Tropical and Subtropical Agroecosystems, 8 (2008): 61 - 67

Tropical and Subtropical Agroecosystems

PERFORMANCE CHARACTERISTICS AND NITROGEN UTILIZATION OF PREGNANT WEST AFRICAN DWARF GOATS FED GROUNDNUT CAKE, UREA AND RUMEN EPITHELIAL WASTES IN CASSAVA FLOUR AND CITRUS PULP–BASED DIETS

[COMPORTAMIENTO PRODUCTIVO Y UTILIZACIÓN DE NITRÓGENO EN CABRAS ALIMENTADAS CON PASTA DE CACAHUATE, UREA Y EPITELIO RUMINAL EN DIETAS ELABORADAS CON HARINA DE YUCA Y PULPA DE CITRÍCOS]

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SUMMARY

Rumen epithelial waste (REW) is a cheap source of protein for livestock. Twenty-four pregnant West African dwarf goats (WAD) were allotted to six diets consisting REW, cassava flour (CFL), groundnut cake (GNC), urea and citrus pulp (CPP) based diets as diets A) REW + CFL, B) GNC + CFL, C) Urea + CFL, D) REW + CPP, E) REW + CPP and F) GNC + CPP. At weeks 12 and 16 of gestation, does were transferred to individual metabolic cages modified for separate collection of faeces and urine for 7 days. Results showed that 60% of the total voluntary dry matter consumed by the goats came from the concentrate supplement. Dietary effects on DMI were not significant. DMI (range from 896.3 – 915 g/d) were adequate as the animals gained daily (80.0 – 110.0 g). Pregnancies were carried to term with similar gestation lengths (150.0 – 152.0 days). Birth weights (1.8 – 2.2 kg), milk yield varied (469.7 to 482.6 g/day) and nutrient digestibility were not influenced by diets. Regression equation relating N-intake to N-balance showed that WAD goats required (g/d/kg $w^{0.75}$), 1.04 digestible crude protein (DCP) for maintenance during pregnancy. It is concluded that the performance of WAD goats fed REW-based diets compared well with groundnut cake based diets.

Key words: Rumen epithelial wastes, groundnut cake, urea, pregnancy, goats

RESUMEN

El epitelio ruminal (REW) es un subproducto económico que puede ser empleado como fuente de proteína para los rumiantes. Se emplearon 24 cabras gestantes para evaluar seis dietas formuladas con REW, harina de yuca (CFL), pasta de cacahuate (GNC), urea y pulpa de cítricos (CPP). Las raciones fueron A) REW + CFL, B) GNC + CFL, C) Urea + CFL, D) REW + CPP, E) REW + CPP y F) GNC + CPP. En la semana 12 y 16 de gestación los animales fueron transferidos a jaulas metabólicas para la colección heces y orina por 7 d. Se encontró que el 60% del consumo total de materia seca (DMI) fue concentrado. No se encontró efecto de los tratamientos sobre DMI. El rango de consumo (896.3 a 915 gMS/d) permitió ganancias entre 80 y 110g/d. Todas las gestaciones llagaron a término. No hubo efecto sobre peso al nacimiento (1.8 a 2.2 kg), producción de leche (469.7 a 482.6 g/d) y digestibilidad de nutrimentos. Se estimó por balance de N una necesidad para mantenimiento (durante la preñez) de 1.04 g/d/kg $w^{0.75}$) de proteína cruda digestible. Se concluyó que el comportamiento productive de las cabras enenas africanas alimentadas con REW es comparable al obtenido con dietas de pasta de cacahuate.

Palabras clave: Epitelio ruminal, pasta de cacahuate, urea, cabras, preñez, necesidades nitrógeno.

