

## COMPARATIVE ANALYSIS OF THE NUTRITIONAL QUALITY OF BROWSE LEAVES (*SPONDIAS MOMBIN* AND *ALBIZIA SAMAN*) AND TUBER PEELS (YAM AND CASSAVA) USED AS RUMINANT FEEDS.

Afolabi, T. A.<sup>1\*</sup>, Onadeji, R. S.<sup>2</sup>, Ogunkunle, O. A.<sup>3</sup>, and Bamiro, F.O.<sup>1</sup>

<sup>1</sup> Department of Chemistry, Federal University of Agriculture, Abeokuta, Nigeria.

<sup>2</sup> Department of Chemistry, University of Ibadan, Ibadan, Nigeria.

<sup>3</sup> Department of Chemistry, Obafemi Awolowo University, Ile-Ife, Nigeria.

\* Corresponding Author

E-mail: [nivyafo@yahoo.com](mailto:nivyafo@yahoo.com) (T.A. Afolabi)

Telephone: +234 803 5718657

(Received: August 2012; Accepted: November 2012)

### ABSTRACT

The proximate and mineral analyses of two browse leaves (*Spondias mombin* and *Albizia saman*) and two tuber peels (yam (*Dioscorea rotundata*) and cassava (*Manihot esculentum*)) were carried out in order to justify their use as feedstuff for ruminant animals and then compare the nutritional parameters of the browse leaves with that of the tuber peels. The proximate composition (moisture content, ash, crude fibre, crude protein, etc) of the samples were determined using standard procedure by AOAC, while the mineral contents were determined with the aid of Atomic Absorption Spectrophotometer (AAS). The results of the proximate analyses showed that the browse leaves have 24.42% and 15.98% protein for *Albizia saman* and *Spondias mombin* respectively, while the tuber peels are 7.66% and 3.72% for yam and cassava peels respectively. However, the tuber peels are better dietary sources of energy as they have higher Nitrogen Free Extract (Carbohydrate) values (81.67% and 78.97% for yam and cassava peels respectively) as compared to the browse leaves (39.37% and 51.95% for *Albizia saman* and *Spondias mombin* respectively). The Fe content of the browse leaves was 23.95 and 12.80 mg/100g for *Albizia saman* and *Spondias mombin* respectively, while the tuber peels had 12.30 and 9.00 mg/100g Fe content for cassava and yam peels respectively. The browse leaves had higher Ca contents of 780 and 1798 mg/100g for *Albizia saman* and *Spondias mombin* respectively, while that of the tuber peels was significantly lower with 712 and 63 mg/100g for cassava and yam peels respectively. Also yam peels had the highest K concentration (1548 mg/100g). This analysis showed that the browse leaves (*Albizia saman* and *Spondias mombin*) and tuber peels when combined (by mixing the dried tuber peels and browse leaves at different ratios) in the diet of ruminant animals will meet their nutritional needs, but it is inadequate if any of them is used as a single diet.

**Key words:** Browse Leaves, Tuber Peels, Feedstuff, Ruminant Animal.

### INTRODUCTION

The success of the livestock industry anywhere in the world depends greatly on feed quality and quantity (Babayemi and Bamikole, 2008). For livestock to reach their genetic potential for milk, meat, wool, and hides production, it is important that they have sufficient source of energy (carbohydrate, protein, etc), nitrogen, sulphur and essential minerals. Animals receiving inadequate diets are more prone to disease and fail to reach their genetic potential.

Inadequate nutrition has been the major factor limiting the expansion of animal production in Nigeria (Kassam and Andrew, 1975). To salvage this nutritional problem, there is need for utilization of cheap and indigenous sources of protein and energy particularly those that attract no competition from man and other types of livestock

animals (World Bank, 2006; Kings, 1983; Underwood, 1981). Crop residues such as yam and cassava peels are thus important because of the ability of ruminants to digest cellulose and other structural polysaccharides of plants origin (Kings, 1983; Lambourne *et al.*, 1983). These tuber peels are regarded as 'waste product' that is ordinarily discarded, hence a cheap source of diet for the ruminant animals, most especially the domesticated ones.

