Nigerian J. Anim. Sci. 2018, 20 (1): 115-122

Nutrient and Anti-Nurient Components of Some Tropical Tree Seeds

Akinfemi, A[1], Ososanya, T. O[2] and Ahoatu, E.O[3]

[1]Yaba College of Technology, Department of Agricultural Technology, Epe Campus, Lagos
[2] *Department of Animal Science, University of Ibadan, Ibadan, Nigeria*
[3]*Department of Animal Production Technology. Imo State Polytechnic, Umuagwo.*

Corresponding Author: akinfemiabayomi@gmail.com

Target audience: Livestock farmers, Animal scientists, Animal nutritionists.

Abstract

Experiments were conducted to evaluate the potential feeding value of seven different tropical seeds: Delonix regia, Vitellaria paradoxa, Tectonia grandis, Cyperus alternifolius, Parkia biglobosa, Khya ivorensis and Vetex dunianna. The proximate composition, crude fiber fractions, mineral composition and the in vitro gas production of the selected tropical seeds were determined. The results obtained showed that crude protein (%) ranged from 5.36 (Cyperus alternifolius) to 15.05 (Parkia buglobosa), CF (%) ranged from 11.75 (Vitellaria paradoxa) to 43.58 (Tectonia grandis). Delonix regia recorded the highest value in NDF and Hemicellulose contents. All the investigated tropical seeds were generally low in mineral composition. However, Khya Ivorensis was rich in Ca, Mg, Na and Zn. There were wide variations observed in the in vitro gas production characteristics. The fastest rate of gas production was obtained in D. regia while Cyperus alternifolius had the least. Fermentation of the insoluble but degradable fractions (b, ml) ranged from 25.50 (T. grandis) to 40.35 (D. regia). The estimated ME observed in D. regia, K. ivorensis and Vetex dunianna were not significant ($P<0.05$) but differed significantly from D. regia. Vitellaria paradoxa recorded the highest levels of oxalate and Tannin. From the results obtained in this study, D. regia is a promising source of protein and also contains appreciable contents of mineral. However, mineral fortification could be applied in ruminant nutrition to cater for deficiency.

Description of Problem

Several tree seeds species abound in north central Nigeria, which could be used as potential feeds to livestock during period of scarcity. In North central Nigeria, there is a gap between animal requirements and the animal's feeds, especially during the dry season. There is therefore an urgent need to bridge the gap using cheap and available feed resources such as tropical tree seeds.

Period of dry season is always a stressful circumstance for livestock, as the environment is characterized by insufficient feed, occasioned by scarce forage and fibrous standing hays (1). The negative effect of the period is obvious in the lost weight, reduced milk production and high mortality of the animals (1). This is more evident in livestock produced in the dry part of the country. In most cases, the cattle herdsmen often move with large entourage of cattle, sheep and goat to southern part of Nigeria, for lush forages. Such journey is often associated with conflict between Fulani cattle herdsmen and crop farmers. This perennial conflict necessitate the urgent need to provide

alternative feed resources that will be good enough to sustain livestock during the periods of scarcity, especially one that will supplement fibrous feed materials. In view of this, this study was conducted to examine the nutrient and anti-nutrient contents of few selected tropical tree seeds and its use as ruminant feed.

This study shows the nutrient profile of seven tropical seeds with a view of accessing their suitability as feeds for ruminants and also to appropriately recommend the use of any of these tropical seeds.

Materials and Methods

Sample collection

Samples of *Delonix regia, Vitellaria paradoxa, Tectonia grandis, Cyperus alternifolius, Parkia biglobosa, Khya ivorensis* and *Vetex dunianna* were collected from the Teaching and Research Farm, Nasarawa State University, Keffi Shabu-Lafia Campus, Lafia, Nasarawa, Nigeria. The seeds were collected in late raining season (October) when they have attained full maturity. The materials were milled and oven-treated at 65^0C until a constant weight was obtained for any dry matter determination.

Chemical Analysis

Dry matter (DM) was determined by oven drying the milled samples to a constant weight at 105^0C for 8 hours. Crude protein was determined as Kjeadhal nitrogen x 6.25. Ether extracts and ash were determined according to (2) method. Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) were determined using the method described by (3). Hemicellulose was calculated as the difference between NDF and ADF while cellulose is the difference between ADF and ADL. Anti-nutritional properties like saponin were determined by gravimetric method, oxalate by permanganate titrimetric method, and tannins by Folin-Dewis spectophotometric method and cyanogens (4).