INTRODUCTION

Pregnant West African dwarf (WAD) goats require a quality feeding. Dietary energy and protein are paramount to excellent productivity. The conventional protein and energy sources in concentrate supplement to such grazing animal are groundnut meal and grains (maize and millet), which are also use as human food (Babayemi and Bamikole, 2006). Wastes or by-products from livestock (Bawala and Akinsoyinu, 2006) or plant origin (unconventional feedstuffs) are useful resources if properly managed and processed. Utilization of agro-industrial by–products or crop residues in goats feeding could curtail cost of production by replacing the conventional sources of dietary energy or protein with these wastes.

Groundnut cake (GNC) is a residue from the groundnut oil processing industry, in Nigeria, is still expensive and unaffordable to many ruminant livestock farmers. Groundnut is a conventional protein source mainly for monogastrics and human consumption. Urea is non protein nitrogen (NPN), obtained from petroleum industry. It had been used as a source of dietary protein for ruminants but is becoming expensive due to a renewed interest for arable crop farming. Citrus pulp is a by-product of fruit juice producing industries, which now strive well in Nigeria. It is obtained after a thorough extraction of the juice and the residue is available in sun-cured form throughout the year. Rumen epithelial waste (REW) is an abattoir disposal, being a scrapped-off from the rumen linings, suggesting a high protein source. Information on REW is scanty (Bawala *et al.,* 2006) and yet to be exploited for livestock feed. The objectives of the study were (i) to determine the performance and nitrogen utilization of pregnant WAD goats fed unconventional rumen epithelial wastes, conventional groundnut cake, urea, citrus pulp and cassava flour-based diets and (ii) to appraise the extent to which the diets could support pregnancy, lactation and requirements for dietary proteins.

MATERIAL AND METHODS

Experimental site

The study was carried out at the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. The location is 7º27'N and 3º45'E at altitude 200 - 300 m above sea level; mean temperature of 25 - 29 ºC and the average annual rainfall of about 1250 mm.

Sample collection and preparation

Rumen epithelial waste (REW) was collected at abattoir, Bodija, Ibadan. This waste was sun cured on clean concrete floor until it was properly dried to about 12% moisture and then stored until ready for inclusions into the diet. The citrus pulp was chopped into pieces and sun cured. It was then ground in a feed mill and stored in a jute bag until required for analysis or incorporated into balance ration.

Animals and their management

Twenty-four primiparous WAD female goats aged 14 - 18 months and 16 - 18 kg body weight were purchased from the villages around the University where the experiment was carried out. The goats were quarantined and were certified free from endo and ecto parasites by resident veterinarian. Proper adaptation was ensured by supplying the animals with the local feed they were used to such as corn gluten, cowpea husk and cassava peels as supplement to grass (*Panicum maximum*).

Heat inducement

The twenty four goats were kept in individual pens where each was induced into heat through synchronization by injecting 0.5 ml of prostaglandin F_2 α. After 24 hours of inducement, a herd buck was released to each doe and this was repeated three times daily for four consecutive days in order to detect heat. Does that have been confirmed to be on heat were then served by the buck. An additional dose of 0.5 ml was repeated for animals that failed to come on heat.

Experimental diets

The twenty-four pregnant experimental goats were randomly divided into six groups of four goats per group. Each group was fed any of the six iso-nitrogenous and iso-caloric diets which were formulated as urea + citrus pulp (A), REW + cassava flour (B), GNC + cassava flour (C), urea + cassava flour (D), REW + citrus pulp (E) REW + CPP and (F) GNC + citrus pulp (Table 1 and 2). The diets were fed to the goats as supplement to Guinea grass (*Panicum maximum*). Diets A, B, C, D, E and F were formulated such that REW, GNC and urea supplied 15% of dietary protein in either citrus pulp or cassava based media. The pregnant does had free access to fresh water daily. Each doe was offered 500 g DM of Guinea grass and 600 g DM of supplement daily (Table 2). Daily intake was measured by deducting the remnants from the amount served. Changes in body weight were determined from the records obtained by weighing the animals once a week before morning feeding.

