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Full Length Research Paper

Nutritional and chemical value of *Amaranthus hybridus* L. leaves from Afikpo, Nigeria

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The nutritional and chemical value of *Amaranthus hybridus* were investigated using standard analytical methods in order to assess the numerous potential of the plant leaves. The Proximate analysis showed the percentage moisture content, ash content, crude protein, crude lipid, crude fibre and carbohydrate of the leaves as 84.48, 13.80, 17.92, 4.62, 8.61 and 52.18%, respectively while its calorific value is 268.92 Kcal/100 g. Elemental analysis in mg/100 g (DW) indicated that the leaves contained sodium (7.43), potassium (54.20), calcium (44.15), Magnesium (231.22), Iron (13.58), Zinc (3.80) and phosphorus (34.91). The vitamin composition of the leaves in mg/100 g (DW) was β-carotene (3.29), thiamine (2.75), riboflavin (4.24), niacin (1.54), pyridoxine (2.33), ascorbic acids (25.40) and α-tocopherol (0.50). 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. The chemical composition in mg/100 g (DW) for alkaloid, flavonoid, saponin, tannins, phenols, hydrocyanic acid and phytic acid were 3.54, 0.83, 1.68, 0.49, 0.35, 16.99 and 1.32, respectively. 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.

Key words: *Amaranthus hybridus* L. leaves, diet, minerals, vitamins, amino acids, phytochemicals.

INTRODUCTION

Most developing countries depend on starch-based foods as the main staple food for the supply of both energy and protein. This accounts in part for protein deficiency which prevails among the populace as recognized by Food and Agricultural Organization (Ladeji et al., 1995). 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 (Okafor, 1983). Many of the local vegetable materials are under-exploited because of inadequate scientific knowledge of their nutritional potentials. Though several works reporting compositional evaluation and functional properties of various types of edible wild plants in use in the developing countries abound in literature, much still need to be done. Many workers (Lockeett et al., 2000; Akindahunsi and Salawu, 2005; Edeoga et al., 2006; Hassan and Umar, 2006; Ekop, 2007) have reported the compositional evaluation and functional properties of various types of edible wild plants in use in the developing countries.

Amaranthus hybridus L, popularly called “Amaranth or pigweed”, is an annual herbaceous plant of 1- 6 feet high. The leaves are alternate petioled, 3 – 6 inches long, dull green, and rough, hairy, ovate or rhombic with wavy margins. The flowers are small, with greenish or red terminal panicles. Taproot is long, fleshy red or pink. The seeds are small and lenticellular in shape; with each seed averaging 1 – 1.5 mm in diameter and 1000 seeds weighing 0.6 – 1.2 g. It is rather a common species in waste places, cultivated fields and barnyards. In Nigeria, *A. hybridus* leaves combined with condiments are used to prepare soup (Oke, 1983; Mepha et al., 2007). In Congo, their leaves are eaten as spinach or green vegetables (Dhellot et al., 2006). These leaves boiled and mixed with a groundnut sauce are eaten as salad in Mozambique and in West Africa (Oliveria and DeCarvalho, 1975; Martin and Telek, 1979). *A. hybridus* has been shown to

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Table 1. Proximate composition of *Amaranthus hybridus* L. leaves

Parameter	Concentration (% DW)
Moisture Content	83.48
Ash Content	13.80
Crude Protein	17.92
Crude Lipid	4.65
Crude Fibre	8.61
Available Carbohydrate	52.18
Calorific value (Kcal/100g)	268.92

contain large amount of squalene, a compound that has both health and industrial benefits (Rao and Newmark, 1998; Smith, 2000; He and Corke, 2003). Despite the use of this plant for such purposes, there is little information on the nutritional and chemical composition of *A. hybridus* leaves. This work is therefore aimed at documenting the nutrient and chemical compositions of *A. hybridus* leaf in a bid to determining its usefulness and suitability as an edible vegetable or otherwise.

MATERIALS AND METHODS

Sample collection and treatment

The *Amaranthus hybridus* L. leaves were obtained from cultivated farmlands located at Afikpo North L.G.A., Ebonyi State, in South-eastern Nigeria. The collected sample was thoroughly mixed, had their stalks removed, rinsed with de-ionized water and the residual moisture evaporated at room temperature before sun-drying for 2 - 3 days on a clean paper with constant turning over to avert fungal growth. The sun-dried sample was ground into fine powder using pestle and mortar, and sieved through a 2.0 mm mesh sieve to obtain a dried powdered sample that was used for all the analyses.

Proximate analysis

The recommended methods of the Association of Official Analytical chemists (AOAC, 1999) were used for the determination of moisture, ash, crude lipid, crude fibre and nitrogen content.

