

Crop-residue supplementation of pregnant does influences birth weight and weight gain of kids, daily milk yield but not the progesterone profile of Red Sokoto goats

Bunmi Sherifat MALAU-ADULI^a, Lawrence EDUVIE^b, Clarence LAKPINI^b,
Aduli Enoch Othniel MALAU-ADULI^{b*}

^a Department of Animal Science, Ahmadu Bello University, PMB 1044 Zaria, Nigeria

^b National Animal Production Research Institute, Ahmadu Bello University, PMB 1096 Zaria, Nigeria

(Received 2 July 2003; accepted 20 January 2004)

Abstract – The parameters investigated in this study with the objective of evaluating growth, lactation and reproductive performances, included birth weight, litter size, 0–90 days gain and average daily gain of kids as well as the milk yield and progesterone profile of Red Sokoto does supplemented with crop-residue based rations during the long-dry period of the subhumid zone in Nigeria. A total of 7 treatments of 4 goats each was utilised. All treatment groups had a basal diet of *Digitaria smutsii* hay and natural pasture ad libitum. Ration A supplemented with the conventional concentrate was used as the positive control; rations B and C were supplemented with crop residues; and ration D without supplement was used as the negative control. Supplementation with concentrate and crop residues significantly increased ($P < 0.05$) the birth weight and liveweight gains of kids, but litter size was unaffected. The heaviest kids at birth (1.3–1.4 kg) were from does in treatments 1A, 2A and 2C, while does in treatments 1B, 2B, 1C and D had the lightest kids (1.07–1.18 kg). The highest gains of 53.9 g·day⁻¹ were recorded in treatment 2A and the least (32.4 g·day⁻¹) in treatment 1B. Supplementation also significantly influenced ($P < 0.01$) the daily milk yield of dams over the 90-day period of the dry season. All the does had similar progesterone profiles from late gestation through parturition to early lactation irrespective of their treatment group. It was concluded that ration C fed at the 2% level is a good and affordable supplementary feed package for increased birth weight and preweaning gains in kids for meat production.

Red Sokoto goats / supplementation / weight gains / milk / progesterone

1. INTRODUCTION

The success of any livestock production enterprise depends largely on adequate and qualitative nutrition. The majority of small ruminant farmers in Nigeria practice the extensive system of management which does not make provision for adequate fee-

ding. In the northern region of Nigeria where most of the nation's livestock are concentrated, there is a long and pronounced dry season lasting for six to nine months, often causing serious feed shortages for animals. The prolonged dry season and high temperatures are also accompanied by rapid deterioration in the nutrient

* Corresponding author: aduli40@yahoo.co.uk, aduli@affrc.go.jp

quality of available pasture hence, the basic nutritional requirements of the animals during pregnancy or lactation are not met [1]. The majority of Nigerian smallholder goat farmers resort to the easily available, cheap and abundant crop-residues from post-harvest farm operations to feed their animals instead of using the expensive, conventional concentrate ration. These crop residues are also limiting in nutrients necessary for maintenance and production. Therefore, supplementary feeding to boost the nutritional status of the animals has been advocated [2]. However, feed supplementation packages for improving reproductive and lactation performance of small ruminants during the long dry periods of the year are currently not available in Nigeria. Progesterone is the most important reproductive hormone necessary for the initiation and maintenance of pregnancy in female animals. Not much is known about the progesterone profiles of Red Sokoto does during late pregnancy, at parturition and during the early lactation period when the animals are supplemented with crop-residue rations, thus justifying the need for this study and its potential benefit to goat production in Nigeria. Therefore, this study was undertaken to investigate the effect of crop residue supplementation on the birth weight, 0–90 days gain and average daily gains in kids as well as daily milk yield and progesterone profile from late gestation through parturition to early lactation of the Red Sokoto doe.

2. MATERIALS AND METHODS

2.1. Experimental location

The experiments were conducted in the Experimental Unit of the Small Ruminant Research Programme of the National Animal Production Research Institute, Shika, Zaria, Nigeria. Shika falls between latitudes 11 and 12° N and between longitudes 7 and 8° E, with an altitude of 640 m above sea level. Shika is located within the North-

ern Guinea Savannah Zone with an average annual rainfall and temperature of 1107 mm and 24.4 °C respectively. The seasonal distribution of the annual rainfall is approximately 0.1% (11.0 mm) in the late-dry season (January–March), 25.8% (285.6 mm) in the early-wet season (April–June), 69.6% (770.4 mm) in the late-wet season (July–September) and 4.5% (49.8 mm) in the early dry season (October–December). The experiments were conducted during the dry seasons (between October and March).

