UTILIZATION OF CROP RESIDUES AND AGRO-INDUSTRIAL BY-PRODUCTS AS COMPLETE DIETS FOR WEST AFRICAN DWARF SHEEP AND GOATS

E.A. ADEBOWALE AND A.A. TAIWO

Institute of Agricultural Research and Training, Obafemi Awolowo University, P.M.B. 5029, Ibadan Nigeria.

Received 23 January 1995, Accepted 25 June 1996

ABSTRACT

Two experiments consisting of three dietary treatments each were conducted on the use of crop residues and agro-industrial wastes for formulating complete diets for growing West African dwarf sheep and goats. Growth performance and digestibility studies were carried out with the animals. In experiment I Crude proten (CP), ash and gross energy levels increased from diet 1 to diet 3 while the crude fibre contents decreased progressively. Sheep consumed more nutrients ($P < 0.01$) than goats. In the sheep, the highest dry matter intake (DMI) was on diet 2 (74.1g/kgw 0.75). However, the intakes of CP and energy on diets 2 and 3 were similar (P0.05). Energy intake was highest in diet 3 for goats, while DMI (47.6g/kgW $^{0.75}$) was comparable ($P > 0.05$) to those on diets 1 and 2 (50.5 and 45.0g/kg $W^{0.75}$ respectively. Sheep and goats digested DM, CP and energy similarly ($P > 0.05$). Diet 3 was the most digestible ($P < 0.01$) for energy in both species. Digestibility of DM and CP was best in diet 3 for the sheep. The highest ($P < 0.05$) weight gain of 60.3g/day was for sheep on diet 3. The best feed conversion efficiency (FCE) was also recorded for the same diet for sheep (10.0%) and goats (9.2%). In Experiment 2, crude protein levels also increased from diets 1 to diet 3 while crude fibre decreased from diets 1 to 3. Concentrations of HCN (16.7 and 19.3mg/kg for diets 1 and 2 respectively) were low. Sheep consumed more ($P < 0.05$) DM than goats (83.8 and 79.5g/kg $w^{0.75}$ respectively) while CP was consumed similarly ($P > 0.05$). Goats digested DM (68.2% better ($P < 0.05$) than sheep (59.6%). Diets did not influence ($P > 0.05$) the DM digestibility within the two species. The highest ($P < 0.05$) weight changes were recorded on diet 3 for sheep and goats (112.4 and 55.2g/day respectively). Diets 2 and 3 had comparable ($P > 0.05$) FCE in sheep while that of diet 3 (9.9%) was better ($P < 0.01$) among the goats. The results show that some of the diets could be productive for commercial small ruminant production.

Keywords: Crop residue, agro-industrial waste utilization, complete diets, small ruminants.

INTRODUCTION

The scavenging image of small ruminants cannot be relied on to provide adequate nutrients for optimal livestock production. Thus it is important to ensure adequate feeding in order to enhance the productivity of the stock. The abundancy of crop residues and agro-industrial by products make them cheap sources of nutrients for ruminants. Nevertheless, they are generally low in nutrients (Nicolson, 1984). Various strategies have been adopted in improving their nutrients and utilization. One of such is by treatment to reduce the negative influence of lignin on the utilization of complex carbohydrates (Jackson, 1977; Adebowale, 1985, 1989) while the other is by supplementation to provide the most limiting nutrients e.g. rumen degradable protein, rumen by pass protein or degradable carbohydrate (Preston, 1985; Alhassan, 1988).

Balancing of the nutrients that provide the major building blocks for tissue synthesis and milk production should be the primary concern of the nutritionist (Leng, 1990). This can be achieved by careful blending of the crop residues to meet the nutrient requirements of ruminant livestock. Some studies have been conducted in which crop residues e.g. cowpea husk, maize cob, yam peels and plantain peels partly replace maize in the diets of ruminants (Adebowale, 1981; 1982.

Thus this study aims at determing the suitability of crop residues and agro-industrial by-products as complete diets for growing West African dwarf sheep and goats.

about 2000 kcal ME/kgDM and protein levels from 9 to 15%. Six of the diets were selected for experimentation. The feeds were tested in threes.

