Nutritive evaluation of some tropical under-utilized grain legume seeds for ruminant's nutrition.

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Abstract: This study was undertaken to evaluate the nutritional potential of seeds of African yam bean (*Sphenostylis stenocarpa*), Lima bean (*Phaseolus lunatus*), Bambara groundnut (*Vigna subterranean*), sword bean (*Canavalia gladiata*), jack bean (*Canavalia ensiformis*), pigeon pea (*Cajanus cajan)*, Lablab (*Lablab purpureus*) and soybean (*Glycin max*) for feeding livestock using in-vitro techniques. The crude protein of the seeds ranged from 18.8% in jack bean to 33.5% in soybean. The neutral detergent fibre (NDF) was between 16.4% in soybean and 23.2% in African yam bean. Soybean was lowest (4.5%) in acid detergent lignin (ADL) compared to other legumes investigated. Tannin content was between 2.1 g/100g in soybean and 7.2 g/100g in lima bean. The seed of soybean was least in concentrations of phytic acid, trypsin inhibitor, saponin and oxalate whereas significant ($P<0.05$) variations were observed among the under-utilized grain legume (UGL) seeds for these anti-nutrients. The metabolizable energy (ME), Organic matter digestibility (OMD) and short chain fatty acids (SCFA) of the UGL seeds differed ($P<0.05$) significantly. The ME was between 8.8 and 12.1 MJ/Kg, OMD was between 49.6 and 80.5% while the SCFA ranged from 0.7 to 1.2 mmol. Gas production characteristics revealed that methanogenesis was low in jack beans (35 ml) and highest in soybean (48.7 ml), potential gas production, b, was between 23.4 ml in lima bean and 38.5 ml in soybean. The rate of substrate fermentation was lowest in jack bean and highest soybean. It is concluded that among the UGL seeds investigated Lima bean, pigeon pea and jack bean seeds are unsuitable as feed resources for ruminant livestock. [Journal of American Science 2010;6(7):1-7]. (ISSN: 1545-1003).

Keywords: Degradation coefficients, gas fermentation, secondary metabolites, under-utilized grain legume seeds.

1. Introduction

Inadequate nutrition all year round is one of the major causes of low productivity of ruminants in sub-Sahara Africa (Osuji et al. 1995). Majority of ruminant livestock in tropical Africa are raised on natural pastures which decline rapidly in quality during the dry season (Ajayi, 2007). During the dry season, poor nutrition of animals results in irregular growth and weight loss. Supplementation of forage legumes to grass or crop residue based diets of ruminants increases the weight and productivity of the animals (Babayemi et al. 2006).

Under-utilized grain legume seeds are potential sources of supplement in ruminant livestock diet. African yam bean (AYB) (*Sphenostylis stenocarpa* Hochst ex A Rich), Lima bean (*Phaseolus lunatus*), Bambara groundnut (*Vigna subterranean*), sword bean (*Canavalia gladiata*), jack bean (*Canavalia ensiformis*), pigeon pea (*Cajanus cajan*), and lablab (*Lablab purpureus*) are under-utilized grain legumes that posses high crude protein content between 22 and 37% (Adeparusi 2001; Fasoyiro et al. 2006). These legumes are widely grown in Nigeria and in other West African countries like Ghana, Cameroon, Cote d'lvore and Togo (Klu et al. 2001).The major constraint to the utilization of these legumes is the long hour of cooking. However, the seeds could be relevant in ruminant livestock nutrition. Although, anti-nutritional factors were reported in these legumes (Borget 1992), ruminants can tolerate some anti-nutrients because of their rumen ecology.

A lot of seeds are produced from these legumes and is likely that some of the seeds possess defaunating property. The seeds with high protein contents combined with defaunating activities could result in greater microbial protein flow into the small intestine thus providing the host animal with more protein (Odeyinka 2004). This study was designed to evaluate the nutrient contents, organic matter digestibility, metabolizable energy, short chain fatty acids and degradation coefficients of Lima bean, Bambara groundnut, sword bean, African yam bean, jack bean, pigeon pea, and Lablab *in-vitro* for ruminant livestock nutrition.