In vitro gas production

Rumen fluid was obtained from, three West African Dwarf female goats through suction tube via the oesophagus before morning feed (5). The animals were fed with 40% concentrate feed (40% corn, 10% wheat offal, 10% palm kernel cake 20% groundnut cake, 5% soybean meal, 10% brewers grain, 1% common salt, 3.75% oyster shell and 0.25% fishmeal) and 60% Guinea grass. Incubation was carried out according to (6) in 120ml calibrated syringes in three batches at 39^0C. To 200mg sample in the syringe was added 30ml inoculum that contained cheese cloth strained rumen liquor and buffer (9.8g $NaHCO_3$ + 2.77g Na_2HPO_4 + 0.57g KCL + 0.47g NaCL + 0.12g $MgSO_4$. $7H_20$ + 0.16g $CaCI_2$. $2H_20$ in a ratio (1:4 v/v) under continuous flushing with CO_2. It was dispensed using another 50ml plastic calibrated syringe. The syringe was tapped and pushed upward by the piston in order to completely eliminate air in the inoculums. The silicon tube in the syringe was then tightened by a metal clip so as to prevent an escape of gas. Incubation was carried out at 39± 1^0C and the volume of gas production was measure at 6, 12, 18, 24 and 30h. The post incubation parameters such as metabolisable energy, organic matter digestibility and short chain fatty acids were estimated at 24h post gas collection according to (6). The average of the volume of gas produced from the blanks was deducted from the volume of gas produced per sample.

The volume of gas produced at intervals was plotted against the incubation time and from the graph, the gas production characteristics were estimated using the equation $y = a + b(1 - e^{-ct})$ as described by (7), where y = volume of gas produced at time 't', a = intercept (gas produced from the soluble fraction), b = gas production from the insoluble fraction, c = gas production rate constant for the insoluble fraction (b), t = incubation time. Metabolisable energy (ME) was calculated as ME = 2.20 + 0.136 GV + 0.057Cp + 0.0029CF (6). Organic matter digestibility (OMD %) was assessed as OMD = 14.88 + 0.889GV + 0.45CP + 0.651XA (6). Short chain fatty acids (SCFA) as 0.0239 GV – 0.0601 (8) was also obtained, where GV, CP, CF and XA are total gas volume, crude protein, crude fibre and ash, respectively.

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) and means separation was by Duncan multiple range tests using Statistical Analysis System (SAS) 1999 package.

Result and Discussion

Proximate composition and crude fiber fractions

The proximate composition and crude fiber fractions of selected tropical tree seeds are shown in Table 1. The least (5.36) and the highest (15.05%) CP was in *Cyperus alternifolius* and *Parkia biglobosa* respectively. Crude fiber was generally low (11.75 – 43.58%) among the tropical seeds. The CP content obtained in *Delonix regia* (11.62%) is comparable to the CP obtained for *Pennisetum purpureum* (11.4%) and higher than the value obtained for *Termilania catappa* (8.9%) (1).

Similarities in nutrients, especially CP content may be used as the basis for selecting tropical seeds more so; *Vitellaria paradoxa* recorded the highest contents of ether extract (15.58%) and carbohydrate fractions (61.68%). The lignin content was relatively low among the tropical seeds under investigation (1.77 to 2.85%). The variation in the CP contents may be attributed to varietal differences, period and stage of harvesting and the physiological plant parts and fraction used for the study (8).

Mineral Composition

Presented in Table 2 is the result of mineral composition of selected tropical seeds. The calcium constituent ranged between 0.113 in *Delonix regia* to 0.183% in *Tectonia grandis*. Phosphorus content ranged from 3.24% in *Vetex dunianna* to 5,53% *Vitallaria paradoxa*. Magnesium content ranged from 0.253% (*Vitallaria paradoxa* to 0.40% in *Khya ivorensis* and *Cyperus alternifolius*. Copper was lowest in *Vetex dunianna* (0.427%) and highest in *Delonix regia* (0.527%).

