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Effect of urea treatment on digestibility and utilization of sorghum straw

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Nine male goats and nine castrated lambs were randomly divided into three groups of six animals to receive one of three experimental diets in a digestion trial. Diet S_1 provided chopped sorghum straw (SS), 28% concentrate (C) and 10% *Dolichos lablab* hay (D). Diet S_{u1} provided SS containing 2% urea, 24% C and 12% D, and diet S_{ue1} provided SS treated to contain 2% urea and ensiled for 28 days, plus 25% C and 14% D. Twenty four lambs were randomly divided into three groups of eight animals to receive one of three diets in a 56-day growth trial; diet S_2 provided SS plus 60% C; diet S_{u2} provided SS containing 2% urea plus 60% C, and diet S_{ue2} provided SS treated to contain 2% urea and ensiled for 28 days, plus 60% C. The digestion trial showed higher ($P<.05$) daily intake of dry matter, organic matter, crude protein and neutral detergent fiber for S_1 than for S_{ue1} and S_{u1}. Dry matter intake was 55.93; 39.42 and 42.34 $g{\cdot}(kg^{0.75})^{-1}$ for S_1, S_{u1} and S_{ue1}, respectively. Dry matter intake was slightly higher for lambs [50 $g{\cdot}(kg^{0.75})^{-1}$] than for goats [42 $g{\cdot}(kg^{0.75})^{-1}$]. There was no effect of dietary treatments on apparent nutrient digestibility. During the growth trial, intake of straw varied from 17.97 (S_2) to 24.78 $g{\cdot}(kg^{0.75})^{-1}$ (S_{ue2}), but differences were not significant. Daily gain did not differ between treatments. Total feed intake and feed efficiency were only slightly affected by dietary treatments. Average feed intake was 4.36% of body weight. High concentrate intakes may have upset the effect of urea treatment and silo fermentation in this study.
Keywords. Sorghum straw, *Lablab purpureus*, hay, urea, digestibility, growth, lambs, goats.

Effet du traitement à l'urée sur la digestibilité et l'utilisation de la paille de sorgho. Neuf agneaux et neuf chevreaux répartis en trois lots de six ont reçu trois rations expérimentales au cours d'un essai de digestibilité. La ration S_1 était constituée de paille de sorgho hachée (PS), de 28 % de concentré (C) et de 10 % de fanes de *Dolichos lablab* (D). La ration S_{u1} était constituée de paille de sorgho hachée, de 2 % d'urée, de 24 % de C et de 12 % de D, et la ration S_{ue1} de PS traitée à 2 % d'urée et ensilée pendant 28 jours, plus 25 % de C et 14 % de D. Vingt-quatre agneaux répartis en trois lots de huit ont été utilisés dans un essai de croissance de 56 jours au cours duquel ils ont reçu les rations suivantes : la ration S_2 était constituée de PS plus 60 % de concentré ; la ration S_{u2} était constituée de PS à 2 % d'urée plus 60 % de C et la ration S_{ue2} était constituée de PS à 2 % d'urée et ensilée pendant 28 jours plus 60 % de C. La consommation de la matière sèche (MS), de la matière organique, de la matière azotée totale et des parois cellulaires a été significativement plus élevée ($P< 0,05$) pour la ration S_1 comparativement à S_{ue1} et à S_{u1}. La consommation de MS a été respectivement de 55,93 ; 39,42 et 42,34 $g{\cdot}(kg^{0,75})^{-1}$ pour S_1, S_{u1} et S_{ue1}. Elle a été supérieure chez les agneaux [50 $g{\cdot}(kg^{0,75})^{-1}$] comparativement aux chevreaux [42 $g{\cdot}(kg^{0,75})^{-1}$]. Le traitement n'a pas eu d'effet sur la digestibilité des rations. Pour l'essai sur la croissance, la consommation de la paille a varié de 17,97 $g{\cdot}(kg^{0,75})^{-1}$ (S_2) à 24,78 $g{\cdot}(kg^{0,75})^{-1}$ (S_{ue2}), mais aucune différence significative n'a été notée. Le gain moyen quotidien n'a pas été différent selon les traitements. L'ingéré total d'aliment et l'efficacité alimentaire ont été légèrement affectés par les traitements. La consommation moyenne d'aliment a été de 4,36 % du poids vif. Dans cette étude la forte ingestion de concentrés a sans doute masqué l'effet du traitement à l'urée et de la fermentation dans le silo.
Mots-clés. Paille de sorgho, *Lablab purpureus*, foin, urée, digestibilité, croissance, agneau, chevreau.

