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ORIGINAL ARTICLE

Supplementation with groundnut haulms for sheep fattening in the West African Sahel

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Abstract Groundnut haulms along with cowpea hay are major crop residues used for animal fattening in the West African Sahel. In traditional sheep fattening, feeds are always provided ad-hoc and in an unregulated fashion, which is rather wasteful. As a preliminary study to establish the optimal feeding levels of groundnut haulms for profitable sheep fattening, a feeding trial was conducted for 70 days with four levels of groundnut haulms (0, 150, 300 and 450 g/day) and a basal diet of bush hay. The effects of supplementation with groundnut haulms on feed intake, water consumption, live weight changes and economic return were determined. Twenty-four Peuhl Oudah rams with average initial weight of 28.6 kg (SD = 1.4) were randomly allocated to four treatments defined by the four levels of groundnut haulms in the diet. Faeces and urine were collected in weeks 5 and 9 of the trial. Digestible organic matter intake (g/(kg LW)$^{0.75}$) and nitrogen intake (g/day) increased linearly with the level of groundnut haulms offered. Sheep that were fed only bush hay lost 18.4 g/day, while those that were offered 150, 300 and 450 g of groundnut haulms gained 1.4, 19.3 and 40.2 g/day, respectively. The gross return ranged from 1883 to 4946 FCFA per ram. Net benefit, after removing the feed and veterinary costs from the gross return, ranged from 368 to 1400 FCFA per ram.

Keywords Crop residues · Sheep fattening · Supplementation · Ruminant nutrition · Sahel

Abbreviations

ADF	acid detergent fibre
ADG	average daily gain
DM	dry matter
DOM	digestible organic matter
DOMI	digestible organic matter intake
FCFA	CFA franc
GH	groundnut haulms
IVOMD	*in vivo* OMD
LW	live weight
NDF	neutral detergent fibre
OM	organic matter
OMD	organic mater digestibility

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Introduction

Feed scarcity is one of the major constraints to livestock production in the West African Sahel (Glatzle, 1992). Livestock subsist on natural rangelands for about 6 months and depend mainly on crop residues for the rest of the year (Williams *et al.*, 1997). The importance of crop residues as animal feed in the region is growing rapidly with the significant decline in grazing areas due to increasing cultivation of marginal lands and fallows as a result of demographic pressure (Ramaswamy and Sanders, 1992). Common crop residues in the Sahel include millet straw, sorghum straw, cowpea hay and groundnut haulms (Williams *et al.*, 1997). Groundnut haulms at the harvest and cake after extraction of the oil are a major source of nutrients for animals, especially as supplements for lactating cows and animal fattening (Larbi *et al.*, 1999). In addition, the sale of groundnut haulms is a major source of household income (Williams *et al.*, 1997).

Sheep fattening is an important economic activity in the West African Sahel, especially during the Islamic festival of Eid-al-Kabir, commonly called Tabaski in the region (Dan-Gomma, 1998; Hiernaux and Ayantunde, 2004). It is particularly attractive to poor farmers including women because of low initial investment, rapid rate of turnover, social acceptance and easy market access. The main strategy is to fatten young, lean male sheep either obtained from the farmer's own flock or, more often, purchased on the open market, over a 2–3 month period with each farmer fattening between 1 and 5 animals. The sheep are normally tethered or kept in a small sheltered enclosure at the homestead. They are fed and watered individually. The rapid growth and good condition required within a short time makes feeding of appropriate quantity and quality critical to the profitability of the activity (Savadogo, 2000). In traditional sheep fattening, feeds are always provided ad-hoc and in an unregulated fashion. That is, farmers often give the animals whatever is available and this leads to considerable waste, especially when feed availability is high, but when feed availability is low the animals are underfed (Sangaré, 2002; Fernández-Rivera *et al.*, 2005). The result of such practices is that the growth rates in traditional sheep fattening are always below the genetic potential of the animals (Savadogo, 2000). The combination of low growth rates and long fattening period that often characterises the traditional sheep fattening makes it largely unprofitable. To make sheep fattening profitable, it is pertinent to address alternative feeding strategies.

To address the questions of what to feed and at what quantity, between 1991 and 1998, the International Livestock Research Institute (ILRI) Niger conducted several experiments, involving hundreds of rams, on-station at ICRISAT Sahelian centre, Niamey, Niger and on-farm in south-western Niger into the nutrition and performance of sheep fed varying amounts of millet stover, cowpea hay and millet bran (Hiernaux and Ayantunde, 2004; Fernández-Rivera *et al.*, 2005). From these experiments, feeding levels between 300 and 600 g/day of cowpea hay and 400 g/day of millet bran were established for a profitable sheep fattening, along with *ad libitum* feeding of roughage such as bush hay or millet stover. However, farmers also have access to groundnut residues and optimal levels of feeding for this resource are yet to be established.