TABLE 1 COMPOSITION OF THE COMPLETE DIETS

EXPERIMENTS	1			2		
DIETS	1	2	3	1	2	3
INGREDIENTS						
Maize cobs	43.2	-	29.5	12.5	..	17.0
Cassava peels	10.8	8.2	-	30.0	21.5	-
Rice husk	-	30.0	-	40.0	20.0	7.0
Plantain peels	-	2.2	13.6	-	-	-
Maize offals	-	-	-	-	31.0	-
Brewers dried grains	15.5	20.0	20.0	7.0	10.0	10.0
Soyabean hulls	-	-	-	8.0	5.0	11.5
Palm kernel cake	13.5	-	8.5	-	10.0	10.0
Cotton seed cake	-	10.0	-	-	-	-
Wheat offals	-	-	-	-	-	42.0
Giiricidia leaves	-	12.6	10.4	-	-	-
Groundnut haulms	15.0	15.0	-	-	-	-
Poutry litter	-	-	15.0	-	-	-
Urea	-	-	1.0	-	-	-
Bone meal	1.5	1.5	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5
*Vitamin-mineral premix	-	-	-	0.5	0.5	0.5
	100	100	100	100	100	100

*Vit-min-Premix. Each kg contains: Vit A4 x 10^6 (I.U); Vit D_3 1x10^6 (I.U); Vit E 4800 (I.U); Vit K 0.8g; Vit B_1 0.4g; Vit B_2 1.8g; Vit B_6 1.2g; Mn 40g; Fe 20.0g; Zn 18.0g; C_4 0.8g; 1 0.62g; Co 0.09g; Se 0.04g.

TABLE 2: CHEMICAL COMPOSITION OF DIETS (DRY MATTER BASIS)

EXPERIMENTS	1			2		
DIETS	1	2	3	1	2	3
NUTRIENTS						
Dry matter (%)	87.7	89.1	90.8	91.4	90.8	88.6
Crude protein (%)	8.4	14.9	15.6	8.9	12.5	15.9
Crude fibre (%)	34.0	29.1	20.6	32.5	30.2	22.4
Ether extract (%)	1.4	3.4	3.3	0.8	2.5	1.2
Ash (%)	4.8	16.2	19.4	19.3	23.5	9.6
Nitrogen free extract (%)	51.4	36.4	41.1	38.5	31.3	51.0
Total cyanide (mg HCN/kg	-	-	-	16.7	19.3	-

- Not determined.

MATERIALS AND METHODS

About 44 different types of crop residues which could be sources of nutrients were composited. They were selected based on such criteria as: cost/unit, availability, ease of harvesting/collection, nutritional limitations, and toxicological consideration.

The by-products were analysed for their proximate composition. Nutrient requirement were specified for different classes of sheep and goats. Linear programming by computer analysis was used to formulate about 50 different least cost diets for growing small ruminants. The diets had energy density of

Table 1 shows the composition of the diets used in experiments 1 and 2. Some of the ingredients were dried and ground in a hammer mill before mixing with the others in the feeds. The diet formed the sole feeds offered the animals without any other supplement. Four male West African dwarf (WAD) goats and four male WAD sheep 12 - 15 months of age with average initial body weights of about 8.1kg and 15.3kg (Experiment 1) and 11.0kg and 15.4kg (Experiment 2) respectively were randomly assigned to each diet for the feeding trials. During the digestibility studies, 2 goats and 2 sheep were alloted to each diet. Prior to the commencement of the experiments, the animals were dewormed with an antihelmithic drug, "systamex" and dipped in an acaricide solution: asuntol against ectoparasites. The animals were offered the diet *ad libitum* in feed troughs provided in individual pens. Water was also made available *ad libitum*. Wood shavings was used as litter for the floor in the pens. This was changed regularly.

The animals were let out in an enclosed yard, without access to any feed, to exercise their body and received direct rays of sun for a few hours once a week. Data collected were analysed using a 2 x 3 factorial arrangement. The two species of livestock; sheep and goats were the two groups while the three diets formed the sub-groups. Analysis of data was carried out using analysis of variance technique (Steel and Torrie, 1980).