Digestibility trial

At weeks 12 and 16 of gestation, each doe was transferred into individual metabolic cages, which had been modified (Akinsoyinu, 1974) for separated collection of faeces and urine. A week was allowed for adjustment to the cages before daily collection of faeces and urine for an upward of 7days. Total faeces were weighed and urinary outputs were measured and aliquots (10%) were taken. Samples of urine were however treated with 2 drops of concentrated tetra oxo sulphate six acid and stored at -20 ºC untill required for analysis.

Parturition and gestation

Immediately after kidding and cleaning of the kids, the litters were weighed to determine the birth weight. After the drop of placenta, each dam was weighed to assess the change in weight. The gestation period was determined by the period between served and the parturition.

Table 1. Feed composition (Kg/100 Kg DM) of concentrate supplement fed to pregnant West African dwarf goats.

	Diets					
Feed ingredients	A	B	C	D	E	F
Cassava flour	0	61.0	51.0	75.5	0	0
Citrus pulp	75.5	0	0	0	61.0	51.0
Groundnut cake	0	0	30.0	0	0	30.0
Urea	5.5	0	0	5.5	0	0
Rumen epithelial wastes	0	20.0	0	0	20.0	0
Wheat bran	18.0	18.0	18.0	18.0	18.0	18.0
Common salt	0.5	0.5	0.5	0.5	0.5	0.5
Bone meal	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100

[1]A = Urea in citrus pulp, B = REW in cassava flour, C = GNC in cassava flour, D = urea in cassava flour, E= REW in citrus pulp, F = GNC in citrus pulp

Table 2. Proximate composition (g/100 g DM) of the diets fed pregnant WAD goats.

	Diets[1]						
	A	B	C	D	E	F	Grass
Crude protein	14.6	15.0	15.2	14.9	15.0	15.1	8.6
Crude fibre	26.8	26.2	26.9	28.4	26.4	27.0	43.4
Ether extract	2.0	1.5	6.4	2.2	1.4	6.6	1.3
Ash	9.1	6.4	3.1	9.4	6.8	3.0	10.5
Nitrogen free extract	46.2	50.9	48.4	45.1	50.4	48.3	36.5
Energy (Kcal/100 g DM)	5.61	5.82	6.01	5.90	5.76	5.82	3.84

[1]A = Urea in citrus pulp, B = REW in cassava flour, C = GNC in cassava flour, D = urea in cassava flour, E= REW in citrus pulp, F = GNC in citrus pulp

Chemical analysis

The ground samples of dried grass, concentrate supplements and dried faeces for each animal were analyzed for their content of CP, CF, EE and Ash according to AOAC (1995) and urine was assessed for nitrogen only. Dietary energy values of diets were determined with ballistic bomb calorimeter (Gallenkamp, London)

Statistical analysis

Data were subjected to analysis of variance (ANOVA) and where there was any significance difference, means were separated using Duncan's (1955) method. Linear regression was employed to determine the relationship between nitrogen intake and outputs using the model Y = mx + c, where Y = nitrogen balance, x = nitrogen intake, c = intercept. The intercept as the N-intake when N-balance is hypothetically zero, it is an indices for assessing dietary crude protein (DCP) requirement for maintenance. The gradient 'm' facilitates the estimate of DCP requirement for performance during pregnancy.

RESULTS

Dry matter intake and performance

Table 3 depicts the proximate composition of the test ingredients. Rumen epithelial waste (REW) was high in CP (59.7%) and EE (7.4%) but lowest in CF (1.5%) and ash (3.0). Table 4 shows the summary of the performance characteristic of the does. The dry matter intake (DMI) of the does got to the peak at week 16 (data not shown) of pregnancy and declined slightly between weeks 17 and 20. The results obtained are depicted in Table 4 and the value ranged between 895.8 and 907.1 g/d. Treatment effects on DMI of goat were not significant (P>0.05). Variations observed for DMI g/d $kg^{0.75}$ were not significant as well. Summaries of changes in body weight as well as gestation length of pregnant goats and birth weight are also shown in Table 4. The growth rate of the goats varied from 84 to 94 g/d. Treatment effects were significant (P > 0.05).

