The Bioscientist Vol. 5(1): 1-12, January 2017 Available online at
http://www.bioscientistjournal.com

Full Length Research Paper

COMPARATIVE STUDIES ON THE NUTRIENT COMPOSITION AND ANTI-NUTRITIONAL FACTORS IN DIFFERENT PARTS OF *MORINGA OLEIFERA* PLANT FOUND IN AWKA, NIGERIA.

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ABSTRACT

Moringa oleifera plant has been used as an essential vegetarian diet to bridge the gap in protein energy demands in the West African sub-region. Since parts of the plant have multi-purpose uses, the comparative studies on the nutrient composition and anti-nutritional factors in the different parts of the plant found in Awka, Nigeria were studied. The methods of Association of Analytical Chemists were used for the proximate analysis, and the amino acid content estimated using Technicon Sequential Multi-sample amino acid analyzer (TSM). The percentage (%) crude protein was comparatively high in the seed (28.02±0.01), leaf (27.60±0.14), and flower (25.99±0.07) in that order, but low in the root (5.02±1.52) and stems (3.59±0.96). The seed (33.78 ± 2.41) and leaf (20.00 ± 2.31) had high amount of % crude lipid compared to the flower (9.44 ± 3.08), root (6.33 ± 1.64) and stem (1.77 ± 0.98). Only the leaf contained all the water-soluble vitamins estimated in the following proportions: ascorbic acid (773.30mg/100g), thiamine (18.47mg/100g), riboflavin (14.82mg/100g), pyridoxine (57.29mg/100g) and niacin (50.35mg/100g). The amino acid assay results indicated that the ratio of the essential amino acids (EAA) and non-essential amino acids (NEAA) were almost equal unlike in many plants where NEAA are always significantly higher than EAA. Statistical analyses showed that there was no significant difference ($p>0.05$) between the essential and non-essential amino acids present in all the parts of the plant studied. The tannins were highest in the leaf (420.00mg/100g) followed by the stem (100.00mg/100g), the flower (60.00mg/100g) and the root (45.00mg/100g) and lowest in the seed (40.00mg/100g). However, the phytates were low in all the parts of the plant studied. The anti-nutrient values indicated that *Moringa oleifera*, apart from its high nutrient

composition, also contains medically and pharmacologically important agents. It is not therefore surprising that the plant is used in traditional medicine in Africa, Asia, and Americas.

Keywords: *Moringa oleifera*, comparative studies, nutrient composition, anti-nutrition.

INTRODUCTION

Over the decades, *Moringa oleifera* plant has been used as an essential vegetarian diet to bridge the gap in protein energy demands in the West African sub-region. *Moringa* is a fast growing tree that is available all-year round (Aktar *et al.*, 2007; Ozumba *et al*., 2009; Igwilo *et al*., 2010). The different parts of the plant have multi-purpose uses. In short the leaves, the pods, flowers and growing tips of the tree are edible and nutritious (Fuglie, 2001, Ozumba, 2008). Apart from its dietary importance, local folklore credits *Moringa* with a lot of herbal potency as reported by Fuglie (2001) and Ozumba (2008). The leaves are used to treat malaria, anxiety and jaundice, and have stabilizing effect on blood pressure. An infusion of leaf juice is used to control glucose levels in diabetes. It is also used to treat fever, scurvy, bronchitis, eye and ear infections, and catarrh (Ozumba *et al*., 2009) The seeds and pods of *Moringa oleifera* are used against fevers and abdominal tumours. They are used in the treatment of malnutrition, infections of liver and spleen, and joint pains. The *Moringa* seed contains natural polypeptides (anti-coagulants) and anti-microbial agents which are reportedly used in treating or purifying water for drinking in traditional setting (Ozumba *et al*., 2009, Igwilo *et al*., 2013).