Hence, this preliminary study was carried out to establish the optimal feeding levels of groundnut haulms for sheep fattening in the region. The specific objective of this study was to determine the effect of different levels of groundnut haulms on feed intake, water consumption, live weight changes of rams and economic return.

Materials and methods

Study site

The experiment was carried out during the dry season (December 2004 to February 2005) at International Crop Research Institute for the Semi-Arid Tropics (ICRISAT-SC) in Sadoré (13°14′ N, 2°16′ E), Niger.

Treatments, feeds and animals

Twenty-four Peul Oudah rams bought from a livestock market in Balleyara (about 100 km east of Niamey), aged about 15–18 months with an average initial live weight (LW) of 28.6 kg (SD = 1.4), were randomly allotted into four treatments representing four feeding levels of groundnut haulms (0, 150, 300 and 450 g/animal per day), in groups of six. The sheep were placed in individual metabolic cages that allowed for the collection of urine and were fed individually during 70 days according to treatments.

Bush hay was offered *ad libitum* at 40 g/kg LW as basal feed. To determine the proportion by weight of different herbaceous species in bush hay, two bales of bush hay were randomly selected, weighed and separated by species. Two samples of each species found in each bale were collected for analysis. The constituent species of the bush hay (in decreasing order by weight) were *Indigofera strobilifera*, *Digitaria gayana*, *Alysicarpus ovalifolius*, *Ctenium elegans*, *Polycarpaea linearifolia* and *Schizachyrium exile* (Table 1). The average weight of a bale of bush hay used during the study was 5810 g (SD = 87). The dominant herbaceous species found in the bush hay (Table 1) were *Indigofera strobilifera* and *Digitaria gayana*, constituting together about 75% of the total weight. The remaining was composed of *Alysicarpus ovalifolius* (6.0%), *Ctenium elegans* (3.3%), *Polycarpaea linearifolia* (3.1%) and *Schizachyrium exile* (2.5%). Nitrogen concentration of the dicotyledonous species such as *Alysicarpus ovalifolius*, *Indigofera strobilifera*, and *Stylosanthes mucronata* was higher than those of grasses such as *Ctenium elegans*, *Schizachyrium exile*, *Cenchrus biflorus*, and *Andropogon gayana*, while the reverse was observed for organic matter digestibility and lignin content (Table 1). *In vitro* OMD ranged from 319 to 565 g/kg DM. The chemical composition of bush hay and groundnut haulms offered during the feeding trial is shown in Table 2. Generally, there was no difference in quality between the two periods of data collection. Each animal had free access to water throughout the experiment.

Measurements

The study included two 9-day periods of collection of faeces and urine, which started in weeks 5 and 9 of the experiment. The sheep were accustomed to carrying canvas bags for faecal collection during the last week before the data collection started. Faecal output was weighed daily, and a 10% sub-sample was taken for each animal and frozen for subsequent analysis. During the collection periods, urine was collected in a plastic bucket containing 100 ml of 10% sulphuric acid as preservative to prevent nitrogen volatilization and measured every morning. The volume of urine excreted was standardized to 3 litres by adding distilled water, and a sub-sample of 50 ml was taken for laboratory analysis. Feed refusals were weighed every morning to determine voluntary intake of groundnut haulms and bush hay. Samples of feed refusals were collected and stored for laboratory analysis. Two samples per treatment of feed offered (groundnut haulms and bush hay) were taken daily during each 9-day data collection period. Water intake was also measured in weeks 5 and 9 of the experiment. Sheep were weighed for three consecutive days at the beginning, every two weeks afterward

Table 1 Average proportions (%) of species found in bush hay offered during the experiment and their chemical composition (g/kg DM)