The feeding trials comprised the growth trial and the digestibility study. The growth phase lasted for twelve weeks with 2 weeks for adjustment. The animals were weighed at the beginning of the experiment and thereafter once weekly in order to estimate weight changed. Known amounts of the feeds were offered daily in the morning to each animal. The remnants were weighed the following morning to estimate feed intake.

Digestibility study comprised a 2 week preliminary period and a week of collection. The animals were housed in individual metabolism cages with facilities for separate collection of faeces and urine. The animals were weighed at the beginning and at the end of the digestibility study. The diets were offered in feed troughs and water was provided. The daily feacal output of each animal was separately weighed during the collection period. Samples of the feed and feaces were taken daily for dry matter analysis and bulked for the collection period prior to other chemical analysis.

Proximate analysis of feed and faeces was carried out by the A.O.A.C. (1980) methods. Dry matter of samples was determined in an oven at 105^{0}c for 48 hours. Nitrogen determination was by the micro kjeldahl method, while the soxhlet extraction procedure was used for ether extraction. Crude fibre was determined by alternate refluxing with weak

TABLE 3: INTAKE OF NUTRIENTS BY WAD SHEEP AND GOATS FROM THE DIETS (g/kg $W^{0.75}$)

EXPERIMENT 1

SPECIES DIETS	SHEEP 1	SHEEP 2	SHEEP 3	GOATS 1	GOATS 2	GOATS 3	LEVEL OF SIGNIFICANCE
Dry matter intake	60.9^{c}	74.1^{a}	69.0^{b}	50.5^{a}	45.0^{b}	47.6^{ab}	0.05*
X		68.0^{a}			47.7^{b}		0.01*
Crude protein intake	5.1^{b}	11.0^{a}	10.8^{a}	4.2^{c}	6.7^{b}	7.5^{a}	0.01*
X		9.0^{a}			6.1^{b}		0.01*
Energy intake (kcal/kgw$^{0.75}$)	262.3^{b}	409.5^{a}	395.3^{a}	217.2^{a}	248.6^{b}	271.9^{a}	0.01**
X		355.7^{a}			245.9^{b}		0.01**

EXPERIMENT 2

SPECIES DIETS	SHEEP 1**	SHEEP 2	SHEEP 3	GOATS 1**	GOATS -	GOATS 3	
Dry matter intake	57.0^{c}	82.2^{b}	85.3^{a}	39.9	87.1^{a}	71.8^{b}	0.01*
X		83.8^{a}		79.5^{b}			0.05*
Crude protein intake	4.9^{c}	10.2^{b}	13.5^{a}	3.6^{b}	10.8	11.4^{a}	0.01*
X		11.9^{a}			11.1^{a}		NS

(a,b,c)* Means within the same subclass with different superscripts differ (P < 0.05 or < 0.01)

NS: Not Significant (P > 0.05).

** Data collected uptill the end of the 6th week (not included in the specie mean) when the diet was discontinued because of the sudden death of some of the animals on it.

solutions of H_2SO_4 and KOH. The determination of cyanide in some of the feeds was by the enzymatic method (Cooke, 1978)

RESULTS

Experiment 1

All the diets had high dry matter contents with a mean value of about 89% (Table 2). Crude protein levels increased from diet 1 (8.4%) to diet 3 (15.6%). Crude fibre levels decreased progressively from diet 1 (34.0%) to diet 3 (20.6%). Ether extract (EE) value in diet 1 (1.4%) was less than those in diets 2 and 3. There was an increase in the ash contents of the diets from diet 1 to 3. The highest concentration of nitrogen free extract (NFE) was contained in diet 1 (51.4%). Energy values of the diets were 4.3, 5.5 and 5.7 kcal/g in diets 1, 2 and 3 respectively.

Intake of nutrients by sheep was higher ($P<0.01$) than the goats (Table 3). Likewise there were significant differences in nutrients among the diets. In the sheep, dry matter intake (DMI) was highest ($P<0.05$) for diet 2. Crude protein and energy intakes were similar ($P>0.05$) for diets 2 and 3 but different ($P<0.05$) from diet 1. Among the goats differences ($P<0.05$) exist in DMI only with respect to diets 1 and 2. Protein and energy intakes were higher ($P<0.05$) on diet 3 and least on diet 1.