1. INTRODUCTION

Ruminant livestock in most Sahelian countries rely on natural pastures for survival; however, crop residues contribute for about 25% of feed ingested by ruminants in Burkina Faso (M.A.E, 1990). The only concentrates used for ruminants are agro-industrial by-products (peanut and cottonseed meals, cottonseeds, molasses, and wheat bran), and the supply is limited. Furthermore, there is an increase in land occupation in favour of cereal crops, but to the detriment of natural pastures; this trend should bring about an increase in the supply and contribution of crop residues.

However, crop residues have been shown to contain low amounts of digestible nitrogen and energy (Tagel-Din *et al.*, 1989; Sourabié *et al.*, 1995), and dry matter intake is usually low (Dolberg *et al.*, 1981). Animals fed on sorghum straw alone usually result in negative nitrogen balance (Tagel-Din *et al.*, 1989). These negative aspects of cereal straws are believed to result from high neutral detergent fiber (NDF) content (resulting in high cell wall rigidity), and poor nitrogen content. Several treatments have been applied to try to increase intake and digestibility of cereal straws; perhaps the most widely used treatments are chopping the straw, addition of ammonia or urea N (Jackson, 1979; Dolberg *et al.*, 1981; Ibrahim *et al.*, 1987; Adu *et al.*, 1990), anaerobic in-silo fermentation, treatment with ammonium hydroxide (Solaiman *et al.*, 1979; Diarra, 1983) and supplementation with concentrates (Huston *et al.*, 1988), or with good quality hay (Zan, 1989; Adu *et al.*, 1990).

Results of cereal straw treatment with urea N appear to vary greatly. Urea supplementation usually results in higher dry matter intake and digestibility (Ibrahim *et al.*, 1987; Nyarko-Badohu *et al.*, 1994; Nianogo *et al.*, 1997), however some authors (Ibrahim *et al.*, 1987) have found no effect of urea treament on animal performance. Supplementation with concentrates (Huston *et al.*, 1988; Tagel-Din *et al.*, 1989) or with legume hay usually improves straw utilization (Adu *et al.*, 1990; Pouya, 1989; Zan, 1989), although results may vary depending on the level of supplementation. High levels of supplementation with concentrates have caused intake of the straw to decrease (Adu *et al.*, 1990). Questions appear to remain unanswered on the effect of straw treatment on digestion and utilization at high levels of concentrate.

Two trials were conducted to determine the effect of urea treatment in ensiling sorghum stovers while supplementing with both concentrates and legume hay on:

1. nutrient digestibility (trial I) of adult sheep and goats, and
2. dry matter intake and growth of lambs (trial II).

2. MATERIALS AND METHODS

2.1. Preparation of sorghum straw

Sorghum stovers were harvested about two weeks after grain harvest, and chopped to a maximum particle length of 5 cm using a hand chopper; for one of the dietary treatment, chopped straw (96.45% DM) was humidified with a urea solution (100 ml·kg^{-1} straw DM) designed to provide 2% urea (DM basis). For the preparation of ensiled straw, the chopped straw was spread in a 45-cubic meter pit silo in successive loads of about 110.5 kg air-dry material; to each load, 155.94 liters of urea-treated tap water was added to provide 2% added urea (DM basis) and a final wet straw DM content of 40%. Each batch was then pressed several times using a tractor, before the addition of another load. Once the silo was full, the straw was pressed again and covered with a plastic sheet; the silo was opened after 30 days of fermentation.

2.2. Digestion trial (Trial I)

Nine castrated Sahelian goats averaging 25.9 kg body weight and 26 months of age and nine Mossi sheep averaging 33.3 kg body weight and 26 months of age were utilized for a digestion trial. All 18 animals were treated for internal (Panacur) and external (Bestox 100 DT, FMC Corp.) parasites prior to the study. Within each species, animals were randomly divided into three groups to receive one of three experimental rations (**Table 1**) :

– S_1: chopped sorghum straw (SS) plus 28% concentrates and 10% *Dolichos lablab* L. hay;
– S_{u1}: SS with 2% urea top dressed plus 24% concentrates and 12% *Dolichos lablab* hay;
– S_{uel}: SS with 2% urea and ensiled, plus 25% concentrates and 14% *Dolichos lablab* hay.

Water and Kaya[1] salt licks were offered ad libitum. They also received an appropriate amount of vitamins[2] fed orally every two days during the study.