Estimation of energy value

The sample calorific value was estimated (in Kcal) by multiplying the percentage crude protein, crude lipid and carbohydrate by the recommended factor (2.44, 8.37 and 3.57 respectively) used in vegetable analysis (Asibey-Berko and Tayie, 1999).

Mineral analysis

The mineral elements comprising sodium, calcium, potassium, magnesium, iron, zinc and phosphorus were determined according to the method of Shahidi et al. (1999) and Nahapetian and Bassiri (1975) with some modifications. 2.0 g of each of the processed samples was weighed and subjected to dry ashing in a well-cleaned porcelain crucible at 550^{0}C in a muffle furnace. The resultant ash was dissolved in 5.0 ml of $HNO_3/HCL/H_2O$ (1:2:3) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5.0 ml of de-ionized water was added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100.0 ml volumetric flask by filtration through Whatman No.42 filter paper and the volume was made to the mark with de-ionized water. This solution was used for elemental analysis by atomic absorption spectrophotometer. A 10 cm long cell was used and concentration of each element in the sample was calculated on percentage (%) of dry matter i.e. mg/100 g sample. Phosphorus content of the digest was determined colorimetrically according to the method described by Nahapetian and Bassiri (1975).

Vitamins analysis

Determination of vitamin A was by the method of Davies (1976).

Determination of vitamin A was by the method of Davies (1976). Determination of thiamine (B_1) Riboflavin (B_2), Niacin (B_3), vitamin E was by spectrophotometric method while pyridoxine Vit B_6 was by titremetry. These methods are as described by AOAC (1999). Ascorbic acid (vitamin C) was determined titremetrically by the method of Barakat et al. (1973).

Preparation of fat free sample

2.0 g of each of the processed sample was defatted with 100 ml of diethyl ether using a Soxhlet apparatus for 2 h.

Other analysis

Amino acid determination was carried out using ion-exchange chromatography with Technicon Sequential Multisample Amino Acid Analyzer, TSM (Technicon Instruments Corporation, Dublin, Ireland), as outlined in Adeyeye and Afolabi (2004).
Determination of Alkaloid, Saponin, Phenols were according to the methods of Harborne, 1973 as described by Obadoni and Ochuko (2001).
Tannin was determined by the method of Van-Burden and Robinson (1981), Hydrocyanic acid according to Bradbury et al. (1991), while Phytic acid was estimated by the method of Wheeler and Ferrel (1971).

RESULTS AND DISCUSSION

Proximate analysis

The results of proximate composition of *A. hybridus* leaves (Table 1) show high moisture content (83.48% wet weight). This is within reported range (81.4-90.3%) in some Nigerian green leafy vegetables. Ash content, which is an index of mineral contents in biota, is low (13.8% DW) in *A. hybridus* leaf compared to the values reported in leaves of *Talinum triangulare* (20.05% DW) (Ifon and Bassir, 1980; Ladan et al., 1996), but compared favourably with the values reported for *Ipomea batatas* (11.10%), *Vernonia colorate* (15.86%) and *Moringa oleifera* (15.09% DW) (Lockett et al., 2000; Antia et al., 2006). It is however, higher than that of some Nigerian leafy vegetable such as *Ocimum gratissium* (18.00% DW) *and Hibiscus esculentus* (8.00% DW) (Akindahunsi

Table 2. Mineral composition of *Amaranthus hybridus* L. leaves.

Mineral element	Composition (mg/100 g)
Sodium (Na)	7.43
Potassium (K)	54.20
Calcium (Ca)	44.15
Magnesium (Mg)	231.22
Iron (Fe)	13.58
Zinc (Zn)	3.80
Phosphorus (P)	34.91
Na/K	0.14
Ca/P	1.26

Each data is mean of three replicates.

and Salawu, 2005).

The crude protein content of A. *hydridus* L (17.92% DW) is higher than protein content of *Momordica balsamia* L. (11.29% DW), *Lesianthera africana* (13.1-14.9%), *Momor-dica foecide* (4.6%) leaves consumed in Nigeria and Swaziland (Ogle and Grivetti, 1985; Isong and Idiong, 1997; Hassan and Umar, 2006), but lower than those of *I. batatas* (24.85% DW), *Amaranthus candatus* (20.5% DW), *Piper guineeses* (29.78% DW) and *T. triangulare* (31.00% DW) (Etuk et al., 1998; Akindahunsi and Salawa, 2005; Antia et al., 2006). However, it compares favourably with *Gnetum africana* (17.50% DW) and *Leptadenia hastata* (19.1% DW) (Sena et al., 1998; Ekop, 2007). According to Pearson (1976), plant food that provides more than 12% of its calorific value from protein is considered good source of protein. Therefore, *A. hybridus* leaves (16.26%) meet this requirement. Furthermore, adults, children, pregnant and lactating mothers require 34 - 56, 13 - 19 and 17 and 71 g of protein daily, respectively (FND, 2002). Assuming com-plete protein absorption, 100 g DW of *A. hybridus* leaves would contribute about 32 - 53, 94-134, 25 and 25% of their daily protein requirement respectively. However, the presence of tannins is known to inhibit the bioavailability of proteins and minerals (Davidson et al., 1975).