2. Materials and Methods

Rumen liquor was collected from three West African dwarf goats through suction tube prior to morning feeding. The goats were fed concentrate feeds consisting of 20% maize, 20% corn bran, 25% wheat offal, 20% palm kernel cake, 10% groundnut cake, 4% oyster shell, 0.5% common salt, 0.25% fish meal and 0.25% grower premix. In addition, *Gliricidia sepium* and *Panicum maximum* forages were fed to the goats *ad libitum* for 7 days prior to rumen liquor collection. The liquor was filtered through three layers of cheese cloth, mixed and stirred with a buffered mineral solution ($NaHCO_3$ + Na_2HPO_4 + KCl + NaCl +$MgSO_4.7H_2O$ +$CaCl_2.2H_2O$ (1.4, v/v) under continuous flushing with carbondioxide.

Two hundred milligrams of ground samples of the UGL seeds were weighed into 100ml syringes with lubricated pistons. Thirty mls of the mixed buffered solution and rumen liquor was added to the samples in the syringes, stirred gently, clipped and placed in the incubator at 39^{o}C. Gas production rates were recorded at 3, 6,9,12,15,18,21 and 24 hour. At the end of 24 hour incubation, 4mls of NaOH was added to the substrate in each syringe to determine the methane production. Rates and extent of gas production were determined for each substrate from linear equation $\mathbf{Y = a + b\ (1 - e^{-ct})}$ described by Ǿrskov and McDonald (1979) where **Y** = volume of gas produced at time‘t’, **a** = intercept (gas produced from soluble fraction), **b** = Potential gas production (ml/g DM) from insoluble fraction, **c** = gas production rate constant (/h) for the insoluble fraction, **t** = incubation time. The metabolizable energy (MJ/Kg) and organic matter digestibility were estimated from the volume of gas produced after 24 hr of incubation (GP, ml/g) and the proportion of crude protein as established by Menke and Steingass (1988):

OMD = 24.91 + 0.7222 GP + 0.0815CP ME = 2.2 + 0.1357GP + 0.0057CP+ 0.0002859CP^2. Short chain fatty acids were calculated as described by Getachew et al. (1999).

Chemical Analysis

Ground samples of seeds were analyzed for nitrogen by the Micro-kjeldahl method. Crude protein was obtained by multiplying N by 6.25. Dry matter (DM), Ether extract (EE) were determined according to AOAC (1990) methods. Nitrogen free extract was obtained by calculation while neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined by method of Van Soest et al. (1991). Saponin, phytate and trypsin inhibitors were analyzed by methods of Okwu and Josiah (2006), Maga (1983) and Kakade et al. (1969) respectively while tannin and oxalates were determined by method of Beutler et al. (1980).

Statistical Analysis

Data obtained were analyzed by ANOVA and significant differences between means were compared using Duncan (Duncan 1955) multiple range test with the aid of SAS/STAT program (SAS 1998).

3. Results and Discussion

The dry matter of the UGL seeds ranged from 63.6% in sword bean to 70.3% in AYB. Crude protein (CP) ranged from 18.8% in Jack bean to 33.5% in soybean (Table 1). The ether extract (EE) was between 2.4% and 10.1% in pigeon pea/lima bean and soybean respectively. The neutral detergent fibre (NDF) ranged from 44.2% in lima bean to 50.1% in lablab. Acid detergent fibre (ADF) was between 16.4% and 23.2% in soybean and AYB respectively. Acid detergent lignin (ADL) ranged from 4.3% in lima bean to 6.8% in jack bean. The nitrogen free extract (NFE) was between 10.6% and 17.3% in lima bean respectively. The DM values obtained in this study for the UGL seeds were slightly lowered than those reported (Fasoyiro et al. 2006) for Bambara groundnut, Lima bean, AYB, pigeon pea and soybean. The CP values obtained however, correspond with values earlier reported (Odeyinka 2004; Fasoyiro et al. 2006).

Tannin contents of the UGL seeds ranged from 3.5g/100g in lablab to 7.2 g/100g in Lima bean while that of soybean was 2.1 g/100g. Tannin forms strong insoluble complexes with proteins and divalent metals which results in poor digestibility and palatability in monogastrics (Adeparusi 2001; Ologhobo et al. 2003). However, sheep and cattle can tolerate 2-5%