Table 3. Proximate Composition (g/100g DM) of rumen epithelial waste and citrus pulp.

	Rumen epithelial Waste	Citrus pulp
Crude protein	59.7	8.5
Crude fibre	1.5	22.4
Ether extract	7.4	4.9
Ash	3.0	5.3
Nitrogen free extract	15.7	58.9

Nutrient digestibility

Digestibility data are shown in Table 5. Dry matter (DM) digestibility values (%) obtained for the goats varied from 59 to 60. Treatment effects on DM digestibility were significant (P < 0.05) but the values observed for goats on diets A to E were similar (P > 0.05). Crude protein digestibility value (%) also ranged from 68 to 71. Variations observed were significant (P < 0.05). Higher CP digestibility value was observed for animals fed on diet B (REW in cassava flour) as supplement. Crude fibre digestibility values (%) varied from 74 to 79. The goat fed on diet D (Urea in cassava flour) recorded the highest value of 79% and the animals on diet F (GNC in citrus pulp recorded the lowest value of 74%. The treatment effects were also significant (P < 0.05). The values obtained for NFE digestibility ranged from 62 to 67% as the treatment effects were not however significant (P > 0.05).

Treatment effects on CF digestibility were significant (P < 0.05). Values obtained for goats fed urea in cassava flour were similar to those on GNC in cassava flour, (REW in citrus and urea in citrus pulp). Also the goats on diet REW in cassava and GNC in citrus were similar. NFE digestibility showed that there were significant (P< 0.05) differences among the various values obtain which ranged from 62 to 67%.

Table 4. Performance characteristics of West African dwarf goats fed urea, rumen epithelial wastes and groundnut cake based diets.

	Diet composition[1]						
Parameters	A	B	C	D	E	F	SEM
Initial weight (kg)	18.3	18.1	17.9	18.1	18.8	18.7	
Final weight (kg)	22.8	23.3	22.8	22.7	23.7	23.6	0.67
Weight gain (kg)	4.5	5.2	4.5	4.6	4.5	4.5	0.21
Weight gain (g/d)	84.9[c]	94.0[a]	90.9[ab]	86.3[c]	90.5[b]	90.5[b]	0.25
Dry matter intake (g/d)							
Grass	359.3	359	362	360	361.1	357.9	2.25
Concentrate	539.1	538.5	544.3	540.1	549.3	537.9	2.39
Total	898.4	897.5	907.1	900.1	915.4	895.8	3.75
Birth weight (kg)	1.9	2	2.1	2.1	2.1	2.2	0.07
Litter size	1	1	1	1	1	1	00
Gestation length (d)	150	151	152	150	150	151	0.33

[a b c d]Means along the same row with any identical superscripts are not significant (P>0.05.)

[1]A = Urea in citrus pulp, B = REW in cassava flour, C = GNC in cassava flour, D = urea in cassava flour, E= REW in citrus pulp, F = GNC in citrus pulp

Table 5. Nutrient digestibility (g/100 g DM) of West African dwarf goats fed urea, rumen epithelial wastes and groundnut cake based diets.

	Diet composition[1]						
Nutrients	A	B	C	D	E	F	SEM
Dry matter	59.8[a]	59.8[a]	60.5[a]	60.0[a]	60.0[a]	59.2[b]	0.04
Crude protein	69.9[a]	70.7[a]	69.3[a]	70.5[a]	67.4[ab]	68.2[b]	0.09
Crude fibre	76.8[b]	75.8[bc]	77.8[a]	79[a]	76.9[b]	74.1[c]	0.00
Ether extract	51.0[b]	56.40[b]	80.0[a]	51.5[b]	53.9[b]	79.3[a]	0.25
Nitrogen free extract	63.7	64.3	64.2	67.7	64.7	62.3	0.02

[a b c d]Means along the same row with any identical superscripts are not significant (P>0.05.)