A. hybridus leaf is a poor source of lipid. The crude lipid content (4.65% DW) is low compared to reported values (8.3 - 27.0% DW) in some vegetables consumed in West Africa (Ifon and Bassir, 1980; Sena et al., 1998). However, it compares favorably with 4.20% reported for *Calchorus africanum* leaves and 1.85 - 8.71% DW in some edible green leafy vegetables of Southern India and Nigeria Agbo, 2004; Gupta et al., 2005).

The carbohydrate content of (52.18% DW) is higher than 20, 23.7 and 39.05% reported for *Senna obtusfolia Amaranthus incurvatus M.balsamina* leaves, respectively (Faruq et al., 2002; Hassan and Umar, 2006). It is, however, lower than reported values for *Corchorus tridens* (75.0% DW) and sweet potatoes leaves (82.8%) (Asibey-Berko and Tayie, 1999). The recommended dietary allowance (RDA) values for children, adults, pregnant and lactating mothers are 130 g, 130, 175 and 210 g, respectively. It implies that 40, 40, 30 and 25% of their respective daily requirement can be met when 100 g dried leaves are consumed.

The crude fibre content (8.61% DW) is high when compared to *I. batatas* (7.20%), *T. triangulare* (6.20%) *P. guineeses* (6.40%), *Corchorus olitorius* (7.0%) *Vernonia amagydalina* (6.5%) (Akindahunsi and Salawu, 2005; Antia et al., 2006). Adequate intake of dietary fibre can lower the serum cholesterol level, risk of coronary heart disease, hypertension, constipation, diabetes, colon and breast cancer (Ishida et al., 2000; Rao and Newmark, 1998). The RDA of fibre for children, adults, pregnant and lactating mothers are 19 – 25, 21-38, 28 and 29 g, respectively. This shows that the plant is capable of contributing 34 - 45, 23 - 41, 31 and 30% of their respective daily requirement when 100 g dried leaves are consumed and as such could be valuable sources of dietary fibre in human nutrition.

The estimated calorific value (268.92 kcal/100 g DW) in *A. hybridus* leaves compare favourably to 248.8–307.1 Kcal/100 g DW reported in some Nigerian vegetables (Isong et al., 1999; Antia et al., 2006). Asibey–Berko and Tayie (1999) also reported comparable energy content in some Ghanaian green leafy vegetables. Thus, the calorific value agreement with general observation that vegetables have low energy values (Lintas, 1992).

Mineral composition

Mineral composition of *A. hybridus* leaves in decreasing order in mg/100 g is 231.22, 54.20, 44.15, 34.91, 13.80, 7.43 and 3.80 for Mg, K, Ca, P, Fe Na and Zn, respectively. The ratio of sodium to potassium (Na/K) and calcium to phosphorus (Ca/P) are shown in Table 2. The Na/K ratio in the body is of great concern for prevention of high blood pressure. Na/K ratio less than one is recommended (FND, 2002). Hence, consumption of *A. hybridus* would probably reduce high blood pressure diseases because its Na/K is less than one.

Calcium and phosphorus are associated with each other for growth and maintenance of bones, teeth and muscles (Dosunmu, 1997; Turan et al., 2003). The Calcium level in the leaves studied compares favourably with the value reported in some green leafy vegetables consumed in Nigeria and some wild edible leaves grown in Eastern Anatolia, Turkey (Ladan et al., 1996; Turan et al., 2003). The phosphorus content (34.91 mg/100 g) compares favourably with that of *I. batatas* (37.28 mg/1000 g) (Antia et al., 2006) but is low compared to 166 – 640 mg/100 g observed in some green leafy vegetables consumed in Nigeria (Ladan et al., 1996). For good Ca to P intestinal absorption, Ca/P ratio should be close to unity (Gull-Guerrero et al., 1998). The ratio in this

Table 3. Vitamin composition of *Amarathus hybridus* L. leaves.