2.2. Crop residue selection and preparation

The crop residues used in this study were guinea-corn bran, maize offal, cowpea husks, groundnut shells and groundnut haulms as depicted in Table I. They were

Table I. Components of ingredients in the experimental rations.

Ration	Ingredients	% inclusion
A + basal diet	Maize	40.0
	Wheat offal	35.0
	Cottonseed cake	20.0
	Bone meal	3.0
	Salt	2.0
B + basal diet	Guinea-corn bran	39.5
	Cowpea husk	30.0
	G/Nut haulms	30.0
	Salt	0.5
C + basal diet	Maize offal	49.5
	Groundnut shells	20.0
	Groundnut haulms	30.0
	Salt	0.5
	D (basal diet)	Digitaria hay and natural grazed pasture

Ration A = conventional concentrate (positive control). Ration B = crop-residue test ration 1. Ration C = crop-residue test ration 2. D = unsupplemented group (negative control) that was the basal diet common to all treatments.

selected because they were easily available, abundant, cheap and easy to process. These residues were bought in bulk from an open market. To aid consumption and digestibility, the groundnut shells were crushed before inclusion into the ration. All the crop residues were stored in a well-ventilated barn and required amounts compounded every fortnight to maintain freshness.

2.3. Animals, experimental rations and management

Twenty-eight adult Red Sokoto does with an average liveweight of 28 ± 3.5 kg were used for this study. Besides the negative control, the other treatments consisting of three experimental rations (A, B, C) and 2 feeding levels (1 and 2% of body weight) for each ration were arranged as a 3×2 factorial design. Thus, a total of 7 treatments of 4 goats each were utilized after balancing the animals for weight. All treatment groups had a basal diet of *Digitaria smutsii* hay and natural pasture ad libitum. Ration A the conventional concentrate ration, was used as the positive control, rations B and C were the two crop residue based test rations, while ration D the unsupplemented treatment, was used as the negative control. Does in treatment 1A had conventional concentrate at 1% of their body weight, those in treatment 2A also had conventional concentrate but at 2% of their body weight. Animals in treatments 1B, 2B, 1C and 2C were those fed the two crop-residue test rations B and C at 1% and 2% of body weight respectively. In terms of management, all animals were routinely dewormed with anthelmintic drugs (Ivomec and thiabendazole) and dipped in an acaricide (Asuntol) solution against ectoparasites. The animals were fed for two hours each day between 08.00–10.00 h with the appropriate ration. Feed was weighed before offering it to individual animals. The left-over was again weighed at the end and the difference between what was offered and the residual was taken as feed intake. Thereafter, they were released into a specified paddock to

graze natural pastures and *Digitaria smutsii* hay ad libitum under the supervision of a herdsman until 18.00 h. The animals were housed in well-ventilated pens during the night. The rations in all the groups were subjected to digestibility trials prior to being fed to the experimental animals as described below.

2.4. Digestibility measurement

Red Sokoto does ($n = 28$) ranging between 24.6 and 26.4 kg were used for the digestibility trial. Each doe was individually offered its appropriate corresponding ration to evaluate the digestibility of the diets. The study comprised a two-week preliminary period of realimentation and adjustment, and one week of sample 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 end of the study. The faeces were collected each morning just before feeding. Ten per cent of each daily faecal output was collected from which sub-samples were bulked for chemical analyses. Samples of the different rations fed were taken daily and bulked, from which sub-samples were taken for laboratory analysis. Also, samples of the individual feed ingredients were analysed in the laboratory. Water was made available to the animals ad libitum. The inventory, abundance and palatability of the plant species in the grazed paddock has been described by Lakpini et al. [3].

2.5. Kid weight and milk sampling

The animals were fed from the last trimester of pregnancy to parturition. At parturition, the doe and its kid(s) were separated and placed in individual pens. The kids were weighed within 8 h after birth and subsequently once every week until they were weaned. Dams were also weighed weekly starting from 20 days postpartum, until the end of the study. Measurements for milk yield commenced from day 7 postpartum to allow kids have access to all their

dams' colostrum. The two halves of the udder of each lactating doe were hand-milked early in the morning. The quantity of milk collected at each milking was recorded and the does were monitored from a week after delivery to the last day of milk let-down when the total lactation length was recorded. Milk samples were collected twice daily (morning and evening) from 7 days postpartum to 90 days after parturition.

2.6. Blood sampling

Blood samples (10 mL) for the progesterone assay were collected from each doe by jugular venipuncture twice a week during the last trimester of pregnancy. The blood samples were allowed to clot within two hours of collection and the sera were decanted into plastic tubes and stored at -20°C until analysis.