Table 2, shows the secondary metabolites in the selected tree seeds. The oxalate content of the tree seeds ranges from 133.76mg/100g in *Khya ivorensis* to 2213.00mg/100g in *Vitellaria paradoxa*. These values are comparably higher than the value attained elsewhere (9) for under-utilized crop seeds in Nigeria and also, oxalate forms an insoluble complex and therefore interferes with calcium metabolism. In the present study, the high concentration of oxalate explains the low calcium content in the selected tree seeds. Report (10) showed that the risk for calcium deficiency due to consumption of oxalate containing plant is very minor because human being are able to efficiently

use very low amount of calcium in the food. The value of phytate (mg/100g) ranged from 3.35 (*Vitex dunianna*) to 41.84 (*Khya ivorensis*). The values obtained in this study are below the values obtained for some lesser known crop seeds (11). Phytic acid is known to form complexes with some minerals like iron, zinc, calcium, and magnesium therefore preventing their release to the animals. Apart from this, phytate also inhibit the protease and amylases of the intestinal tract (12). Study by (13) indicated that the minimum amount of phytic acid to cause negative effect on iron and zinc absorption were 10 – 50mg per seed. In view of this, the phytate content of the tree seeds in this study will not in any way prevent the utilization of iron and zinc in the diet.

The value of tannin (mg/100g DM) obtained in the study ranged from 59.24 (*Delonix regia*) to 414.68 (*Vitellaria paradoxa*). The value obtained in the present study is lower than 760mg/100g reported for mucuna (14) and higher than 7.50mg/100g and 18.60mg/100g reported for *Jathropha cucas*, *Trichosanthe cucumerina* and *Citrillues vulgaris* respectively (11).

Gas Production Characteristics and Estimated Gas Production Parameters.

The gas volume (Gv 24, ml) ranged from 28 (*Tectonnia grandis*) to 44.90 (*Vetex dunianna*). Similar observations were recorded for metaboliable Energy (ME) and the mean values were significant ($P < 0.05$). The mean values of fermentation of the insoluble but degradable fraction (b, ml) differed significantly ($P < 0.05$) with the lowest value recorded for *Tectonia grandis* while the highest value was obtained for *Vetex dunianna*. The estimated organic matter digestibility (%) and short chain fatty acid (μ*mol*) also differed significantly ($P < 0.05$) among the different treatments. The highest gas production rate constant (c h^{-1} was obtained in *Delonix regia* (0.421) with the least value recorded in *Cyperus alternifolius*. Expectedly, gas volume (Gv24,*ml)* was high in *D. regia*, this may be due to the fact that lignin has been implicated in rations with depressed digestibility (15) due to its effect in lowering the rate of microbial colonization of such high fiber feed (16). However, the higher lignin content recorded for *K. ivorensis* and *V. duniana*, though contrary to expectation, the result of the improvement in the soluble carbohydrate fractions, leading to high rate of gas production.

The gas production rate constant (c) that was best in *D. regia* was a reflection of the lignin contents of the incubated materials and this is consistent with previous studies (17, 18). Earlier studies, (19) reported that the rate of degradation is an important parameter in the assessment of fermentation of crop residues in the rumen. The fast rate (c) obtained in *D. regia, Vitellaria paradoxa* and *Parkia biglobosa*, may be possibly influenced by the soluble carbohydrate fractions readily available to the microbial population (20). Slow rate of gas production obtained in *V. dunianna* suggests that those seeds were less readily available to the microbes in the rumen. The highest fermentation of the insoluble but degradable fraction (b,ml) which were observed in *D. regia* and *V. dunianna,* are possibly influenced by the carbohydrate fractions readily available to microbial population (20). High organic matter digestibility (OMD) recorded in *D. regia*, *Vetex dunianna* and *Khya ivorensis* was because major carbohydrate of the

tropical tree seeds is starch, which is fermented by amylolytic bacteria and protozoa (21). This implies that the microbe in the rumen and animal have high nutrient uptake. The high crude fiber content of *T. grandis* probably resulted in lower OMD when compared with others since high NDF and ADL content in feedstuffs result in lower fiber degradation (22).

The estimated Metabolizable energy (ME) for the tropical seeds is comparable to those reported in literature (23). It was reported (16)**,** that a strong correlation exists between ME values measured *in vivo* and predicted from 24h in vitro gas production, and chemical composition of feed. The *in vitro* gas production method has also been widely used to evaluate the energy value of several classes of feeds (24, 25 and 26)**.** Others (27), suggested that *in vitro* gas production technique should be considered for estimating ME in tropical feedstuffs because other methods requires labour, cost and time.