VITAMIN	Composition (mg / 100 g)
β-Carotene (Vitamin A)	3.29
Thiamine (Vitamin B_1)	2.75
Riboflavin (Vitamin B_2)	4.24
Niacin (Vitamin B_3)	1.54
Pyridoxine (Vitamin B_6)	2.33
Ascorbic acid (Vitamin C)	25.40
α-Tocopherol (Vitamin E)	0.50

Figures are mean of three replicates.

Table 4. Amino acid composition of *Amaranthus hybridus* L. leaves.

Amino acid	Concentration (g/100 g protein)
Isoleucine	3.39
LEUCINE	6.70
LYSINE	3.03
METHIONINE	1.76
CYSTEINE	0.46
TOTAL SULPHUR AMINO ACIDS (TSAA)	2.22
PHENYLALANINE	4.00
TYROSINE	3.05
TOTAL AROMATIC AMINO ACID (TARAA)	7.05
THREONINE	2.62
VALINE	3.50
HISTIDINE	2.15
ALANINE	3.35
ARGININE	3.94
ASPARTIC ACID	5.40
GLUTAMIC ACID	15.79
GLYCINE	3.81
PROLINE	3.43
SERINE	3.04

Figures are mean of three replicates.

sample meets this requirement and as such predicates good Ca to P intestinal absorption.

Magnesium content (231.22 mg /100 g) of the leaves is within the range reported in some green vegetables (Ladan et al., 1996; Antia et al., 2006; Hassan and Umar, 2006). This is a component of chlorophyll (Akwaowo et al., 2000). It is an important mineral element in connection with ischemic heart disease and calcium metabolism in bones (Ishida et al., 2000).

Iron content of the leaves (13.58 mg/100 g) compares favourably with the value reported in *I batatas* (16.00 mg/100 g) (Antia et al., 2006), but low compared with values of other green leafy vegetables (DW) (Ibrahim et al., 2001). Iron is an essential trace element for haemoglobin formation, normal functioning of the central nervous system and in the oxidation of carbohydrates, protein and fats (Adeyeye and Otokiti, 1999).

The Zinc content (3.80 mg/100 g) compares favourably to most values reported for green leafy vegetables in literatures (Ibrahim et al., 2001; Hassan and Umar, 2006). Zinc is involved in normal function of immune system.

Vitamin composition

The vitamin composition in mg/100 g of *A. hybridus* leaves is presented in Table 3. The result shows that the leaves contain appreciable values of β-carotene, thiamine, riboflavin, niacin, pyridoxine and ascorbic acid but low value of α-tocopherol and as such are good sources of these vitamins. The vitamin composition of the plant is higher than those reported for *Aspilla africana*, *Bryophyplum pinnatum*, *V. amygdalina*, and *Eucalyptus globules* L. and *O. gratissium* K. (Alabi et al., 2005; Okwu and Josiah, 2006). The vitamin contents of the sample compare favourably with the values reported in some Nigerian leafy vegetables (Ifon and Bassir, 1979). Therefore, consumption of adequate quantities of this plant will help meet the daily requirements for adult male and female (NRC, 1975).

Vitamin A is needed for maintenance of skin, mucous membranes, bones, teeth, hair, vision and reproduction. Thiamine is needed for nervous system and helps release energy from carbohydrates. Riboflavin helps release energy from foods and is essential for healthy eyes, skin, nails and hair. Pyridoxine helps form red blood cells and is needed for metabolism, normal reproductive process and healthy pregnancies. Ascorbic acid is necessary for healthy teeth, gums and bones and is essential for proper functioning of adrenal and thyroid glands. Also, ascorbic acid is an anti-oxidant and as such acts as a general de-toxicant. Vitamin E also acts as an anti-oxidant and protects cell walls (Harper, 1999; Wardlaw and Kessel, 2002). Thus the plant could be a valuable source of dietary vitamins in human nutrition.

Amino acid profile

The amino acid profile in g/100 g protein of *A. hybridus* leaves is presented in Table 4. In this study, Seventeen (17) amino acids, instead of the twenty amino acids commonly found as components of proteins (McDonald et al., 1995), are determined. This is due to the conversion of glutamine and asparagines to glutamic acid and aspartic acid respectively (Salo-Vaananen and Koivistoinen, 1996) and the complete destruction of tryptophan during acid hydrolysis (Wathelet, 1999). The result indicated that nonessential amino acids (histidine, alanine, arginine, aspartic acid, glutamic acid, glycine,

Table 5. Chemical composition of *Amaranthus hybridus* L. Leaves.

