the recommended daily averages of these nutrients than the seeds. Many amino acids in its leaves have been tied to good health benefits. The amino acid trytophan counters social anxiety, insomnia and improves sleep and in concert with histidine assists neurotransmitters involved in appetite, mood and energy production. Isoleucine assists the body in raising endurance, fixes muscle tissues and promotes blood clotting and in conjunction with valine, isoleucine and leucine stabilizes blood sugar and enhance muscle performance. Also, lysine in cowpea is reported to help in healing cold and genital sores whereas phenylalanine functions to prevent depression and raises levels of biochemicals such as noreptrophine and dopamine which alleviate migraine and insomnia. In addition threonine in the leaves improves antibody production, enhancing the production of serine and glycine which are essential requirements for synthesis of collagen and elastin in the body (HBT, 2016).

Pulses and legumes' carbohydrates are rated as low glycemic index nutrients which could contribute to reducing inflammation, diabetes, obesity and/or preventing coronary heart diseases in both healthy individuals and persons challenged with metabolic syndrome (Rizkalla *et al*., 2014; BHM, 2016). The nutrient-rich status of cowpea leaves could therefore strengthen the immunity, vision, heart and circulatory health, fight depression and diabetes, prevents cold sores, and enrich the blood of its consumers and contribute to offsetting protein-calorie deficiency in sub-Saharan Africa (Hallensleben *et al*., 2009; Okonya and Maas, 2012; HBT, 2016).

Leaves of the crop (Fig. 1) which is reported to rank among the top 4 vegetables in 24 countries of Africa and 7 in Asia is suited for production in high rainfall agro-ecologies (SADAFF, 2013). In such rain fed systems up to 6 tonnes fresh leaf yield per ha have been reported (source: www.leafforlife.org>VIGNAUNG). One hundred grams (100 g) of this edible leaf is reported to contain protein 4.2 g, Ca 110 mg, iron 4.7 mg, beta carotene 2.4 mg and ascorbic acid 35 mg and delivers 34 calories of metabolizable energy, phosphorus 383.20 mg, zinc 12.91 mg and carbohydrate 39.11.mg (Nielsen *et al*., 1997; Olayiwole *et al*., 2012; Chikwendu *et al.,* 2014). Generally, Mamiro *et al*. (2011) reported that its leaves are higher in nutrients than the seeds. Compared to the grains, cowpea leaf is reported to produce 9 times more calories, 1.5 times more protein, 90 times more calcium and a thousand times more ascorbic acid and beta carotene than the grains of the crop (source: www.leafforlife.org>VIGNAUNG; Nielsen *et al*., 1997).

In terms of organoleptic properties, cowpea leaves are mild and good tasting comparing favourably with other tropical potherbs and vegetables such as amaranth, taro, spinach, pumpkins, lettuce and sweet potato (Nielsen *et al*., 1997; Hallensleben *et al*., 2009). In an evaluation at the University of Nigeria Nsukka, Igbatim *et al.* (2014) reported that cowpea leaves enhanced the acceptability and organoleptic attributes of three cowpea-based soups. The husks and leaves of the crop according to these authors provided nutrient-dense food that could be exploited, diversified and promoted in sub-Saharan Africa.

However, consumption of this valuable vegetable though increasing in many other parts of Africa including Tanzania, Uganda and Southern Africa (Hallensleben *et al*., 2009; Okonya and Maas, 2012) so far is at very low ebb especially in eastern Nigeria. This poor utilization and consumption of the crop as vegetable in eastern Nigeria, is reasoned to be due largely in part to poor awareness about the nutrients and chemicals it contains and the possible health benefits of the crop amongst others.

Hence, in a bid to create and step up awareness that could contribute to offsetting protein-calorie deficiency as well as mineral imbalances in the nation through use of lesser known vegetables; this paper sought to determine and document the nutrient composition of cowpea leaves grown in eastern Nigeria and to relate same to their potential health benefits.

MATERIALS AND METHODS

Preparation of plant samples for analyses.