The seed oil is applied externally to relieve pain and swelling in case of gout or rheumatism, and to treat skin diseases. The oil is used to treat hysteria, scurvy and applied to treat prostrate and bladder troubles. It is a tonic and a purgative (Fuglie, 2001). *Moringa* flowers are used in treating malnutrition in traditional settings. They are used as tonic, di-uretic and considered to be anti-helminthic.

The roots are used to treat epilepsy, nervous debility and hysteria. They are used as purgative, abortifacient, diuretic and as cardiac and circulatory tonic. They are used as carminative and as laxative (Ozumba, 2008).

Moringa stem and root bark are aphrodisiac and ant-helminthic. It is useful in treating scurvy and to cure eye diseases. They are taken as appetizers and digestives (Ozumba, 2008).

Unfortunately, many of these claims and reports of efficacy in human beings are not supported by placebo controlled, randomized clinical trials nor have they been published in high quality, peer-reviewed journals (Fahey, 2005).

Therefore, there is need to do comparative studies on the nutrient compositions and anti-nutritional factors of the different parts of *Moringa oleifera* plant found in Awka, Nigeria and be able to advise accordingly.

Collection and preparation of plant materials

Mature, dry M*oringa oleifera* pods, fresh leaves, stems, roots and flowers were collected from family gardens in Ifite, Awka, Anambra state, Nigeria. The pods were split open and the seeds removed, and then pooled together to form the bulk sample. The seeds, the leaves, and the flowers were air-dried at 30 ^{o}C (under room temperature) for two days and separately ground into fine powder using manual grinder, while the roots and stems were cut into pieces first using knives and dried separately, before grinding into fine powder. The milled samples were kept in screw-capped containers and stored in a freezer until required for analysis.

Proximate analysis

The methods of the Association of Official Analytical Chemists (AOAC, 1999) were used for the determination of moisture, crude protein, crude lipids, ash and dry matter of the seeds, leaves, flowers, roots and the stems of *Moringa oleifera*.

Estimation of energy values

The calorific values of seed, leaf, flower, root and stem of *Moringa oleifera* were estimated in kilocalories by multiplying the percentage crude proteins, lipids and carbohydrates by the recommended factors4,9,and4 respectively (Amadi *et al*., 2004).

Mineral analysis

The mineral compositions of the different parts of *Moringa oleifera* (seed, leaf, flower, root and stem) were determined using atomic absorption spectrophotometer (Agilent Technology, USA), according to methods of the Association of Official Analytical Chemists (AOAC, 1999).

Vitamin determination

The determination of the water-soluble vitamins namely niacin, pyridoxine, riboflavin, thiamine and ascorbic acid were by high performance liquid chromatography (HPLC), as described by AOAC (1999).

Determination of amino acid content

The amino acid contents of the different parts of *Moringa oleifera* were determined using methods described by Speckman *et al.*, (1958). The dried and milled seed, leaf, flower, root and stem samples were defatted, hydrolysed, evaporated in a rotary evaporator and then loaded into the Sequential Multi-Sample Amino Acid Analyzer (Technicon, USA). The amino acid values of the samples were calculated from the chromatogram peaks.

Determination of the anti-nutritional factors

The amount of tannins, saponins and cyanogenic glycosides were determined (AOAC, 1984), while oxalates (Munro and Bassir, 1969) and phytates (Griffiths and Thomas, 1981) were determined accordingly.

RESULTS

The results of the proximate composition of *Moringa oleifera* seed, leaf, flower, root and stem are shown in Table 1.The % crude protein content is comparatively high in the seed (28.02±0.01%), leaf (27.60±0.14%), and flower (25.99±0.07%) in that order, but low in the root (5.02±1.52%) and stem (3.59±0.96%). The seed (33.78 ± 2.41%) and leaf (20.00 ± 2.31%) have high amount

of crude lipid compared to the flower (9.44 ± 3.08%), root (6.33 ± 1.64%) and stem (1.77 ± 0.98%).