[1]A = Urea in citrus pulp, B = REW in cassava flour, C = GNC in cassava flour, D = urea in cassava flour, E= REW in citrus pulp, F = GNC in citrus pulp

Nitrogen utilization

The data obtained for N–utilization by pregnant does in weeks 12 and 16 of pregnancy were similar as the differences observed were not significant. Hence the information in Table 6 is a summary of results obtained for weeks 12 and 16. Treatment effects on N–balance (g/d) were significant ($p < 0.05$) and the trend followed the same pattern as N-intake. However, when N–balance was expressed in g/d/$kg^{0.75}$ the apparent variations observed were not significant ($p > 0.05$).

There was a linear relationship between N–balance (g/d) $kg^{0.75}$ (Y) and N–intake g/d (X). The relationship is described by the equation 1;

$Y = 1.04 + 0.057X$ ($r = 0.40$, $P < 0.05$).

The intercept on Y axis when N intake is hypothetically zero is the requirement for maintenance during pregnancy. This reaches to a value of 1.04 g/d DCP/day/$kg^{0.75}$

The relationship between (Y) faecal-N (g/d/kg DMI) and (X) N- intake g/d is described by the equation 2;

$Y = 0.46 + 0.67X$ ($r = 0.82$, $P < 0.05$).

A linear relationship obtained between urinary-N g/d $kg^{0.75}$ (Y) and N-intake g/d (X) is given by the following mathematical model (equation 3):

$Y = 0.36 - 0.53X$ ($r=0.63$, $P < 0.05$).

When N-intake was zero the estimate value of EUN is 0.5g/$kg^{0.75}$.

DISCUSSION

The quality of any feed is dependent on its nutrient particularly the energy and protein content in adequate proportion. Therefore digestible energy (2.62 kcal.kg DM^{-1}) and the percentage crude protein of 15% of the six experimental diets fed to the goats were within 2.1–2.7 kcal DE and 14–18% respectively, recommended for pregnant does (NRC, 1981). This shows that the nutrients were within recommended limits and the animals gained weight accordingly and showed no symptom of nutritional disorder. About 60% of total DMI emanated from the supplements. The total voluntary DMI of 5 to 6% of body weight satisfied ARC (1995) recommendation for goat's maintenance and production. The value was higher than the recommendation of NRC (1981) of 3.0 to 3.5%. The DMI increased up to week 16 of gestation and declined after. The increasing DMI could be due to the growth of fetus and the supporting tissue in the uterus as well as hormonal changes declining DMI after 16 weeks of gestation may be due to the size of fetus in the womb that may compress some portions of alimentary canal thereby reducing the amount of feed intake by the pregnant does. Various gestation lengths have been reported (Williamson and Paynes, 1978). The range of 150 – 152 days obtained in this study is at the top limit of gestation length 140 – 150 reported elsewhere (Steele, 1996; Ebing and Rutgers, 1991). The difference be due to the differences in breeds, the plane of nutrition, adequate feeding and perhaps the birth weight. The average daily weight gain was higher, for goats that consumed rumen epithelial wastes (REW in cassava flour). This suggests the superiority of REW over urea in encouraging faster growth.

In this study, nutrient digestibility did not follow any pattern. Dry matter digestibility revealed that there were no significant differences among the treatment whether urea, GNC and REW in cassava flour or in citrus pulp base. This supported that DM digestibility were utilized to the same extent. However, the similarity in CP digestibility of goats placed on GNC in citrus pulp and those on REW in citrus pulp probably established the fact that REW can substitute for an expensive protein ingredient like GNC in goat diet formulation.

Table 6. Nitrogen utilization (g/d) by the WAD goats fed test diets during pregnancy.