The animals were adjusted to digestion cages and to their respective diets during a four-week period. They were weighed at the beginning and end of the six-day collection period. During the collection period, feed intake was monitored, all fecal output and samples of feed offered and orts were collected. Fecal samples were first frozen; they were then mixed together for

[1] Kaya salt licks provided 76.5% NaCl, 20% dicalcium phosphate, 2% Mg sulfate, 1% Fe sulfate, 0.4% Mn sulfate, 0.04% Cu sulfate, 0.1% Zn sulfate, 0.1% Co sulfate, and 0.004 % Ca iodine.

[2] Vitamin mix provided 420,000 IU vitamin A, 1.05mg vitamin D3, 46.2 mg vitamin E, 42 mg vitamin B1, 21mg vitamin B6, 126mg pyridoxal phosphate, 42mg Ca pantothenate, 42mg Cu sulfate, 8 mg Co sulfate, 3.16 mg Mg sulfate, 7.44mg Mn sulfate, and 6.79 mg Zn sulfate.

Table 1. Composition of experimental rations for digestion trial — *Composition des rations expérimentales pour l'essai sur la digestibilité*.

Ingredients (%)	S_1	S_{u1}	S_{ue1}
Chopped sorghum straw	62	-	-
Chopped sorghum straw with 2% urea added	-	64	-
Chopped sorghum straw ensiled with 2% urea	-	-	61
Sugarcane molasses	18	20	22
Cottonseed meal	10	4	3
Dolichos lablab hay	10	12	14
Expected total digestible nutriment	60.98	61.02	60.21
Expected crude protein	9.26	9.28	9.52

Table 2. Composition of experimental rations for the growth trial — *Composition des rations expérimentales pour l'essai de croissance.*

Ingredients (%)	S_2	S_{u2}	S_{ue2}
Chopped sorghum straw	40	-	-
Chopped sorghum straw with 2% urea added	-	40	-
Chopped sorghum straw ensiled with 2 % urea	-	-	40
Sugarcane molasses	12	12	12
Cottonseed meal	20	14	16
Whole cottonseed	10	10	10
Wheat bran	18	24	22
Expected total digestible nutriment	69.73	69.70	70.23
Expected crude protein	16.1	16.25	16.34

each animal, ground, and dried at 65°C until the weight became constant. Aliquot samples were then taken for proximate analyses as described by AOAC (1970) and for cell wall contents as described by Robertson and Van Soest (1981). Feed and ort samples were also analysed as described for feces. Digestion coefficients were calculated for dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF).

2.3. Growth trial (Trial II)

Twenty four Mossi lambs averaging 15 kg body weight and six months of age were selected for a 56-day feeding trial. Animals were randomly divided into 12 pairs and each pair was assigned to a pen. Pens were randomly divided into three groups to be fed with one of three experimental diets (**Table 2**):

– S_2: 40% untreated, chopped sorghum straw (SS) plus 60% concentrate;

– S_{u2}: 40% chopped sorghum straw, mixed with 2% urea top dressed plus 60% concentrates;

– S_{ue2}: 40% urea treated and ensiled chopped sorghum straw, plus 60% concentrates.

Straw and concentrates were served in separate feeders. All pens were served water and salt licks *ad libitum*. Animals were treated for internal and external parasites as in the digestion trial and were adjusted to their respective diets during a 14-day pretrial period. Feed offerings were readjusted at the end of week 4, following body weight changes.

Samples of straws and concentrates were analyzed for DM, CP, NDF, ADF, acid detergent lignin (ADL) and ash as described for the digestion trial.

Data were analyzed using SAS general linear models procedures (SAS, 1982). Because of differences in body weights among diet groups at the beginning of the study, initial body weights were used as covariates to evaluate weight differences at the end of the study. Means separation was performed using the Ryan-Einot-Gabriel-Welsh (SAS, 1982) multiple range test.

3. RESULTS

3.1. Digestion trial (Trial I)

Partial compositional analysis of diets and orts is shown in **table 3**. Diets were similar in terms of DM, OM and CPcontent. NDF content was highest (57.11%) for S_1 and lowest (43.79%) for S_{ue1}. For all diets, orts were higher in cell wall content and lower in CP content than feed offered.