The ADF values recorded in the present study are comparable with the ADF range of 19 – 37% reported for cassava leaf (28). Values obtained in this study for NDF, ADF and ADL respectively for the seven different tropical seeds were above the values obtained by different researchers for tropical tree leaves (14). The fact that the varieties contained above 50% NDF shows that they have high proportion of soluble carbohydrate, which is good for rumen function (29).

Conclusion and Applications

1. The present study compares the nutrient profile of seven different tropical tree seeds for possible use in the diet of ruminant.
2. Results indicate that *D. regia* and *P. biglobossa* are better source of energy, with high levels of digestibility, therefore, they could be applied in ruminant feeds as sources of protein and energy.
3. There is need for further research to ascertain the appropriate levels of inclusion in the diet of ruminants.

TABLE 1: Proximate composition and crude fiber fraction of tropical seeds

PARAMETERS	CP	CF	EE	ASH	CHO	CELL	HCEL	NDF	ADF	ADL
Delonix regia	11.62^{a}	26.22^{bc}	4.67b^{c}	3.93^{c}	53.56^{ab}	9.61^{d}	61.75^{a}	73.35^{a}	11.59^{f}	1.98^{e}
Vitellaria Paradoxa	6.83^{b}	11.75^{d}	15.58^{a}	4.18^{c}	61.68^{a}	0.40^{c}	58.80^{c}	71.57^{b}	12.77^{c}	2.36^{d}
Tectoria grandis	6.15^{b}	43.58^{a}	2.35^{c}	3.84^{c}	44.07^{c}	9.55^{d}	60.23^{b}	71.56^{b}	11.33^{g}	1.77^{f}
Cyperus alternifolius	5.36^{b}	38.84^{ab}	6.29b^{c}	4.57^{bc}	44.94^{c}	11.11^{b}	56.91^{e}	70.45^{c}	13.55^{b}	2.44^{c}
Parkia biglobosa	15.05^{a}	24.39^{c}	9.02^{b}	7.05^{a}	44.50^{c}	8.93^{f}	57.98^{d}	69.76^{a}	11.78^{e}	2.85^{a}
Khya ivorensis	6.98^{b}	28.38^{bc}	4.19b^{c}	5.94^{ab}	54.53^{ab}	12.04^{a}	53.84^{f}	68.39^{e}	14.55^{a}	2.52^{b}
Vetex dunianna	6.72^{b}	30.30^{bc}	7.03^{bc}	4.94^{bc}	51.02^{bc}	9.39^{e}	53.74^{f}	65.99^{f}	12.24^{d}	2.85^{a}
SEM	0.86	2.27	0.96	0.27	1.53	0.86	0.02	0.006	0.02	0.04

^{a,b,c,d} means along the same row with different superscripts are significant ($p < 0.05$) CP = crude protein, CF = Crude fibre,
EE = Ether Extract, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber, ADL = Acid Detergent lignin, CHO = Carbohydrate

Table 2: Mineral composition (mg/100g) of tropical seeds

Parameter	Ca	Mg	Na	Mn	Fe	Cu	Zn	P
Delonix regia	0.113^{d}	0.547^{c}	0.043^{a}	0.487^{a}	0.460^{g}	0.527^{a}	0.560^{c}	4.43^{d}
Vitellaria Paradoxa	0.133^{c}	0.253^{f}	0.030^{a}	0.467^{b}	1.22^{d}	0.417^{d}	0.267^{f}	5.53^{a}
Tectoria grandis	10183^{a}	0.577^{b}	0.163^{a}	0.340^{e}	1.86^{b}	0.457^{b}	0.847^{b}	5.51^{b}
Cyperus alternifolius	0.133^{c}	0.487^{d}	0.400^{a}	0.377^{d}	0.777^{e}	0.380^{e}	0.473^{d}	5.48^{c}
Parkia biglobosa	0.167^{b}	0.276^{e}	0.146^{a}	0.473^{b}	1.32^{c}	0.456^{b}	0.383^{e}	3.39e
Khya ivorensis	0.176^{a}	0.946^{a}	0.40^{a}	0.393^{c}	0.533^{f}	0.440^{c}	0.947^{a}	5.52^{b}
Vetex dunianna	0.130^{c}	0.197^{g}	0.220^{a}	0.313^{f}	5.68^{a}	0.427^{d}	0.847^{b}	3.24^{f}
SEM	0.002	0.002	0.04	0.002	0.002	0.001	0.005	0.002

$^{a\text{-}f}$ means along the same row with different superscripts are significant ($p < 0.05$)