The calorific values of the different parts of *Moringa oleifera* plant are also shown in Table 1. At 531.18 Kcal/100g, the seed had the highest calorific value followed by the leaf (426.12Kcal/100g), the flower (391.20Kcal/100g), and the root (384.05Kcal/100g) while the stem had the least calorific value at 380.05 Kcal/100g. The energy content profile, %crude proteins and %crude lipids of the different parts of the plant are in the order:

Seed> $leaf > flower > root > stem.$

Table 1: Proximate composition and energy values of the seed, leaf, flower, root and stem of *Moringa oleifera* (Mean ± S.E.M).

Parameter	Seed	Leaf	Flower	Root	Stem
Crude lipids (%)	33.78±2.41	20.00±2.31	9.44±3.08	6.33±1.64	1.77±0.98
Crude Proteins (%)	28.02±0.01	27.60±0.14	25.99±0.07	5.02±1.52	3.59±0.96
Carbohydrates (%)	28.77	33.93	50.57	76.75	87.44
Ash (%)	3.03±0.07	11.60±3.65	3.57±0.12	4.97±0.53	1.63±0.22
Moisture (%)	6.40±0.31	6.87±0.50	10.43±0.58	6.93±0.58	5.57±0.35
Energy values (Kcal/100g)	531.18	426.12	391.20	384.05	380.05

The mineral composition of *Moringa oleifera* plant is shown Table 2. The sodium (Na) content is highest in the roots (514mg/100g) followed by the stem (378.38mg/100g), seed (129.03mg/100g) and flower (120.94mg/100g) while the least value is found in the leaf (104.06mg/100g). The calcium (Ca) contents are 2.84mg/100g, 13.45mg/100g, 2.32mg/100g, 3.99mg/100g and 1.38mg/100g in the seed, leaf, flower, root and stem respectively. Although, no potassium (K) was detected in the seed, the other parts of the plant contained potassium. The leaf, flowers, root and stem contained 20.81mg/100g, 3.02mg/100g, 15.40mg/100g and 32.40mg/100g of potassium respectively. Lead and Barium were not detected in any part of the plant studied.

Table 2: Mineral composition of the seed, leaf, flower, root and the stem of *Moringa oleifera*

Mineral content	Seed	Leaf	Flower	Root	Stem
Na (mg/100g)	129.03	104.06	120.93	514.80	378.38
Ca (mg/100g)	2.84	13.45	2.32	3.99	1.38
K (mg/100g)	-	20.81	3.02	15.4	32.4
Pb (mg/100g)	-	-	-	-	-
Ba (mg/100g)	-	-	-	-	-

The vitamin composition of *Moringa oleifera* seed, leaf, flower, root and stem are presented in Table 3. Only the leaf contained all the water-soluble vitamins estimated in the following proportions: ascorbic acid (773.30mg/100g), thiamine (18.47mg/100g), riboflavin (14.82mg/100g), pyridoxine (57.29mg/100g) and niacin (50.35mg/100g). The concentrations of ascorbic acid were higher in the leaf (773.30mg/100g) and flower (459.21mg/100g) compared to the seed (94.74mg/100g), stem (71.44mg/100g) and root (48.13mg/100g).

Table 3: Vitamin composition of the seed, leaf, flower, root and the stem of *Moringa oleifera.*

Vitamins	Seed	Leaf	Flower	Root	Stem
Ascorbic acid (mg/100g)	94.74	773.30	459.21	48.13	71.44
Thiamine (B1),mg/100g	-	18.47	-	-	-
Riboflavin (B2),mg/100g	-	14.82	-	-	-
Pyridoxine (B6), mg/100g	-	57.29	7.69	-	-
Niacin (B3), mg/100g	-	50.35	-	5.83	1.32

The amino acid compositions in g/100g protein of the seed, leaf, flower, root and the stem of *Moringa oleifera* are shown in Table 4. All the fractions consistently are

composed of 17 out of the 20 naturally occurring amino acids lacking only in asparagine, glutamine and tryptophan. The essential amino acids (EAA) and non-essential amino acids (NEAA) in the different parts of the plant are almost equal in concentration in all circumstances. The proportion of total amino acids, EAA and NEAA in the whole plant follow the pattern as thus:

Leaf > seed > flower > stem > root.

