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NUTRITIONAL POTENTIALS AND CHEMICAL VALUE OF SOME TROPICAL LEAFY VEGETABLES CONSUMED IN SOUTH WEST NIGERIA

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ABSTRACT
The human population in tropical African depends largely on a number of edible leafy vegetables to meet up with shortages in minerals and vitamins. Data base on the nutritional value of these leafy vegetables is scanty. Therefore, we report the nutritional components in three species of leafy vegetables using standard analytical methods. All the vegetables contained moisture (79.92 to 84.0%), crude protein (20.61 to 22.7%), crude fibre (10.7 to 22.44%), ash (6.8 to 10.44%), carbohydrate (55.86 to 68.22%) crude lipid (4.24 to 5.6%) and food energy (1507.19 to 1673.96 kJ/100g). The mineral element content were high with remarkable concentration of K(35.2 to 48.8mg/100g),Na(11.4 to 14.4 mg/100g),Ca(15.4 to 18.7mg/100g), Mg(12.2 to 18.7mg/100g), P(13.8 to 15.08mg/100g). The relationship between Na and K as well as between Ca and P; are desirable with the respective ratios of Na/K (0.6) and Ca/P (1.2). They also contain high levels of carotenoids (30 to 41.5 mg/100g DW), vitamin C (137.5 to 197.5 mg/100g DW). Seventeen amino acids (isoleucine, leucine, lysine, methionine, cysteine, phenylalmine, tyrosine, threonine, valine, alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, proline and serine) were detected**.** Their amino acid composition compare favourably with that of WHO/FAO protein standard indicating favourable nutritional balance except for lysine and methionine which appear marginal. The nutritional values of the phytochemicals were also assessed with a view of establishing and understanding their nutritional uses. The functional properties for the three vegetables were similar. Comparing the nutrient and chemical constituents with recommended dietary allowance (RDA) values, the results reveal that the leaves contain an appreciable amount of nutrients, minerals, vitamins, amino acids and phytochemicals and low levels of toxicants**.**
Keywords: vegetables, nutrients, amino-acids, phytochemicals, functional properties

INTRODUCTION
The most serious threat to survival of humanity is the increasing gap between population growth and food supply. It has been estimated that over 500 million people in the world today are malnourished [1]. Unfortunately an estimated 789 million people in developing countries still suffer from malnutrition especially infants and children of rural areas [2]. In Nigeria, as in most other tropical countries of Africa where the daily diet is dominated by starchy staple foods, vegetables are the cheapest and most readily available sources of important proteins, vitamins, minerals and essential amino acid [3]. Green leafy vegetables are succulent plant grown in the gardens and consume as side dish or soup with foods among the Nigerian tribes. Vegetables have been identified to contain high content of mineral, antioxidant and vitamins [4]. Organoleptically, vegetables are valued for their

supreme flavor and aroma, crop texture, attractive colour and their overall appeal to human sense of smell, taste, touch, and sight [5]. They contribute considerable amount of vitamins A, C, B_6, thiamin, niacin, riboflavin and minerals which are essential to metabolic process in the body system in addition they supply proteins, starch and sugars and are important source of dietary and crude fibre. [6, 7, 8, 9, 10, 11, 12]. Many of the local vegetable materials are under-exploited because of inadequate scientific knowledge of their nutritional potentials. The lack of nutritional information and inadequate development of nutritionally improved products from local raw materials have direct bearing on nutrition. In order to arrest the situation, much attention has been centered on the exploitation and utilization of non-conventional plant material for food [13].

Several species of these vegetables abound in Nigeria and many West African countries where they are used as condiments or spices in human diets, condiments or supplementary feeds to livestock such as rabbit, swine and cattle [14, 15]. Though several works reporting compositional evaluation and functional properties of various types of edible plants in use in the developing countries abound in literature, much still need to be done. Many workers [16, 17, 18, 19, 20, 21, 22, 23, 24] have reported the compositional evaluation of various types of leafy vegetables in use in the developing countries. Several of these vegetables species abound in Nigeria, O. gratissimum, T. occidentalis, V. amygdalina are known to be amongst the leafy vegetables consumed in Nigeria. Their nutritional contribution has not been widely exploited hence nutritional information on these species of vegetables will be useful for the nutritional education of the public and to improve the nutritional status of the population. As a result of the beneficial attributes of these leafy vegetables, there is need to establish chemical, nutritional and toxicological properties before advocating for increased utilization.