There were differences ($P>0.05$) between sheep and goats in the digestibility of dry matter, crude protein and energy (Table 4). Diet 3 was highly digestible for CP, energy ($P<0.01$) and DM ($P<0.05$) than the other two diets among the sheep. In the goats, there were no significant differences ($P>0.05$) in the dry matter digestibility (DMD) of diets 1 and 3. However, the DMD values for diets 1 and 2 were also similar ($P>0.05$). Crude protein digestibility of diet 1 and the energy digestibility of diet 3 were different ($P<0.01$) from the other two diets.

Sheep on diet 3 had the highest ($P<0.05$) weight gain (60.3g/day) (Table 5). Those on diets 1 and 2 had similar ($P>0.05$) weight gain of 43.9 and 43.1g/day respectively. Weight gain by the goats increased ($P<0.05$) from diet 1 (15.4g/dat) to diet 3 (28.4g/day). Sheep and goats on diet 3 had the best feed conversion efficiency (FCE) (10.0 and 9.2% respectively). The FCE of goats on diet 2 was similar ($P>0.05$) to those on diet 3.

Experiment 2

The diets had a mean DM of about 90% (Table 2). Crude protein contents increased

TABLE 4: DIGESTIBILITY OF NUTRIENTS BY SHEEP AND GOATS ON THE DIETS (%)

EXPERIMENT 1

SPECIES	SHEEP			GOATS			LEVEL OF SIGNIFICANCE
DIETS	1	2	3	1	2	3	
DM Digestibility	55.7^b	49.4^c	67.9^a	60.7^{ab}	52.7^b	66.4^a	0.05*
X		57.7			59.9		0.05NS
CP digestibility	44.8^c	66.9^b	76.8^a	52.8^b	66.0^a	69.2^a	0.01*
X		62.8			62.7		0.05NS
GE digestibility	41.1^c	48.9^b	63.3^a	50.1^b	49.2^b	66.3^a	0.01*
X		51.1			55.2		0.05NS

EXPERIMENT 2

SPECIES	SHEEP			GOATS			LEVEL OF SIGNIFICANCE
DIETS	1**	2	3	1**	2	3	
DM digestibility	-	60.5	58.8	-	67.0	69.3	0.05NS
X		59.6^b			68.2^a		0.05*

(a,b,c)* Means within the same subclass with different superscripts differ ($P<0.05$ or $P<0.01$)

NS: Not Significant ($P>0.05$)

**: Experimentation with diet 1 (Expt. 2) was discontinued because of the sudden death of some of the animals.

from 8.9% in diet 1 to 15.9% in diet 3. The crude fibre value was highest in diet 1 (32.5%) and least in diet 3 (22.4%). Diet 2 had the highest values of ether extract (2.5%) and ash (23.5%) and the least value of NFE (31.3%). The hydrogen cyanide (HCN) contents of diets 1 and 2 were 16.7 and 19.3 mg HCN/kg DM respectively. Dry matter intake (DMI) was higher ($P<0.05$) in sheep (83.8g/kg $w^{0.75}$) than in goats (79.5g/kg $w^{0.75}$) (Table 3). Goats and sheep on diets 2 and 3 respectively had the highest DMI (87.1 and 85.3g/kg $w^{0.75}$). There were no significant differences ($P>0.05$) in the crude protein intake of sheep and goats (11.9 and 11.1g/kg $w^{0.75}$ respectively). The highest amount of protein was consumed on diet 3 while the least intake was on diet 1 in both species. Goats on diet 2 and 3 consumed crude protein almost to the same ($P>0.05$) extent. Goats digested dry matter better ($P<0.05$) than the sheep (Table 4). Diet 3 was slighly more digestible than diet 2 in goats (69.3 versus 67.0%) while diet 2 was better digested than diet 3 among the sheep (60.5 versus 58.6%). However, the differences observed within the diets were not significant ($P>0.05$). The dietary effect on liveweight changes was highly significant ($P<0.01$) (Table 5). The highest weight gain was recorded by sheep on diet 3 (112.4g/day). Diet 2 and 3 in sheep had comparable ($P>0.05$) feed conversion efficiency while that of diet 3 was the best among the goats.