About 90% of the domestic livestock in sub-Saharan Africa are ruminants (also known as pseudo-ruminants; FAO, 1986). Ruminant animals possess four stomachs with which they digest plant-based materials by initially softening it within the animal's first stomach (rumen) and regurgitating the semi-digested mass (cud) and chewing it again. This helps to further break down

plant matter and stimulate digestion. The microbial population in the ruminant fore-stomach is responsible for the digestion of both the fibrous and soluble fraction of plant materials consumed. The fermentation results in the production of volatile fatty acids which are the major source of energy for ruminants. Maximum fermentation rates are obtained when all the factors required by ruminant micro-organisms are available namely a source of energy, nitrogen, sulphur and essential minerals. When the rate of fermentation is reduced, feed intake decreases, and nutrient availability to the animal is limited (Gartner *et al.*, 1980). Low quality diets i.e. unbalanced rations that do not contain all these nutrients are characterized by low animal productivity, since the shortage of one or more of the essential nutrients limit microbial activity. Feed rations that contain these nutrients are thus essential to ensure proper growth and development.

In Nigeria, and most part of Africa, feed rations for ruminant animals are usually composed of discarded food/crop product and browse leaves. For instance, it is uneconomical to feed yam to livestock, but yam peels which are often discarded are of great value as animal feed (Eka, 1998). The importance of yam as an indigenous and cheap source of nutrition cannot be over-emphasized, hence the necessity to evaluate its dietary importance. Another cheap source of feedstuff for ruminant animals in Nigeria is cassava peels. Cassava is a woody shrub native to South America and West Africa with Nigeria being the world's largest producer. It is extensively cultivated as an annual crop in tropical and sub-tropical region for its edible starchy tuberous root. Cassava peel regarded as 'waste' is readily available from the local processing of cassava tuber for *garri* (a popular staple food in West Africa) and in the production of industrial starch.

Apart from the tuber peels, browse leaves is also a popular source of diet for ruminant animals, and two common browse leaves that are readily available in all seasons are Hog plum (*Spondias mombin*) and Monkey pod (*Albizia saman*). *Spondias mombin* is a tree, a specie of the flowering plant in the family Anacardiaceae. It is native to the tropical Americas including the West Indies. The tree is readily available in parts of Africa, India, and Indonesia. In Nigeria its fruit is called "Iyeye" (Yoruba), "Ngulungwu" (Ibo), and "Isada"

(Hausa), while its common name is Hog plum. *Albizia saman* is a fast growing tree with very large size. It is used commonly as pasture, shade or ornamental tree, etc. Common names include saman, monkey pod, tamarind, algarrabo and guango.

Browse plants have high potentials as important feed resources for ruminants during the long period of the dry season and are quite palatable (Ayo-Enwerem, 2008). They are less susceptible to climatic fluctuation. Since they are trees or perennial shrubs they remain green all year round thus constituting a ready source of feed during the off-season (Oji *et al.*, 2007). Of all the 2000 trees and shrubs listed as being suitable for livestock in Africa, it has been suggested that only 80 are of real fodder value while 5 may be recorded as good (Brewbaker, 1986). This probably underscores the lack of information on the value of so many of these plants and the need to scientifically evaluate their nutritive importance.

The relevance of evaluating the nutritional value of some indigenous shrubs, trees and browse plants is evident as their foliage can make important contribution to the protein and energy consumption of ruminant animals. Browse plants and crop residues are commonly used supplements given to livestock particularly during the dry season when pasture is dried and lignified. The purpose of this study therefore is to determine if these supplements possess adequate nutrients to meet the ruminant requirements for growth and maintenance and to compare and contrast the differences that occur in the nutritional content of browse plants and tuber peels. The outcome of this study would also provide information on the possibility of using these browse leaves and tuber peels as animal feeds.