dietary tannin ((Diagayete and Hugg 1981) while goats can tolerate about 9% tannin in their diets (Nastis and Malecheck 1981). Tannin is water–soluble phenolic metabolite concentrated beneath the testa of the seed and can be removed by soaking in water. Tannin contents were removed from sorghum (Nyachoti et al. 1997) and African yam bean (Adeparusi 2001) by soaking in water all night. Phytate concentration was highest in pigeon pea (16.2 mg/g) and lowest in soybean (10.3 mg/g). Phytin chelates metals such as Calcium, phosphorus, copper, magnesium and iron and forms complexes with proteins in legumes thereby reducing the nutritive value (Adeparusi 2001). Phosphorus deficiency occurs in animals when phytin combines with phosphorus. It is reported that soaking and boiling for ten minutes completely removed phytin in seed (Reddy et al. 1982). Trypsin inhibitor (TI) ranged from 12.0 Tiu/mg in soybean to 22.6 Tiu/mg in Bambara groundnut. It has been shown that all night soaking followed by boiling for ten minutes totally eliminates TI (Borge 1992) The concentration of saponin was highest in jack bean and sword bean (1.8 and 1.7 g/100g respectively) and lowest in soybean (0.8 g/100g).

Saponin containing seeds reduces methane production in the rumen by suppressing protozoa which influences butyrate production during rumen methanogenesis. The higher the contents of saponin in seed, the lower the volume of methane produced in the rumen. Methane production is loss of energy derivable from a feedstuff by the animal. Sword bean and jack bean with high saponin contents had low methane production whereas soybean with low content of saponin had the highest production of methane. Since methanogenesis is energy loss, it is essential that livestock diets should be balanced with a rich energy source (Ajayi 2007). Oxalate content ranged from 0.1 mg/100g in soybean to 0.9 mg/100g in lablab. Oxalate contents obtained in seeds of jack bean and lima bean was similar to reported values (Ologhobo et al., 2003). Oxalates have been implicated to impair magnesium metabolism in forages (Oke 1969). However, soaking in water all night before boiling for ten minutes eliminates oxalate content in seed.

Metabolizable energy (8.8 – 13.4 MJ/Kg) obtained for the UGL seeds are adequate for daily maintenance and production of ruminants. The ME of seeds was far above the 2.32 MJ/Kg reported for confined goats with liveweight of 10 kg (Steele 1996). The OMD obtained (49.6 – 77.2%) were higher than 45.0 – 60.8% reported (Juarez-Reyes et al. 2004) and 35.8 – 42.06% reported (Ajayi and Babayemi 2008). The variations observed in OMD and SCFA of these legumes were due to the level of secondary metabolite in them; especially tannin. High secondary metabolite in a feedstuff lowers the OMD and SCFA. Higher values of OMD and SCFA were observed in lablab and soybean. Gas fermentation and methane production of the legumes showed a progressive rise in gas volume as incubation time increased to 24 hr. The increase volume of gas reflects increase digestion of feedstuffs (Menke and Steingass 1988) and production of SCFA which is energy source for host animal (Hoffmann et al. 2003). It was observed that the seeds having high secondary metabolite had the least gas production at the end of incubation (24 hr). Higher gas is produced when substrate is fermented to acetate or butyrate. However, lower gas production is associated with propionate production (Ngamsaeng et al. 2006). The variations observed in the methane production in the legumes were due to the saponin contents of the legumes. Jack bean and sword bean with higher saponin contents had the least methane production values. This observation corroborates earlier findings that saponin containing seeds showed the ability to reduce rumen methane and butyrate production (Babayemi et al. 2004).

The gas production coefficients of the UGL seeds differed ((P<0.05) significantly (Table 5). The potential gas production, ***b*** varied from 23.4 ml/g in Lima bean and jack bean to 37.3 ml/g in lablab; soybean had the highest value of 38.5 ml/g. The observed values for gas production in AYB, pigeon pea, sword bean and Bambara groundnut were not significantly (P<0.05) different. The total volume of gas produced, Y, ranged from 18.4 ml/g in jack bean to 32.6 ml/g in lablab. The rate of substrate fermentation among the UGL seeds was between 1.4 $\%h^{-1}$ in jack bean and $21.5\%h^{-1}$ in lablab; soybean seed had the highest rate of fermentation ($23.2\%h^{-1}$). Higher gas production coefficients were recorded (Odeyinka 2004) for *Clitoria ternatea, Centrosema pubescens, Leucaena leucocephala, Macroptillium artropurpureum Clitoria ternatea, Centrosema pubescens, Leucaena leucocephala, Macroptillium* than values observed in this study.