DISCUSSION

The quantity and type of ingredients used in formulating the feeds influenced their chemical composition. In experiment 1, the levels of gliricidia leaves, brewers' dried grains (BDG) and poultry litter aided the relatively high concentration of protein in diet 3, whereas diet 1 contained low levels of protein rich ingredients. Likewise in experiment 2, concentrations of wheat offals, BDG, soyabean

TABLE 5: LIVEWEIGHT CHANGES AND FEED EFFICIENCY OF SHEEP AND GOATS ON THE DIETS

EXPERIMENT 1

SPECIES	SHEEP			GOATS			LEVEL OF
DIETS	1	2	3	1	2	3	SIGNIFICANCE
Average liveweight (kg)	17.1	17.3	17.9	9.1	8.6	9.8	
Liveweight changes (g/day) +	43.9[b]	43.1[b]	60.3[a]	15.4[c]	23.2[b]	28.4[a]	0.05*
Dry matter intake (g/day)	512.1	623.1	600.5	264.6	225.0	263.6	
Feed efficiency + (Feed/gain) (%)	11.6[b]	14.4[a]	10.0[c]	17.1[a]	9.7[b]	9.2[b]	0.05*

EXPERIMENT 2

SPECIES	SHEEP			GOATS			LEVEL OF
DIETS	1**	2	3	1**	2	3	SIGNIFICANCE
Average liveweight (kg)	13.6	19.4	19.8	9.1	12.8	14.8	
Liveweight changes (g/day) +	-31.1[c]	108.9[b]	112.4[a]	-12.7[c]	42.9[b]	55.2[a]	0.01*
Dry matter intake (g/day)	403.7	759.8	800.7	209.1	589.4	541.8	
Feed efficiency + (Feed/gain) + (%)	-13.3[b]	7.0[a]	7.1[a]	-16.7[c]	13.7[b]	9.9[a]	0.01*

+: Subjected to statistical analysis.

(a,b,c,)*: Means within the same subclass with different superscripts differ ($P<0.05$ or $P<0.01$).

**: Data collected uptill the end of the 6th week when experimentation with the diet was discontinued because of the sudden death of some of the animals on it.

hull and palm kernel cake boosted the protein level of diet 3. The preponderance of ligno-cellulose containing ingredients e.g.maize cob and rice husk in diet 1 of both experiments was responsible for their high crude fibre levels. The large volume of the digestive tract of the sheep, especially the reticulorumen, has the capacity to retain more feed than that of goats. This could be responsible for its relatively higher intake of feed and nutrients recorded.

High crude protein content of a feed stimulates appetite and feed intake (Tolkamp, 1988). Thus it can be deduced that more of a diet with high crude protein (CP) content would be consumed compared with another diet low in CP content. This works by providing rumen degradable nitrogen for micro-organisms to build their body protein. The low feed intake of diets with low CP contents would be accentuated by high crude fibre diet to be digested. This increases its retention time in the reticulorumen (Orskov and Ryle, 1990) thereby depressing the intake of more feed. The higher digestibility of DM in goats relative to the sheep can be attributed to the higher feed intake in sheep. Higher feed intake results in a faster rate of passage of digesta, from the reticulo-rumen. This reduces the rate of passage of feed via the reticulo-rumen to allow for degradation, hence lowering its digestibility (McDonald *et al.*, 1988). The improvement in the DM digestibility of goats over sheep is supported by another study (Adebowale, 1989) where NaOH-treated maize cobs at levels between 0 to 40% in their diet. However, when *Echinochloa stagnina* was fed as the sole feed, goats and sheep exhibited similar patterns in their ability to digest the various nutrients, except for ADF in the forage (Adebowale, 1988).