Nutrient intakes are shown in **tables 4** and **5**. On a metabolic weight basis (MBW), daily intake of DM, OM, NDF, and CP were higher (P<.05) for S_1 than for S_{uel} and S_{ul}. Dry matter intake was 55.93, 39.42, 42.34 $g\cdot(kg^{0.75})^{-1}$ for S_1, S_{uel} and S_{u1}, respectively. Absolute intake of DM, OM, NDF and CP were higher (P<.05) for sheep than for goats; however, differences between species were not significant on a metabolic weight basis. Average DM intake was 50 $g\cdot(kg^{0.75})^{-1}$ for sheep, and 42 $g\cdot(kg^{0.75})^{-1}$ for goats.

As for the effect of treatment combination on intake, differences were found only for CP and NDF. Sheep fed with S_1 had the highest NDF and CP intakes, goats fed with S_{u1} had the lowest NDF intake, and the lowest CP intake.

Animals consumed 0.12 to 0.17 liter of water $g\cdot(kg^{0.75})^{-1}$, or 2.83 to 3.96 $l\cdot kg^{-1}$ DM consumed. Differences were not significant.

Table 3. Partial compositional (%) analysis of rations (Feed) and orts for digestion trial — *Composition chimique (%) des rations et des refus pour l'essai sur la digestibilité.*

Ration		DM	OM	Ash	CP	NDF	ADF	ADL
S_1	Feed	96.30	91.40	8.60	9.47	57.11	38.55	7.07
	Orts	97.08	90.43	9.57	8.57	65.15	41.28	9.02
S_{u1}	Feed	96.09	91.60	8.40	9.37	47.89	35.65	7.81
	Orts	96.38	88.88	11.12	6.61	62.87	41.24	8.38
S_{ue1}	Feed	96.04	93.21	6.88	9.58	43.79	35.85	4.78
	Orts	96.60	88.24	11.76	7.99	54.03	37.35	7.69

DM = dry matter; **OM** = organic matter; **CP** = crude protein; **NDF** = neutral detergent fiber; **ADF** = acid detergent fiber; **ADL** = acid detergent lignin.

Table 4. Effect of ration and species on intake for digestion trial — *Influence de la ration sur l'ingestibilité dans l'essai sur la digestibilité*.

Parameters		Ration			Effect of species	Standard error
		S_1	S_{u1}	S_{ue1}		
DM	$g \cdot j^{-1}$	740.71[a]	529.55[b]	481.73[b]	0.0017	43.64
	$g \cdot (kg^{0.75})^{-1}$	55.93[a]	42.34[b]	39.42[b]	NS	0.003
OM	$g \cdot j^{-1}$	675.14[a]	492.79[b]	452.79[b]	0.02	39.32
	$g.(kg^{0.75})^{-1}$	51.00[a]	39.38[b]	37.05[b]	NS	0.002
NDF	$g \cdot j^{-1}$	395.27[a]	211.34[b]	197.75[b]	0.0301	26.81
	$g \cdot (kg^{0.75})^{-1}$	30.01[a]	16.88[b]	16.22[b]	NS	0.002
CP	$g \cdot j^{-1}$	76.91[a]	57.88[b]	52.84[b]	0.0001	5.25
	$g \cdot (kg^{0.75})^{-1}$	5.75[a]	4.63[b]	4.36[b]	NS	0.0003
ADF	$g \cdot (kg^{0.75})^{-1}$	272.86[a]	171.39[b]	168.76[b]	0.559	16.46
	$g \cdot j^{-1}$	20.69[a]	14.00[b]	13.65[b]	NS	0.001
NDS	$g \cdot (kg^{0.75})^{-1}$	345.45[a]	318.22[b]	283.98[a]	0.003	21.13
	$g \cdot (kg^{0.75})^{-1}$	25.91[a]	25.45[b]	23.20[a]	0.024	0.001

[abc] Means bearing no common superscript differ (P<.05); NS = not significant; NDS = neutral detergent solution.

Table 5. Combined effect of ration and species on intake of dietary components — *Influence combinée de la ration et de l'espèce sur l'ingestibilité*.

