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Full Length Research Paper

Nutritional potentials of some tropical vegetable leaf meals: Chemical characterization and functional properties

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Three tropical vegetable species (Talium triangulare, Amaranthus cruentus and Telfairia occidentalis) were selected based on their availability and agronomic desirability. The freshly harvested vegetable leaves were subjected to 2 processing techniques (shredding and sundrying) before milling into the vegetable leaf meals (VLMs). The crude protein ranged from 19.9+1.8 to 35.1+1.7. The crude fibre ranged from 8.8+3.1 to 12.7+4.2. Ether extract (fat) had a wide range of 5.4+3.2 to 29.2+2.1. Ash contents had a range of 10.9+6.2 to 19.4+3.0. The nitrogen free extract ranged from 19.7+0.3 to as high as 43.5+0.7. Gross energy values had a range of 251.5MJKg -1 to 383.2MJKg-1. The mineral contents of the air-dried VLMs indicated that Ca, Mg, Na, K are the most abundant minerals with values as high as 2.0, 2.5, 7.1 and 4.8gkg-1DM for Ca, Mg, Na and K respectively in some samples analysed. The amino acid profiles of the VLMs indicated favourable nutritional balance except for lysine and methinone which appear marginal. The Water Absorption Capacity (WAC), Fat Absorption Capacity (FAC), Fat Emulsion Capacity (FEC) and Emulsion Stability (ES) were similar for the 3 VLMs. The values obtained for Foaming Capacity, Least Gelation Concentration and Foaming Stability after 30 minutes for the 3 VLMs were also similar. The protein solubility curves of all VLMs were similar at both alkaline and acid media with minimum solubility (isoelectric point) at between pH 4 and 5 for the VLMs.

Key words: Vegetable leaf meals, nutritional potentials, amino acid profile.

INTRODUCTION

Several vegetable species abound in Nigeria and most West African countries where they are used partly as condiments or spices in human diets or as supplementary feeds to livestock such as rabbits, poultry, swine and cattle (Aletor and Adeogun, 1995). These vegetables are harvested at all stages of growth and fed either as processed, semi-processed or fresh to man while they are usually offered fresh to livestock.

The nutritional interest in some of these vegetable species stems from their rich contents of essential amino acids, vitamins and minerals. Further to their rich content of the mentioned nutrients, it is established that green vegetable leaves are the cheapest and most abundant source of proteins because of their ability to synthesize amino acids from a wide range of virtually available primary materials such as water, carbon dioxide, and atmospheric nitrogen (as in legumes). However, the presence of inherent toxic factors or anti-nutritional components in plants has been one major obstacle in harnessing the full benefits of the nutritional value of plant foods, vegetables inclusive (Liener, 1969; Nwokolo and Bragg, 1977; Lewis and Fenwick, 1987) . Although the presence of these antinutritional factors is always in trace quantities, they have been established to play significant roles in the nutritional quality of food.

However, many food processing techniques have been highlighted as possible means of reducing or totally eliminating the antinutrient levels in plant food sources to innocuous levels that can be tolerated by animals particularly in monogastric nutrition (Fasuyi and Aletor, 2005). The present study aims at highlighting the potentials of some commonly grown tropical leafy

Table 1. Proximate composition (g kg^{-1}DM) and gross energy values (MJ kg^{-1}) of vegetable leaf meals (means, n=2).

Vegetable leaf meal	Dry matter (%)	Crude protein (g kg^{-1} DM)	Crude fibre (g kg^{-1} DM)	Ether extract (g kg^{-1} DM)	Ash (g kg^{-1} DM)	N-free extract (g kg^{-1} DM)	Gross energy (MJ kg^{-1})
Talinum triangulare	89.6±1.2	19.9±1.8	11.9±2.3	29.2±2.1	19.4±3.0	19.7±0.3	383.2
Amaranthus cruentus	88.6±2.2	23.0±1.3	8.8±3.1	5.4±3.2	19.3±5.7	43.5±0.7	251.5
Telfairia occidentalis	91.0±2.0	35.1±1.7	12.7±4.2	9.6±4.1	10.9±6.2	31.7±0.8	341.3

Table 2. Mineral contents of air-dried vegetable leaf meals (means, n=2).

Vegetable leaf meal	Ca (g kg^{-1}DM)	Mg (g kg^{-1}DM)	Zn (g kg^{-1}DM)	Ni (g kg^{-1}DM)	Na (g kg^{-1}DM)	K (g kg^{-1}DM)	P (g kg^{-1}DM)	Fe (g kg^{-1}DM)
Talinum triangulare	0.8	0.7	0.5	1.3	3.8	2.7	0.771	0.392
Amaranthus cruentus	2.0	2.5	0.9	1.2	7.1	4.8	0.927	1.109
Telfairia occidentalis	1.8	1.2	0.7	0.8	8.2	3.7	1.028	0.992

vegetables as veritable nutritional sources in livestock diets particularly monogastric.

