PJN

ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Mob: +92 300 3008585, Fax: +92 41 8815544

E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 11 (6): 566-571, 2012
ISSN 1680-5194

Productive and Blood Indices of Dwarf Rams Fed a Mixture of Rice Straw and Groundnut Haulms Alone or Supplemented with Concentrates Containing Different Levels of Shea Nut Cake

S.P. Konlan[1], P.K. Karikari[2] and T. Ansah[3]
[1]Animal Research Institute, Council for Scientific and Industrial Research, Tamale, Ghana
[2]Dairy/Beef Cattle Research Station,
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[3]Department of Animal Science, University for Development Studies, Nyankpala, Ghana

Abstract: Six juvenile West African dwarf rams were used for three periods in a double 3 x 3 Latin square design to test the nutritional value of three home-made diets meant for use as dry season sheep feed in the Tolong-Kumbungu district of the Northern region of Ghana. The three dietary treatments were: mixture of 625 g/kg DM rice straw and 375 g/kg DM groundnut haulms (T1), T1 + concentrate feed containing 115 g/kg DM shea nut cake (T2) and T1 + concentrate feed containing 230 g/kg DM shea nut cake (T3). Each period consisted of 14 days of adaptation to the feed and 14 days in which data were collected. Total DMI was significantly low ($p<0.05$) when the rams were on T1 (453.4 g/d) compared to when on T2 (612.0 g/d) and T3 (627.6 g/d). Daily weight gain values obtained when rams were on T1 and T3 differed ($p<0.05$), but the value obtained when on T2 was similar to T1 and T3; the values being 20.3 g, 31.2 g and 39.3 g for T1, T2 and T3, respectively. Concentrate supplementation improved DM and CP digestibility with values being significantly higher on T2. Supplementation did not affect the haematological and serum biochemical indices of the rams except total protein and albumin, which two values were significantly high on T3. It was observed that supplementation increased DMI, daily weight gain and serum total protein and albumin due to the high crude protein and energy contents of the supplemental concentrate. It was concluded that all three test diets were suitable for dry season sheep feeding in the test area and that shea nut cake could be included in sheep diets up to 230 g/kg DM without any harmful effect on their haematological and serum biochemical profile.

Key words: Blood indices, dwarf ram, groundnut haulms, rice straw, shea nut cake

INTRODUCTION

Wild bush fires and decline in nutritive value of vegetation resulting from senescence combine to make it difficult for livestock to meet their nutritional requirement in the Tolong-Kumbungu district of Ghana during the dry season. Indeed many of the animals reared in this district survive mainly on straw during the dry season. Such a situation has long been recognized to result in cyclic body weight gain in the rainy season and weight loss in the dry season (Annor *et al*., 2007). To break this cycle, animal nutritionists have recommended feed supplementation. However, the use of staple cereal grains as supplements leads to competition between humans and animals and increases the cost of feed supplementation, making supplementation unprofitable or unsustainable, especially in poor communities. The need, therefore, exists to find reliable and sustainable sources for feed supplementation with the view to helping to improve the profitability of livestock production during periods of inadequate and/or poor quality herbage supply. According to Ranjhan (2001) crop residues (straws and stovers) and agro-industrial by-products will remain important sources of feed for livestock production. One agro-industrial by-product which can widely be used as animal feed in the Tolong-Kumbungu district of Ghana is the shea nut cake. This cake is a by-product arising out of the processing of shea nut into shea butter. It is abundant in northern Ghana and is currently being underutilized. According to Annongu *et al.*(1996) shea nut cake contains anti nutritional factors such as saponin and theobromine which at high levels of inclusion in the diet may depress feed intake and weight gain in sheep (EFSA, 2008). Madubuike and Ekenyem (2006) reported that haematological and serum chemistry assay in livestock could indicate the physiological response of livestock to their nutrition. Esonu *et al*. (2001) had earlier come to the same conclusion that haematological constituents reflect the physiological responsiveness of the animal to its internal and external environment. The objective of this work was, therefore, to evaluate the nutritional value of

Corresponding Author: P.K. Karikari, Dairy/Beef Cattle Research Station, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

three diets formulated from locally available feedstuffs in the Tolong-Kumbungu district of Ghana as feed for sheep in the dry season. The test diets were a mixture of rice straw and groundnut haulms fed alone or supplemented with concentrates containing different levels of shea nut cake. West African dwarf rams were used for the dietary testing and the data collected and evaluated included feed intake, body weight changes, nutrient digestibility and haematological and serum biochemical indices.

