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Nutritional quality and antinutritional composition of four non-conventional leafy vegetables

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The leaves of *Xanthosomas mafaffa*, *Ipomoea involucrata*, *Launaea taxaracifolia* and *Euphorbia hirta* were analysed for their nutritive value and antinutritional factors. Protein content of the leaves ranged between 2.60 and 3.42%, while fibre and mineral (ash) contents were 1.15–7.73% and 1.48–2.86%, respectively. The amino acid spectrum revealed that the leaf proteins were generally deficient in more than one amino acid. Methionine was the most limiting amino acid in *X. mafaffa*, *E. hirta* and *L. taxaracifolia*, while lysine was most limiting in *I. involucrata*. The highest chemical score was recorded for the *E. hirta* protein while *L. taxaracifolia* registered the lowest scores. Therefore, *L. taxaracifolia* leaf protein was the poorest in quality. *E. hirta* leaves contained the highest concentration of calcium (175 mg%), copper (14.7 mg%), iron (45.8 mg%) and lead (26.4 mg%). A high level of phosphorus (34.1 mg%) was observed in *I. involucrata*. In terms of antinutritional principles, all the leaves studied had comparatively lower concentrations of oxalate, phytate, tannins, alkaloids and saponins.

INTRODUCTION

The most serious threat to the survival of humanity is the ever-increasing gap between population growth and food supply. It has been estimated that over 500 million people in the World today are malnourished (F.A.O., 1985). In order to arrest the situation, much attention has been centred on the exploitation and utilization of unusual plant materials for food (Marfo *et al.*, 1988). Much of these efforts have, however, been concentrated on seeds while the leafy vegetable sources have, to a large extent, been ignored. Leaves are reportedly inexpensive, easy to cook and rich in vitamins and minerals and, in addition, provide roughage (Oke, 1966).

Ghana, like other tropical countries, has an abundance of plant species that grow all year round. A few of these and their leaves are cooked and consumed but many go to waste. For instance, 10–30 t ha^{-1} of cassava leaves obtained annually from cassava harvest are usually thrown away or used as manure (Oke, 1978).

Euphorbia hirta, locally called "kaka wie adwe", is a small annual herb used as a delicacy in Ghana. Usually the reproductive parts are consumed with palm kernel. A decoction of the entire plant is very efficacious for allaying the dyspnoea of asthmatics (Uphof, 1959). *Ipomoea involucrata* popularly called "Iehowa dua" in Ghana is widely distributed throughout Ghana and tropical West Africa. The Lele of Guinea reportedly eat the leaves and it is superstitiously considered a good talisman for fecundity (Burkill, 1985) and used for treating anaemic cases by local herbalists in Ghana (Akodam, 1986). *Launaea taxaracifolia* (wild lettuce) enjoys the patronage of a few people who usually use it for salad and in the preparation of beverage and stew. *Xanthasomas mafaffa*, the commonly grown cultivar in Ghana and similar to the West Indian type *X. saggittifolium* (Whitby, 1968), is very popular in Ghana, especially the leaves which are used in the preparation of stew and soup.

In view of the potential beneficial attributes of leafy vegetables, there is a need to comprehensively establish chemical, nutritional and toxicological properties before advocating their increased utilization. The purpose of this study was to conduct a systematic investigation of the chemical composition, nutritional quality and toxic principles possibly inherent in four non-conventional leafy vegetables in order to ascertain their suitability for use in human diets or as animal feed.

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MATERIALS AND METHODS

Sample preparation

Samples of fresh, tender and green leaves of *X. mafaffa* (cocoyam), *E. hirta* (kaka wie adwe), *I. involucrata* (Iehowa dua) and *L. taxaracifolia* (wild lettuce) were obtained from the Department of Horticulture, University of Science and Technology, Kumasi, Ghana. The samples were washed under running water and blotted dry. The moisture contents of the leaf samples were determined at 60°C and the dried matter obtained was ground in a laboratory mill to a fine powder. This was stored at −5°C in air-tight and coloured glass containers until required for analysis.

Chemical analysis

Crude protein, ether extract, crude fibre, mineral ash and non-protein nitrogen were determined according to standard procedures (A.O.A.C., 1980). Carbohydrate content (N_2-free extract) was estimated by difference. Alkaloids, tannins, phytate, total oxalate and saponins in the leaves were quantified by the methods described by Harborne (1979), Josyln *et al.* (1968), Oke (1966) and Gestetner *et al.* (1966), respectively.

Mineral content

The mineral content was determined by a wet ashing method (A.O.A.C., 1970). Estimation of mineral ions was by flame analyser (Na, K and Ca) and atomic absorption spectrophotometer (Zn, Cu, Mg, Ni and Fe) using a Carl Zeiss instrument.