Dominant species	Percentage of total weight	OM	N	P	OMD	DOM	NDF	ADF	Lignin	Cellulose	Hemicellulose
Alysicarpus ovalifolius	5.98	955	9.3	0.6	474	452	701	612	129	89	483
Andropogon gayanus	1.57	963	2.1	0.3	526	507	794	489	89	306	399
Aristidia sieberiana	0.60	966	3.8	0.4	409	395	882	668	139	214	529
Brachiaria zantholeuca	0.71	936	3.2	0.4	515	482	791	544	64	246	481
Cenchrus biflorus	1.65	943	5.2	0.4	471	445	813	584	84	229	500
Ctenium elegans	3.26	961	2.1	0.3	419	402	874	599	73	275	525
Digitaria gayana	21.89	934	6.8	0.6	565	528	730	576	86	153	490
Indigofera strobilifera	55.88	913	8.3	0.7	527	481	688	565	106	123	459
Polycarpaea linearifolia	3.05	923	4.1	0.6	435	401	652	570	104	82	466
Schizachyrium exile	2.50	957	2.5	0.3	521	498	785	595	62	190	533
Stylosanthes mucronata	0.73	946	11.3	0.6	435	411	735	667	153	67	718
Waltheria indica	1.01	974	5.1	0.3	319	311	825	777	271	48	506

The average weight of the bush hay was 5810 ± 87 g.

Table 2 Chemical composition (g/kg dry matter; mean ± standard error) of bush hay and groundnut haulms offered and the refuse in period 1 (week 5) and period 2 (week 9) of the feeding trials

Parameter	Period 1				Period 2			
	Bush hay		Groundnut haulms		Bush hay		Groundnut haulms	
	Offer	Refuse	Offer	Refuse	Offer	Refuse	Offer	Refuse
Organic matter	927 ± 2[a]	936 ± 3[a]	904 ± 2[a]	920 ± 2[a]	886 ± 18[a]	893 ± 26[a]	909 ± 2[a]	850 ± 19[a]
Nitrogen	7.2 ± 0.3[a]	4.9 ± 0.2[b]	13.7 ± 0.2[c]	7.2 ± 0.4[a]	6.7 ± 0.3[a]	5.1 ± 0.2[b]	13.3 ± 0.5[c]	7.9 ± 0.8[a]
Phosphorus	0.7 ± 0.1[a]	0.6 ± 0.1[a]	2.4 ± 0.1[b]	1.2 ± 0.1[c]	0.8 ± 0.1[a]	0.6 ± 0.1[a]	2.2 ± 0.2[b]	1.6 ± 0.3[c]
In vitro OMD	540 ± 17[a]	449 ± 12[b]	718 ± 9[c]	565 ± 6[a]	552 ± 24[a]	446 ± 11[b]	719 ± 29[c]	556 ± 11[a]
DOM	501 ± 16[a]	421 ± 11[b]	649 ± 9[c]	520 ± 5[a]	488 ± 19[a]	401 ± 17[b]	653 ± 26[c]	474 ± 15[a]
NDF	749 ± 8[a]	793 ± 7[a]	509 ± 8[b]	584 ± 7[b]	736 ± 18[a]	799 ± 7[a]	549 ± 12[b]	561 ± 14[b]
ADF	576 ± 5[a]	595 ± 6[a]	431 ± 12[b]	485 ± 4[b]	555 ± 12[a]	611 ± 6[a]	465 ± 6[b]	446 ± 16[b]
Lignin	79 ± 4[a]	115 ± 6[b]	75 ± 2[a]	103 ± 5[b]	107 ± 4[b]	120 ± 4[b]	86 ± 7[a]	110 ± 12[b]
Cellulose	174 ± 5[a]	482 ± 5[b]	78 ± 5[c]	382 ± 8[b]	182 ± 8[a]	491 ± 7[b]	84 ± 9[c]	336 ± 18[b]
Hemicellulose	496 ± 5[a]	200 ± 6[b]	356 ± 13[c]	98 ± 5[d]	447 ± 10[a]	188 ± 6[b]	359 ± 8[c]	115 ± 6[d]

[a,b,c,d] Values with different superscript letters denote significant difference ($p < 0.05$) between means within the same row.

and at the end of the study. Average daily gain (ADG) was estimated by regression of individual live weight data over time.

Laboratory analyses

Samples of feed offered and refusals (groundnut haulms and bush hay) were analysed for DM, OM, N, P and fibre components (NDF, ADF and lignin). Fibre analysis was determined according to procedures of Van Soest and colleagues (1991). Hemicellulose and cellulose were calculated as the differences NDF − ADF and ADF − lignin, respectively. Organic matter digestibility (OMD) was determined by the *in vitro* gas production technique calibrated with standards obtained *in vivo* (Menke et al., 1979). Faecal samples collected in each collection period were analysed for DM, OM, N and P, while urine samples were analysed for N concentration.