MATERIALS AND METHODS

Location: The experiment was conducted at the Nyankpala Station of the Animal Research Institute (ARI). Nyankpala is in the Northern region of Ghana, located at 0° 58' 42'' W, 9° 25' 41'' N and at an altitude of 183 m above mean sea level (AMSL). It is in the dry savannah ecological zone of Ghana, with a unimodal rainfall pattern which starts from May to October and averages 1043 mm per annum. The ambient temperatures average 28.3°C per annum but daily temperatures range between 15°C and 42°C. The area experiences dry cold harmattan winds from November to February and warm dry conditions from March to April. The dry season, therefore, stretches from November to April.

Table 1: The experimental layout

	Diet offered					
Period	Ram No. 1	Ram No. 2	Ram No. 3	Ram No. 4	Ram No. 5	Ram No. 6
1	T2	T2	T3	T3	T1	T1
2	T3	T3	T1	T1	T2	T2
3	T1	T1	T2	T2	T3	T3

Diets: T1 = Rice straw + Groundnut haulms only; T2 = T1 + concentrate containing 115 g/kg DM SNC; T3 = T1 + concentrate containing 230 g/kg DM SNC; SNC = Shea Nut Cake

Experimental design and animal care: Six juvenile West African dwarf (WAD) rams averaging 12.0±2.0 months of age and 12.8±2.4 kg live body weight were used for three periods in a replicated 3 x 3 Latin square design (Table 1). Each period comprised 14 days of adaptation to the feed and 14 days in which data were collected. The three dietary treatments were: mixture of 625 g/kg DM rice straw and 375 g/kg DM groundnut haulms (T1), T1 + concentrate feed containing 115 g/kg DM shea nut cake (T2) and T1 + concentrate feed containing 230 g/kg DM shea nut cake (T3). The rice straw and groundnut haulms were chopped into 20 mm pieces and mixed together to constitute treatment T1. Each ram received a daily DM supply of 700 g of T1 and if supplemented (T2 and T3), an additional 200 g of the appropriate concentrate feed. Both concentrate and T1 diets were offered once daily at about 08:00 h local time. Mineral lick and water were provided *ad libitum* to the rams throughout the experimental period. The rams were kept individually in well ventilated pens measuring 4.5 x 2.0 x 3.0 m with concrete floors and roofed with aluminum sheets. All the rams were given albendazole 2.5% oral suspension (3 ml per ram; Cipila Ltd., India) to control endo-parasites before the start of the experiment which lasted 12 weeks.

Data collection and analysis: The feed offered and orts were weighed in the mornings and the weight difference between feed offered and the next day's orts was taken as feed consumed. The rams were weighed before feeding at the end of the second and fourth weeks of every experimental period to determine live body weight changes. In the last seven days of each period the rams were fitted with harnesses to collect total faeces voided for the determination of dry matter and crude protein digestibility. The daily faecal collections were weighed and stored in a refrigerator at 4^oC until the seventh day when samples for individual rams were bulked, mixed thoroughly and sampled for moisture and crude protein determination in the laboratory. The apparent total tract digestibility per 100 g DM was calculated following Vhile *et al*. (2005) as: (amount of nutrient in feed minus amount of nutrient in faeces times 100)/ amount of nutrient in feed. Samples of the diets were taken once in the last week of each experimental period, stored in a refrigerator and used later to analyze for moisture, Crude Protein (CP), Crude Fibre (CF), ash and Ether Extract (EE) using the AOAC procedures (AOAC, 1997) and NDF and ADF assay using methods described by Van Soest *et al*. (1991). The metabolisable energy contents of the diets were estimated by the method of MAFF (1975) as: ME (MJ/Kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE, where CP, EE, CF and NFE are in g/kg DM. The rams were bled before feeding by jugular venipuncture between 06:30 and 07:30 h local time at the last day of each experimental period for haematological and blood biochemical assays. The blood samples were sent to the laboratory soon after collection in a sample holder placed in an ice chest. Two different test tubes were used to harvest blood from each of the rams. A plain test tube was used to collect blood to obtain serum for the determination of blood glucose, total protein, albumin and globulin. The other test tube, which contained Ethylene Diamine Tetra Acetic Acid (EDTA) as anticoagulant, was used to analyze for Haemoglobin (Hb) concentration, Packed Cell Volume (PCV), White Blood Cell (WBC) count and WBC count differential. Blood glucose level was determined soon after blood sampling by putting a drop of fresh blood on the strip of One Touch Ultra Glucometer (Johnson & Johnson Company, UK) for the glucose value to be displayed digitally after 5 sec. The serum total protein was determined by the biuret method and the albumin by the bromocresol method, using procedures previously described by others (Singh, 2004; Cheesbrough, 2004).