MATERIALS AND METHODS

Vegetable leaves

Three vegetable species were selected for the purpose of the experiment based on their availability and agronomic superiority. These vegetable leaves were *Talium triangulare, Amaranthus cruentus* and *Telfairia occidentalis*. The vegetable leaves used for the experiment were harvested fresh or purchased directly from local farmers at the farm sites located in sub-urban parts of Akure, a town in the South Western part of Nigeria. This town is located in the humid tropical rainforest with average rainfall of 1150-2000 m with utisols as the predominant soil type. The freshly harvested vegetable leaves were immediately subjected to 2 processing techniques (shredding and sundrying). Shredding was done using a chopping knife to cut the leaves into fine pieces and sundrying was done by constantly exposing the leaves to sunlight for 2-3 days and turning of the vegetable leaves to avert fungal growth. The leaves were later milled to obtain the vegetable leaf meals (VLMs) using a common locally fabricated milling machine.

Proximate/amino acids/mineral compositions and gross energy

The proximate constituents of the air-dried vegetable leaves were determined by the method of the Association of Official Analytical Chemist (AOAC, 1995). The sodium and potassium contents were determined by flame photometry, and phosphorus were determined by the vanodo-molybdate method (AOAC, 1995) . The other mineral elements were determined after wet digestion with a mixture of nitric, sulphuric and hydrochloric acid using Atomic Absorption Spectrophotometer (AAS Model SP9). Gross energy of the dried material was determined against thermocouple grade henzoic acid using a Gallenkamp ballistic bomb calorimeter (model CBB -330-0104L). Amino acids were determined using amino acid analyzer.

Functional properties

The protein stability (PS) of the VLMs were determined (Oshodi and Aletor, 1993); the water absorption capacity (WAC) and fat emulsion stability (FES) were determined by the described procedure of Beuchat (1977); the fat absorption capacity (FAC) was determined as described by Sosulski (1962). Similarly, the lowest gelation concentration (LGC), foaming capacity (FC) and foaming stability of the products were determined using the described techniques of Coffmann and Garcia (1977).

Data analysis

All data were means for duplicate determinations (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Table 1 presents the proximate composition and the gross energy values of the vegetable leaf meals (VLMs). The crude protein ranged from 19.9±1.8 g kg^{-1} DM in *Talinum triangulare* to 35.1±1.7 g kg^{-1} DM in *Telfairia occidentalis*. The crude fibre was highest in *Telfairia occidentalis* at 12.7±4.2 g kg^{-1} DM and lowest in *Amaranthus cruentus* at 8.8±3.1 g kg^{-1} DM. Ether extract (fat) had a wide range of 5.4±3.2 g kg^{-1} DM in *Amaranthus cruentus* to 29.2±2.1 g kg^{-1} DM in *Talinum triangulare*. Ash contents were relatively high with a range of 10.9±6.2 g kg^{-1} DM in *Telfairia occidentalis* to 19.4±3.0 g kg^{-1} DM in *Talinum triangulare*. The nitrogen free extract (carbohydrate) was also relatively high with a range of 19.7±0.3 g kg^{-1} DM in *Talinum triangulare* to as high as 43.5±0.7 g kg^{-1} DM in *Amaranthus cruentus*. Gross energy values had a range of 251.5 MJ Kg^{-1} in *Amaranthus cruentus* to 383.2 MJKg^{-1} in *Talinum triangulare*.

Table 2 shows the mineral contents of the air-dried vegetable leaf meals (VLMs). There is an indication that Ca, Mg, Na, K are the most abundant minerals with values as high as 2.0, 2.5, 7.1 and 4.8 g kg^{-1}DM, respectively, in some of the VLMs analysed. The amino acid profiles of the VLMs are shown in Table 3. There was a favourable nutritional balance of both essential and

Table 2. Mineral contents of air-dried vegetable leaf meals (means, n=2).

Vegetable leaf meal	Ca ($g\ kg^{-1}$DM)	Mg ($g\ kg^{-1}$DM)	Zn ($g\ kg^{-1}$DM)	Ni ($g\ kg^{-1}$DM)	Na ($g\ kg^{-1}$DM)	K ($g\ kg^{-1}$DM)	P ($g\ kg^{-1}$DM)	Fe ($g\ kg^{-1}$DM)
Talinum triangulare	0.8	0.7	0.5	1.3	3.8	2.7	0.771	0.392
Amaranthus cruentus	2.0	2.5	0.9	1.2	7.1	4.8	0.927	1.109
Telfairia occidentalis	1.8	1.2	0.7	0.8	8.2	3.7	1.028	0.992

Table 3. Amino acid profile (g/16 g N) of vegetable leaf meals.