High protein contents of diets 2 and 3 play significant role in improving the digestibility of nutrients over those of diet 1. This is supported by McDonald *et al* (1988) that the concentration of CP in a feed affects its digestibility. High fibre content inhibits digestibility. Thus diet 1 with high fibre could have contributed to its low digestibility. The rate of microbial colonization of a feed with high fibre content is lower (Silva and Orskov, 1988) compared to another with low fibre. Thus this reduced its degradation.

The better weight gain of sheep reflected the higher potentials of WAD sheep over WAD goats in body weight gain. The liveweight gains for sheep and goats were quite low compared with those reported elsewhere (Adebowale, 1989). However, the inclusion of 40% untreated maize cobs in the diets of the goats (Adebowale, 1989) resulted in 24.9 g/day weight gain, which is similar to those for goats on diet 2 and 3 (Experiment 1) in this report. The performance recorded for sheep on diets 2 and 3 (Experiment 2) outstripped the weight gain obtained by Adebowale (1989); Adeleye (1980) and Adegbola *et al* (1990).

Availability of digestible protein and energy reflected by the relatively lower fibre levels, provided ready nutrients for the synthesis of body tissues in the lower gut. This could be responsible for the higher weight gains and efficiency of feed utilization of animals on diets 2 and 3 over those on diet 1. The wide discrepancies in the liveweight gains of the animals between Experiments 1 and 2, despite the similarity in the protein levels of the respective diets, could, among other factors, be due to the simplistic approach of using crude protein contents to determine protein requirement. It would be better to adopt the method of apportioning dietary protein requirements in the forms of rumen degradable protein and rumen bypass protein as it is done in United Kingdom (ARC, 1984) and United States of America (N.R.C., 1985). This would involve the determination of the degradability of local feeding stuffs.

The weight loss by animals on diet 1 (Experiment 2) could be attributed to the probable presence of some anti-nutritional factors in the diet. In the course of the experiment, 2 goats and 1 sheep on diet 1 (Experiment 2) died. The death occurred between the 4th and 6th weeks of the study. Since all the dead animals were on a particular diet, dietary effect was suspected as the causative agent of death. Thus experiment with diet 1 was discontinued and the remaining animals on it were released from the pens. The characteristic patterns preceding death among the animals were bloated stomach and reduction in feed intake. Hydrogen cyanide (HCN) poison from cassava peels was at first suspected. Cyanide analysis of diets 1 and 2 containing cassava peels revealed that they had values less than 20 mg HCN kg sample (Table 2). This is within the limit of 50mg HCN/kg classified as non-toxic (Bolhuis, 1954). The dried nature of the feeds also implied that the HCN contents would have been reduced during the drying process. The likely cause of the death of the animals could then be mycotoxins.

In conclusion small ruminants were able to subsist and make appreciable weight gains on some crop residue-based diets. The combination of feed ingredients in the second experiment gave better weight gain than on the first experiment. The performance of animals on diets 2 and 3 (Experiment 2) were comparable for most of the parameters recorded. More studies should be executed to know the optimal utilization of other different combinations of crop residues as livestock feed. Formulation of diets with crop residues reduces competition for conventional feed ingredients and provides needed nutrients especially during the dry season when available green forage is low in quality and quantity. Transportation and availability of the feed in mash form would be of tremendous advantage to live stock farmers.

ACKNOWLEDGEMENT

The authors are grateful to the Presidency, Federal Government of Nigeria for the facilities provided for this work through the first author who was a member of the Presidential Task Force on Alternative Formulation of Livestock Feeds.

REFERENCES

ADEBOWALE, E.A. (1981) The feeding value of cowpea husks *(Vigna unguiculata Walp)* in rations for goats *Turrialba* 31: 141 - 145

ADEBOWALE, E.A. (1982). Growth, economics and carcass characteristics of goats fed maize cobs, yam peels and plantain peels diets. *Ind. J. Anim. Sci. 52: 288 - 292.*

ADEBOWALE, E.A. (1985). Response of West African dwarf Sheep and goats fed maize straw treated with local alkali. *Nig. J. Anim. Prod.* 12: 137 - 149.