2.7. Chemical analyses

Proximate analyses of feed and faecal samples were carried out by the AOAC methods [4]. Dry matter of samples was determined in an oven at 105°C for 48 h. 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 solutions of H_2SO_4 and KOH. The detergent fibre fractions (neutral detergent fibre, acid detergent fibre and lignin) were determined according to Goering and Van Soest [5].

2.8. Hormonal assay of sera and milk samples

Progesterone concentration in the sera and milk samples was determined by the radio-immunoassay procedure using the solid phase coated tube system employing ^{125}I as the tracer supplied in a kit form by the Joint FAO/IAEA Division, Agriculture Laboratory, Siebersdorf. The assay procedure was as follows: the standard (100 μL)

was added to antibody tubes containing (0.1 to $40\text{ ng}\cdot\text{mL}^{-1}$) of the sample and 1 mL buffered [^{125}I] labelled progesterone solution. The mixture was incubated for 3 h at room temperature, the liquid phase was discarded (centrifugation is not required) and the radioactivity bound to the antibody-coated tube was counted. The immunogen used to raise the antibody and radioiodinated progesterone (tyrosine methyl ester) are both 11 α -linked conjugates. The cross-reactivity, 3.8%, was with 11 α -hydroxy progesterone [6]. The sensitivity of the assay defined as twice the standard deviations away from the zero standard was $0.08\text{ ng}\cdot\text{mL}^{-1}$. The within and between assay coefficients of variation were 8.5% and 9.5% respectively. The potencies of the samples were estimated using a linear logit-log dose response curve.

2.9. Calculations and statistical analysis

Dry matter intake (DMI) was determined using the following equation:

$$\text{DMI (g}\cdot\text{day}^{-1}) = \% \text{DM}/100 \times \text{feed intake.}$$

Dry matter digestibility (DMD (%)) was calculated as:

$100 \times [\text{DM intake (g)} - \text{DM output (g)}] \cdot \text{DM}^{-1} \text{ intake (g)}$. The other digestibilities were calculated as above. Data on kid birth weight and weight gains, dam's daily milk yield and peripheral progesterone concentrations were statistically analysed using the general linear models procedure (PROC GLM) of SAS [7] in a 3×2 factorial (3 rations and 2 feeding levels) analysis to test for significant differences between the means. The model below was utilised:

$$Y_{ijk} = \mu + R_i + F_j + (RF)_{ij} + b_1(w_{ijk} - w) + e_{ijk}$$

where Y_{ijk} = dependent variable of the k th doe on the i th ration and the j th feeding level, μ = the overall mean, R_i = fixed effect of the i th ration ($i = 1, 3$), F_j = fixed effect of the j th feeding level ($j = 1, 2$), $(RF)_{ij}$ = interaction between the i th ration and j th

Table II. Chemical composition of the major feed ingredients (DM basis) (%).

Feedstuff (<i>n</i> = 7 samples/ingredient each)	DM	CP	CF	Ash	EE	NFE
Maize	90.73	9.56	2.20	9.67	4.05	74.52
Wheat offal	87.60	16.90	11.30	6.40	3.80	61.60
Cottonseed cake	93.60	29.94	23.50	5.16	5.76	35.64
Bone meal	75.00	36.00	3.00	49.00	4.00	8.00
Guinea corn bran	93.33	7.60	24.80	6.95	3.01	59.90
Cowpea husks	91.41	7.10	33.40	7.14	0.65	58.91
Groundnut haulms	93.65	15.63	23.26	8.00	2.43	51.00
Maize offal	89.07	10.08	1.50	0.80	1.70	60.30
Groundnut shells	96.05	5.90	31.80	8.50	1.31	50.30

DM = dry matter, CP = crude protein, CF = crude fibre, EE = ether extract, NFE = nitrogen-free extracts.

feeding level, b_1 = partial regression coefficient of initial body weight with mean w , w = initial body weight fitted as a covariate, e_{ijk} = random error associated with each record with a mean of 0 and variance σ_e^2 .

Primary and secondary interactions of fixed effects with initial body weight were also tested but later dropped from the model since all the interactions were not significant, mainly because all the animals were as much as possible, balanced for initial weight and age at the start of the experiment. The contrast option of the Tukey test was used for mean separation where significant differences ($P < 0.05$) were established between the treatments.