Amino acids	*Talinum triangulare*	*Amaranthus cruentus*	*Telfairia occidentalis*
Alanine	6.12	6.34	6.51
Aspartic acid	7.01	5.12	6.21
Arginine	5.96	6.01	5.02
Glycine	5.61	4.02	6.10
Glutamic acid	9.38	10.31	11.01
Histidine	2.01	2.11	1.38
Isoleucine	5.62	4.81	5.10
Lysine	2.68	1.79	2.10
Methionine	2.10	1.38	2.48
Cystine	1.30	1.31	1.08
Meth. ± Cys.	3.40	4.41	4.56
Leucine	9.02	8.47	7.58
Serine	4.02	4.37	3.91
Threonine	4.10	3.15	3.81
Phenylalanine	6.21	5.82	4.85
Valine	6.10	5.23	6.20
Tyrosine	4.71	5.00	5.62
Tryptophan	1.82	2.36	3.12

Table 4. Water and oil absorption capacities, emulsion capacity and emulsion stability, foaming capacity, least gelation concentration and foaming stability of the vegetable leaf meals.

Amino acids	*Talinum triangulare*	*Amaranthus cruentus*	*Telfairia occidentalis*
Water absorption capacity (%)	138.0 1.2	187.5 1.8	190.0 1.4
Fat absorption capacity (%)	34.2±1.8	32.4±2.4	40.2±1.7
Emulsion capacity (%)	28.7±1.2	32.7±3.0	30.1±2.2
Emulsion stability (%)	43.5±0.8	45.8±2.1	42.1±2.4
Foaming capacity (%)	22.1±0.1	18.9±2.0	19.2±3.1
Least gelation concentration (%)	8.0±1.3	8.1±1.2	7.8±2.1
Foaming stability	4.3±0.4	4.4±0.6	4.1±0.8

non-essential amino acids except for lysine and methinone which appear marginal especially for *Amaranthus cruentus* with 1.79 and 1.38 g/16 g N for lysine and methionine, respectively.

The functional properties of VLMs are shown in Table 4 indicating the water absorption capacity (WAC), fat (oil) absorption capacity (FAC), emulsion capacity, emulsion stability, foaming capacity, least gelation concentration and foaming stability after 30 min. The WAC of the VLMs ranges from 118.0±1.2 to 190.0±1.4% in *Talinum triangulare* and *Telfairia occidentalis*, respectively. The FAC varied from 32.4±2.4% in *Amaranthus cruentus* to 40.2±1.7% in *Telfairia occidentalis*. The fat emulsion capacity and emulsion stability were similar for the 3 VLMs with a range of 28.7±1.2 to 32.7±3.0% for fat emulsion capacity and 42.1±2.4 to 45.8±2.1% for emulsion stability.

The values obtained for foaming capacity, least gelation concentration and foaming stability after 30 minutes for the 3 VLMs were similar and had ranges of

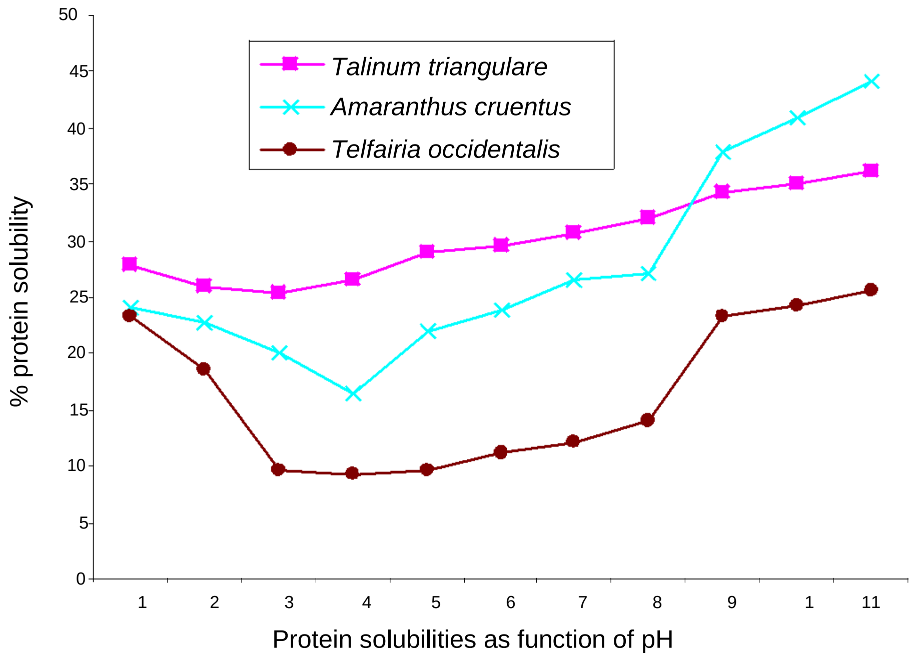

Figure 1. Protein solubility of vegetable leaf meals (VLMs) as a function of pH.