The secondary metabolites in the UGL seeds could be responsible for the low values.

Table 1: Proximate composition of some under- utilized grain legume seeds and soybean.

Seed	DM	CP	EE	NDF	ADF	ADL	NFE
Lima bean	65.8c	21.4d	2.4c	44.2c	21.7b	4.3d	17.3a
African yam bean	70.3a	25.2b	3.1bc	48.6ab	23.2a	6..0b	11.7c
Pigeon pea	68.7ab	21.6d	2.4c	48.3ab	19.2c	5.8c	13.2bc
Sword bean	63.6d	22.7c	3.6b	49.5a	20.6bc	6.2b	12.0c
Jack bean	69.4a	18.8e	3.3b	49.8a	22.3a	6.8a	11.4c
Lablab	67.6b	22.5c	3.6b	50.1a	22.5a	5.8c	10.6c
Bambara groundnut	67.5b	19.4e	2.8c	46.3b	19.8c	6.1b	14.8b
soybean	67.3b	33.5a	10.1a	45.2c	16.4d	4.5d	15.6b
SEM	1.01	0.74	0.55	0.86	0.89	0.22	1.20

[abc] = Means in the same column with different superscripts differ significantly (P<0.05). DM = Dry matter, CP = crude protein, CF = crude fibre, EE = Ether extract, NDF= Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin, NFE = Nitrogen free extract. SEM = standard error of the mean.

Table 2: Secondary metabolite of seeds of some under-utilized grain legumes and soybean.

Seed	Tannic acid (g/100g)	Phytic acid (mg/g)	Trypsin inhibitor (Tiu/mg)	Saponin (g/100g)	Oxalates (mg/100g)
Lima bean	7.2a	13.6c	17.2c	1.5b	0.5b
African yam bean	5.4b	14.9ab	14.5d	1.2b	0.3c
Pigeon pea	4.3bc	16.2a	19.2b	1.4b	0.7ab
Sword bean	5.7b	14.4b	18.7b	1.7a	0.6b
Jack bean	4.5b	13.7c	16.4c	1.8a	0.8a
Lablab	3.5c	15.7a	19.7b	1.3b	0.9a
Bambara groundnut	4.9b	14.8ab	22.6a	1.4b	0.7ab
soybean	2.1d	10.3d	12.0e	0.8c	0.1d
SEM	0.58	0.42	1.22	0.20	0.11

[abc] = Means in the same column with different superscripts differ significantly (P<0.05). SEM = standard error of the mean.

Table 3: Metabolizable energy, Organic matter digestibility and short chain fatty acid of under-utilized grain legume seeds.

Seed	Metabolizable Energy (MJ/Kg)	Organic matter Digestibility (%)	Short chain fatty acid (mmol)
Lima bean	8.8d	49.6f	0.7b
African yam bean	13.4a	66.9d	0.7b
Pigeon pea	11.5bc	71.1c	0.7b
Sword bean	10.4bcd	70.4c	0.8b
Jack bean	8.9d	60.9e	0.8b
Lablab	12.1ab	80.5a	1.1a
Bambara groundnut	10.0cd	60.0e	0.9b
soybean	11.9ab	77.2b	1.2a
SEM	0.51	3.27	0.12

[abc] = Means in the same column with different superscripts differ significantly (P<0.05). SEM = standard error of the mean.

Table 4: Gas fermentation (ml/g) and methane production of some under-utilized grain legume seeds.

Seed	Hour of incubation (hr)			
	12	18	24	CH_4 (ml)
Lima bean	24.0b	31.5d	36.0d	40.0bc
African yam bean	20.0d	35.5c	39.5c	45.3b
Pigeon pea	23.5b	38.0b	40.1c	42.0b
Sword bean	26.0a	34.0c	40.0c	36.4c
Jack bean	23.5b	31.5d	41.0c	35.0c
Lablab	29.0a	44.5a	50.5b	43.7b
Bambara groundnut	19.0c	31.5d	40.7c	43.2b
Soybean	27.0a	38.0b	55.0a	48.7a
SEM	0.80	1.12	1.30	2.14

[abc] = Means in the same column with different superscripts differ significantly (P<0.05). SEM = standard error of the mean.