Statistical analysis

Data analysis was performed with SAS (Statistical Analysis System Institute, 1987) using the General Linear Model (GLM) procedure for variance and regression analyses. An analysis of variance model including treatments as fixed effects was used to analyse data on faecal and urinary output, feed and water intake, live weight changes and net benefit of sheep fattening. Orthogonal contrasts were used to partition the sums of squares of treatments into linear, quadratic and cubic effects. A regression model including the linear and quadratic effects of the levels of groundnut haulms was used to evaluate the responses of feed intake, faecal output, live weight changes, faecal output and economic returns of sheep fattening to levels of groundnut haulms. Unless otherwise specified, the level of significance was declared at $p < 0.05$.

Results

Chemical composition of feed offer and refusals

The nitrogen, phosphorus, *in vitro* organic matter digestibility, digestible organic matter and hemicellulose contents of the leftovers from bush hay and groundnut haulms offered to the animals were significantly ($p < 0.05$) lower than the contents in the feeds offered in both periods of data collection (Table 2). The fibre components except hemicellulose of the leftovers from bush hay and groundnut haulms were significantly ($p < 0.05$) higher than those in the feeds offered in both periods. Cellulose content of the refusals was three times higher than in the bush hay and groundnut haulms offered (Table 2). There was no significant difference ($p > 0.05$) in the chemical composition of the bush hay and groundnut haulms offered and refused between the two periods of data collection.

Table 3 Effect of levels of groundnut haulms (GH) on dry matter intake of bush hay (bhDMI, g/(kg LW)$^{0.75}$), total dry matter intake (tDMI, g/(kg LW)$^{0.75}$), digestible organic matter intake (DOMI, g/(kg LW)$^{0.75}$) and *in vivo* organic matter digestibility (IVOMD, g/(kg DM)) in period 1 (week 5) and period 2 (week 9) of the feeding trials

GH level	Period 1[a]				Period 2[a]			
	bhDMI[b]	tDMI[b]	DOMI[b]	IVOMD[b]	bhDMI[b]	tDMI[b]	DOMI[b]	IVOMD[b]
0	49.3	49.3	23.1	494	49.8	49.8	24.4	519
150	44.3	54.9	26.8	519	41.8	52.6	26.9	543
300	39.1	58.8	29.9	531	38.4	58.0	29.9	557
450	35.3	62.4	32.0	557	33.7	61.8	32.3	583
SEM	1.5	1.6	1.1	9	2.1	2.2	0.9	16

[a] For all the variables, no significant difference ($p > 0.05$) was found between the two periods except for *in vivo* organic matter digestibility (IVOMD).

[b] Linear effect of levels of groundnut haulms offered ($p < 0.05$).

Feed and water intake

Digestible organic matter intake (g/(kg LW)$^{0.75}$) was linearly related to the level of groundnut haulms offered (Table 3) in both periods, with the non-supplemented treatment (groundnut haulms level = 0 g/day) having the lowest intake. Supplementation with groundnut haulms increased total digestible intake by 15–38% and 10–34% in periods 1 and 2, respectively. Dry matter intake of bush hay tended to be depressed with increasing levels of groundnut haulms in both periods. *In vivo* organic matter digestibility (apparent digestibility) increased linearly with levels of groundnut haulms in both periods (Table 3). *In vivo* OMD in period 2 was significantly higher than for period 1. The response of digestible organic matter intake (DOMI, g/(kg LW)$^{0.75}$) and *in vivo* OMD (IVOMD, g/kg DM) to groundnut haulms (GH, g DM/day) offered, for combined data of both periods, is described by the equations below (only variables that were significant at $p < 0.05$ were included in the equations):

$$\mathrm{DOMI} = 23.89(\pm 0.54) + 0.019 \times (\pm 0.002)\mathrm{GH}\left(p < 0.05;\ R^2 = 0.68\right)$$

$$\mathrm{IVOMD} = 507.60(\pm 7.78) + 0.14 \times (\pm 0.03)\mathrm{GH}\left(p < 0.05;\ R^2 = 0.34\right)$$

Sheep supplemented with groundnut haulms consumed more water (ml/day) than those that were not supplemented in both periods (Table 4). However, there was no significant difference in water consumed per gram of dry matter ingested in both periods. On average, the sheep consumed 2.5 and 3.5 ml/g dry matter ingested in periods 1 and 2, respectively. Water intake in period 2 was significantly higher ($p < 0.05$) than for period 1 for all treatments.

Table 4 Effect of levels of groundnut haulms (GH) on water consumption expressed in ml/day (ml), ml/kg live weight (ml/LW), ml/g dry matter intake (ml/DMI) by sheep in period 1 (week 5) and period 2 (week 9) of the feeding trials

GH level	Period 1[a]			Period 2[a]		
	ml[b]	ml/LW[b]	ml/DMI	ml[b]	ml/LW[b]	ml/DMI
0	1492	50.7	2.4	2200	74.6	3.5
150	1673	54.7	2.3	2321	76.1	3.5
300	1947	61.6	2.5	2733	86.8	3.6
450	1990	62.1	2.4	2857	88.6	3.4
SEM	78	3.0	0.1	151	4.9	0.3

[a] For all the variables, significant difference ($p < 0.05$) was found between the two periods.