Table 4: Amino acid profile of the seed, leaf, flower, root and stem of *Moringa oleifera* plant

Amino acids (g/100g)	Seed	Leaf	Flower	Root	Stem
Lysine	4.20	4.40	3.00	2.95	2.60
Histidine	2.10	2.20	1.10	0.50	1.00
Arginine	5.00	4.80	6.50	3.60	2.10
Threonine	3.00	2.20	2.00	2.10	1.00
Valine	3.00	4.80	2.00	1.00	4.30
Methionine	1.00	1.20	0.50	1.00	0.70
Isoleucine	2.30	4.20	2.10	0.80	2.00
Leucine	6.80	7.00	5.20	1.00	4.50
Phenylalanine	3.50	4.00	3.90	1.00	3.70
Aspartate	7.00	6.80	4.00	0.90	3.10
Serine	2.60	3.00	2.80	0.90	2.40
Glutamate	10.50	9.00	7.20	8.00	5.00
Proline	2.50	3.00	2.30	0.50	3.10
Glycine	3.00	3.40	1.00	0.70	2.40
Alanine	4.90	4.10	4.00	5.00	3.80
Cystein	0.50	0.60	0.60	1.20	0.50
Tyrosine	3.00	3.10	1.50	1.00	2.50

The quantitative determination of the anti-nutritional factors in the seed, leaf, flower, root and the stem of *Moringa oleifera* plant are shown in Table 5. The tannins were highest in the leaf (420mg/100g) followed by the stem (100mg/100g), flower (60mg/100g), root (45mg/100g) and the seed (40mg/100g). A similar pattern was noted with cyanogenic glycosides content; it was highest in the leaf (32.40mg/100g) followed by the stem (31.40mg/100g), seed (4.59mg/100g), flower (4.31mg/100g) and the root (2.72mg/100g).On the other hand, the phytates were low in all the parts of the plant studied. We had 0.013mg/100g, 0.048mg/100g, 0.064mg/100g, 0.435mg/100g and 0.436mg/100g for the leaf, stem, root, seed and flower respectively. The levels of oxalates were similar in the stem (51.24mg/100g), seed (51.24mg/100g) and flower (51.23mg/100g) when compared to that in the leaf (7.20mg/100g) and root (17.08mg/100g). Saponin value was highest in the flower (15.23mg/100g) followed closely by the stem (12.10mg/100g), leaf (11.80mg/100g),

seed (9.40mg/100g) and lowest in the root (4.20mg/100g).

Table 5: The levels of anti-nutritional factors in the seed, leaf, flower, root and stems of *Moringa oleifera.*

Anti-nutrients	Seed	Leaf	Flower	Root	Stem
Tannins (mg/100g)	40	420	60	45	100
Cyanogenic glycosides (mg/100g)	4.59	32.40	4.31	2.72	31.40
Phytates (mg/100g)	0.435	0.013	0.436	0.064	0.048
Saponins (mg/100g)	9.40	11.80	15.20	4.20	12.10
Oxalates (mg/100g)	51.24	7.20	51.23	17.08	51.24

DISCUSSION

The nutritional properties of *Moringa oleifera* leaf are well known that there seems to be little doubt of the substantial health benefit to be realized by consumption of *Moringa* leaf powder as a vegetable. Studies on the dietary constituents of the leaf credit it with essential amino acids (Fuglie, 2001), which is important in bridging the protein gap of poor countries like Nigeria. However, the dietary potentials of other parts of the plant are largely lacking in literature, and thus, the utmost importance of this work in evaluating *Moringa oleifera* for dietary or pharmacological purposes.