## MATERIAL AND METHODS

### Sample Collection and Preparation.

Fresh leaves of *Spondias mombin* and *Albizia saman* were collected from the University of Ibadan, Ibadan, Nigeria. Fresh yam and cassava peels were obtained from tubers purchased at Bodija market, Ibadan, Nigeria. Authentication of the plants was carried out at the Botany Department, University of Ibadan, Ibadan, Nigeria. The samples were collected and transferred to the laboratory in polythene bags to prevent moisture loss. The tuber peels were cleaned to remove dirt and clinging soil particles, washed with distilled water, placed in the

oven at 90°C for 12 hours for drying, while the browse leaves were sun-dried. The dried samples were then blended and stored in air tight containers before analysis.

### Proximate Composition

Proximate composition (moisture, ash, ether extract, crude fibre, and carbohydrate by difference) was determined by the standard official methods (AOAC, 1990). The microkjeldahl method was used for the determination of the crude protein as a function of nitrogen (Pearson *et al.*, 1981). The proximate analyses were carried out in triplicates.

### Nitrogen Free Extracts (NFE) Determination.

The nitrogen free extract component was determined by difference:

$$\%NFE = 100 (\text{crude protein} + \text{crude fibre} + \text{ether extract} + \text{ash})$$

### Determination of the Energy Value

The energy value of the samples was estimated in Kilojoules by multiplying the protein, fat (ether extract) and NFE percentages by the factors 16.7, 37.7, and 16.7, respectively (Eknayake, *et al.*, 1999).

### Mineral Analysis

The mineral analysis was carried out as follows: 1.0 g of each sample was placed in a crucible and heated gently in a fume cupboard until the charred mass had ceased to emit smoke and it was transferred to muffle furnace at 650 °C for about 5 hours. The ash produced was cooled after which 0.1 M HCl solution was added to the ash, filtered

(Whatmann No. 43 filter paper) and the concentrated solution used in the minerals determination. An aliquot of the solution was used for the determination of Ca, Mg, K, Fe and Zn with the aid of an Atomic Absorption Spectrophotometer (Bulk scientific- 210 VGP model). The mineral contents of the samples were quantified against standard solutions of known concentrations which were analysed concurrently.

### Statistical Analysis

Data were subjected to Analysis of Variance (ANOVA) using Proc GLM of statistical analytical system (SAS). Means were separated using Duncan Multiple range test of 0.005 level of significance (SAS Institute Inc., 2000; Snedcor and Cochran, 1987).

## RESULTS AND DISCUSSION

### Chemical Composition

The results obtained for the moisture content of the samples (Table 1) showed that there was significant difference ( $p = 0.05$ ) in the moisture content of all the four samples. The yam peels had the highest moisture content of 72.07%, while *Albizia saman* leaves had the lowest moisture content of 61.95%. The higher moisture content of the tuber peels when compared to the browse leaves is probably due to the preliminary treatment done to the leaves, since the leaves had lost substantial part of its moisture during the drying stage. The high moisture content of the peels indicates that they must be dried for proper storage as moisture content >15 % tends to favour microbial growth (Hassan *et al.*, 2005).