This experiment was conducted at the greenhouse of the Michael Okpara University of Agriculture, Umudike (MOUAU), Nigeria. Cowpea seeds (Var. IAR-48) were sown 4 per stand in 20 cm diameter plastic pots containing heat sterilized top soil (4 kg). Two weeks after planting (WAP) the seedlings were thinned to 3 per stand, and watered twice daily. At maturity (8 WAP) leaves of the test crop were harvested from the mid section of the crop enveloped and taken to the Crop Science Laboratory of the University (Chikwendu *et al*., 2014). The whole experiment was repeated twice. Collected samples were air-dried at the Laboratory bench for 1 day and then re-enveloped and oven-dried at 60^{o}C for 3 days. One hundred grams (100 g) of the specimen were weighed out with a digital balance and ground into powder using a hand milling machine (Corona Lavesh 250) (Amadi and Oso, 1996). The powder was stored in an air-tight bottle and kept in a dark cupboard until required for biochemical analyses.

Biochemical composition of healthy leaves of cowpea.

Biochemical analyses of the specimens were conducted at the Analytical Laboratories of the Federal Institute for Industrial Research Oshodi, (FIIRO) Lagos. Standard methods based on the protocols of AOAC (2000) were employed in the determination of the proximate composition of the specimen while the elemental nutrients were determined based on the absorbance of the specimen from atomic absorption spectrometer (AAS) (Model: AA 7000, Schimadzu, Japan). The biochemical composition of the leaves specimen was conducted in triplicate determinations in a completely randomized design (CRD) to ascertain the nutrient values of the leaves of the crop.

Moisture content evaluation of samples

The sample was first scanned from 100^{o}C to 200^{o}C with the moisture analyzer (Model: MS-70, A & D Company limited, UK) to obtain the optimum temperature suitable for the specimen to be dried and it was found to be 140^{o}C. The percentage moisture contents of the sample were then determined and shown automatically on the light emitting diode (LED) of the analyzer.

Ash content

One gram (1 g) of the samples was weighed separately into a dried and preweighed crucible. The samples were then charred on a hot plate to decarbonize them. After complete decarbonization, they were put in the muffle furnace (Model 186A, Fisher Scientific Co.) for 3 h at 560^{o}C to obtain the ash contents using the formula by Kayode *et al.* (2008):

$$\text{Percentage ash content (\%)} = \frac{W2 - W1}{W} \times \frac{100}{1}$$

Where, W_2 is the weight of crucible + ash
W_1 is the weight of dried crucible
W is the weight of sample taken

Protein contents

Using the kjehdahl apparatus, 0.5 g of each of the samples were separately weighed into a digestion tube, to which 1 tablet of kjehdahl catalyst and 10 ml of concentrated sulphuric acid were added and placed in the digestion block to digest at 430^{o}C for 2 h and then placed separately in the distiller before 80 ml of 40% sodium hydroxide was dispensed into each digestate and distilled. The resulting nitrogen (N) from each digestate was trapped inside 50 ml boric acid indicator (a mixture of 40 g boric acid, 0.03 g methyl red stain, 0.06 g bromocresol green in 2 liters of ethanol water) which changes to green indicating the presence of protein in the sample.

The trapped nitrogen in the boric acid was then titrated against 0.1N HCl which gave a red coloration at the end point. The protein content of each sample was determined using the formular by Kayode *et al.* (2008):

$$\text{Protein content (\%)} = \frac{\text{Titre value x Normality of acid x 1.4007 x 6.25}}{\text{Weight of sample taken}} \times \frac{100}{1}$$

Fat contents

Two grams (2 g) of each of the samples were weighed separately onto filter papers, inserted with Soxhlet and put in the Soxhlet apparatus and then 150 ml of 60 % petroleum ether were added in already dried and weighed round bottom flasks placed on a hot plate and set to 80^{o}C and then allowed to extract for about 3 h. The resulting extracts were then dried in an oven and weighed. The fat content was calculated based on the fomular adopted from Kayode *et al*. (2008):

$$\text{Percentage fat content of sample (\%)} = \frac{W2 - W1}{W} \times \frac{100}{1}$$

Where, W_2 is the weight of flask + extract
W_1 is the weight of dried flask
W is the weight of sample taken

Crude fibre (Prebiotics) contents

The method as described by the Tecator Application Manual Number 1978.03.15 ANO/78 (*www.dairyknowledge.in/sites/default/files/7.11.pdf*) for crude fibre determination which involved hot extraction using Fibretec 1020 Tecator System Technology was employed in this study. One gram (1 g) of the de-fatted samples was weighed separately into clean crucibles to which 150 ml each of 0.256 N sulphuric acid was added with 3 drops (0.15 ml) of octanol (to prevent foaming) and heated for 30 min. Thereafter, they were washed in de-ionized water and 150 ml of potassium hydroxide added and the samples were then dried at 130^{o}C for 2 h. The resulting residues were ashed at 500^{o}C for 3 h. the crude. The cude fiber was determined using the formula from the above manual as:

$$\text{Percentage crude fibre content of sample (\%)} = \frac{W2 - W1}{W} \times \frac{100}{1}$$

Where, W_2 is the weight of crucible + extract
W_1 is the weight of dried crucible
W is the weight of sample taken

Determination of total carbohydrate contents of sample

This was determined based on the protocol adopted by Kayode *et al.* (2009) and Afolabi *et al.* (2012) where its value was calculated by difference using the formula:

Percentage carbohydrate content of sample (%) = 100-{∑DC}.