Amino acid assay

Amino acid composition of the samples was determined in acid hydrolysate by an IRICA Automatic amino acid analyser. Chemical scores were calculated using the F.A.O./W.H.O. reference pattern (F.A.O./W.H.O., 1973).

Statistical analysis

Statistical significance of observed differences were determined using the Student *t*-test and correlation analysis (Cochran & Cox, 1957).

RESULTS AND DISCUSSION

Proximate composition of the leafy vegetables

The proximate composition of the four leafy vegetables, as presented in Table 1, showed the leaves to have comparable levels of nutrients to the literature (Owusu-Domfeh *et al.*, 1979; Whitby, 1968). The crude protein range of 2.60–3.42% for the leaves studied was relatively higher than some foodstuffs like *L. sativa* (0.7–1.1%) and Portulaca leaves (1.3–1.5%) consumed in Ghana (Watson, 1971). This range of protein, however, is relatively lower than the 7.1–8.2% reported to be present in cassava leaves (Watson, 1971).

The mineral ash ranged from 1.24% in *X. mafaffa* to 2.96% in *E. hirta*. The results as presented indicated a slightly higher ash content when compared to the 0.7–1.3% determined in some Ghanaian foodstuffs (Watson, 1971).

With the exception of *X. mafaffa*, the fibres in the rest of the samples were comparatively similar to what is reportedly present in most Ghanaian foodstuffs and vegetables (Whitby, 1968; Watson, 1971).

The ether extract content in all the leaves varied between 0.41% in *I. involucrata* and 1.02% in *E. hirta*. The values determined in the samples compare well with that (0.1–1.5%) reported for cabbage, cocoyam and cassava leaves (Watson, 1971) and 0.5–2.6% for Amaranth (Gupta *et al.*, 1989). The relatively low levels of these nutrients, particularly protein, give credence to the fact that leafy vegetables are good sources of roughage, vitamins and minerals and not protein (Oke, 1966).

The amino acid compositions of the protein in the leaves studied are presented in Table 2. The amino acid profile showed that *E. hirta* leaf protein had relatively higher levels of threonine (1.17 g per 16 g N), valine (1.40 g per 16 g N) and lysine (1.59 g per 16 g N) with respect to the rest of the samples. Albeit, the levels were far lower than the 4.00 reported by F.A.O./W.H.O. (1973) for threonine.

Methionine was generally deficient in all the leaf samples studied. This observation agrees with the assertion that green leafy vegetables are deficient in the sulphur-amino acids (Gupta *et al.*, 1989). The amino acid patterns determined are in good agreement with others on non-conventional food and feed sources (Amubode & Fetuga, 1984; Owusu-Domfeh *et al.*, 1979).

Generally, all the leaf samples contained lower concentrations of essential amino acids when compared with the F.A.O./W.H.O. (1973) reference pattern. The lower levels of the essential amino acids cannot be attributed to processing (heating) effects since care was taken initially to dry the samples at 60°C. This partial drying temperature is lower than the temperature zone around 80°C where Maillard reactions have been found to increase very rapidly (Amubode & Fetuga, 1984). It is, therefore, unlikely that any of the essential amino acids, especially lysine, could have been destroyed as a result of Maillard reactions in this assay. Moreover, any lysine bound as a Schiff base or as glycosylamine was most likely to be recuperated by the strong acid hydrolysis.

From the chemical scores shown in Table 3, all the leaf proteins studied were deficient in more than one amino acid. For maximum nutritional benefit, these leaves should be consumed in mixtures with other foodstuffs in

Table 1. Proximate composition of four leafy vegetables on fresh weight basis (%)

Component	*E. hirta*	*I. involucrata*	*L. taxaracifolia*	*X. maffafa*
Moisture	74.41 ± 0.58	84.61 ± 0.37	91.43 ± 0.36	88.41 ± 0.15
Ether Extr.	1.02 ± 0.28	0.41 ± 0.14	0.62 ± 0.12	0.73 ± 0.09
C. Fibre	7.73 ± 0.20	2.63 ± 0.16	2.71 ± 0.48	1.15 ± 0.13
C. Protein	3.42 ± 0.19	2.60 ± 0.58	2.71 ± 0.48	2.61 ± 0.33
Ash	2.89 ± 0.38	1.73 ± 0.16	2.16 ± 0.33	1.48 ± 0.23
Av. Cho.[a]	10.53 ± 0.98	8.02 ± 0.87	1.86 ± 0.25	5.63 ± 0.18

Values are means of triplicate determinations.
[a]Av. Cho, available carbohydrate.