[b] Linear effect of levels of groundnut haulms in the diet ($p < 0.05$).

Table 5 Nitrogen intake (N_i, g/day), faecal nitrogen (N_f, g/day), urinary nitrogen (N_u, g/day) and nitrogen retained (N_r, g/day) during the balance trial in period 1 (week 5) and period 2 (week 9) for different levels (g/day) of groundnut haulms (GH)

GH level	Period 1[a]				Period 2[a]			
	N_i^{bc}	N_f	N_u^{b}	N_r^{bc}	N_i^{b}	N_f^{b}	N_u^{b}	N_r^{b}
0	5.8	4.4	1.4	0.0	5.0	3.7	1.3	0.0
150	7.5	4.5	1.6	1.4	6.3	3.9	1.6	0.8
300	9.3	5.0	2.8	1.5	8.0	4.4	2.4	1.2
450	9.9	4.3	2.2	3.4	9.3	5.0	2.4	1.9
SEM	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.2

[a] For all the variables, no significant difference ($p > 0.05$) was found between the two periods.

[b] Linear effect of levels of groundnut haulms in the diet ($p < 0.05$).

[c] Quadratic effect of levels of groundnut haulms in the diet ($p < 0.05$).

Nitrogen intake and excretion

Nitrogen intake (g/day) increased linearly with increasing level of groundnut haulms offered (Table 5). Nitrogen excreted in faeces and urine accounted for 43–70% and 21–30%, respectively, of the amount ingested in both periods (Table 5). Nitrogen retained increased linearly with increasing level of groundnut haulms, accounting for 13–34% of the nitrogen ingested by supplemented groups in both periods.

The relationship between nitrogen retained (N_r, g/day) and the levels of groundnut haulms offered (GH, g DM/day), for combined data of both periods, is described by the equation

$$N_r = 0.043(\pm 0.019) + 0.005(\pm 0.001)\mathrm{GH} \quad \left(p < 0.05;\ R^2 = 0.57\right)$$

Supplementation with groundnut haulms had no significant effect on faecal dry matter excreted (Table 6). Faecal nitrogen and phosphorus concentrations (g/kg DM) did not differ significantly in both periods (Table 6). Urinary nitrogen concentration (g/L) in both periods increased linearly with levels of groundnut haulms offered. In both periods, between 24% and 35% of the nitrogen excreted was through urine (Table 5). Faecal and urinary nitrogen concentrations were not significantly different between periods.

Growth rate

The growth rate differed significantly during the 70 days of the experiment. Sheep that were fed only bush hay lost 18.4 g/day, while those that were offered 150,

Table 6 Effect of levels of groundnut haulms (GH) on faecal dry matter excretion (FDM, g/kg live weight), faecal nitrogen (N_f, g/kg FDM), faecal phosphorus (P_f, g/kg FDM), and urinary nitrogen concentration (N_u, g/L) in period 1 (week 5) and period 2 (week 9) of the feeding trials

GH level	Period 1[a]				Period 2[a]			
	FDM	N_f^{b}	P_f	N_u^{b}	FDM	N_f	P_f^{b}	N_u^{b}
0	12.2	12.2	2.6	3.8	11.8	10.7	1.9	3.2
150	11.8	12.2	2.5	4.4	10.7	12.2	2.4	4.0
300	13.2	12.1	2.6	6.2	12.0	11.8	2.6	5.7
450	12.5	10.8	2.2	6.9	12.3	12.7	2.8	6.3
SEM	0.4	0.4	0.1	0.4	0.6	0.5	0.1	0.3

[a] For all the variables, no significant difference ($p > 0.05$) was found between the two periods.

[b] Linear effect of levels of groundnut haulms in the diet ($p < 0.05$).

Table 7 Effect of levels of groundnut haulms (GH) on live weight gain (LWG, g/day)

GH level	Initial weight (kg)	Final weight[a] (kg)	LWG[a]
0	28.5	27.2	−18.4
150	28.8	28.9	1.4
300	28.7	30.1	19.3
450	28.4	31.2	40.2
SEM	0.6	0.6	1.7

[a] Linear effect of levels of groundnut haulms in the diet ($p < 0.05$).