The globulin level was determined from the difference between total protein and albumin. The haemoglobin concentration (cyanmethaemoglobin method), packed cell volume (microhaematocrit method), white blood cell count (haemocytometer method) and the WBC count differential were also determined using standard procedures previously used by others (Jain, 1986; Cheesbrough, 2004; Rastogi, 2008).

Statistical analysis: The data collected were analysed by Analysis of Variance (ANOVA) and where appropriate the Duncan's multiple range test was used to compare significant treatment mean differences. The Pearson correlation technique was used to correlate daily weight gain with FCR, total DMI, CP intake and energy intake and DMI with energy intake and CP intake. The SPSS 16.0 for windows computer statistical package was used for the analyses.

RESULTS

The feeds used in the experiment and their analysed chemical contents are shown in Table 2. The rice straw and groundnut haulms mixture (T1) had lower CP, fat and energy and higher fibre content than the concentrate feeds. Crude protein was higher in T2 concentrate than in T3, but T3 concentrate had slightly higher energy content than T2 (Table 2). The productive performance and nutrient digestibility of the rams are presented in Table 3. The concentrate ate by the rams when on T2 and T3 formed 25.60% and 25.17%

Table 2: Inclusion levels of ingredients and analysed chemical composition of feeds offered to West African dwarf rams

	Experimental feed (g/kg DM)		
Ingredient	Rice straw + Groundnut haulms (T1)	T2 concentrate	T3 concentrate
Rice straw	625		
Groundnut haulms	375		
Shea nut cake		115	230
Soybean meal		335	220
Wheat bran		550	550
Analysed composition (Mean±SD)[+]			
Dry matter	917.3±11.9	890.2±18.1	891.7±16.0
Organic matter	895.2±03.8	947.1±10.0	949.4±02.3
Crude protein	87.8±03.1	263.9±03.4	234.3±00.4
Crude fibre	320.4±03.4	85.7±08.1	89.6±06.5
Ether extract	19.4±04.1	44.3±06.1	57.7±01.7
Ash	104.8±00.3	52.9±04.1	50.6±01.0
Nitrogen free extract	467.6±10.7	553.2±04.0	567.8±18.1
Neutral detergent fibre	641.3±01.8	370.9±02.7	393.8±01.1
Acid detergent fibre	442.3±00.4	158.8±04.0	180.7±01.7
ME (MJ/kg DM)*	9.8±00.4	12.7±00.3	13.0±00.3

[+]Mean of two analyses; *Estimated using the formula of MAFF (1975) as ME (MJ/Kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE, where CP, EE, CF and NFE are in g/kg DM

Table 3: Productive indices and nutrient digestibility of dwarf rams fed rice straw and groundnut haulms alone or with concentrate feeds containing different levels of shea nut cake

	Treatment			
Variable	T1	T2	T3	SE
Rice straw + Groundnut haulms (DM) intake, g/d	453.41	455.33	469.64	36.17
Concentrate DM intake, g/d	-	156.67	157.94	1.05
Total DM intake, g/d	453.41^{b}	612.01^{a}	627.58^{a}	36.48
Metabolic DM intake, g/kg $W^{0.75}$/d	58.2^{b}	74.17^{a}	79.44^{a}	2.91
DM intake (as percent of body weight)	2.94^{b}	3.31^{b}	3.99^{a}	0.19
Crude Protein (CP) intake, g/d	39.81^{b}	81.32^{a}	78.24^{a}	3.27
Energy intake, MJ ME/d	4.44^{b}	6.44^{a}	6.61^{a}	0.36
Weight gain, g/d	20.29^{b}	31.22^{ab}	39.29^{a}	4.42
Metabolic weight gain, g/kg $W^{0.75}$/d	2.63^{b}	3.87^{ab}	4.96^{a}	0.54
Feed Conversion Ratio (FCR), feed/gain	23.58	22.66	17.83	3.61
Protein:Energy ratio, g/MJ ME	8. 96^{c}	12.74^{a}	11.86^{b}	0.19
Protein efficiency ratio (gain/protein intake)	0.516	0.386	0.504	0.062
DM digestibility, g/100 g DM	71.50^{b}	77.86^{a}	60.10^{c}	1.33
CP digestibility, g/100 g DM	67.95^{b}	83.66^{a}	68.99^{b}	2.50

Treatments: T1 = Rice straw + Groundnut haulms only; T2 = T1 + concentrate containing 115 g/kg DM SNC; T3 = T1 + concentrate containing 230 g/kg DM SNC; SNC = Shea Nut Cake.