Where,

∑DC is the summation of the determined proximate contents of other variables (crude protein, crude fibre, fat and moisture) in 100 grams of the sample.

Determination of some micro and macronutrients of the samples

The ashes previously obtained above from the specimens were dissolved in 1N nitric acid (about 3 drops of concentrated nitric acid and made up to 100 ml with distilled water). The resulting sample solutions were taken to the AAS (Atomic Absorption Spectrometer) (Model: AA 7000, Schimadzu, Japan) for the analysis of the elements present in the samples. Standards were prepared and run on the AAS, and a calibration curve generated. From the calibration curve the comparative amounts of the elements were determined (Kayode *et al.,* 2008).

STATISTICAL ANALYSIS

Data collected from this study were analyzed using Analysis of Variance (ANOVA) with the general linear model procedure in Genstat Release (PC Windows Vista, Version 12.10) at 5% level of significance. Means were separated and compared using Fisher's least significant difference (FLSD) at probability level of 0.05.

RESULTS

The results presented in Table 1 indicated that cowpea leaves used in this study contain protein 34.91 %, fat 5. 42 %, carbohydrate 31.11 %, ash 11.15 %, and crude fibre 19.46 %. It showed that protein was the highest proximate nutrient present in the test samples. The leaves specimens also contain high amounts of carbohydrate which differed significantly (P≤ 0.05) but compares well with the protein content of the test samples (Table 1). However both were statistically superior to the values of 5.42 %, 19.46 % and 11.15 % recorded for fat, crude fibre and ash respectively. Also, crude fibre recorded at 19.46 % was statistically (P≤ 0.05) superior to 11.15 % obtained for ash content in the study. In the overall fat recorded at 5.42 % was the least of the proximate components tested in this study

Table 1: Proximate composition of tender cowpea leaves per 100 g (dry weight)

Nutrients	Mean Composition (%)
Moisture content	10.88
Protein	34.91
Fat	5.42
Carbohydrate	31.11
Ash	11.15
Crude fibre	19.46
LSD (0.05)	**0.05**

***Data are means of triplicate determinations from two separate experiments**

The results of the macro and micro elemental nutrients analyses presented in Fig. 2 showed that cowpea leaves contain a wide spectrum of useful micro and macro elemental nutrients. It indicated that potassium (k), sodium (Na), phosphorus (P), calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn) were detected in the test samples. The results also showed that amongst the assayed elemental nutrients K (1.35 g) was the most abundant nutrient in the cowpea leaves being statistically ($P \leq 0.05$) superior in amount to every other elemental nutrient. This was followed by Na (2.22 g) and then Mg (1.66 g) and Ca (1.62 g) both of which were statistically ($P \geq 0.05$) at par with each other; and phosphorus (0.55 g) amongst the macronutrients. However iron recorded at 65.21 mg was the least ($P \leq 0.05$) abundant micro-nutrient in test cowpea leaves and it was not significantly ($P \geq 0.05$) different from the value of 121.84 mg obtained for Zn (Fig. 2).

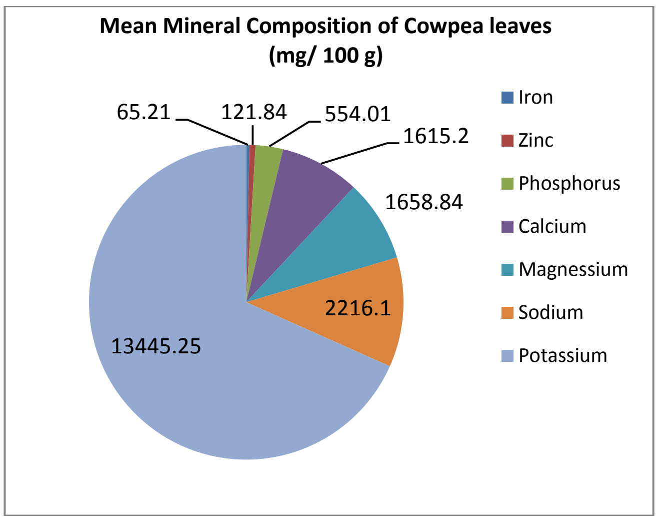

Figure 2: Mean micro and macronutrients composition of the test cowpea (Var. IAR-48) leaves