300 and 450 g of groundnut haulms gained 1.4, 19.3 and 40.2 g/day (Table 7). Thus, increasing level of groundnut haulms led to higher ($p < 0.05$) average daily gain. The following regression equation described the relationship between average daily gain (ADG, g/day), amount of groundnut haulms offered (GH, g/day) and initial weight of the sheep (INIWT, kg). Only variables that were significant at $p < 0.05$ were included in the equation.

$$\mathrm{ADG} = -8.872(\pm 4.814) + 0.1298(\pm 0.0047)\mathrm{GH}$$
$$-0.0106 \pm 0.0049)\mathrm{INIWT}^2$$
$$\left(p < 0.05; R^2 = 0.97\right)$$

Regressions of ADG (g/day) over DOMI (g/(kg LW)$^{0.75}$) and ADG over nitrogen retained (N_r, g/day) are described by the following equations:

$$\mathrm{ADG} = -142.32(\pm 16.64) + 5.40(\pm 0.59)\mathrm{DOMI}$$
$$\left(p < 0.05; R^2 = 0.80\right)$$

$$\mathrm{ADG} = -11.76(\pm 3.99) + 17.77(\pm 2.45)\mathrm{N_r}$$
$$\left(p < 0.05; R^2 = 0.70\right)$$

Regression of ADG over *in vivo* organic matter digestibility, including linear and quadratic effects in the model, showed no significant effect for either component.

Costs and returns of sheep fattening

The rams for the experiment were bought from a local livestock market at the beginning of the study at 650 FCFA (1 USD = 530 FCFA as at October 2005) per kg live weight. The purchase price was the same for all treatments (Table 8). To compute the sale price of the sheep, a market survey was conducted in Niamey livestock market in October 2005. In the market, a ram was sold for 750–850 FCFA per kg live weight. The rate of 750 FCFA was used for the computation of sale price. The rationale for using sale price from a different market is to mimic the practice of the farmers, which entails buying the rams at a local market where price is low and selling the fattened rams in urban market where price is generally high. The sale price per sheep increased linearly with supplementation with groundnut haulms (Table 8). The major cost for sheep fattening was the feed cost. Bush hay cost 25 FCFA per kg, while groundnut haulms cost 75 FCFA per kg. The gross return (sale price − purchase price) ranged from 1883 to 4946 FCFA per ram. However, when the feed and veterinary costs were removed from the gross return, the net return ranged from 368 to 1400 FCFA per ram.

Table 8 Average costs and returns for different levels of groundnut haulms in the diet per sheep for 70 days of fattening (all values are in FCFA[a])

Variable	Groundnut haulms level (g/day)				SEM
	0	150	300	450	
Purchase price	18521	18741	18669	18434	412
Sale price[b]	20404	21663	22554	23380	440
Gross return[b]	1883	2922	3885	4946	84
Bush hay[b]	1315	1185	1079	983	47
Groundnut haulms[b]	0	788	1575	2363	
Total feed cost[b]	1315	1973	2654	3346	56
Veterinary cost	200	200	200	200	0
Total cost[b]	1515	2173	2854	3546	47
Net return[b]	368	749	1031	1400	108

[a] FCFA, CFA francs: 1 USD=530 FCFA as at October 2005.

[b] Linear effect of levels of groundnut haulms in the diet ($p < 0.05$).

Regression of net return (NETRET, FCFA per sheep) over levels of groundnut haulms (GH, g DM/day) is described by the equation:

$$\mathrm{NETRET} = 380.35(\pm 86.30) + 2.25(\pm 0.31)\mathrm{GH} \quad \left(p < 0.05; R^2 = 0.71\right)$$

Discussion

The chemical composition of the constituent species of the bush hay used in this study is comparable to that reported by Ayantunde and colleagues (1999). The nitrogen concentration and organic matter digestibility of these species were much lower than values at peak vegetation in the wet season (Ayantunde *et al.*, 1999) because the bush hay was harvested during the dry season when the nutritional quality had declined significantly. The higher nitrogen concentration of the dicotyledonous species compared to the grasses in the bush hay was expected. However, most of these dicotyledonous species such as *Waltheria indica*, *Indigofera strobilifera*, *Stylosanthes mucronata* and *Polycarpaea linearifolia* are generally refused by ruminants (Hiernaux, 1998). Thus, chemical composition alone of plant species does not adequately explain palatability or acceptance to the animal. An animal's preference involves a variety of factors including plant morphology, animal species and experience, animal management, alternative available feed and animal health (Ayantunde *et al.*, 1999). The choice of basal feed is therefore important in sheep fattening and this may account for wide variation in net benefit (Hiernaux and Ayantunde, 2004).