3. RESULTS

3.1. Feed intake and digestibility

Tables I, II, III and IV show the component of ingredients, chemical composition of the major feed ingredients, chemical composition of the experimental diets and their digestibilities respectively. Ration A had the highest crude protein (CP) of 17.19%, rations B and C had 9.54 and 10.38%

respectively, while ration D had the least with *Digitaria smutsii* hay and natural grazed pastures having 4.75 and 2.76% respectively (Tab. III). There were differences ($P < 0.05$) in nutrient intake, digestibility and cost of feeds between the different treatment groups (Tab. IV). The table shows that generally, the supplemented groups had significantly higher ($P < 0.05$) DM and CP intakes and digestibilities than the unsupplemented group except animals on ration B that had similar values to the unsupplemented group. It was also evident that increasing the level of supplementation also resulted in increased DM and CP intakes of all the experimental rations, with these increases being significant ($P < 0.05$) and similar for rations A and C. It was also observed that supplementation increased the digestibility of all the nutrients. However, the animals on ration B recorded very poor digestibility values and their counterparts in the unsupplemented group had the lowest values. Ration 1A (the conventional concentrate at a 1% body weight) gave the highest digestibility values; a comparison of the unsupplemented animals with all the other treatment groups reveals that DM digestibility improved by a range of 4.1 to 27.9% and CP digestibility by 17.1 to 42.2%,

Table III. Chemical composition of the experimental diets (dry matter basis) (%).

Ration (<i>n</i> = 7 samples/ration each)	DM	CP	Ash	EE	ADF	NDF	LIGNIN
Ration A	93.87	17.19	13.85	14.08	20.00	40.01	4.64
Ration B	94.97	9.54	10.55	10.43	38.10	68.42	8.94
Ration C	95.94	10.38	11.97	12.45	36.65	54.74	8.23
Ration D (Hay)	94.78	4.75	8.47	2.40	49.14	74.73	9.49
Ration D (Natural pastures)	96.26	2.76	7.02	0.78	50.29	80.27	11.50

Calculated analysis of the experimental rations.

	Ration A	Ration B	Ration C
CP (%)	17.05	9.82	10.85
ME (MJ·kg ⁻¹ DM)	11.17	10.29	10.17

The ME values of the experimental rations were calculated as per Alderman [27] as follows: $ME (MJ \cdot kg^{-1} DM) = 11.78 + 0.00654CP + (0.000665EE)^2 - CF(0.00414EE) - 0.0118A$ where CP = crude protein, EE = ether extract, CF = crude fibre, A = ash. DM = dry matter, ADF = acid detergent fibre, NDF = neutral detergent fibre.

Table IV. Mean nutrient intake, apparent digestibility and cost of the experimental diets.

Treatment	1A	2A	1B	2B	1C	2C	D	SEM
Nutrient intake (kg·day ⁻¹)								
DM	0.24 ^b	0.47 ^a	0.21 ^{b,c}	0.30 ^{a,b}	0.23 ^b	0.42 ^a	0.15 ^c	± 0.02
CP	0.044 ^a	0.087 ^a	0.012 ^b	0.017 ^b	0.032 ^a	0.072 ^a	0.009 ^b	± 0.01
Apparent digestibility of nutrients (%)								
DM	84.3 ^a	83.0 ^a	62.5 ^d	60.5 ^c	75.8 ^b	67.8 ^c	56.4 ^f	± 2.8
CP	90.6 ^a	89.2 ^a	69.5 ^d	65.5 ^c	82.7 ^b	78.1 ^c	48.4 ^f	± 3.1
NDF	69.5 ^a	66.6 ^b	62.1 ^{c,d}	61.9 ^d	65.9 ^b	63.7 ^c	60.1 ^e	± 3.2
ADF	51.7 ^a	49.8 ^a	43.9 ^{b,c}	42.8 ^c	46.1 ^b	44.4 ^{b,c}	42.3 ^{b,c}	± 5.0
Economic analysis of the feeds (Naira)*								
Cost of feed consumed per day	2.19 ^b	4.42 ^a	0.50 ^e	1.06 ^d	0.83 ^{de}	1.55 ^c	–	± 0.15

a,b,c,d,e,f Means within the same row bearing different superscript letters differ significantly ($P < 0.05$).
 * Naira = Nigerian currency (100 kobo make 1 naira and current exchange rate is 1 US\$ = 140 naira). DM = dry matter, CP = crude protein, NDF = neutral detergent fibre, ADF = acid detergent fibre. Treatment: 1A = ration A (conventional concentrate) offered at 1% of body weight. 2A = ration A (conventional concentrate) offered at 2% of body weight. 1B = crop-residue test ration B offered at 1% of body weight. 2B = crop-residue test ration B offered at 2% of body weight. 1C = crop-residue test ration C offered at 1% of body weight. 2C = crop-residue test ration C offered at 2% of body weight. D = unsupplemented group.