DISCUSSION

Micronutrients, minerals and protein-calorie deficiencies are primary public health concerns in sub-Saharan Africa (Okonya and Maas, 2014). Less utilized vegetables such as cowpea had contributed immensely to improving the food bank in Ethiopia (Alemu *et al.,* 2016) and provided cheap and easily available sources of protein, minerals and microelements that enhanced the nutritional and health status of resource-poor rural dwellers in the area (Okonya and Maas, 2014). In Nigeria, Afolabi *et al.* (2012) reported that leafy vegetables contribute significantly to supply the body with minerals, vitamins, fibre, and certain hormone precursors, energy and protein which could play roles in preventing cancers, reduce cardiovascular diseases and promote heart health. Findings from this study indicated a wide array of proximate and mineral nutrients in the leaves of cowpea.

Protein

Protein was detected at 34.91% in this study. This is in harmony with 39.24% reported by Chikwendu *et al*. (2014) for dry leaves of cowpea in Benue State, Nigeria. The findings from this study also shows that the protein value of cowpea leaves though lower however, compares well with those reported for water leaf (37.28%), scent leaf (47.17), and green amaranths (47.57) by Afolabi *et al.* (2012). However, it is superior to the protein values of 4.2% and 8.72 mg/100g on dry matter basis reported for fluted pumpkin (*Ugu*) (*Telferia occidentalis*) by Dike (2010) and Idris (2011) respectively. Protein is an important nutrient which plays roles in maintenance of body tissues, building enzymes and hormones (Afolabi *et al*., 2012). In comparative studies with cowpea grains, several workers found cowpea leaves to be richer in protein (34.91-39.24%) and essential amino acids than the seeds which contains 23.32% protein ((Nielsen *et al.,* 1997; Mamiro *et al.,* 2011; Chikwendu *et al.,* 2014). Therefore consumption of cowpea leaves could help heal and repair muscle tissues, improve immunity, prevents cold sores and depression and encourage mental wellbeing (Afolabi *et al*., 2012; HBT, 2016).

Carbohydrate

Findings in this study indicated that 31.11% of carbohydrate was detected in the leaves of cowpea which agrees with 30.39% reported by Chikwendu *et al*. (2014). This value however, is superior to 12.11-16.03% reported for green amaranths, sweet basil, waterleaf, and bitter leaf in western Nigeria by Afolabi *et al.* (2012). On the other hand, it compares well with 26.82% and 39.64 mg/100g carbohydrate on dry matter basis reported for fluted pumpkin (*ugu*) a commonly consumed vegetable in eastern Nigeria by Idris (2011) and Mohd *et al*. (2016) respectively. Carbohydrates are a rich source of metabolizable energy for cellular activities (Afolabi *et al*., 2012). Generally, they are broken down to glucose during tissue respiration and released into the blood stream. Persistently high blood sugar levels have been implicated in diabetes and to increase the threat of heart attacks. It has been reported that people with high blood sugar levels are 3 times more likely to get a heart attack (Best Health Magazine, 2016). However, carbohydrates sourced from fish, skinless chicken, walnut, olive, apples, berries, pulses and legumes including cowpea have been described as of low glycemic index (Rizkalla *et al*., 2002; Glatter, 2014; FAO, 2016). Low glycemic index carbohydrates breakdown and release glucose slowly into the blood stream and thereby increase the body's sensitivity to insulin; and therefore reduce the risk of heart disease and improve control of metabolic syndrome (diabetes) (Glatter, 2014; Body Building, 2016). In coronary heart disease patients, legumes and legumes-derived vegetables modulate glucose, insulin, homocysteine concentration and lipid peroxidation leading to 21% and 11% lower risks of coronary heart disease (CHD) and cardiovascular disease (CVD) respectively (Campos-Vega *et al*., 2010). This wellbeing advantage of pulses to consumers Rizkalla *et al*. (2002) maintained is reaped by both healthy and metabolism-compromised individuals. Though metabolic syndromes including diabetes have genetic undertones, excess body fat, lack of exercise and eating the wrong kind of carbohydrates could worsen the problem (BHM, 2016). According to this source, eating diets rich in pulses and leguminous vegetables up to 4 times a week could reduce the risk of developing Type-2 diabetes by 42% and the risk of coronary heart diseases by 29%. This happens through lowering cellular insulin, reducing tissue triglycerides levels and blood pressure better than low-fat meals. Reduction in triglycerides concentration is thought to result from inhibition of pancreatic activity (Campos-Vega *et al*., 2010). Hence, consumption of cowpea leaves could effectively play a role in preventing metabolic syndromes including diabetes and improve the health status for its consumers.