**Table 1:** Proximate Composition of the Browse Leaves and Tuber Peels (on Dry Weight Basis).

Samples	Moisture (%)	CP* (%)	EE (%)	CF (%)	Ash (%)	NFE (%)	Energy (KJ Kg <sup>-1</sup> )
<i>Albizia saman</i>	61.95 ± 0.56 <sup>a</sup>	23.42 ± 0.31 <sup>d</sup>	2.80 ± 0.08 <sup>a</sup>	28.73 ± 0.19 <sup>d</sup>	5.69 ± 0.01 <sup>c</sup>	39.37 ± 0.52 <sup>a</sup>	1154.15 ± 0.13 <sup>a</sup>
<i>Spondias mombin</i>	63.60 ± 0.42 <sup>b</sup>	15.98 ± 0.31 <sup>c</sup>	2.94 ± 0.06 <sup>b</sup>	21.31 ± 0.04 <sup>c</sup>	7.83 ± 0.06 <sup>d</sup>	51.95 ± 0.15 <sup>b</sup>	1245.27 ± 0.19 <sup>b</sup>
Cassava peel	66.55 ± 0.41 <sup>c</sup>	3.72 ± 0.31 <sup>a</sup>	negligible	12.65 ± 0.01 <sup>b</sup>	4.67 ± 0.01 <sup>b</sup>	78.97 ± 0.32 <sup>c</sup>	1380.92 ± 0.13 <sup>c</sup>
Yam peel	72.07± 0.35 <sup>d</sup>	7.66± 0.31 <sup>b</sup>	negligible	6.41 ± 0.04 <sup>a</sup>	4.26± 0.01 <sup>a</sup>	81.67 ± 0.37 <sup>d</sup>	1491.81 ± 0.11 <sup>d</sup>

CP- crude protein; EE- ether extracts; CF- crude fibre; NFE- nitrogen free extract.

CP\* crude protein was obtained by multiplying %N with 6.25.

Results are means of triplicate determinations ± standard error. Values in the same column with the same superscript are not significantly different ( $P > 0.05$ ).

Protein is one of the most important nutrients needed by ruminants. The proteins are sources of amino acids that are essential for maintenance and growth. Proteins are the structural components of all tissues, blood, enzymes, hormones and immunoglobulins (Le Bot *et al.*, 1998). Therefore deficiency of protein in the diet of ruminants could lead to depressed growth. From Table 1, the protein content of the browse leaves (23.42% and 15.98% for *Albizia saman* and *Spondias mombin* respectively) was much higher than that obtained for the peels (3.72% and 7.66% for cassava and yam respectively) with significant difference among all the four samples. Feeds containing less than 1.3 % N (8 % crude protein) are considered deficient as they cannot provide the minimum ammonia levels required by ruminants (Anonymous, 1980; 1984).

Compared with other feeds reported in literature (Letterme *et al.*, 1996; Glew *et al.*, 2005), the crude protein levels in the *Albizia saman* and *Spondias mombin* are adequate for the maintenance and growth of ruminants, while that in the cassava and yam peel are low or inadequate. The protein content of 15.98% obtained for *Spondias mombin* in this study is higher than the 11.04% reported by Igwe *et al.* (2010). The differences could be due to seasonal variation, plant maturity, and

environmental factors such as soil quality, etc. The 23.42% protein content of *Albizia saman* is lower than that reported for other browse plants such as *Sesbania pachycarpa* (36.20%) and *Crataeva religiosa* (24.5%), but higher than the 18.60% for *Brassica oleracea* (Glew *et al.*, 2005).

The ether extract for the cassava and yam peels was negligible, while that of *Albizia saman* and *Spondias mombin* was significantly different ( $P = 0.05$ ) (2.80% and 2.93%, respectively). The browse leaves also have higher crude fibre values than the peels. The crude fibre values were 28.73% (*Albizia saman*); 21.31% (*Spondias mombin*); 12.65% (cassava peel); and 6.41% (yam peels). The ash content of the browse leaves was also higher than that of the tuber peels. The higher ash content of the browse leaves could be an indication that they will have higher mineral content than the tuber peels. However, the peels had higher nitrogen free extracts (NFE) and higher energy values than the browse leaves. The NFE of 78.97% obtained for cassava peels in this study differed from the 68.60% reported for the NFE of cassava peels by Devendra (1997).

The differences could be due to variability in geographical location and level of maturity of the plant.