Table 5: *In-vitro* gas fermentation characteristics of under-utilized grain legume seeds

Seed	Y (ml)	b (ml)	c (h^{-1})
Lima bean	20.9c	23.4d	0.020d
African yam bean	22.0c	30.6b	0.062bc
Pigeon pea	22.0c	27.0c	0.028d
Sword bean	27.5b	30.4b	0.087b
Jack bean	18.4c	23.5d	0.014e
Lablab	32.6a	37.3a	0.215a
Bambara groundnut	25.7b	33.0b	0.083b
soybean	31.4a	38.5a	0.232a
SEM	2.86	1.31	0.006

[abc] = Means in the same column with different superscripts differ significantly (P<0.05). SEM = standard error of the mean.

4. Conclusion

The productivity of livestock can be enhanced by adequate nutrition in quality and quantity. The seeds of African yam bean, Bambara groundnut, sword bean and lablab are suitable as supplements for ruminants. However, seeds of Lima bean, jack bean and pigeon pea are unsuitable as legume supplements and if it has to be used at all, minimal quantity should be used in diets of livestock. There is need to further research on the inclusion level of these UGL seeds when used as supplements in diets of livestock.

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References

1. Adegbola AA (1985) Proceedings of theNational Conference on Small Ruminant Production, Zaria, Nigeria pp 85-99.
2. Adeparusi EO (2001) Effect of processing on some minerals, anti-nutrients and nutritional composition of African yam bean. Journal of Sustainable Agriculture and Environment 3: 101-108.
3. Ajayi FT (2007) Nutritional Evaluation of guinea grass (*Panicum maximum* cv Ntchisi) intercropped with some legumes for west African dwarf goats. Ph.D Thesis. University of Ibadan, Ibadan.
4. Ajayi FT, Babayemi OJ and Taiwo AA (2008) Effects of supplementation of

Panicum maximum with four herbaceous forage legumes on performance, nutrients digestibility and nitrogen balance in West African dwarf goats. Animal Science Journal 79: 673-679.

5. Ajayi FT and Babayemi OJ (2008) Comparative *in-vitro* evaluation of mixtures of *Panicum maximum* cv Ntchisi with stylo (*Stylosanthes guianensis*), lablab (*Lablab purpureus*), centro (*Centrosema pubescens*) and histrix (*Aeschynomene histrix*). Livestock Research for Rural Development 20 (6) art. # 83.
6. AsJuarez-Reyes, Nevarez-Carrasco G, Cerrillo-soto MA (2004) Chemical composition, energy content, intake and in-situ crude protein degradability of the forage consumed by goats in a thorn scrubland in semi arid region of north Mexico. Livestock Research for Rural Development 16 (1) art. # 3
7. AOAC (1990) Official Methods of Analysis, 15th edition, Washington, D.C., USA; Association of Official Analytical Chemist, pp 69-88.
8. Babayemi OJ, Demeyer D and Fievez V (2004) In-vitro rumen fermentation of tropical browse seeds in relation to their content of secondary metabolites. Journal of Animal and Feed Science 13 (1): 32-34.
9. Babayemi OJ, Ajayi FT, Taiwo AA, Bamikole MA and Fajimi AK (2006) Performance of West African dwarf goats fed *Panicum maximum* and concentrate diets supplemented with lablab (***Lablab purpureus***), leucaena (***Leucaena leucocephala***) and Gliricidia (***Gliricidia sepium***) foliage. Nigerian Journal of Animal Production 33: 102-111.
10. Bamikole MA, Babayemi OJ, Arigbede OM and Ikhatua UJ (2003) Nutritive value of *Ficus religiosa* in West African dwarf goats. Animal Feed Science and Tech. 10920: 1-9.
11. Bamikole MA Ikhatua UJ, Anota B and Omaduvie F (2003) Feed intake, feed utilization and weight gain of West African dwarf goat fed varying proportions of *Ficus religiosa* and *Panicum maximum*. Proceedings of the 28th Annual Conference of the Nigerian Society of Animal Production, held in I.A.R.&T., Obafemi Awolowo University, Moor Plantation, Ibadan, March 16-20. pp 274-278.
12. Borget M (1992) Food Legumes. The tropical Agriculturist, CTA, Macmillan Press Limited, London, pp 103.
13. Diagayete M and Huss W (1983) Tannin contents of African pasture plants: Effects on analytical data and *in-vitro* digestibility. Animal Research and Development 15: 79-80
14. Duncan DB (1955) Multiple Range and Multiple F-test. Biometrics 11: 1-42.
15. Fasoyiro SB, Ajibade SR, Omole AJ, Adeniyan ON and Farinde EO (2004) Proximate, minerals and anti-nutritional factors of some under-utilized grain legumes in south western Nigeria. Nutrition and Food Science 36: (1) 18-23.
16. Getachew G, Makkar HPS and Becker K (1999) Stoichiometric relationship between short chain fatty acid and *in-vitro* gas production in presence and absence of polythene 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.
17. Hoffmann EM, Muetzel S and Becker K (2003) Effects of *Moringa oleifera* seed extraction on rumen fermentation *in-vitro.* Archives of Animal 57: 65-81.
18. Kakade ML, Simon N and Leiner IE (1969) An evaluation of natural vs synthetic for measuring the antitryptic activity of soybean samples. Cereal Chemistry 46: 518-526
19. Klu GYP, Amoatey HM, Bansa D and Kumaeja FK (2001) Cultivation and use of African yam bean (*Sphenostylis stenocarpa* ex A Rich) in the Volta region of Chana. The Journal of Food Technology in Africa 6 (3)
20. Maga JA (1983) Phytate: Its chemistry, occurrence, food interactions, nutritional significance and methods of analysis. Journal of Agriculture and Food chemistry 30: 1-9
21. Menke KH and Steingass H (1988) Estimation of the energetic value from chemical analysis and *in-vitro* gas production using rumen fluid. Animal Research and Development 28: 7-55.
22. Mupangwa JF, Ngongoni NT, Topps JH and Hamudikuwanda H (2000) Effects of supplementing a basal diet of *Chloris gayana* hay with one of three protein-rich legume hays of *Cassia rotundifolia, Lablab purpureus* and *Macroptilium atropurpureum* forage on some nutritional parameters in