Prebiotics (Crude fibre)

Crude fibre was detected at 19.46% in this study. This value does not agree with 14.26% reported for cowpea leaves by Chikwendu *et al*. (2014). The differences in the values may be due to differences in cultivars or method of analyses adopted in the study. Compared to fluted pumpkin, it compares well with 20.17 mg/100g reported for the leafy vegetable by Mohd *et al.* (2016). Pulses are high in content of prebiotics which function to improve or better digestion (FAO, 2016). Dietary fibre provides substrate for bifidobacteria in the colon of the human gastrointestinal tract (GIT) which is antagonistic to harmful bacteria. Prebiotics absorb water, and reduce pouches in the colon and in addition functions to prevent haemorrhoids and cancer (Afolabi *et al*., 2012; HBT, 2016). It is also reported to lower the risk of endometrial cancer, breast cancer and colorectal adenoma. Prebiotics and the low fat content of cowpea leaves could contribute to glycemic control leading to reduction of obesity by lowering average body mass index, waist circumference and waist-to-hip ratio (Campos-Vega *et al*., 2010). It is reported that consuming up to 20 g of food-borne fibre leads to 63% reduction of inflammation in humans (Campos-Vega *et al*., 2010; BHM, 2016). Though the phytochemical contents of leaves of cowpea were not evaluated in this study, flavonoids and polyphenols had been detected previously at 26.72% and 32.56% respectively in the leaves of the crop (Olayiwole *et al.,* 2012; Chikwendu *et al*., 2014). These classes of plant-derived secondary metabolites possess antioxidant, stress fighting, anticancer and antibacterial activities (Okwu and Njoku, 2009; Enyiukwu and Awurum, 2013b). These antioxidant phytochemicals and prebiotics in conjuction with copper, potassium, folate and thiamine aid in the formation of acetylcholine and play significant roles in maintaining healthy metabolism and ventricular function (HBT, 2016).

Fat

Fat was detected at 5.2% in this study. This value is significantly higher than 1.31% reported by Chikwendu *et al.* (2014). Though generally vegetables have low fat content, however, unimproved varieties have much more lower fat contents (Mamiro *et al*., 2011); indicating that IAR-48 used in this study is improved compared with local varieties used by Chikwendu *et al*. (2014) in their study. Lipids are good sources of lipophilic vitamins. Unsaturated fatty acids as found in plant-obtained oils reduce risk of coronary cancer and contribute to heart health (Afolabi *et al*., 2012). They lower triglyerides and cholesterol and hence contribute to improving heart and bladder health and maintaining the wellbeing of the circulatory system (BHM, 2016; FAO, 2016). Legumes-derived vegetables could also contribute to lowering serum lipid level and reducing the risk associated with low-density lipoprotein and cholesterol (Campos-Vega *et al*., 2010). Besides fat soluble vitamins, cowpea leaves is also a cheap and rich source of folate and B-vitamins (FAO, 2016). Folate aid in DNA replication in fetuses and contributes to preventing anencephaly (lack of a major part of the brain, skull and scalp during embryonic development usually at 23-24 days after conception) and fight limb and heart malformation. Hence being low in unsaturated fatty acids, and containing fat-soluble vitamins makes cowpea leaves a vegetable of choice to prevent or combat heart attacks, anencephaly and improve health of its consumers.