Table V. Effect of ration supplementation of Red Sokoto does on daily milk yield, litter size, birth weight, 0–90 days weight gain and average daily gains of their kids (\pm SEM).

Ration	Dam's milk yield (kg·day ⁻¹)	Littersize	BWT (kg)	WT30 (kg)	WT60 (kg)	WT90 (kg)	ADG (g·day ⁻¹)
1A	0.48 ^b	1.34	1.3 ^a	2.33 ^b	3.50 ^b	5.54 ^{a,b}	47.11 ^b
2A	0.62 ^a	1.32	1.4 ^a	3.30 ^a	4.70 ^a	6.25 ^a	53.88 ^a
1B	0.27 ^d	1.34	1.09 ^b	1.95 ^b	3.09 ^b	4.01 ^c	32.44 ^d
2B	0.36 ^c	1.30	1.07 ^b	2.04 ^b	3.05 ^b	4.33 ^c	36.11 ^c
1C	0.60 ^a	1.31	1.11 ^b	2.55 ^b	3.85 ^{a,b}	5.88 ^{a,b}	53.00 ^a
2C	0.45 ^b	1.32	1.34 ^a	2.20 ^b	3.45 ^b	5.33 ^b	44.33 ^b
D	0.25 ^d	1.31	1.18 ^b	1.88 ^b	2.98 ^c	4.16 ^c	33.11 ^d
SEM	\pm 0.02	\pm 0.09	\pm 0.16	\pm 0.21	\pm 0.30	\pm 0.27	\pm 0.17

Column means bearing different superscripts differ from each other significantly ($P < 0.01$). BWT = birth weight, WT30, WT60, WT90 are liveweights at 30, 60 and 90 days, ADG = average daily gain. Ration symbols as described in Table IV.

the highest being in animals on ration 1A. Similar improvement trends were also noticeable for neutral detergent fibre (NDF) and acid detergent fibre (ADF). A simple economic analysis (Tab. IV) revealed that the conventional concentrate feed was the most expensive for supplementation particularly at the 2% level (4.42 naira per animal per day). Amongst the two tested crop-residue rations, ration 1B was significantly cheaper ($P < 0.05$) than rations 2B and 2C, but similar to ration 1C.

3.2. Influence of supplementation on kid birth weight and weight gains, litter size and milk yield

Portrayed in Table V is evidence that there was a highly significant ($P < 0.01$) effect of feed supplementation during gestation on the birth weight of kids whereas litter size was unaffected ($P > 0.05$). Does on ration 2A had the heaviest kids (1.4 kg) at birth, followed by kids whose dams were fed ration 2C (1.34 kg). Does on ration 2B had the lightest kids at birth (1.07 kg) but this was not significantly different from the birth weights of kids whose dams were fed

rations 1B, 1C and D. It was also evident that supplementation significantly ($P < 0.001$) increased dam's daily milk yield in that does on ration 2A gave 0.62 kg of milk per day (not significantly different from the 0.60 kg·day⁻¹ from does on ration 1C), compared to the lowest milk yield of 0.25 kg·day⁻¹ from the unsupplemented does (ration D). There were significant differences in the liveweights and gains of kids as they advanced in age. At 30 days of age (WT30), kids of does fed ration 2A were significantly ($P < 0.01$) heavier than all the others. This weight advantage was consistently maintained from 60 (WT60) to 90 (WT90) days of age with kids weighing 4.70 and 6.25 kg respectively. This superiority over the other treatment groups was also reflected in the average daily gain (ADG) of 53.88 g. However, kids from does fed crop-residue test rations 1C ranked next with WT30, WT60, WT90 and ADG values of 2.55, 3.85, 5.88 kg and 53.00 g·day⁻¹ respectively. It was also consistently evident that kids from dams that were unsupplemented (ration D) and those fed crop-residue test rations 1B and 2B recorded the least weights and average daily gains.

Table VI. Progesterone concentration ($\text{ng}\cdot\text{mL}^{-1}$) during late gestation, pre-partum, at parturition and post-partum (\pm SEM) in Red Sokoto does supplemented with crop residue rations.