Moringa oleifera seed (28.02 ± 0.01%), leaf (27.60 ± 0.14%) and flower (25.99 ± 0.07%) shown in Table 1 are rich in proteins since according to Pearson (1976), any plant food that provides more than 12% of its calorific value from protein is considered a good source of protein. It should be noted that the % crude protein content of the seed, leaf and flower of *Moringa oleifera* grown in Awka are higher than that reported in some legumes such as *Canavalia ensiformis* seed, 24.48±0.28% (Igwilo *et al.*, 2007a); *Gnetum africana* seed, 17.50% (Ekop, 2007); *Amaranthus hybridus* leaf, 17.92% (Akubugwo *et al.*, 2007), and *Momordica balsamia* leaf, 11.29% (Hassan and Umar, 2006). The protein content of the seed and leaf compared favourably with that of *Piper guineeses*, 29.78% (Akindahunsi and Salawa,2005), while that of the flower compared favourably with the protein content of *Ipomoea batatas* leaf, 24.85% (Anita *et al.*, 2006). The implication of this

is that these *Moringa oleifera* plant parts grown in Awka, Nigeria are good sources of proteins for man and animals.

The *Moringa oleifera* seed (33.78 ± 2.41%) and leaf (20.00 ± 2.31%) have higher amount of crude lipid compared to the flower (9.44 ± 3.08%), root (6.33 ± 1.64%) and stem (1.77 ± 0.98%). In particular, is the crude lipid content of the seed which is higher than that found in some vegetables consumed in West Africa, 8.3-27.0% (Ifon and Bassir, 1980; Akubugwo *et al.*, 2007; and Agbo, 2004).Therefore, the seed of *Moringa oleifera* is a very good source of lipid when compared to other parts of the plant and some vegetables consumed in West Africa.

The percentage carbohydrate in the leaf (33.93%) compared favourably with that reported by Fuglie, 2001 (38.2), but higher than the amount reported by Oliveira *et al.*, 1999 for the seed (212.2g/kg). The % moisture in the seed (6.40 ±0.31), leaf (6.87 ± 0.50), flower (10.43 ± 0.58), root (6.93 ± 0.58) and stem (5.57 ± 0.35) compared favourably with that reported by Fuglie, 2001 for the dry leaf powder (7.5%). The leaf had the highest % ash (11.60 ± 3.65) compared to the other parts of the plant studied. However, the ash content, which is the index of the mineral content in biota, is low compared to that reported for *Talinum triangulare* leaf, 20.05%, (Ladan *et al.*, 1996) and in *Amaranthus hybridus*, 13.80%,(Akubugwo *et al.*, 2007). The implication of these findings is that *Moringa oleifera plant* grown in Awka contains the necessary nutrients to sustain growth in humans and animals.

The calorific values of *Moringa oleifera* plant (380.05 to 531.18 Kcal/100g) are higher than the values reported for some Nigerian vegetables, 248.8 - 307.1 (Anita *et al.*, 2006; Akubugwo *et al.*, 2007). Nevertheless, the calorific values agree with the general observation that vegetables have low energy values (Lintas, 1992). Therefore, dependency on the plant as a sole source of calories would prove insufficient.

The proximate analysis results when subjected to one way analysis of variance (ANOVA) showed that the mean differences were significant ($p<0.05$). However, when multiple comparisons (MANOVA) were used, the protein values in the seed were not significantly different with that of the leaf and flower ($p>0.05$) but were different with stem and root ($p<0.05$).

The seed, leaf, flower, root and stem of *Moringa oleifera* contained sodium (Na) and calcium (Ca) ions. Although, no potassium was detected in the seed in the present study, Fuglie (2001) reported that the pods contained 259 mg of potassium per 100g sample. Also, the amount of calcium in this study was far lower than what was reported by Fuglie (2001) in the leaf of *Moringa oleifera* (440mg/100g). The implication of this is that *Moringa oleifera* grown in Awka, Nigeria, might not be a good source of calcium.