Magnesium

Magnesium which is one of the six essential macro-minerals in the body was also detected at 1.66 g in this study. This is significantly superior to the range of 195-212 mg reported by Afolabi *et al*. (2012) in a similar evaluation in western Nigeria for sweet basil, water leaf, bitter leaf and green amaranths. Idris (2011) reported that the recommended daily intake (RDI) for the nutrient is 350 mg meaning that cowpea leaves could supply 3.5 times the RDI of the nutrient. Magnesium is an important nutrient which plays crucial role in the prevention of diabetes. In the metabolism of carbohydrates, magnesium functions in improving insulin production and sensitivity reducing Type-2 diabetes by 15% (Health Benefit Times, 2016). Magnesium thus aids in the regulation of blood sugar levels, and promote normal blood pressure. It also plays an important role in regulating vital energy processes, helps in protein synthesis and maintaining healthy cells and muscles and communicating nerve impulses. The nutrient also functions in keeping the heart rhythm steady, support healthy immune system and strong bones (Ancient-Minerals, 2016). High magnesium rich foods was found to be associated with reduced loss of bone mineral density, reduced risk of type-1 diabetes and lower risk of heart disease as well as contributes to cheerfulness. However, irrespective of age, gender, and socioeconomic status of individuals considered in a study, low or deficient magnesium in diets correlated with depression in all the studied groups (Ancient-minerals, 2016). At 470 mg/day magnesium is reported to prevent or treat all forms of diarrhea and gastrointestinal disorders; and at 384 mg/day and 1200 mg/day treats congestive heart failure and duodenal cancers respectively (Afolabi *et al*., 2012). Consumption of cowpea leaves which contain up to 658.84 mg of magnesium therefore could aid in preventing depression and diabetes, congestive heart failure, duodenal cancers and maintain healthy tissues and bones.

Iron

Ferrous compound (iron) was detected at 62.12 mg in this study. This is significantly superior to 7.50 mg reported for cowpea leaves by Chikwendu *et al.* (2014). It is however, comparable to 76.09 mg detected in bitter leaf samples but inferior to 99.01-120.59 mg reported for sweet basil, water leaf and green amaranths (Afolabi *et al*., 2012). Iron is essential for the formation of heme cells (haemoglobin) in the blood. Haemoglobin is the oxygen carrying pigment in the blood (Afolabi *et al*., 2012). In addition, iron plays an essential role in the cytochrome involved in energy (ATP) production and enzymes of the immune system. Anaemia is one of the health conditions implicated in lowering disease resistance (immunity) and causing poor brain functioning (HBT, 2016). Plant-derived iron is more bio-available than heme-derived iron from animal sources (Afolabi *et al*., 2012). Therefore cowpea leaves could easily and significantly contribute to preventing or ameliorating iron deficiency induced diseases in sub-Saharan Africa.

Zinc

This nutrient detected at 121.84 mg in this evaluation is an important microelement. Sweet basil, spinach, water leaf, bitter leaf and green amaranths which are commonly consumed vegetables in Nigeria are reported to contain zinc in the range of 19-64 mg (Afolabi *et al.,* 2012). Findings from this study where zinc was detected at 121.84 mg show that cowpea leaves are significantly superior in regard to this nutrient when compared with them. In humans, its recommended daily average requirement is 8-11 mg/day for adolescents and 12-19 mg/day for adult males and females (Idris, 2011; Axe, 2016). In the body tissues zinc is needed for healthy cell division. It acts as an antioxidant, fighting free radicals and slowing the aging process. This nutrient also fights common cold, diabetes, diarrhea and chronic fatigue. Zinc binds to insulin, making the biochemical to be adequately stored in the pancreas and be released only when glucose enters the blood stream. It is both a prophylactic and cure for chronic diarrhea and fatigue. It also prevents cancerous cell mutation and stunts tumour growth (Axe, 2016). This important trace nutrient furthermore functions in the production of testosterone, progesterone and estrogen which could affect menstruation, and cause mood swings, early menopause and increase the risk of certain cancers (Axe, 2016). Hence, consumption of cowpea as leafy vegetable could aid in offsetting fatigue, cancer and other zinc-deficiency related health conditions.

Calcium

About 1615.20 mg of calcium was detected in leaves of cowpea in this study. This compares well with the value 1563.87 mg reported for water leaf a popular leafy vegetable in southern Nigeria (Afolabi *et al*., 2012). However, it is inferior to range of values (2074.43-3797.59 mg) also recorded by Afolabi *et al*. (2012) for green amaranths, water leaf, sweet basil and bitter leaf. Nevertheless, findings from this study shows that cowpea leaves contain significantly higher amount of zinc than fluted pumpkin reported to contain the nutrient at 75 mg (Mohd *et al*., 2016). Zinc is reported to be commonly found in considerable quantities in legumes and pulses such as ricotta, green pea and cowpea. The recommended intake of this nutrient in humans is 1200 mg/day and 1500 mg/day for females and males respectively (Boden, 2016); meaning that cowpea leaves could effectively meet calcium needs for humans. Calcium and phosphorus play roles in strengthening bone and teeth structure whereas potassium participates in improving bone density preventing osteoporosis, osteopenia and forbidding fracture and breakage (Health Benefit Times, 2016). Besides playing a role in preventing the formation of kidney stones, calcium (Ca) in concert with magnesium, potassium and crude fibre also aids in reducing hypertension (Organic Facts, 2016). Consumption of cowpea as leafy vegetable could contribute amongst other things to maintain general wellbeing, healthy circulation, bone and teeth.