Ration	Late gestation (day 120–day 140)	Pre-partum (day 6–day 2)	Parturition (day 0)	Post-partum (day 1–day 15)
1A	13.03	8.90	0.09	0.17
2A	12.98	9.06	0.09	0.16
1B	13.04	9.05	0.11	0.20
2B	12.98	8.92	0.09	0.18
1C	12.92	8.94	0.09	0.19
2C	12.88	9.04	0.10	0.17
D	13.05	8.98	0.10	0.18
SEM	± 0.45	± 0.22	± 0.05	± 0.11

3.3. Progesterone profile

Hormonal assay results shown in Table VI and Figure 1 reveal that right from late gestation through parturition to early lactation, the progesterone profile was remarkably similar for all does irrespective of treatment groups. The progesterone (P_4) concentrations were quite high in late gestation with an average value of $13 \text{ ng}\cdot\text{mL}^{-1}$ (Tab. VI) and the highest value of $17.08 \text{ ng}\cdot\text{mL}^{-1}$ at day 140. At parturition, the P_4 concentration dropped sharply to an average of $0.10 \text{ ng}\cdot\text{mL}^{-1}$, then rose slowly in early lactation to $0.18 \text{ ng}\cdot\text{mL}^{-1}$. However, there were no significant supplementation effects on progesterone profiles of the does.

4. DISCUSSION

4.1. Ration intake and digestibility

The preponderance of crop residues in rations B and C was responsible for their high crude fibre and lignin levels compared to the conventional concentrate ration A. The current study showed that even though rations B and C were isocaloric and isonitrogenous, the animals on ration C had better intakes and digestibilities than those on ration B, possibly due to the low palatability, hence low voluntary intake, and poor digestibility of ration B.

The observed higher digestibilities of DM, CP, NDF and ADF at the 1% level in comparison to the 2% level can be attributed to the higher feed intake at the 2% level of inclusion. It has been established that higher feed intake results in a faster rate of passage of digesta from the reticulo-rumen [8]. This does not allow for effective degradation, hence lowering the digestibility of feed. Increasing the level of crop residue inclusion in the diet also increases the amount of lignin, which depresses the digestibility of the ration [9], because the rate of microbial colonisation of a feed with high fibre content is comparatively lower [10]. The poor intake and digestibility values obtained for the unsupplemented animals is due to the fact that ration D was of low quality as a result of its high NDF and lignin contents. This shows that there is the need for dry season supplementation in goats because the available feeds at that time are limiting in crude protein.

Amongst the two tested rations, ration C seemed to have produced better intakes and digestibilities in the animals, possibly due to the composition of the rations. It contained maize offal which has very low fibre content [2], groundnut haulms which have been demonstrated to be better quality roughages than *Digitaria smutsii* hay and contain adequate protein to maintain ruminants without any form of supplementation

during the periods of feed scarcity [11]. The groundnut shells fed to the animals were also crushed before inclusion into the ration as earlier stated. This must have aided their consumption and digestibility. Even though ration B contained groundnut haulms, the combination of Guinea corn bran and cowpea husk which had low crude protein percentages, must have reduced the intake and digestibility of the ration. Alhassan et al. [12] observed lower digestibility values in sheep and goats (48.8 and 56.3% respectively) compared with cattle (73.6%) when they fed them cowpea vines. This might imply that cattle do better on cowpea residues than small ruminants. Generally speaking, digestibility of feeds in cattle is lower than that in sheep or goats under similar conditions because of the higher rate of passage from the rumen in cattle than sheep or goats. From the economic analysis, the high cost of the conventional concentrate ration shows that it is beyond the reach of a typical smallholder goat farmer; whereas the crop-residue based rations seem quite affordable. Even though ration B had the lowest cost, it was clear that it had lower intake and digestibility compared to ration C, indicating in essence, that ration C had a better efficiency of utilisation.

4.2. Birth weight and weight gains of kids

The importance of supplementation during the last lap of pregnancy was confirmed in this study with does on ration 2A producing the heaviest kids at parturition compared to the unsupplemented does (ration D) having the lightest kids at birth. However, dams fed ration 1A and 2C also had kids with birth weights similar to those of ration 2A.

The growth rate of kids was influenced by the type of ration offered to their dams during lactation, and the average daily gain was found to be the lowest ($32.44 \text{ g}\cdot\text{day}^{-1}$) in kids from dams fed ration 1B and highest in ration 2A ($53.88 \text{ g}\cdot\text{day}^{-1}$). As the kids advanced in age from birth to 90 days, the effect of dam supplementation was reflected

in their liveweight gains in agreement with the report of Ahmed et al. [13]. The highest ADG value of $53.88 \text{ g}\cdot\text{day}^{-1}$ in this study fell within the range of $64 \text{ g}\cdot\text{day}^{-1}$ reported in West African Dwarf does [14–16], but much lower than $150 \text{ g}\cdot\text{day}^{-1}$ in Yankasa lambs [17]. The lower values in this study are justifiable given the fact that it was conducted in the long-dry season of the year when naturally grazed pasture and feed resources are critically low. The average litter size of 1.3 reported herein was similar to the findings of Adu et al. [1]. The observation that supplementation did not affect litter size agreed with that of Sibanda et al. [18], indicating that litter size may be controlled more by genetic, rather than nutritional, factors.