Table 2. Amino acid composition (g per 16 g N) of the leaf proteins of *E. hirta*, *I. involucrata*, *L. taxaracifolia* and *X. maffafa* on fresh wt basis

Amino acid (g per 16 g N)	*E. hirta*	*I. involucrata*	*L. taxaracifolia*	*X. mafffafa*	F.A.O./W.H.O. pattern
Aspartate	2.56	1.10	0.73	0.50	—
Threonine	1.17	0.23	0.26	0.24	4.00
Serine	0.93	0.54	0.32	0.22	—
Glutamate	2.56	1.91	1.04	1.09	—
Glycine	1.05	0.77	0.52	0.29	—
Alanine	1.02	0.79	0.54	0.34	—
Valine	1.40	0.67	0.44	0.34	4.96
Methionine	0.18	0.21	0.12	0.06	3.52
Isoleucine	0.88	0.57	0.35	0.30	4.00
Leucine	1.57	0.90	0.55	0.42	7.04
Tyrosine	0.80	0.46	0.18	0.15	—
Phenylalanine	0.86	0.72	0.43	0.57	6.08
Lysine	1.59	0.11	0.37	0.23	5.44
Histidine	0.56	0.35	0.16	0.16	—
Arginine	1.59	0.79	0.48	0.34	—

Values are means of triplicate determinations.

Table 3. Chemical score and lysine:arginine ratio of leaf proteins of *E. hirta*, *I. involucrata*, *L. taxaracifolia* and *X. maffafa* on fresh wt basis

Amino acid	*E. hirta*	*I. involucrata*	*L. taxaracifolia*	*X. maffafa*	F.A.O./W.H.O. pattern
Lysine	45	4	11	11	5.44
Threonine	42	27	10	14	4.00
Valine	35	22	11	14	4.96
Methionine	5	4	4	4	3.52
Isoleucine	25	21	10	14	4.00
Leucine	33	24	12	14	7.04
Lys:Arg ratio	0.28	0.02	0.07	0.09	

Values are means of triplicate determinations.

order to obtain adequate amounts of all the essential amino acids in good proportions, or better still fortify the leafy meal with other protein sources high in the limiting essential amino acids (Owusu-Domfeh *et al.*, 1979).

Mineral ion concentration

In general, the mineral ion content (Table 4) of the leaves studied were higher when compared with other leafy vegetables indigenous to and consumed in Ghana (Owusu-Domfeh *et al.*, 1979; Watson, 1971; Eyeson & Ankrah, 1975). *E. hirta* contained the highest concentration of Ca (175 mg%), Cu (14.7 mg%), Fe (45.8 mg%), Zn (5.29 mg%), Mg (150 mg%) and Pb (26.4 mg%), while P was found to be highest in *I. involucrata* (34.1 mg%).

Apart from *E. hirta* which had a higher content of Pb, the other three had insignificant levels. The presence of Pb has been reported to restrict the availability and utilization of some of the essential elements such as Ni, Zn, Cu, etc. when included in the diet (Chowdhurry & Chandra, 1987) as well as possibly causing nephrotoxicity (*Nutrition News*, 1990). However, it is not likely that *E. hirta* would be consumed as a main foodstuff and in sufficient quantities to give concern to consumers.

Of all the leafy vegetables, *L. taxaracifolia* contained the highest amount of K (451 mg%) but the lowest level of Cu (3.10 mg%). Ni was found in trace amounts in all four samples. Variations in the levels of mineral ions among the four leafy samples studied could be attributed to differences in species and, to some extent, agronomic practices.

Antinutritional principles

In Table 5, the concentrations of some antinutritional factors are presented. The saponin level of the leaves varied between 6.67 mg% in *E. hirta* and 481 mg% in *X. mafaffa*. The amounts of saponin in the leaves studied were lower than other workers have reported (Gupta *et al.*, 1989; Marfo *et al.*, 1986).

The level of phytate determined in *E. hirta* was the highest among the four leaf samples. However, this was comparatively lower than that reported to be present in some seeds (Marfo *et al.*, 1986; Bressani *et al.*, 1987). High dietary phytate content is reported to cause growth reduction (O'Dell & Savage, 1960), affect food value by binding and making mineral ions unavailable to the consumer, affect the homeostasis of Zn and Fe, inhibit enzymatic digestion of proteins by forming complexes with enzyme proteins and cause rickets in young dogs (Marfo *et al.*, 1990). The low level of phytate in the leaves, therefore, would be nutritionally advantageous.