Phosphorus

About 554.01 mg of phosphorus was detected in the leaves of cowpea used in this study. Findings from this study for phosphorus are moderately higher than about 400 mg reported for the vegetable by Chikwendu *et al.* (2014); which may be attributed to differences in variety or analytical method. However, our findings also shows that cowpea leaves are superior in content of phosphorus compared to 13.02 mg reported by Idris (2011) for fluted pumpkin (*Ugu*) a very popular leafy vegetable in the southern hemisphere of Nigeria. Up to 700-1000 mg/day is the average daily intake amount of the macronutrient recommended for adults in the tropics. Findings from this study shows clearly that the vegetable would not provide the RDI of the nutrient per day; hence other sources of the nutrient must be consumed alongside it. Potassium is abundantly present in fish, dairy products, eggs, nuts, seeds and beans including cowpea (HBT, 2016). Adequate quantity of phosphorus in the diet has been linked with boosting libido and sexual performance, increase sperm health; and reduce frigidity and impotence in human males. Because the nutrient is commonly found in and around brain cells; neurologists suggest that it improves cognition and reduces or delays the onset of degenerative neurological conditions like Alzheimer's disease (AD) and dementia. Therefore, consumption of cowpea could contribute to fighting dementia and maintaining sexual health and mental wellbeing.

Potassium

About 13,445.25 mg of this essential macronutrient was detected in this study. This leafy vegetable based on results of this evaluation (Fig. 2) is significantly ($P \leq 0.05$) superior in content of potassium compared to 2760.05 mg reported by Idris (2011) for fluted pumpkin a commonly and widely consumed leafy vegetable in eastern Nigeria. Potassium is one of the 7 essential macronutrients in the body and is usually present in the range of 528-650 mg in some food such as beans, members of the *Solanacea*, whole grains and leafy vegetables. Its daily recommended average is 3519-4700 mg/day. This shows that cowpea leaves contains about 3 times the RDI amount of potassium for humans. The nutrient regulates body fluids, controls electrical activity of the heart, counteracts the effects of sodium to maintain healthy blood pressure, and maintain acid-base balance of the body. It also contributes to a reduced risk of strokes and kidney stone (Ware and Carter, 2018). According to these authors, low levels of potassium leads to high blood pressure and a study indicated that high intake of potassium on the other hand is associated with a 20% decreased risk of death from all causes, whereas up to 4062 mg/day of food-derived potassium lowered death from ischemic heart disease by 49%. The nutrient promotes cell alkaline environment by neutralizing the effects of acidifying foods like processed grains, dairy products and meat which could make nitrogen less bio-available, and hence participate in promoting the growth and accumulation of lean muscles. Up to 3.6 more pounds of lean muscles accumulation has been attributed to consumption of 5.226 mg/day of food-derived potassium (Ware and Carter, 2018). Diets rich in cowpea leaves could provide more than twice the daily recommended average of the nutrient and thus could help to maintain wellbeing and reduce the risk of death from both heart disease and all causes.

Sodium

Sodium was detected at 2216.10 mg in this evaluation. This shows that cowpea as a leafy vegetable is richer in sodium than fluted pumpkin whose range of sodium content was reported at 47.51 and 89.70 mg by Idris (2011) and Mohd *et al*. (2016) respectively. Sodium is a primary electrolyte in body fluids required for regulating blood flow. It is also important in enzyme operations (Organic Facts, 2016). Fresh vegetables and fruits are naturally high in sodium. The recommended daily average by the World Health Organization is 2000-2300 mg/day; however, much lower amount is needed for people living with congestive heart failure, liver cirrhosis and kidney disease where according to the New York Times (2016) due to the inability of the kidney to excrete the mineral in high doses causes buildup of fluid in tissues. On the other hand however, high sodium in diets could lead to osteoporosis due to impaired calcium metabolism, cardio-vascular diseases, stroke and 50% higher risk of death in the long run (Harvard T. H. School of Public Health, 2016; Whelton and He, 2014). The amount of sodium detected in this study, all things being equal could more or less meet the daily requirement of sodium for an average adult per day.