MATERIALS AND METHOD

Preparation of samples: Fresh leaves of some of the vegetables species were harvested from an experimental farm in Abeokuta. They were rinsed in water to remove dust, sorted and sliced. Some of the fresh samples were used for moisture determination while the rest of the samples were dried at 45^0C to constant weight using a Gallenkamp oven. They were ground to fine power in a sieve through 1.0mm mesh and stored in airtight container for laboratory analysis.

Chemical analysis: Proximate composition, dietary fibre, total carotenoids and gross energy value of the vegetable leaves were determined by method of the Association of official chemists [25] while mineral like sodium and potassium content were determined by flame photometry, phosphorus were determined by the vonodomobybdate method [25].Other mineral were determined after wet digestion using Atomic Absorption spectrophotometer (AAS model, SP9). Amino acid analysis was carried out using amino acid analyzer.

Determination of antinutrient: Oxalic acid, Saponin. Tannin content of the raw and processed vegetables samples were determined according methods described by AOAC [25].

Statistical analysis: All data obtained in triplicate were subjected to analysis of variance (ANOVA) using the SPSS statistical package (version 10.0), (2000 edition).

RESULTS AND DISCUSSION

The proximate composition of the three leafy vegetables is shown in Table1 with O. gratissimum having the highest moisture content of 84.00% followed by *V.amygdalin* with a value of 82.12% and T. occidentalis with 80.88%. The high level of moisture in all the samples investigated suggests that the leafy vegetables would not store for long without spoilage since a higher water activity could enhance microbial action bringing about food spoilage. It has been reported that fruits and vegetables contain as high as 85% water [26] consistent with the range of moisture level obtained in this study. The crude protein range of 5.7-21.02% for the leaves investigated and was relatively higher than some foodstuffs like L. sativa (0.7-1.1%), Portulaca leaves (1.3-1.5%), cassava leaves (7.1-8.2%) [27]. Values for these samples are close to values obtained by Igile [28] for *V.* amygdalina*,* Ejoh [11] for V.amygdalin and Fevrier and Viroben [29] for other leafy vegetables. The potentials of these vegetables as food or alternative protein source are shown by their protein and mineral composition. Aletor and Adeogun [15] opined that the use of these vegetables in amino acid supplementation in meeting protein and energy requirement could be a beneficial factor. The supplementation of plant foods with other food can give rise to high biological value and satisfactorily meeting the protein needs of adults [29]. The protein in leafy vegetables would require dietary supplementation with cereal protein and legume to alleviate kwashiorkor. The crude fibre was highest in *V.amygdalin* with 22.44g/100gdw and lowest in O. gratissimum at 10.7g/100gdw. These vegetables have high level of dietary fibre which varied significantly in the different species. Craplet and craplet-Meuner [30] and Tanya et al., [31] affirmed that leafy vegetables are rich in dietary fibre. Eun-Hee et al., [32] opined that the average level of dietary fibre in leafy vegetables in Asian countries to be 33% dry weight. This result is in close agreement with work [11, 32].

High level of dietary fibre in leafy vegetables are advantageous for their active role in the regulation of intestinal transit, increasing dietary bulk and increasing faeces consistency due to their ability to absorb water[33,34]. Ash content was relatively high with values ranging from 10.44% in T. occidentalis to 6.8% in O. gratissimum. These values except for O.gratissimum were found to be higher than values obtained for Amaranthus species [35]. These values obtained is higher than the values obtained by [11] for V.amygdalin and in close agreement with the work of Fasuyi [36] for Telfairia occidentalis. These values are an indication that these vegetables species are good sources of minerals when compared to values obtained for cereals and tubers [37]. Ether extract (fat) had a wide range of 7.62% in Telfairia occidentalis to 1.08% in O.gratissimum. Igile [28] and Ejoh [11] reported a similar value for V. amygdalina while Fasuyi [36] reported similar values for T. occidentalis. Singhai and Kulkami [35] reported higher values for Amaranthus spp. These values for fat in these vegetables species confirmed the findings of many authors which showed that leafy vegetables are poor sources of lipids [11]. However, their consumption in large amount is a good dietary habit and may be recommended to individuals suffering from obesity.