Table 3: *In vitro* Gas Production Characteristics and Estimated organic matter digestibility, metabolizable energy and short chain fatty acid

Parameter	C(h^{-1})	*b(ml)*	OMD%	ME	SCFA	Gv24 (ml)
Delonix regia	0.00042^{a}	40.35^{a}	60.40^{a}	10.43^{a}	1.074^{a}	42.45^{a}
Vitellaria Paradoxa	0.00033^{ab}	27.63b^{c}	47.13^{bc}	7.98^{b}	0.771^{bc}	29.75^{bc}
Tectoria grandis	0.00029^{ab}	25.50^{c}	45.04^{c}	7.64^{b}	0.729^{c}	28.00^{c}
Cyperus alternifolius	0.00021^{b}	32.06^{abc}	50.96^{abc}	8.90^{ab}	0.885^{abc}	34.52^{abc}
Parkia biglobosa	0.00033^{ab}	33.19^{abc}	57.63^{ab}	9.08^{ab}	0.904^{abc}	35.31^{abc}
Khya ivorensis	0.00027^{ab}	39.50^{ab}	59.22^{a}	10.40^{a}	1.06^{ab}	42.00^{ab}
Vetex dunianna	0.00025^{b}	42.81^{a}	61.04^{a}	10.91^{a}	1.13^{a}	44.90^{a}
SEM	0.03	2.21	2.04	0.42	$^{0.05}$	0.42

^{a,b,c,d} means along the same row with different superscripts are significant ($p < 0.05$) C = gas production rate constant; b = fermentation of the insoluble but

ME = metaboliable energy; SCFA = short chain fatty acid, Gv24 = gas volume @ 24hr

Table 4: Secondary metabolites (mg/100g) in tropical seeds

Parameter	Oxalate	Phytate	Tannin
Vetex dunianna	665.00^{c}	3.35^{e}	71.71^{e}
Vitellaria Paradoxa	2913.00^{a}	30.78^{c}	414.63^{a}
Tectoria grandis	176.00^{e}	30.00^{c}	367.87^{b}
Cyperus alternifolius	875.00^{b}	25.32^{d}	302.79^{c}
Parkia biglobosa	469.50^{d}	40.89^{a}	134.06^{d}
Khya ivorensis	133.76^{f}	41.84^{a}	324.22^{c}
Delonix regia	479.50^{d}	33.56^{b}	59.24^{e}
SEM	3.42	0.21	7.45

^{a,b,c,d} means along the same row with different superscripts are significant ($p < 0.05$)

References

1. Babayemi O. J. (2007). In vitro fermentation characteristics and acceptability by West African dwarf goats of some dry season forage. *African Journal of Biotechnology* 6(10): 1260 – 1265

2. AOAC, 1995. Official methods of analysis, 16th ed. Of the Association of Official Analytical Chemists.
3. Van Soest P J, Robertson J B and Lewis B A 1991 Methods for dietary fiber, neutral detergent fiber and non–starch polysaccharides in relation to annual nutrition. *Journal of Dairy Science* 74: 3583 – 3597
4. Onwuka G I. 2005. Food Analysis and Instrumentation. pp 140-143
5. Menke KH, Steingass H (1988). Estimation of the energetic feed value from chemical analysis and in vitro gas production using rumen fluid. *Animal Research and Development* 28: 7 – 55.
6. Getachew G, makkar HPS, Becker K (1999). Stoichiometric relationship between short chain fatty acid and *in vitro* gas production in presence and absence of polyethylene glycol for tannin containing browses, EAAP Satellite Symposium, Gas production: fermentation kinetics for feed evaluation and to assess microbial activity, 18-19 August, Wageningen, The Netherlands.
7. Qrskov ER, McDonald I (1979). The estimation of protein degradability in rumen from incubation measurements according to rate of passage. *Journal of Agricultural Science. Cambridge* 92: 449 – 503.
8. Oni A. O., Onwuka CFI, Arigbede OM, Oni OO, Anele UY, Yusuf KO, Oduguwu BO and Onifade OS (2010). Chemical composition and in sacco degradability of four varieties of cassava leaves grown in South Western Nigeria in the rumen of sheep. *Tropical Animal Health Production* 42: 1385 – 1393
9. Balogun A.M and Fetuga B.L (1998). Nutritional and anti-nutritional characteristics of Mucuna utilis bean seeds *Journal of Science Food and Agriculture* 46: 71 – 79
10. Liener I. E. (1989). Oxalate. In Toxic constituents of plants foodstuff. ed I. E. Liener. Academy Press, New York, U.S.A.
11. Ilelaboye N. O. A. and Pikuda O. O (2009). Determination of minerals and anti-nutritional factors of some lesser – known crop seeds. Pakistan Journal of Nutrition. 8(10): 1652 – 1656.
12. Vaintraub I, and Bulmaga (1991). Effect of phytate in the in vitro activity of digestive proteinases Journal of Agricultural Food Chemistry: 39: 859 – 861
13. Sanberg A. S. (1991). Phytate hydrolysis by phytase in cereals. Effect on *in vitro* estimate of iron availability. Journal of Food Science. 56: 1330-1333.
14. Ravindran, Y. and Ravindran G. (1988). Nutritional and anti-nutritional characteristics of Mucuna utilis beans seeds. J. Sci. Food and Agric. 46:71-79
15. Van Soest PJ (1994). Nutritional Ecology of the ruminant. Cornell University Press, Ithaca, NY, USA.
16. Silva AT and Orskov ER 1988. The effect of five different supplements on the degradation of straw in sheep given untreated barley straw. Animal Feed Science and Technology 19: 289 – 298.
17. Sandoval – Castrol CA, LIzarraga – sandies HL, Solorio – Sanches, F J. (2005). Assessment of the tree fodder preferences by cattle using chemical composition, in vitro gas production