So far, about 185 species of legumes related to cowpea including blackgram (*Vigna mungo*), rice bean (*V. umbellata*), *vigna marginata* L. are reported to be eaten as leafy vegetables by humans in many parts of the world (source: www.leafforlife.org>VIGNAUNG). A recent survey conducted in southern Africa indicated that cowpea leaf is one of the highly appreciated vegetables in that part of the continent (Hallensleben *et al*., 2009).

In general, the results of this study indicated the presence of a wide array of nutritionally important and health promoting micro and macronutrients in the leaves of cowpea. It showed that the leaves of the crop contain significant amounts of protein, fat, carbohydrate, crude fibre and ash. In addition it contains several minerals including calcium, sodium, potassium, phosphorus, iron, magnesium and zinc in significant amounts. These findings are in agreement with the submissions of Olayiwole *et al.* (2012), Igbatim *et al.* (2014) and Chikwendu *et al*. (2014) who working in western and middle belt regions of Nigeria also reported the presence of a wide range of valuable nutrients including protein, carbohydrate, fat, crude fibre (prebiotics) as well as magnesium, potassium, iron, phosphorus, manganese and zinc in leaves of the crop. In like study in Tanzania Mamiro *et al*. (2011) found that the mean amounts of these nutrients in cowpea leaves were significantly higher than that of the seeds. This could explain the increasing adoption, utilization and consumption of cowpea leaf in Tanzania and Uganda than the seeds (Hallensleben *et al.,* 2009; Okonya and Maas, 2014).

Compared to nutrient contents of commonly consumed leafy vegetables in Africa such as taro, spinach, amaranths, pumpkins, cassava and sweet potato leaves, Nielsen *et al.* (1997) reported that the nutrient composition of cowpea leaves compared favourably with all of them. Similarly, nutrient contents and values of protein, carbohydrate, crude fibre, fat, ash (Table 1) and minerals (Fig. 2) obtained in this study also compared very well with the content and range of values reported by Afolabi *et al*. (2012) for sweet basil, water leaf, bitter leaf and green amaranths which are commonly consumed leafy vegetables in southern Nigeria. Fluted pumpkin (*Telferia occidentalis*) commonly called *Ugu* is the most popular and frequently consumed leafy vegetable in the region. Findings from this study shows that nutrient contents of cowpea leaves (Table 1; Fig 2) were comparatively superior to the values of corresponding nutrients in fluted pumpkin as reported in studies conducted by both Dike (2010) in Umudike, southeast Nigeria and Idris (2011) and Mohd *et al*. (2017) in Kano State in the northern region of the country.

The results of this evaluation showed that cowpea leaves therefore are rich in nutrients; and as vegetable has the potential to maintain and/or promote human health comparable to other tropical leafy vegetables like spinach, bitter leaf, taro, water leaf, sweet potato and lettuce. Hence, its consumption could be exploited and promoted especially in eastern Nigeria (Igbatim *et al.,* 2014).

CONCLUSION

Cowpea leaves are mild and good tasting vegetable that could be produced profusely in the rain-fed, low-input agriculture which characterize the humid southeast Nigeria. Outcome of the nutrient profiling of the leafy vegetable in this evaluation shows that it is rich in a wide array of nutrients such as iron, protein, carbohydrate, magnesium, potassium, zinc, sodium and calcium. With the exception of phosphorus (0.55 g) whose value is lower than the WHO recommended daily intake (RDI) of 700-1000 mg, the leafy vegetable, can effectively provide their WHO recommended daily averages in diets of its consumers. As a result of the significant heart, circulation, hormone, bone and muscle improving activities of the identified macro and micronutrients in the test cowpea leaves, their consumption could help to prevent or at least ameliorate iron, mineral and protein-calorie deficiencies reported to be endemic in Africa south of the Sahara. It could also reduce the risks of diabetes, high blood pressure, heart failure, cancer, depression, dementia and osteoporosis. Because the leaves are low in anti-nutrient factors; and have contributed immensely in improving the food baskets of other countries such as Tanzania, Uganda, Ethiopia and Southern Africa, it could be exploited as a rich source of health-promoting food-source in southeast Nigeria. Therefore, adoption, utilization and consumption of cowpea leaves as vegetables will be a step forward towards combating the protein-calorie malnutrition and iron deficiency in this part of the world.

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