**Table 2:** Mineral Content of Browse Leaves and Tuber Peels (mg/100g) on Dry Weight Basis

Samples	Ca	Mg	K	Fe	Zn
<i>Albizia saman</i>	780.00 ± 6.00 <sup>b</sup>	185.20 ± 0.80 <sup>c</sup>	1454.00±5.00 <sup>c</sup>	23.95±0.05 <sup>c</sup>	1.51 ± 0.01 <sup>a</sup>
<i>Spondias mombin</i>	1798.00 ±8.00 <sup>d</sup>	238.80 ± 0.90 <sup>d</sup>	1200.00±5.00 <sup>b</sup>	12.80±0.20 <sup>b</sup>	2.75 ± 0.05 <sup>d</sup>
Cassava peel	712.00 ± 3.00 <sup>c</sup>	21.55 ± 0.48 <sup>a</sup>	896.00 ±3.00 <sup>a</sup>	12.30±0.60 <sup>b</sup>	1.75 ± 0.01 <sup>b</sup>
Yam peel	63.00 ± 5.00 <sup>a</sup>	74.90 ± 0.70 <sup>b</sup>	1548.00±1.00 <sup>d</sup>	9.00± 0.50 <sup>a</sup>	2.12 ± 0.01 <sup>c</sup>
*NR	20 - 82	12 - 18	50 - 80	50 - 100	20 - 33

\*NR Nutrient requirements for ruminants animals (Source: NRC, 1984)

Results are means of triplicate determinations ± standard error. Values in the same column with the same superscript are not significantly different ( $P < 0.05$ ).

### Mineral Content

The mineral content of the browse leaves and tuber peels are presented in Table 2. Calcium is required for bone and teeth development, muscle contraction, conduction of nerve impulses, activation of enzymes, and alteration of cell permeability, blood clot formation and synthesis

of milk (FAO, 2011). The calcium content of the *Albizia saman*, *Spondias mombin* and cassava peel was 780.00, 1798.00 and 712.00 mg/100g dry weight, respectively. Both the tuber peels and browse leaves contain adequate calcium content which is between 20-82 mg/100g (NRC, 1984). The calcium requirement in browse leaves for grazing

animals is influenced by animal type, age, weight, etc (McDowell, 1985). Reuter and Robinson (1997) suggested that calcium requirement for maintenance of growing and lactating cattle and sheep is between 120 to 260 mg/100 g, although other researchers recommended calcium concentration between 200 to 600 mg/100g (Khan *et al.*, 2006; Thacher *et al.*, 1999; Anonymous, 1985, 1984, 1980).

Magnesium is an activator of many enzymes in the cells, and also plays a role in neuromuscular transmission (FAO, 2011). The browse leaves had higher magnesium content of 185.20 and 238.80 mg/100g for *Albizia saman* and *Spondias mombin* respectively than the tuber peels which had 21.55 and 74.90 mg/100g for cassava and yam peels, respectively. The browse leaves and tuber peels contained adequate Mg concentration for ruminants since the Mg requirements for ruminants range between 12 and 18 mg/100g (NRC, 1984). Under normal conditions the browse leaves will be able to meet the magnesium requirements of most ruminants since Mg concentrations in browse leaves for most ruminants are reported to be between 40 and 100 mg/100g (Leterme *et al.*, 2006; Leterme & Munoz, 2002). Magnesium deficiency leads to hypomagnesaemia tetany or grass tetany is characterised by anorexia, increased excitability, intermittent convulsions (tetany), frothing at the mouth, profuse salivation, falling on its side with its legs alternately rigidly extended and relaxed (FAO, 2011). In places where grass tetany is prevalent, Mg concentrations of up to 250 mg/100g are required (Anonymous, 1985; Ortiz-Monasterio *et al.*, 2007).

The potassium content of all the samples was high with yam peel having the highest mineral content of 1548.00 mg/100g and cassava peel having the lowest of 896.00 mg/100g. Since the potassium requirements for ruminants is within 50 - 80 mg/100g (NRC, 1984), both the peels and leaves are adequate sources of potassium. Potassium deficiency in ruminants leads to muscular weakness, poor intestinal tone, decreased feed intake, reduced weight gain, and/or decreased milk production.