Carbohydrate content of these leafy vegetables was relatively high with T. occidentalis having 55.86% and V. amygdalina having 68.22%. These carbohydrate sources are not used in the body because most of them remain undigested. Igile [28] obtained slightly higher value for v. amygdalina while Ejoh [11] obtained slightly lower values. The differences may be due to the physiological state of the plant before harvesting, climate and agricultural practices [35].

The gross energy values of these vegetables species are in the range of 392.67 in V. amygdalina to 44.8 in ocimum gratissimum. These levels are low due to low crude fat and relatively high level of moisture. The daily energy requirement of 2500 to 3000 kCal has been reported for adult [37]. Hence, individual would need to consume 700g of V.amygdalin to obtain an energy value of 2750 kcal per day which is within the range reported by Bingham [38]. When one considers the roles of protein, fiber, Ca, Fe, total carotenoids and ascorbic acid in human nutrition, the average nutritive value of the T. occidentalis is superior to those the other species (Table 3). These values are lower than values obtained by Kuti and Kuti [39] for different species of spinach. These results are close to those reported by Ejoh [11] for other leafy vegetables.

Table 4 shows the amino acid analysis of the three leafy vegetables (g/100 g protein) .The major abundant amino acids were Glutamic acid, Arginine, Aspartic acid and Leucine with the values of 15.2, 5.8, 5.2 and 5.1 g/100 g protein respectively. This observation is in close agreement with the work of [40, 41, 42, 43]. The sum of the aspartic acid and glutamic amino acid was 21.2 g/100 g protein. This value is lower than values obtained from selected oil seeds (melon, pumpkin, cashew nut flour and gourd seeds) ranging between 24.2-29.5 [40, 43, 44.]. The Total Amino Acid (TAA) of 34.8 g/100 g protein indicated that these vegetables will contribute significantly to the supply of amino acid in diet. This value is lower than that of melon, pumpkin and gourd seed of 53.4, 38.3 and 53.6 g/100 g protein respectively reported by [40]; soybean, 44.4 g/100 g protein [44]; Pigeon peas, 45.2 g/100 g protein [23]. This is an indication that vegetables are good sources of essential amino acids. The amino acid requirements mg/kg/day for infants and 10-12 year old children have been reported to be 31 for Isoleucine, 64 for lysine, 27 for sulfur amino acids, 37 for threonine and 14 for tryptophan [45]. There are also evidences that histidine is an essential amino acid for adults and its dietary requirement in both normal and uremic men has been reported to be between 8 and 12 mg/kg/day [46, 47]. However, Wallece [48] found that the essential amino acids were lower than the FAO/ WHO reference protein in some non conventional leafy vegetables. Comparatively most of the amino acid profile was similar for all the different species of leafy vegetables. However *V. amygdalina* had slightly lower essential amino acids is evident as values of isoleucine, leucine and valine were lower for the other samples. Histidine, tyrosine and proline were highest in T. occidentalis while *V. amygdalina* has the highest level of aspartic acid, glycine and methionine. Deosthale [49] showed that excess leucine in foods interfered with the utilization of isoleucine and lysine.