	Diets[1]						
Parameters	A	B	C	D	E	F	SEM
N-intake	17.57^{c}	17.83^{b}	18.50^{a}	17.83^{b}	18.20^{a}	19.30^{a}	0.11
N-output in faeces	1.46	1.45	1.46	1.42	1.62	1.56	0.04
N-output in urine	0.89^{c}	1.12^{b}	1.20^{b}	0.92^{c}	1.42^{a}	1.37^{a}	0.14
N-balance	15.21^{c}	15.27^{c}	15.84^{a}	15.49^{b}	15.19^{d}	15.01^{e}	0.01
N-balance ($KgW^{0.75}$)	1.57a	1.57a	1.63	1.61	1.53	1.53	0.05

[a, b, c, d,] e = Means along the same row with any identical superscript are not significant (P > 0.05).
[1]A = Urea in citrus pulp, B = REW in cassava flour, C = GNC in cassava flour, D = urea in cassava flour, E= REW in citrus pulp, F = GNC in citrus pulp.

The appreciable effect of treatment on N-intake and N-balance was in accordance with the reports for goats (Akinsoyinu, 1974). All the animals recorded positive N-balance on the various dietary treatments. These observations suggest that the various rations were able to meet the protein need of the animals for maintenance and production. The values obtained for faecal nitrogen were higher than that of urinary nitrogen. This was in line with what was obtained by McDowell (1992). The data recorded for N-balance in this study ranged from 15.0 to 15.8. Animals on GNC in cassava flour had the highest N-balance, which was similar to the value obtained for animals on urea in cassava flour. This corresponds with available information in literature (Mba, 1977) in which urea; non protein nitrogen is readily available in the presence of soluble carbohydrate like cassava flour.

The data recorded for N-balance was higher than such report (Matras *et al*., 1991) in which urea blood meal-corn gluten meals were used as protein sources in the diet of growing lamb. Matras *et al.* (1991) reported a N-balance of 4.1 g/day. The present study was however in line with report of Makkar (1994) in which values or 14.4 to 21.2 g/day were obtained for buffalo calves fed different protein sources such as GNC, poultry excreta, cottonseed cake and guar meal. The value of 1.04 g/d DCP/day/kg$^{0.75}$ obtained in this study is 11% higher than the value of 0.88 – 0.94 g DCP/day/kg$^{0.75}$reported in literature (Akinsoyinu, 1974; NRC 1990; ARC 1995). It is very likely that maintenance needs during pregnancy would be higher due to growing of fetus. Thus a value of 1.04 seems to be a meaningful value for maintenance during pregnancy by the WAD goats.

Significant correlation (r = 0.82 and 0.63) were observed for N–intake and Urinary N. Major proportion of N was excreted in faeces (9%) and in urine (5%). The stable minimal urinary nitrogen excretion by animals on N-free diet is the endogenous nitrogen (EUN) and it represents the smallest loss of body N commensurate with the continuing existence of the animal. The EUN can be used to estimate the N-requirement for maintenance. The maintenance requirements for protein are essential to balance the endogenous losses and metabolic faecal N (MFN) losses, growth and renewal of hair, nail and hoofs. Thus, the MFN value of 4.6g/d/kgDMI in the present study is quite within the range of 3-5 g/d/kg DMI reported in literature (Akinsoyinu, 1974), but higher than the value of 2.6 g/kg DMI reported (Babayemi *et al*., 2000) for West African dwarf goats. The EUN value of 0.5g/d/kgw$^{0.75}$ also compares well with recommendation of 0.3 – 0.5 reported (Famewo, 1984). However the value was lower than the 0.74 g obtained with red Sokoto goats (Mba *et al.,* 1975) in Nigeria.

CONCLUSION

Rumen epithelial wastes, urea and groundnut cake supported growth, maintenance and pregnancy of the WAD goats when citrus pulp or cassava flour constitute the energy source.

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Submitted February 14, 2007 – Accepted October 25, 2007
Revised received December 19, 2007