The concentration of oxalate in the leaves (107–1115 mg%) is far lower than that determined in six leafy vegetables by Gupta *et al.* (1989). Though the level of oxalate in *X. mafaffa* was not high compared with levels determined in *E. hirta* and *I. involucrata*, some varieties of the *Xanthosomas* species are reported to cause irritation to handlers, as well as the mucus membrane of consumers, when poorly handled or prepared. The oxalate level in *E. hirta* correlated positively with mineral ash (0.76) while the concentration in *L. taxaracifolia* correlated negatively with ash (−0.40). Again, correlation analysis indicated a positive correlation (0.51) between fibre and phytate in *E. hirta*; confirming the notion that foods high in fibre also contain equally high amounts of phytate (Harland & Oberleas, 1985; Harland & Prosky, 1979).

A tannin range of 167–1222 mg% was determined in the four leaf samples used in this study. The concentrations of tannins in the samples were altogether comparatively lower than those that other workers have reported on (Kays, 1979; Gupta *et al.*, 1989). The interest in dietary tannins is due to evidence of adverse effects. For instance, tannins in the diet are reported to cause growth depression (Davis, 1981) and have the potential to complex divalent ions (Zn, Fe, Cu, etc.) resulting in their unavailability. The unavailability of Zn reportedly causes paralysis (Marfo *et al.*, 1986).

Launaea taxaracifolia contained the lowest alkaloid content of 35.0 mg% while the highest of 176 mg% was found in *E. hirta*. The bitterness and marked physiological effects characteristic of the presence of alkaloids in the diet, which invariably influence the nutritive value of such diets (Trease & Evans, 1978), are not expected to cause a problem when these leafy vegetables are consumed. The levels determined are too low to give concern to prospective consumers.

Table 4. Mineral ion concentration in the leaves of four leafy vegetables on fresh basis (mg%)

Component	*E. hirta*	*I. involucrata*	*L. taxaracifolia*	*X. maffafa*
Phosphorus	0.004	34.1	12.1	16.9
Sodium	62.7	29.1	25.3	20.8
Potassium	386	387	451	418
Calcium	176	38.4	47.6	36.1
Lead	26.4	2.97	0.502	Trace
Copper	14.7	5.83	3.10	5.45
Zinc	5.29	2.3	2.63	1.65
Iron	45.9	0.245	4.32	3.42
Magnesium	150	96.3	53.4	64.0
Nickel	Trace	Trace	Trace	Trace

Values are means of triplicate determinations.

Table 5. Concentration of some antinutritional factors in four leafy vegetable on fresh basis (mg%)

Component	*E. hirta*	*I. involucrata*	*L. taxaracifolia*	*X. maffafa*
Saponin	6.67 ± 0.15	386 ± 0.09	424 ± 0.14	481 ± 0.19
Phytate	655 ± 0.13	176 ± 0.06	9.28 ± 0.02	131 ± 0.13
Oxalate	1115 ± 0.51	913 ± 0.23	108 ± 1.01	654 ± 0.23
Tannin	1222 ± 0.12	869 ± 0.04	168 ± 0.31	655 ± 0.09
Alkaloid	176 ± 0.06	101 ± 0.21	35.6 ± 0.22	72.2 ± 0.81
Zinc	5.29	2.31	2.63	1.65
Phy:Zn[a] ratio	3.41	1.34	0.03	0.99

Values are means of triplicate determinations.
[a]Phy: Zn ratio, phytate : zinc molar ratio.

The phytate:Zn molar ratio determined in the sample ranged between 0.03 in *L. taxaracifolia* and 3.41 in *E. hirta* as shown in Table 5. Phytate:Zn molar ratios determined in all the samples were comparatively low and therefore Zn deficiency and its associated complications, is not envisaged to occur since the ratios determined in the leaves are well below the safe limit of 6.0. Within this limit, Harland and Prosky (1979) have reported that the Zn level necessary to maintain serum levels in human subjects is assured.

CONCLUSION

Results indicate that the leaves of these non-conventional vegetables had levels of nutrients characteristic of other more conventional ones. Though antinutritional factors were found to be present, the levels were such that consumption would not result in any deleterious effect on the consumer and, moreover, vegetables in this part of the world are consumed fresh, and not in the dry form.

The study also demonstrated clearly that leaf proteins were deficient in more than one amino acid. Methionine was most limiting in all the leaf protein samples studied except in *I. involucrata*, where lysine was found to be the most limiting amino acid. This apparent limitation of the amino acid profile of the leaf proteins in terms of methionine and lysine would suggest that they would be no better than conventional plant sources of protein, which are deficient in these amino acids, particularly methionine.

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