^{a,b,c}Values with differing superscripts in the same row differ significantly ($p<0.05$)

Table 4: Blood indices of dwarf rams fed rice straw and groundnut haulms alone or supplemented with concentrate feeds containing different levels of shea nut cake

	Treatment			
Variable	T1	T2	T3	SE
Haemoglobin (g/DL)	10.87	10.53	10.67	2.83
PCV (%)	32.70	31.20	31.50	8.16
WBC ($x10^6$/L)	8.67	8.37	9.30	2.13
WBC differential				
Lymphocytes (%)	53.80	50.50	53.08	10.95
Monocytes (%)	1.33	1.17	1.38	0.86
Neutrophils (%)	37.87	41.30	38.70	12.04
Eosinophils (%)	5.83	5.64	5.84	3.35
Basophils (%)	1.17	1.39	1.00	0.66
Serum metabolites				
Total protein (g/L)	56.00^a	59.50^b	61.34^b	4.54
Albumin (g/L)	18.33^a	19.67^{ab}	21.17^b	1.62
Globulin (g/L)	37.67	39.83	40.17	4.42
Glucose (Mmol/L)	5.63	5.90	5.77	1.03

Treatments: T1 = Rice straw + Groundnut haulms only; T2 = T1 + concentrate containing 115 g/kg DM SNC; T3 = T1 + concentrate containing 230 g/kg DM SNC; SNC = Shea Nut Cake. ^{a,b}values with differing superscripts in the same row differ significantly (p<0.05)

respectively of their total DMI. Supplementation improved DM, CP and energy intakes. Total DMI as percent of body weight was similar when rams were on T1 and T2 but was significantly higher on T3. Daily weight gain was highest when rams were on T3 followed by T2 and then T1, but only the difference between T1 and T3 was significant. FCRs were high in this experiment and appeared to decline with higher levels of SNC in the diet. The protein:energy ratios were different across treatments, with the lowest value being obtained when rams were fed on T1 and the highest when fed on T2. The protein efficiency ratio was, however, similar across treatment groups but it appeared that efficiency of protein utilisation declined slightly with increasing levels of protein intake. T2 had the best DM and CP digestibility and the trend of the data appeared to suggest that higher levels of SNC may lower nutrient digestibility. Daily weight gain was negatively correlated with FCR ($r = -0.77$; $p<0.01$) and positively with total DMI ($r = 0.51$; $p<0.05$), CP intake ($r = 0.56$; $p<0.05$) and energy intake ($r = 0.53$; $p<0.05$) while DMI was positively correlated with CP intake ($r = 0.90$; $p<0.01$) and energy intake ($r = 0.99$; $p<0.01$). Table 4 presents the blood profile of the rams. Supplementation did not appear to have affected the blood picture of the rams, except serum total protein and albumin which increased with supplementation.

DISCUSSION

All the three diets tested in this experiment were good enough for dry season feeding in the test area since they all promoted growth instead of the usual loss of weight that sheep in the area suffer in the dry season. The concentrate supplementation of the roughage did not improve the basal diet intake in this experiment even though total DMI was improved by it. A similar observation was made by Migwi *et al*. (2006) in Border Leicester x Merino cross wether lambs when oaten straw (7.4% CP) was supplemented with protein or protein and energy. In other experiments, however, concentrate supplementation reduced roughage intake even though total DMI increased (Jabbar and Anjum, 2008; Farid *et al*., 2010). The substitution effect of supplements on roughage intake or the lack of it may depend on the quantity of the supplement fed. Farid *et al*. (2010) reported that increasing concentrate levels caused a decline in roughage intake and increased total DMI in camels fed hay or straw, but when concentrate levels were reduced to 50% or 75% of ad libitum intake, roughage intake increased while total DMI decreased. The present concentrate level was less than 26% of total DMI and should, therefore, not be surprising that no substitution effect was observed. The present result corroborates the earlier observation that when forage has poor chemical-nutritive content dietary supplements do not have any substitution effect, as is usually seen in good pasture conditions (Avondo *et al*., 2008). The significant effect of concentrate supplementation on total DMI in this experiment may, therefore, be attributed to the higher CP intake when rams were fed on T2 and T3 compared to the control T1. The significant linear relationship between total DMI and CP intake ($r = 0.90$; $p<0.01$) in this experiment may attest to this. The present DMI obtained at periods that supplements were given is similar to the 629-636 g/d recorded by Baiden *et al*. (2007) when WAD sheep were supplemented with cassava pulp.