Iron is an essential component of haemoglobin and is involved in transport of oxygen to cells. Iron deficiency rarely occurs in adult ruminants except under conditions of parasitic infestations (FAO,

2011). All the samples contain sufficient iron concentration needed by the ruminants. *Albizia saman* with a concentration of 23.95 mg/100g had the highest concentration while yam peels had the lowest concentration of 9.00 mg/100g. There was no significant difference ( $P = 0.05$ ) in the iron concentration of *Spondias mombin* and cassava peel. Ruminant forage should contain at least 5 mg/100 g of iron (Khan *et al.*, 2006; McDowell, 1985). The concentration of zinc in the browse leaves was 1.51 mg/100g (*Albizia saman*) and 2.75 mg/100g in *Spondias mombin*. Cassava and yam peel's Zn concentrations was 1.76 and 2.12 mg/100g respectively. However, 3 mg/100g of zinc is a critical dietary level, while 1.2 to 2.0 mg/100g is adequate for growing ruminants (Dardenne, 2002; Sanchez-Castillo *et al.*, 1998).

A comparison of the results obtained for the browse leaves with that obtained for other edible leaves such as Nacedoro, Elephant ear, Cecego, godilo, Cabbage leaf, etc., reported in the literature (Letterme *et al.*, 1996; Glew *et al.*, 2005) showed that *Spondias mombin* had the highest calcium concentration among all the leaves, while *Albizia saman* had the highest potassium concentration. Also, among the tubers of Arracacha, wild taro, Arrow root, Oca, Potato, etc reported in the literature (Letterme *et al.*, 1996; Glew *et al.*, 2005), cassava peels has the highest potassium mineral concentration, while yam had the highest Mg concentrations. Comparing the result obtained by other researchers (Monti *et al.*, 2008; Ozcan, 2004; Turan *et al.*, 2003; Cook *et al.*, 2000; Sacherz-Castillo *et al.*, 1998; Glew *et al.*, 1997; de Leeuw and Chara, 1985) on leaves used as spice, industrial products, or consumed by man and livestock, also showed that the mineral content of *Spondias mombin* and *Albizia saman* compared favourably with those reported in the literature. This shows the enormous potentials of the browse leaves under study as animal feed.

## CONCLUSION

This study has shown that yam and cassava peels are good sources of carbohydrate and are thus a very good source of energy for ruminants. They however do not contain adequate amounts of protein and vital minerals required for the growth and maintenance of the ruminants. The browse leaves have higher protein content than the tuber peel and are capable of meeting the protein requirements of ruminants. They also contain

adequate amounts of minerals for ruminants. They however do not provide as much energy as the tuber peels.

Thus a combination of browse plants and tuber peels will serve to complement each other in completely meeting the nutritional needs of ruminants. The browse leaves and tuber peels can be combined by mixing the dried tuber peels and browse leaves at different ratios, depending on the nutrient required. Such combinations will go a long way in solving the problem of inadequate nutrition for ruminants particularly during the dry season when grasses are dried and lignified. This study also reveals that fortification of either yam or cassava peel with browse would meet the daily energy and mineral requirements for ruminants.