ADEBOWALE, E.A. (1988): Performace of young West African Dwarf goats and sheep fed on an aquatic macrophyte *Echinochloc stagnina, Small Rumin. Rs. 1:* 167 - 173

ADEBOWALE, E.A. (1989): Response of West African Dwarf sheep and goats fed maize cobs treated with different concentrations of caustic soda. Trop. Agric. (Trinidad) *66:* 213 - 216

ADEGBOLA, A.A., SMITH, O.B and OKEUDO, N.J. (1990): Response of West African Dwarf sheep fed cassava pees and poultry manure based diets. In: utilixation of research results on forages and agricultural by-product materials as animal feed resources in Africa. PP. 357 - 366. (Eds. Dzowela B.H., Said A.N.; Wendem - Agenuhu A. and Kategile, H.H.) ILCA Addis Ababa.

ADELEYE, I.O.A. (1980): The effect of NaOH spray treatment of maize cobs on consumption and digestibility by the West African Dwarf Sheep. *Nig. J. Anim. Prod.* 7: 132 - 137

AGRICULTURAL RESEARCH COUNCIL (1984): The Nutrient Requirements of Ruminant Livestock, Supplement No. 1. Commonwealth Agricultural Bureaux, Farnham Royal, London.

ALHASSAN, W.S. (1988) Studies on untreated crop residue utilization in red sokoto goats. In: Goat Production in the humid tropics. (Eds. O.B. Smith and H.G. Bosman) Pudoc, Wageningen. pp. 62 - 66

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (1980): Official methods of analysis (13th edition). A.O.A.C. Washinton D.C.

BHATTACHARYYA, A.N. and TAYLOR, J.C. (1975): Recycling animal waste as a feed stuff. A Review. *J. Anima. Sci. 41:* 1438 - 1457

BOLHUIS (1954): The toxicity of cassava roots. *Neth. J. Agric. Sci.* 2: 176

COOKE, R. (1978): Cyanide assay by manual method *J. sci. Food Agric.* 29: 345 - 352.

JACKSON M.G. (1977) Review article: The alkali treatment of straws *Anim. Feed Sci. Technol.* 2: 105 - 130

LENG R.A. (1990): Factors affecting the utilization of poor quality forages by ruminants particularly under tropical conditions. Nut. *Res. Rev.* 3: 277 - 303.

McDONALD P. , EDWARDS R.A. and GREENHALGH J.F.D. (1988): *Animal* Nutrition (4th edition). Longman Scientific and technical, England.

NATIONAL RESEARCH COUNCIL (NRC) (1985): *Ruminant Nitrogen Usage.* National Academy of sciences. Washinton DC

NICHOLSON J.W.G. (1984): Digestibility, nutritive values and feed intake. Chapter 12. In: Straw and othe fibrous feed (F. Sundstol and E., Owen, Editors) Elseiver, Amsterdam.

ORSKOV E.R. and RYLE M. (1990): *Energy Nutrition in Ruminants.* Elsevier Applied Science, London.

PRESTON T.R. (1986). Strategic supplementation to optimise rumen function and the balance of absorbed nutrients in ruminants fed largely on crop residues. In: Towards optimal feeding of agricultural by-products to livestock in Africa (T.R. Preston and M.Y. Muwanyakpa Eds.) ILCA Addis Ababa. PP: 167 - 180

SILVA A.T. and ORSKOV E.R. (1988): The effect of Five different supplements on the degradation of straw in sheep given untreated barley straw. *Animal Feed sci. Technol.* 19: 289 - 298

STEEL R.G.D. and TORRIE J.G. (1980): *Principles* and *Procedures* of statistics. (2nd Edition). McGraw Hill Books Company Inc. New York, Toronto and London.

TAIWO A.A., ADEBOWALE E.A. GREENHALGH J.F.D. and A.O. AKINSOYINU (1992): Effect of urea treatment on chemical composition and degradation characteristics of some crop residues. *Nig. J. Anim.* Prod. 19: 25-36.

TOLKAMP B: (1988): Feed intake regulation and small ruminants. In: Goat production in the humid tropics (Eds. O.B. Smith and H.G. Bosman) Pudoc Wageningen. pp: 67 - 75.