The vitamin composition showed that only the leaf contained all the water-soluble vitamins studied. However, aside riboflavin (14.82mg/100g), the values were higher than what were reported by Fuglie (2001), Foild *et al*, (2001) and Ozumba (2008). Fuglie (2001) reported that the leaf of *Moringa*

oleifera contained thiamine (2.64mg), riboflavin (20.5mg), nicotineamide (8.2mg), and ascorbic acid (17.3mg). Furthermore, Fuglie (2001) reported the pods to contain 0.05mg/100g, 0.07mg/100g, 0.2mg/100g and120mg/100g of thiamine, riboflavin, niacin and ascorbic acid respectively, this study detected only ascorbic acid (94.74mg/100g) in the seeds. The result may still suggest that the leaf of *Moringa oleifera* grown in Awka, Nigeria, might be a good source of anti-oxidants since vitamin C is a very good anti-oxidant.

In this study, seventeen (17) amino acids were found instead of the twenty (20) naturally occurring amino acids commonly found in proteins (Mc Donald *et al.*, 1995 and Akubugwo *et al.*, 2007). Glutamine and Asparagine, which are merely amide derivatives, were not detected perhaps because they are easily converted to their corresponding acids, glutamic and aspartic acids respectively (Salo-Vaananen and Koivistoinen, 1996). Also, tryptophan was not detected because of its complete destruction during acid hydrolysis (Wathelet, 1999 and Akubugwo *et al.*, 2007). This might explain the higher levels of glutamic acid and aspartic acid in the results of this study. The results showed that the amino acid contents of the leaf are higher than the values reported by Fuglie (2001) for the dry leaf powder. However, this study confirmed the earlier observations of Fuglie (2001), Oliveira *et al* (1999) and Makkar and Becker (1997) that *Moringa oleifera* contained all the essential amino acids needed for normal body functioning.

The levels of tannins and oxalates were high in almost all the parts of *Moringa oleifera* plant studied. Makkar and Becker (1997) reported that tannins, saponins, and cyanogenic glycosides were detected in the stem of *Moringa oleifera* but the concentrations were negligible. The levels of phytates (mg/100g) were low in the plant, 0.013, 0.048, 0.064, 0.435 and 0.436mg/100g for the leaf, stem, root, seed and flower respectively. This is lower than what was reported by Makkar and Becker (1997) for the leaf of *Moringa oleifera* (21g/Kg).The value is also lower than what was reported by Akubugwo *et al.*, (2007) for *Amaranthus hybridus (*1.32mg/100g). The low content of these anti-nutrients in the plant is a good omen for the use of those plant parts as nutrients. The anti-nutrient values indicate that *Moringa oleifera*, apart from its high nutrient composition, is also medically and pharmacologically important. It is not therefore surprising that the plant is used in traditional medicine in Africa, Asia, and Americas (Morton, 1991; and Fuglie, 2001). Tannic acid is astringent and is known to be used in the treatment of bedsores and minor ulceration (Harborne, 2006; Akubugwo *et al.*, 2007). Saponins are used in the manufacture of shampoos, insecticides and various drug preparations and synthesis of steroid hormone (Okwu, 2003).

Phytic acid has complicated effect in the human system, particularly indigestion of food and flatulence (Maynard, 1997 and Akubugwo *et al.*, 2007). Tannins have antagonistic competition with proteins, thereby, lowering their bio-availability, thus,

eliciting protein deficiency syndrome and kwarshiorkor.

However, these anti-nutrients can easily be removed by soaking, boiling or frying (Ekop and Eddy, 2005; Kidmose *et al.*, 2006).

CONCLUSION

The results of the nutritional profiling and anti-nutrient analysis of different parts of *M. oleifera* reinforces its use in culinary, formulation of nutraceuticals and to an extent in herbal medicine. However, while this work empirically validates the nutritional use of *M. oleifera* parts, we are in no way consolidating the many medicinal uses of the plant parts. Further research is therefore necessary to validate the many supposed medicinal benefits of the plant parts.

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