## REFERENCES

- Anonymous 1980. *The Nutrients Requirements of Ruminant Livestock*. 4th edition CAB International, Wallingford.
- Anonymous 1984. *Nutrient Requirements of Domestic Animals*. No. 4: *Nutrient Requirements of Beef Cattle*. 6th revised ed. (National Academy of Sciences, National Research Council, Washington DC.).
- Anonymous 1985. *Nutrient requirements of sheep*. 6th ed. National Research Council, National Academy Press, Washington, D.C.
- AOAC 1990. *Official Methods of Analysis (15<sup>th</sup> ed.)*. Washington DC. Association of Official Analytical Chemists.
- Ayo-Enwerem M.C., Oji U.I., Etela, I. and Ahaotu., E.O. 2008. *Nutrient composition and preference of selected multi-purpose trees and shrubs fed to West African Dwarf goats*. Proceedings of 13<sup>th</sup> annual conference of Animal Science Association of Nigeria. Ahmadu Bello University, Nigeria. Sept 15-19<sup>th</sup> 2008, 581-585.
- Babayemi O.J. and Bamikole, M.A. 2008. Nutritive value of *Tephrosia candida* seed in West African goats. *Journal of Central European Agriculture* 7 (4): 731-738.
- Brewbaker J.L. 1986. *Nitrogen fixing trees for fodder browse in Africa*. In: Alley farming in the humid and sub-humid tropics. Kang, B.T. and Reynolds, L. (eds). IDRC-271. Ottawa, Canada, 55-70.
- Cook J.A., VanderJagt D.J., Pastuszyn A., Mounkaila G., Glew R.S., Millson M., Glew R.H., 2000. Nutrient and chemical composition of 13 wild plant foods of Niger. *Journal of Food Composition and Analysis* 13, 8392.
- Dardenne M. 2002. Zinc and immune function. *European Journal of Clinical Nutrition* 56 (Suppl. 3), S20S23.
- de Leeuw P. and Chara P. 1985. *Species preferences in browse of sheep and goats in mixed Maasai flocks in eastern Kajiado, Kenya* Paper presented to the fourth CRSP (Collaborative Resource Support Programme) workshop on small ruminants, Kebete, Kenya, 5-6 March 1984.
- Devendra C. 1977. *Cassava as a feed resource for ruminants*. In Nestle B and Graham M(eds), *Cassava as animal feed*. IDRC, Canada. 107-119.
- Eka O.A. 1998. *Roots and tuber crops*. In: Nutritional quality of plant foods. Osagie, A. and Eka, O.A. (Editors). Postharvest research unit publishing. University of Benin, 1-31.
- Eknayake S., Jansz E.R., and Nair B.M. 1999. Proximate composition, mineral and amino acid content of mature *Canavalia gladiata* seeds. *Food Chemistry* 66, 115-119.
- FAO (Food and Agriculture Organization of the United Nations). 1986. *FAO production yearbook*. Vol. 39, FAO Statistics Series 70. FAO, Rome, Italy.
- FAO 2011. *Rearing young ruminants on milk replacers and starter feeds*. FAO Animal Production and Health. Manual No. 13. Rome.
- Gartner R. J. W., McLean R. W., Little D. A., and Winks L. 1980. Minerals limiting production of ruminants grazing tropical pastures. *Tropical Grasslands* 14, 266 - 272.
- Glew R.S., VanderJagt D.J., Bosse R., Huang Y.-S., Chuang L.-T., and Glew R.H. 2005. The nutrient content of three edible plants of the Republic of Niger, *Journal of Food Composition and Analysis* 18, 1527.
- Glew R.H., VanderJagt D.J., Lockett C., Grivetti L.E., Smith G.C., Pastuszyn A., Millson M. 1997. Amino acid, fatty acid, and mineral composition of 24 indigenous plants of Burkina Faso. *Journal of Food Composition and Analysis* 10, 205217.