The values of nitrogen concentration and *in vitro* organic matter digestibility for groundnut haulms found in this study agree with values reported by Dan-Gomma (1998) and Savadogo (2000) in their feeding trials. The lower values of N and P concentrations, *in vitro* OMD and digestible organic matter of the leftovers from bush hay and groundnut haulms compared to the values of the feed on offer demonstrate the selective behaviour of the sheep. However, an animal's selectivity cannot compensate for the low intake characteristic of the poor quality of dry season forage (Breman and de Wit, 1983).

Digestible organic matter intake by sheep in this study was lower than the range (40.1–52.7 g/(kg LW)$^{0.75}$) reported by Dan-Gomma (1998) for sheep that were offered groundnut haulms *ad libitum*. Apart from the restricted amount of groundnut haulms offered to sheep in this trial, the generally low intake could be associated with low palatability of the dominant species of the bush hay (the basal feed), especially *Indigofera strobilifera* which accounted for 56% of the total weight of a bale of bush hay. This demonstrates that the quality of the basal feed affects the nutritional benefits resulting from supplementation. Higher intake was reported when legume hay, such as cowpea hay, was fed along with energy supplement, for example millet bran, while bush hay served as basal feed (Hiernaux and Ayantunde, 2004). Feeding energy-rich supplements generally increases total food intake where available forage is of low or poor quality (Minson, 1990). The substitution effect of increasing level of groundnut haulms in the diet on consumption of bush hay could be attributed to a much lower quality of the bush hay compared to groundnut haulms. Manyuchi and colleagues (1997) also reported similar observations that supplementation with groundnut haulm depressed the intake of poor-quality natural pasture hay by sheep. *In vivo* organic matter digestibility values found in this study are consistent with the range (484–546 g/kg DM) reported by Manyuchi and colleagues (1997) when sheep fed poor-quality pasture hay were supplemented with groundnut haulms at levels ranging from 0 to 300 g/day. The linear effect of supplementation with groundnut haulms on *in vivo* organic matter digestibility found in this study also agrees with results from the above authors.

Low intake of digestible organic matter by the sheep partly explains low nitrogen retention across the treatments in both periods. The concentration of nitrogen in faeces and urine has implications for nutrient management in mixed crop–livestock systems where animal manure is used for soil fertility (Powell *et al.*, 1994). Higher urinary nitrogen, mostly voided in form of urea-N, increased with N level, probably because the concentration in the rumen of ammonia-N was larger than what microbes could use owing to relatively low availability of energy. The results of this study on water consumption show that supplementation with legume hay has no effect on water requirement. Higher water consumption in period 2 than in period 1 could be attributed to a rise in ambient temperature during the second collection period, which was at the beginning of the hot dry season. This suggests that season of sheep fattening has implications for water consumption by the animals, especially when the Tabaski festival falls in the dry season.

Low intake of digestible organic matter by the sheep also explains the relatively low average daily gain for the treatments supplemented with groundnut haulms. However, similar ADG (44.6 g/day) was reported by Alli-Balogun and colleagues (2003) for sheep supplemented with even a higher amount of groundnut haulms (1 kg/day) along with basal diet of Gamba hay offered *ad libitum*. Ngwa and Tawah (2002) also reported similar ADG of 48.9 g/day for sheep supplemented with 300 g of groundnut haulms along with basal diet of rice straw. For profitable sheep fattening, the live weight gain recorded in this trial is low. For higher growth rate, it is advisable to feed energy supplement such as millet bran along with legume hay and the basal diet.

The results on cost and returns from sheep fattening show that profitability of the scheme depends heavily on purchase and sale price of the sheep, and feed cost. Minimizing the purchase price and feed cost, and maximizing the sale price will increase the profit margin. Under traditional sheep fattening, sheep to be fattened are often selected from the household flock, thereby incurring no additional cost in procuring the animals. The feed cost is also normally kept very low as the farmers normally feed crop residues (millet straw, cowpea hay and groundnut haulms) from their crop harvest and millet bran from processing of millet grain for household food to the animals. In spite of the low cost of procuring the animal and of feed, the profit margin in traditional sheep fattening is still low because of the low sale price (Hiernaux and Ayantunde, 2004). In peri-urban sheep fattening schemes, sheep are normally sold at a high price, especially towards the Islamic festival of Tabaski, but the profitability of the scheme is often undermined by feed cost. Low growth rate is another limiting factor to profitability of sheep fattening. Hiernaux and Ayantunde (2004) reported a positive net benefit of 6320 FCFA per sheep fattened with higher growth rate (187.5 g/day) than recorded in this study (maximum of 40.2 g/day) for sheep supplemented with 300 g/day of cowpea hay and 400 g/day of millet bran along with a basal diet of bush hay. The linear effect of levels of groundnut haulms on net benefit found in this study indicates that further studies are required to establish optimal feeding levels of groundnut haulms for economically viable sheep fattening. Such studies should focus on sheep performance when supplemented with groundnut haulms and energy supplement such as millet bran, all of which are available to these farmers. The effect of combined feeding of groundnut haulms and cowpea hay on sheep performance and economic returns also needs to be studied. These studies are necessary to address the main issue of establishing feeding strategies that balance the available feeds with their best use.