For all the species, the levels are generally high and stand the risk of complexing with minerals such as calcium (50]. Oke [51] in Nigeria obtained similar observations. Similar values in amaranth [52] and spinach leaves [53] have been reported earlier. [54] reported a toxic level for oxalic acid at 3g per day. Polyphenol values ranged from 5.52mg/100g dry weight for T. occidentalis to 10.12mg/100g dry weight for O.gratissimum. Higher polyphenols content in fenugreek leaves and lower in amaranth leaves have been reported earlier [Gupta *et al*., 1989; 55]. Saponin values for these species ranged from 0.57 in O. gratissimum to1.94mg/100g dry weight in *V. amygdalina.* Saponin in foods can be astringent [56] or not bitter [57]. Saponins in plants have been known to protect the plant from fungal and insect attacks [56]. Other studies have proven that saponin have the ability to reduce the cholesterol levels in man and animals [57]. According to Ladeji [58], oxalate can bind to calcium present in food thereby rendering calcium unavailable for normal physiological and biochemical role such as the maintenance of strong bone, teeth, cofactor in enzymatic reaction, nerve impulse transmission and as clotting factor in the blood. The calcium oxalate, which is insoluble, may also precipitate around soft tissues such as the kidney, causing kidney stones [Oke, 1969]. Though lost of calcium leads to degeneration of bones, teeth and impairment of blood clotting process [59], the values obtained for these fruits were below the established toxic level. According to Oke [1966], a phytate diet of 1-6% over along period decreases the bioavailability of mineral elements in mono gastric animals. Phytic acid can bind to mineral elements such as calcium, zinc, manganese, iron and magnesium to form complexes that are indigestible, thereby decreasing the bioavailability of these elements for absorption [60]. Phytic acid also has a negative effect on amino acid digestibility thereby posing problems to non-ruminant animals due to insufficient amount of intrinsic factor phytase necessary to hydrolyze the phytic acid complexes [61]. Phytate is also associated with nutritional diseases such as rickets and osteomalacia in children and adult respectively. High saponin level has been associated with gastroenteritis manifested by diarrhea and dysentery [62]. However, it was reported that Saponin reduces body cholesterol by preventing its re-absorption and suppresses rumen protozoan by reacting with cholesterol in the protozoan cell membrane thereby causing it to lyse. It also binds to both exogenous and endogenous proteins including enzymes of the digestive tract, thereby affecting the utilization of protein [63, 64, 65].

The functional properties of the selected leafy vegetables are shown in Table 4 indicating the water absorption capacity (WAC), fat absorption capacity (FAC), emulsion capacity, emulsion stability foaming capacity, least gelation concentration and foaming stability after 30minutes. The WAC of the leafy vegetables ranges from 181.5 to 195.0 in ocimum gratissimum to Telfairia occidentalis respectively. The FAC varied from 30.4 in Vernonia amygdalina to 38.2 in Telfairia occidentalis. The fat emulsion capacity and emulsion stability of the three leafy vegetable were in close range of 32.7 to 38.2 for emulsion capacity and 42.8 to 45.4 for emulsion stability. Also, foaming capacity, foaming stability and least gelation concentration were similar for the three vegetables (20.9 to 25.0 %, 4.4 to 4.6% and 7.8to 8.3 % respectively. The functional properties (Table 4) shows that water absorption capacity is high and higher than the value reported for soybean(130%)[66],134% reported by [67] for African yam bean but in close agreement with the work of Fasuyi,36], Ige [68] for melon seeds. WAC is important protein property in viscous food such as gravies, soups, dough and bakery products [67]. With these WAC values, it suggests that their incorporation into food formulation especially low protein traditional food such as maize-gruel, cassava flour and yam flour to enhance their nutritive values. Fat absorption capacity of the leafy vegetables were lower than the values reported for soybean and sunflower, 84.4 and 20% respectively [66] but in close agreement with work of [36]. Also, fat emulsion capacity values were higher than the values reported for soybean flour and sunflower (11.7 and 18%) respectively [66]. Fat absorption capacity is a critical factor in flavour retention while emulsion capacity is important for the stabilization of fat in the production of foods such ad sausages, soups and cakes [69]. The ability of protein to aid the formation and stabilization of emulsion is very important in application such as mayonnaise, milk comminuted meat and salad dressing [67].

CONCLUSION

The results suggest that the vegetables if consumed in sufficient amount could contribute greatly towards meeting human nutritional requirement for normal body growth and adequate protection against diseases arising fro malnutrition. Hence, they are highly recommended for consumption. These species contained substantial quantities of minerals like iron, calcium, phosphorus, potassium, magnesium and zinc. These species also contain high levels of some antinutritional factors like oxalic acids, polyphenols and Saponin, which are required to be removed to improve the nutritional quality of these leafy vegetables. However, values obtained for these vegetables are lower than the established toxic level. Hence they can be consumed without any restriction. However, consumption in large amounts of vegetables with higher levels of antinutrient should be avoided.