and in situ degrability. Animal Feed Science and Technology 123 – 124, 277 – 289.

18. Bamikole MA and Babayemi OJ 2008. Chemical composition and in sacco dry matter degradability of residue and by products of palm fruit processing in the rumen of steers Animal Science Journal 79: 414 – 321.
19. Preston TR (1986). Better utilization of crop residue and by product in animal feeding: research guideline. A practical manual for research workers http://www.fao.org/DOCREP/003/x6554=/ x6565E00.HTM
20. Chumpawadee S, Chantiratikul A and Chantiratikul P 2007 Chemical composition and Nutritional evaluation of energy feeds for ruminant using in vitro gas production technique. Pakistan Journal of Nutrition 6(6): 607-612 http://www.pjbs.org/pjnonline/fin749.pdf
21. Kotarski SF, waniska RD and Thurn KK (1992). Starch hydrolysis by the ruminal microflora, Journal of Nutrition. 122: 178 – 190.
22. Van Soest, P.J., 1988. Effect of environment and quality of fiber on nutritive value of crop residues. In; proceeding of a workshop plant Breeding and Nutritive Value of Crop Residues. Held at ILCA, Addis Ababa, Ethiopia, 7-10 December 1987, pp: 71-96.
23. NRC 2001 Nutrient requirements of Dairy cattle (7th Rev. Ed.) National Research Council, National Press, Washington, DC.
24. Getachew G., Blummel M., Makkar HPS and Becker K. (1998). In vitro gas measuring techniques for assessment of nutritional quality of feeds: A review. Animal Feed Science and Technology 72: 261 – 281
25. Getachew G., Grovetto GM, Fondivila M., Krishnamoorthy U, Singh B, Spaghero M, Steingass H, Robison PH and Kailas MM (2002). Laboratory variation of 24h in vitro gas production and estimated metabolizable energy values of ruminant feeds. Animal Feed Science and Technology 102: 169 – 180.
26. Aiple KP, Steingas H, and Drochner w. (1996). Prediction of net energy content of raw materials and compound feeds for ruminants by different laboratory methods. Arch. Animal Nutrition 49: 213 – 220.
27. Krishnamoorthy U, Soller H, Steingass H and Menke KH (1995) Energy and Protein evaluation of tropical feedstuffs for whole tract and ruminal digestion by chemical analysis and rumen inoculums studies in vitro. Animal Feed Science and Technology. 52: 177 – 188.
28. Khang DN (2004) Cassava foliage as a protein source for cattle in Vietnam. Doctoral thesis. Agrarian 471. Swedish University of Agricultural science Uppsala, Sweden.
29. Oni A. O., Onwuka CFI, Oduguwa OO, Onifade O. S. and Arigbede O. M. (2008). Utilization of citrus based diets and Enterolobium cy clocapum (JACQ GRISEB) foliage by West African dwarf goats. *Livestock Science.* 117 : 184 – 191