goats. Tropical Animal Health and Production 32: 245-256.
23. Nastis AS and Matechek JC (1981) Digestion and utilization of nutrients in Oak browse by goats. Journal of Animal Science 52: 283-288.
24. Ngamsaeng A, Wanapat M and Khampa S (2006) Evaluation of local tropical plants by in-vitro rumen fermentation end-products. Pakistan Journal of Nutrition 5 (5): 414-418.
25. Nwokolo E (1987) A nutritional assessment of African yam bean (*Sphenostylis stenocarpa* ex A.Rich) Harms and Bambara groundnut (*Voandzeia subterranean L*) Journal of Food Science and Agriculture 41: 123-129.
26. Nyachoti CM, Atkinson J and Leeson L (1997) Sorghum tannin: A review. World poultry Science Journal 53: 1-21.
27. Odeyinka SM, Hector BL, Ǿrskov ER and Newbold CJ (2004) Assessment of the nutritive value of the seed of some tropical legumes as feeds for ruminants. Livestock Research for Rural Development 16 (9) Art. # 69
28. Oke OL (1969) Oxalic acids in plants and in nutrition. World Review of nutrients Diet. 10: 262-302.
29. Okwu DE and Josiah C (2006) Evaluation of the chemical composition of two Nigerian medicinal plants. African Journal of Biotechnology 5(4): 357-361.
30. Ologhobo A, Mosenthin R and Alaka OO (2003) Products from under-utilized plant seed as poultry feed ingredients. Tropical Journal on Animal Science 6 (1): 101-110.
31. Osuji PO, Fernandez-Rivera S and Odenyo A (1995) Improving fibre utilization and protein supply in animals fed poor quality roughages: In Rumen Ecology Research Planning (eds) Wallace, R.J and Lahlou-kassi, A. International Livestock Research Institute, Addis Ababa, Ethiopia pp 1-22.
32. Ǿrskov ER and McDonald I (1979) The estimation of protein degradability in the rumen from incubation measurements weighted according to the rate of passage. Journal of Agriculture Science. Cambridge 92: 499-503
33. Reddy NR, Sathe SK and Salukhe DK (1982) Phytates in legumes and cereals. Advance Food Research 28: 1-92.
34. SAS (1998) Statistical Analytical Systems Institute, SAS/STAT User's Guide. Statistics, SAS Institute, Cary. North Carolina, USA. 943
35. Steele M (1996) Goats: The Tropical Agriculturist. Macmillan CTA, Netherlands. Pp 125.
36. Van Soest PJ, Robertson JB and Lewis BA (1991) Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74 (10): 3583-3597.

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