Higher feed intake and better efficiency of feed utilisation may account for the higher weight gain observed in periods that the rams were supplemented. This opinion may be supported by the positive linear relationship that daily weight gain had with total DMI ($r = 0.51$; $p<0.05$) and the negative linear relationship established between daily weight gain and FCR in this experiment ($r = -0.77$; $p<0.01$). The significant positive linear relationship between daily weight gain and CP and energy intakes may be used to explain the positive effect of supplementation on weight gain. It is well established that growth rate improves with increase in energy intake when protein is taken in excess of requirement. The better performance observed when the rams were on T3 is, therefore, ascribed to the high energy content of the feed due to the high proportion of SNC in the concentrate feed. The high dietary energy of T2 and T3 in this experiment may have allowed the production of more ME and fermentable products for rumen microorganisms, which may have resulted in a rise in the synthesis of microbial protein and hence the amount of protein available to the animal. An increase in the dietary protein level may have then caused a change in the process of rumen fermentation which increases fatty acid production and the ratio of propionate to fatty acids. These ruminal changes may have improved the energy balance of the rams allowing more nitrogen to be stored and thereby increasing the body weight (Kioumarsi *et al.*, 2008; Sayed, 2009). The present daily weight gains compare closely with the 16-48 g/d reported by Adu *et al.* (1992) when they fed stover supplemented with lablab to sheep, but they were low compared to the 79-91 g/d obtained by Baiden *et al.* (2007), most probably because of age and feed quality differences. The present results suggest that even though moderate levels of dietary SNC (T2) may improve nutrient digestibility, higher levels may reduce it (Table 3). This may be the result of the negative effects of anti-nutritive factors like theobromine and saponin in SNC (Annongu *et al.*, 1996).

The haemoglobin and PCV levels in this experiment were similar among treatment groups and fell within normal ranges previously reported for sheep (Baiden *et al.*, 2007; Bawala *et al.*, 2007). This means that the quality of the test feeds was good enough to maintain the good health of the rams. The WBC counts were similar among the treatment groups and fell within the normal range (5×10^6/dl to 11×10^6/dl) reported by Scott *et al.* (2006) for sheep. The similar WBC count and WBC count differential obtained imply that the ability of the rams to respond to and eliminate infection was not compromised with the inclusion of SNC in the diet up to the 230 g/kg DM level. The normal lymphocyte levels suggest that the immune systems of the rams were not impaired while the normal monocyte levels may indicate that the rams did not react to any infections during the experimental period (AACC, 2011). The similarity in basophil levels indicates that the rams showed no hypersensitivity reaction to the diets offered. The normal levels of eosinophils may indicate that the rams did not suffer from parasitic infections during the experimental period (AACC, 2011) while that of neutrophils may show the absence of bacterial infection or inflammatory disease (Naskalski *et al.*, 2007).

The serum metabolite values obtained in this experiment were all within the normal range reported for sheep (Pampori, 2003) and they compared favourably with values reported by Bawala *et al.* (2007). The glucose levels were higher than what Sowande *et al.* (2007) obtained, but the total protein values were lower. The serum total protein and albumin levels increased with concentrate supplementation, most probably due to improved dietary protein intake following supplementation.

Conclusion: Concentrate supplementation of roughage increased DMI, daily weight gain and serum total protein and albumin of the growing WAD rams. Shea nut cake inclusion in the concentrate feed up to 230 g/kg DM had no deleterious effect on the haematological and serum biochemical profile of the rams. It was concluded that all three test diets in this experiment could be used to feed sheep in the test area and that shea nut cake could be included in sheep diets up to the 230 g/kg DM inclusion level.

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