Phytochemicals	Composition (mg/100 g)
Alkaloid	3.54
Flavonoid	0.83
Saponin	1.68
Tannins	0.49
Phenols	0.35
Hydrocyanic Acid	16.99
Phytic Acid	1.32

each data is mean of three replicates.

proline and serine) are higher in concentration (58.9%) compared to essential amino acids (Isoleucine, leucine, lysine, methionine, cysteine, phenylalanine, tyrosine, threonine and valine), which constitute 41.1% of the total amino acids analyzed. Similar observations have been reported (Aremu et al., 2006; Hassan and Umar, 2006). It is observed that glutamic acid (22.7%) and aspartic acid (7.8%) are the most abundant nonessential amino acid while leucine (9.7%) and phenylalanine (5.8%) were the most abundant essential amino acid in *A. hybridus* leaves. Similar observations had been made in other plants (Olaofe and Akintayo, 2000; Adeyeye, 2004).

Evaluation of the nutritional quality of *A. hybridus* leaves made by comparing the percentages of the essential amino acids in the sample with those of reference standard amino acid profile established for both adults and preschool children by WHO/FAO/UNU/ (1985). The result indicates that all essential amino acids exceeded the reference value for preschool children and adults with the exception of lysine, threonine and sulphur containing amino acids, which values are below the standard requirement for preschool children. Thus, lysine, threonine and sulphur containing amino acids are the most limiting amino acids for preschool children while there is no limiting amino acid in *A. hybridus* leaves for adults.

Chemical composition

The result of chemical composition in mg/100 g (DW) of *A. hybridus* leaves is shown in Table 5. The abundant phytochemicals were hydrocyanic acid (16.99 mg/100 g) and alkaloid (3.54 mg/100 g). The alkaloid content (3.54 mg/100 g) is higher than the values reported for the leafy vegetables *Aspilia Africanaa*, *Bryophyllum pinnatum*), *Cleome rutidosperma* and *Emilia coccinea* consumed in Nigeria (Edeoga et al., 2005; Okwu and Josiah, 2006).

The flavonoid content of the leaves (0.83 mg/100 g) and saponin (168 mg/100 g) compare favourably with the value reported for some medicinal plants used in Nigeria but was lower than values reported for *O. gratissiumum* and *Hypits sauvelens*. The tannin contents were, however, lower than values reported for a number of medicinal plants (Edeoga et al., 2005, Okwu and Josiah, 2006).

The Hydrocyanic acid content (16.99 mg/100 g) is higher than values reported for *V. amygdalina Bryophyllum pinnatum*, *Ecalyptus globules*, *O. gratissiumum* and *Gnetum africana* leaves (Ifon and Bassir, 1979; Alabi et al., 2005) but lower than that reported for *I. batatas* (Antia et al., 2006).

The phytic acid content (1.32 mg/100 g) of the leaves compares favourably with the value reported for *I. batatas* but lower than that for *G. africana* leaves (Ifon and Bassir, 1979; Antia et al., 2006).

Values for all the chemical parameters were within the tolerable limit permissible for children and adult (McDonald et al., 1995). The chemical constituents of *A. hybridus* predicate that it may not only be useful due to its dietetic value but also medicinally and pharmacologically. Saponin is used in the manufacturing of shampoos, insecticides and various drug preparation and synthesis of steroid hormones (Okwu, 2003). Phenols and phenolic compounds had been used as disinfectants and remain the standard with which other bactericides are compared. Alkaloids on the other hand are known to play some metabolic role and control development in living system and have a protective role in animals (Edeoga et al., 2006, Edeoga and Eriata, 2001).

The anti-nutrients such hydrocyanic acid have been implicated in cerebral damage and lethargy in man and animals. Tannins are capable of lowering available protein by antagonistic competition and can therefore elicit protein deficiency syndrome, kwarshiorkor while phytic acid has complicated effect in human system including indigestion of food and flatulence (Maynard, 1997). However, the anti-nutrients present in this plant is within the tolerable limits and can easily be detoxified by soaking, boiling or frying (Ekop et al., 2004; Eka and Osagie, 1998; Ekop and Eddy, 2005).

Conclusion

Our data show that the leaves of *A. hybridus* contain appreciable amount of proteins, fat, fibre, carbohydrate and calorific value, mineral elements, vitamins, amino acids and generally low level of toxicants. Thus, it can therefore be concluded that *A. hybridus* leaves can contribute significantly to the nutrient requirements of man and should be used as a source of nutrients to supplement other major sources. Chemical analysis, however, should not be the sole criterion for judging the nutritional value of this plant. It is necessary to consider other aspects such as the biological evaluation of the nutrient content of the plant in order to determine the bioavailability of the nutrients and also the effects of processing on the chemical and nutritive value of the plant. Study on the effects of processing on the nutritive and chemical values of the plant is in progress by the same authors.

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