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Supplément alimentaire de fanes d'arachide pour l'engraissage des moutons dans le Sahel Ouest africain

Résumé – Les fanes d'arachide ainsi que le foin de dolique à oeil noir sont des résidus de cultures majeurs utilisés pour l'engraissage d'animaux dans le Sahel ouest-africain. Dans l'engraissage de moutons traditionnel, les alimentations sont toujours données de façon improvisée et non régulée, ce qui est plutôt du gaspillage. À titre d'étude préliminaire pour l'établissement des taux d'alimentation optimaux de fanes d'arachide à donner pour un engraissage profitable des moutons, il a été mené un essai d'alimentation pendant 70 jours avec 4 taux de fanes d'arachide (0, 150, 300 et 450 g/jour) et une alimentation de base de paille de brousse. On a déterminé les effets du supplément alimentaire avec des fanes d'arachide sur l'apport alimentaire, la consommation d'eau, les changements du poids vif et le revenu économique. Vingt-quatre béliers Peuhl Oudah d'un poids initial moyen de 28,6 kg (ES = 1.4) ont été affectés au hasard à quatre traitements définis par les quatre taux de fanes d'arachide dans l'alimentation. Les fèces et les urines ont été recueillis aux semaines 5 et 9 de l'essai. La consommation de matières organiques digestibles (g/(kg de poids vif)^{0,75} et l'apport en azote (g/j) ont diminué de façon linéaire avec le taux de fanes d'arachide offert. Les moutons qui n'ont été nourris que de paille de brousse avaient perdu 18.4 g/jour) tandis que ceux auxquels avait été offert 150, 300 et 450 g de fanes d'arachide avaient pris 1.4, 19.3 et 40.2 g/jour, respectivement. Le revenu brut s'est situé dans la plage de 1883 à 4946 FCFA par bélier. Le bénéfice net, après avoir soustrait les coûts d'alimentation et les frais vétérinaires du revenu brut, ont été de 368 à 1400 FCFA par bélier.

Suplementación con tallos de cacahuetes para engorde de ovejas en el Sahel del oeste de África

Resumen – Los tallos de cacahuete junto con el heno de caupí son importantes residuos de cosecha utilizados para el engorde de los animales en el Sahel del oeste de África. En el engorde tradicional de ovejas, los alimentos se suministran siempre *ad-hoc* y de una forma no regulada, lo que es bastante derrochador. Como estudio preliminar para establecer los niveles óptimos de alimentación de los tallos de cacahuete para el engorde provechoso de las ovejas, se llevó a cabo un estudio de alimentación durante 70 días con cuatro niveles de tallos de cacahuete (0.150, 300 y 450 g/día) y una dieta base de heno de mata. Se determinaron los efectos de la suplementación con tallos de cacahuete en el consumo alimenticio, el consumo de agua, las variaciones del peso vivo y los ingresos económicos. Se distribuyeron al azar veinticuatro carneros Peuhl Oudah con peso inicial medio de 28.6 kg (SD = 1.4) en cuatro tratamientos definidos por los cuatro niveles de tallos de cacahuete en la dieta. Se recogieron heces y orina en las semanas 5 y 9 del estudio. El consumo de materia orgánica digestible (g/(kg PV)$^{0.75}$) y el consumo de nitrógeno (g/día) incrementaron linealmente con el nivel de tallos de cacahuete ofrecidos. Aquellas ovejas a las que se le alimentó sólo con heno de mata perdieron 18.4 g/día mientras que aquellas a las que se les ofrecieron 150, 300 y 450 g de tallos de cacahuete ganaron 1.4, 19.3 y 40.2 g/día, respectivamente. Los ingresos brutos fluctuaron desde 1883 a 4946 FCFA (Francos de la Comunidad Financiera Africana) por carnero. Los beneficios netos, después de quitar los costes alimenticios y de veterinarios de los beneficios brutos, variaron de 368 a 1400 FCFA por carnero.