- Hassan L.G., Umar K.J., Adeyemi J.O. and Mohammed A.S. 2005. Proximate composition and physiochemical properties of seed and oil of *Cassia siamea*. *Bull. Sci. assoc. Nig*, 26, 373-380.
- Igwe C.U., Onyeze G.O., Onwurili A., Osuagwu V.A and Ojako. C.G. 2010. Evaluation of the chemical composition of the leaf of *Spondias mombin* Linn. from Nigeria. *Australian Journal of Basic and Applied Sciences* 4(5), 706-710.
- Kassam A. and Andrews D. 1975. Effects of sowing date on growth, development and yield of photosensitive sorghum at Samaru, northern Nigeria *Experimental Agriculture* 11(2): 227-240.
- Khan Z.I., Hussain A., Ashraf M. and McDowell L.R. 2006. Mineral Status of Soil and Forages in South Western Punjab, Pakistan. *Asian-Australian Journal of Animal Sciences* 19(8): 1139-1147.
- King J. M. 1983. *Livestock water needs in pastoral Africa in relation to climate and forage*. ILCA Research Report 7. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp 95.
- Lambourne L. J., Dicko M. S., Semenye P., and Butterworth M. 1983. Animal nutrition. In. *Pastoral systems research in sub-Saharan Africa*. Proceedings of the IDRC/ILCA workshop held at ILCA, Addis Ababa, Ethiopia, 21-24 March 1983. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 183-208.
- Le Bot J., Adamowicz S., and Robin P. 1998. Modeling plant nutrition of horticultural crops: a review. *Scientia Horticulturae*, 74, 4782.
- Leterme P, Buldgen A., Estrada F, Londono A. M. 2006. Mineral content of tropical fruits and unconventional foods of the Andes and the rain forest of Colombia. *Food Chemistry* 95, 644-652.
- Leterme P., & Munoz L. C. 2002. Factors influencing pulse consumption in Latin America. *British Journal of Nutrition*, 88 (Suppl. 3), S251S254.
- McDowell L.R. 1985. In: *Nutrition of Grazing Ruminants in Warm Climates*. Academic Press New York, pp-443.
- Monti A., Di Virgilio N., Venturi G. 2008. Mineral composition and ash content of six major energy crops, *Biomass and Energy*, 32, 216-223.
- NRC 1984. National Research Council, Nutrient requirement of domestic animals, Nutrients requirements of beef cattle, 6<sup>th</sup> rev ed., National Academic of Science, Washington D.C.
- Oji U.I., Ayo-Enwerem M.C., Isilebo J.O and Etela, I. 2007. *Nutritional potentials of some trees and shrubs of the humid forest as feed*. Proceedings of 32<sup>nd</sup> of the Nigerian Society of Animal Production. Calabar. March 18<sup>th</sup> -21<sup>st</sup> 2007.
- Ortiz-Monasterio J.I., Palacios-Rojas N., Meng E., Pixley K., Trethowan R., Pena R.J. 2007. Enhancing the mineral and vitamin content of wheat and maize through plant breeding, *Journal of Cereal Science*, 46, 293-307.
- Ozcan M. 2004. Mineral contents of some plants used as condiments in Turkey. *Food Chemistry* 84, 437-440.
- Pearson D., Egan H., Kirk R.S. & Sawyer A. 1981. *Pearson's Chemical Analysis of foods*, 8<sup>th</sup> eds., Churchill Livingstone, Edinburgh, 22-78.
- Reuter D.J. and Robinson J.B. 1997. *Plant Analysis. An Interpretation Manual*. 2<sup>nd</sup> ed. CSIRO Publishing, Melbourne.
- Sanchez-Castillo C., Dewey M., Aguirre A., Lara J., Vaca R., Leonde-la-Barra P. 1998. The mineral content of Mexican fruits and vegetables. *Journal of Food Composition and Analysis*, 11, 340-356.
- SAS Institute Inc. 2000. SAS software release 9.1. SAS Institute Inc., Cary, North Carolina, USA.
- Snedcor G.W. and Cochran W.G. 1987. *Statistical methods* (17<sup>th</sup> ed.). The Iowa state University Press, Ames., IA.
- Thacher T., Glew R.H., Isichei C., Lawson J.O., Scariano J.K., Hollis B.W., VanderJagt D.J. 1999. Rickets in Nigerian children: response to calcium therapy. *Journal of Tropical Pediatrics*, 45, 202-207.
- Turan M., Kordali S., Zengin H., Dursun A., & Sezen Y. 2003. Macro- and micro-mineral content of some wild edible leaves consumed in Eastern Anatolia. *Soil and Plant Science*, 53, 129-137.

Underwood E.J. 1981. *The Mineral Nutrition of Livestock*. Commonwealth Agricultural Bureaux, Slough, England, p. 10.

World Bank 2006. *Repositioning Nutrition as Central*

*to Development: A Strategy for Large-Scale Action*. The International Bank for Reconstruction and Development, The World Bank, Washington, DC.