Table1: Proximate composition of different leafy vegetable species (100g/dry weight)

	O. gratissimum	V. amygdalina	T. occidentalis
Moisture (%)	84.0±0.1	80.12±0.2	79.92±0.1
Crude protein (g)	22.7±0.2	21.02±0.4	20.61±0.2
Total carbohydrate (g)	62.2 ±0.1	68.22±0.1	55.86±0.3
Crude fibre (g)	10.7±0.2	22.44±0.2	18.28±0.2
Ether extract	4.35±0.3	4.24±0.2	5.6±0.4
Ash	6.8±0.2	7.22±0.3	10.44±0.2
Fatty acids	1.17	3.65	4.82
Energy(kJ/100g)	1604.25	1673.96	1507.19

[a]calculated fatty acids (0.86 x crude fat).
[b]calculated metabolizable energy (kJ/100g) (Protein x 17 + Fat x 37 + carbohydrate x 17)

Table 2: Mineral and vitamin content of species of leafy vegetable (mg/100 g)

	O. gratissimum	V. amygdalina	T. occidentalis
Sodium(Na)	11.4	12.6	14.4
Potassium (K)	35.2	44.8	48.8
Calcium (Ca)	15.4	15.8	18.7
Phosphorus (P)	13.8	13.1	15.08
Iron (Fe)	0.4	7.6	8.4
Magnesium (Mg)	12.2	14.2	18.7
Zinc (Zn)	3.2	1.2	1.4
Nickel	0.1	0.5	0.7
Na/k	0.32	0.28	0.30
Ca/P	1.12	1.21	1.24
Riboflavin	0.3	3.24	4.12

Vitamin C (mg/100g)	75.04	178.5	162.5
Niacin	1.2	1.3	1.4
Carotenoids (mg/100g)	28.0	35.0	48.0

Figures are mean of three replicates

Table 3. Concentration of some vitamins and antinutritional factors in three leafy vegetables

	O. gratissimum	V. amygdalina	T. occidentalis
Oxalate (mg/100g)	6.52±0.2	5.25±0.2	15.21±0.2
Saponin (mg/100g)	0.57±0.2	1.44±0.2	0.76±0.2
Polyphenol	10.12±0.2	6.68±0.2	5.52±0.2
Tannin	0.59±0.2	25.21±0.2	20.22±0.2
Phytate	0.63±0.2	22.24 ±0.2	18.40±0.2

Table 4 Amino acid contents of different leafy vegetable species(g/100 g) protein

Amino acids	O. gratissimum	V. amygdalina	T. occidentalis	FAO/WHO Pattern
Alanine	8.8	8.6	6.5	----
Aspartic acid	11.2	9.3	6.2	----
Cysteine	1.1	1.5	1.2	----
Arginine*	7.5	8.2	5.2	---
Methionine*	0.5	1.6	2.5	3.52
Glutamic acid	10.4	14.5	11.2	----
Histidine*	1.4	9.2	7.4	----
Glycine	4.1	6.6	6.2	----
Isoleucine*	3.8	4.7	5.2	4.00
Leucine*	7.1	7.2	7.6	7.04
Lysine*	3.1	3.4	2.4	5.44
Tyrosine	2.4	2.3	5.8	-----
Phenylalanine*	5.1	6.2	5.0	6.08
Threonine*	3.2	4.8	3.7	4.00
Tryptophan	1.6	1.5	3.2	1.00
Serine	4.4	5.2	4.0	----
Valine*	5.1	7.6	6.3	4.96

Figures are mean of three replicates
*Essential amino acids

Table 5. Functional properties of different leafy vegetable species

Amino acids	O. gratissimumm	V. amygdalina	T. occidentalis
Water absorption capacity (%)	181.5±1.8	184.0±2.0	195.0±1.4
Fat absorption capacity (%)	34.2±0.8	30.4±3.0	38.2±1.7
Foaming capacity (%)	20.9±1.8	22.2±2.1	25.0±3.1
Foaming stability	43.5±1.2	42.8 ±2.4	45.4±2.2
Emulsion stability	4.4±0.1	4.5±1.2	4.6±3.1
Emulsion capacity (%)	32.7±0.4	38.2±1.8	35.1±2.1
Least gelatin concentration (%)	7.8±1.3	8.3±0.6	8.2±0.8

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