The effects of various crop residues on feed intake, liveweight gains and growth performance of ruminants have been reported by Adu and Lakpini [19, 20] and Ikhatua and Adu [11]. Adu and Lakpini [20] obtained liveweight gains of $90.2 \text{ g}\cdot\text{day}^{-1}$ in Yankasa lambs fed a sole diet of unchopped groundnut haulms. In the study by Ikhatua and Adu [11], supplementation of groundnut haulms with concentrate further enhanced the intake and performance of the animals. Similar effects of supplementation were observed in this study.

The observation that birth weight in ration 2C was higher than that of 1C but the subsequent growth thereafter was reversed (Tab. V) was probably a result of the incidence of scouring (diarrhea) that occurred in kids on ration 2C. The weight losses observed in does fed rations 1B and D could be attributed to the low palatability, low intake and poor digestibility of the feeds.

4.3. Daily milk yield of dams

This study also confirmed that the milk yield of does can be improved by supplementing their pasture diets with some concentrates [21]. The observed values of daily milk yield in does fed rations 2A and 1C were higher than those reported by Adu

et al. [1], Akinsoyinu et al. [22] and Ehoche and Buvanendran [16]. This increase in milk yield may be due to improvement as a result of selection over the years within the Red Sokoto breed. The inference that can be drawn from this observation is that feeding lactating does ration 1C irrespective of the fact that it is mainly a crop residue ration, gives just as good a result in terms of daily milk yields, as full concentrate rations. This holds hope for smallholders interested in improving the milk yield of their Red Sokoto dams without necessarily embarking on an expensive concentrate ration. It was expected that ration 2C with a higher dry matter intake in comparison with ration 1C (Tab. IV) would give a higher milk yield, but the reverse was the case (Tab. V). The reason is because the fat content of the milk from does on ration 2C was higher than that of does on ration 1C [23, 24]. There is an inverse relationship between total milk yield and fat content in lactating animals [25] which explains why this trend was observed. This suggests that if Nigerian goat producers in the subhumid zone intend to place more emphasis on total milk yield rather than on fat content of the milk, then going by our results in this study, ration C fed at the 1% level of inclusion is better than at the 2% level.

4.4. Progesterone profile during late pregnancy, at parturition and early lactation

This study indicated that the level of supplementation does not affect the progesterone profile and concentration from the last trimester of gestation to early lactation (Tab. VI). This may mean that the endocrine system is resilient to nutritional stress at this period. Progesterone plays a major role in the development, the luteolytic signal and maintenance of regular ovarian cycles. Therefore, progesterone can probably inhibit the development of the luteolytic mechanism until endometrial progesterone receptor activity is lost [26]. However, more studies are required to ascertain the

effect of undernutrition on the endocrine changes occurring in the Red Sokoto doe through gestation to early lactation.

In conclusion, this study demonstrates that ration C elicited as much favourable response in the birth weight and liveweight of Red Sokoto kids, the daily milk yield of their dams as the conventional concentrate ration A which may be too expensive for the local farmer to purchase. Furthermore, in this experiment, the ration differences did not affect plasma progesterone concentration and profile during late gestation through early lactation.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the International Atomic Energy Agency (IAEA) Vienna, Austria in funding this project through provision of the hormonal assay kits and chemical reagents. The technical assistance in ELISA protocols by Mr. Joe Iyayi of the Animal Reproduction Laboratory, NAPRI, ABU Zaria, is appreciated. We are grateful to the Director of the National Animal Production Research Institute, Ahmadu Bello University Shika-Zaria for permission to publish this work.

REFERENCES

- [1] Adu IF, Buvanendran V, Lakpini CAM. The reproductive performance of Red Sokoto goats in Nigeria. *J Agric Sci (Camb)* 1979, 93: 563–566.
- [2] Alawa JP, Umunna NN. Alternative feed formulation in the developing countries: Prospects for utilisation of agro-industrial by-products. *J Anim Prod Res* 1993, 13: 63–98.
- [3] Lakpini CAM, Balogun BI, Alawa JP, Onifade OS, Oturu SM. Effects of graded levels of sun-dried cassava peels in supplement diets fed to Red Sokoto goats in the first trimester of pregnancy. *Anim Feed Sci Technol* 1997, 67: 197–204.
- [4] AOAC. Association of Official Analytical Chemists. *Official Methods of Analysis*, 13th Ed, Washington DC, USA, 1980.
- [5] Goering HK, Van Soest PJ. Forage fibre analysis (apparatus, reagents, procedures and some