18.9±2.0 to 22.1±0.1%, 7.8±2.1 to 8.1±1.2% and 4.1±0.8 to 4.4±0.6, respectively. The protein solubility as a function of pH for the VLMs is shown in Figure 1. All VLMs showed identical solubilities at both alkaline and acid media. Minimum solubilities (isoelectric points) for the VLMs were obtained between pH 4 and 5.

The potential of the VLMs as food/feed and particularly as alternative protein resource is exemplified by the proximate composition, amino acid profile, mineral composition and the gross energy content of the analysed leaf meal samples. The crude protein values for the VLMs even though untested and reserved for further future studies in feeding assays indicate the potentialities of the VLMs as probable alternative protein sources in monogastric diets.

The amino acid profile (Table 3) of the VLMs compared favourbaly and even surpassed the values quoted for some conventional protein sources in poultry diets. The high CP content of the VLMs is of particular nutritional interest since about 75% of the total nitrogen in most vegetables is protein–nitrogen (Schmidt, 1971). It has been suggested that amino acid supplementation for a higher utilization of VLMs in meeting a substantial proportion of an animal's protein and energy requirement could be benefial (Aletor and Adeogun, 1995). The potassium, sodium, calcium, phosphorus and magnesium contents of these VLMs were particularly high when compared with most other foods. Even iron which is commonly deficient in many diets is fairly abundant in VLMs.

The functional properties (Table 4) shows water absorption capacity (WAC) to be high even averagely higher than 130% reported for soyabean (Lin et al., 1994), 134% reported for African yam bean (Adeyeye et al., 1994) but comparable with values quoted for melon (Ige et al., 1985). The WAC is a critical property of proteins in viscous foods like soups, gravies, dough and baked products (Adeyeye et al., 1994). Given the high crude protein content, the favourable amino acid profile and the WAC of these VLMs, it is altruistic suggesting their incorporation in food/feed formulation especially incorporation into low-protein traditional foods such as maize gruel (pap), cassava and yam flour to enhance their nutritive values.

Fat (oil) absorption capacity (FAC) values of the VLMs were generally lower than 84.4 and 207% reported for soya and sunflower flours, respectively (Lin et al., 1994) while the values for fat emulsion capacity (FEC) for the VLMs were higher than 11.7 and 18% reported for wheat and soya, respectively. FAC is a critical assessment of flavour retention, while FEC and emulsion stability are important attributes of additives for the stabilization of fat emulsion in the production of such foods as sausages, soups and cakes (Kinsella, 1976). The ability of proteins to aid the formation and stabilization of emulsions is important in many applications including mayonnaise, milks, comminuted meats and salad dressings (Adeyeye et al., 1994).

The foaming capacity values of the VLMs were considered lower than those of soya flour (70%) and sunflower (230%) previously reported (Lin et al., 1994). The foaming stability values of these VLMs were lower than values quoted for legume products. Foaming stability is an important index in the suitability of a whipping agent in food systems.

The least gelation concentration was comparable with those quoted for pigeon pea (12%), lupin flour (14%) (Sathe et al., 1982) and cassava leaf meals and cassava leaf protein concentrate (9.0% and 12.5%, respectively) previously reported (Fasuyi and Aletor, 2005). The values were however lower than values quoted for fluted pumpkin (36%) (Fagbemi and Oshodi, 1991). Protein gel formation provides the matrix for holding water, flavours, sugars and ingredients hence it is an important consideration in food product development. This result obtained for the VLMs suggests that VLMs may be useful in the production of curd or as an additive to other materials for gel formation in food products.

Protein stability profiles of the VLMs as functions of pH (Figure 1) indicate their high stability at both alkaline and acid media with minimum solubility (isoelectric point) at between pH 4 and 6. The solubility curves agree with earlier work carried out on cassava leaf meals and cassava leaf protein concentrates (Fasuyi and Aletor, 2005) and other works on African yam bean flour (Adeyeye et al., 1994). The solubility pattern suggests VLMs as being useful in the formulation of both acid and alkaline foods such as protein-rich carbonated beverages.

In conclusion, the empirical data obtained from the proximate analyses, amino acid determination, mineral determination and gross energy of the VLMs clearly exemplify the nutritional potentials of these food items as probable alternative feed ingredients particularly for protein supplementation in monogastric feed formulation. Another nutritional interest is also the desirability of some examined functional properties of the VLMs. These properties are important nutritional indicators of the usefulness of these items as food/feed resource.

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