- applications). Agricultural Handbook 379, ARS, USDA, Washington DC, 1970.
- [6] Kubasik NP, Hallauer GD, Brodows RG. Feeding alternatives to small ruminants. *Clin Chem* 1984, 30: 284–290.
- [7] SAS. Statistical Analysis System. SAS Institute, Cary, North Carolina, USA, 1987.
- [8] Swan H, Lamming GE. Studies on the nutrition of ruminants: II. The effect of crude fibre in maize-based rations on the carcass composition of Friesian steers. *Anim Prod* 1967, 9: 203–208.
- [9] McDonald P, Edwards RA, Greenhalgh JFD. *Animal Nutrition*, 4th Ed, Longman Scientific and Technical, England, UK, 1988.
- [10] Silva AT, Orskov ER. The effect of five different supplements on the degradation of straw in sheep given untreated barley straw. *Anim Feed Sci Technol* 1988, 19: 289–298.
- [11] Ikhataua UI, Adu IF. A comparative evaluation of the utilization of groundnut haulms and *Digitaria* hay by Red Sokoto goats. *J Anim Prod Res* 1984, 4: 145–152.
- [12] Alhassan WS, Ehoche OW, Adu IF, Obilara TA, Kallah MS. Crop residue potential of agricultural development projects: Nutritive value and residue management. NAPRI Annual Report, National Animal Production Research Institute, Shika, Nigeria, 1984, p 35–45.
- [13] Ahmed MMM, El Hag FM, Wahab FS, Salih SF. Feeding strategies during summer for lactating desert goats in a rain-fed area under tropical conditions. *Small Rumin Res* 2001, 39: 161–166.
- [14] Kirkpatrick R, Akindele ZT. Reproduction in West African Dwarf goats. *J Anim Sci* 1974, 39: 163–167.
- [15] Mba AU, Boyo BS, Oyenuga VA. Studies on the milk composition of West African Dwarf, Red Sokoto and Saanen goats at different stages of lactation. *J Dairy Res* 1975, 42: 217–226.
- [16] Ehoche OW, Buvanendran V. The yield and composition of milk and pre-weaning growth rate of Red Sokoto goats in Nigeria. *World Rev Anim Prod* 1983, 19: 19–24.
- [17] Osinowo OA, Abubakar BY. Appropriate breeding strategies for small ruminant production in West and Central Africa. OAU/IBAR, Nairobi, Kenya, 1988.
- [18] Sibanda LM, Ndlovu LR, Bryant MJ. Effects of a low plane nutrition during pregnancy and lactation on the performance of Matebele does and their kids. *Small Rumin Res* 1999, 32: 243–250.
- [19] Adu IF, Lakpini CAM. The utilisation of dried poultry as protein supplement for growing Yankasa sheep. *J Anim Prod Res* 1983, 3: 49–56.
- [20] Adu IF, Lakpini CAM. Effect of feeding chopped and unchopped groundnut haulms (“Harawa”) on nutrient utilisation and the production of rumen metabolites in Yankasa lambs. *Nigerian J Anim Prod* 1983, 10: 110–113.
- [21] Garmo TH. Dairy goat grazing on mountain pasture. I. Effect of supplementary feeding. *Landbrukshwagsk* 1986, 241: 1–19.
- [22] Akinsoyinu AO, Tewe OO, Ngere LO, Mba AU. Milk composition and yield of the Red Sokoto (Maradi) goats. *Dairy Sci Abstr* 1982, 43: 83–84.
- [23] Malau-Aduli BS, Eduvie L, Lakpini C, Malau-Aduli AEO. Chemical compositions, feed intakes and digestibilities of crop-residue based rations in non-lactating Red Sokoto goats in the subhumid zone of Nigeria. *Anim Sci J* 2003, 74: 89–94.
- [24] Malau-Aduli BS, Eduvie L, Lakpini C, Malau-Aduli AEO. Variations in liveweight gains, milk yield and composition of Red Sokoto goats fed crop-residue-based supplements in the subhumid zone of Nigeria. *Livest Prod Sci* 2003, 83: 63–71.
- [25] Malau-Aduli AEO, Anlade YR. Comparative study of milk compositions of cattle, sheep and goats in Nigeria. *Anim Sci J* 2002, 73: 541–544.
- [26] Meyer HHD, Mittermeier T, Schams D. Dynamics of oxytocin, oestrogen and progesterin receptors in the bovine endometrium during the oestrous cycle. *Acta Endocrinol* 1988, 118: 96–104.
- [27] Alderman G. Prediction of the energy value of compound feeds. in: Haresign W, Cole DJA (Eds), *Recent advances in animal nutrition*. Butterworths, London, UK, 1985.