Parameters		Sheep			Goats			Standard error
		S_1	S_{u1}	S_{ue1}	S_1	S_{u1}	S_{ue1}	
DM	$g \cdot j^{-1}$	875.65[a]	657[ab]	523.07[b]	605.78[b]	402.1[b]	440.38[b]	43.64
	$g \cdot (kg^{0.75})^{-1}$	61.77[a]	46.78[a]	39.97[a]	50.08[a]	37.91[a]	38.88[b]	0.003
OM	$g \cdot j^{-1}$	794.64[a]	613.53[ab]	492.84[b]	555.64[ab]	372.05[b]	412.73[b]	39.32
	$g \cdot (kg^{0.75})^{-1}$	56.06[a]	43.68[a]	37.63[a]	45.94	35.08[a]	36.43a	0.002
NDF	$g \cdot j^{-1}$	439.98[a]	263.31[bc]	207.70[bc]	350.56[b]	159.37[c]	187.8[c]	26.81
	$g \cdot (kg^{0.75})^{-1}$	31.05[a]	18.72[bc]	15.91[c]	28.98[ab]	15.03[c]	16.54[c]	0.002
CP	$g \cdot j^{-1}$	103.65[a]	71.75[b]	51.46[bc]	50.17[ab]	43.99[c]	54.22[c]	5.25
	$g \cdot (kg^{0.75})^{-1}$	7.30[a]	5.11[b]	3.94[b]	4.18[bc]	4.15[b]	4.79[c]	0.0003
ADF	$g \cdot j^{-1}$	308.25[a]	191.35[ab]	186.54[ab]	237.47[b]	146.17[b]	156.23[c]	16.46
	$g \cdot (kg^{0.75})^{-1}$	21.74[a]	13.59[a]	14.27[a]	19.63[ab]	13.71[a]	13.74[a]	0.001
NDS	$g \cdot j^{-1}$	435.67[a]	393.70[ab]	315.37[abc]	255.22[bc]	242.74[c]	252.59[bc]	21.13
	$g \cdot (kg^{0.75})^{-1}$	30.73[a]	28.06[a]	24.06[a]	21.10[a]	22.88[a]	22.34[a]	0.001

[abc] Means bearing no common superscript differ (P<.05); NDS = neutral detergent solution.

Digestibility coefficients are shown in **tables 6** and **7**. Digestion coefficients for DM, OM, CP, NDF and ADF were not significantly ($P<0.05$) affected by species or diets. Highest DM digestion coefficient was observed for goats fed with S_{u1} and lowest coefficient was observed for goats fed with S_1; there were more variation among goats fed with different diets than among sheep.

Weight changes (**Table 8**): nearly all animals lost weight during the collection period. Differences in weight loss were not significant.

3.2. Growth trial (Trial II)

Feed intake (**Table 9**) increased from week one to eight; average intakes of straw during the eight-week experimental period were 17.97, 20.14 and 24.78 $g{\cdot}(kg^{0.75})^{-1}$ for S_2, S_{ue2} and S_{u2}, respectively. Concentrates were entirely consumed; however, an average of 42% of straws was refused. Instead of the predicted 60% concentrates, the average percentage of concentrates consumed ranged from 72.81 (S_{u2}) to 79.38% (S_2).

Total dry matter intake averaged 86.63, 91.52 and 89.89 $g{\cdot}(kg^{0.75})^{-1}$ for S_2, S_{uel} and S_{ue2}, respectively. This represents an average of 4.364% of body weight.

Growth performance appears in **table 10**. Weight gain decreased slightly between the first and the second 4-week period. Average daily gains (ADG) were 78.44, 61.70 and 82.54 g for S_2, S_{ue2} and S_{u2}, respectively; these values were not significantly different.

Feed efficiency ratio (kg gain·kg feed^{-1}) was lowest for S_{ue2} (0.0378) and similar for S_2 and S_{u2} (0.0553).

4. DISCUSSIONS

4.1. Digestion trial

Dry matter intake in the digestion trial was comparable to values reported by others on caged lambs (Hébié, 1989; Zan, 1989). The reason for weight losses observed during the digestion trial are unclear.

Digestibility coefficients observed in this study were higher than those reported with lambs (Hébié, 1989) or sheep (Besle *et al.*, 1990) receiving untreated straw alone. Digestibility coefficients were 48.79, 51.07, 12.78, and 44.07% respectively for DM, OM, CP and NDF (Hébié, 1989). Hébié also reported DM digestibility values of 65.37% with chopped sorghum straw (SS) treated with 4% urea and ensiled, 57.39% with urea-treated and ensiled SS supplemented with 20% molasses; 56.66% with straw ensiled with 4% urea and supplemented with 25% cottonseed meal (DM basis). Ouédraogo (1990) found that treatment of SS with 4% urea increased *in situ* DM disappearance. Such results indicate that digestibility of SS may be improved by urea treatment, or with low (less than 25% of DM) concentrate supplementation. However, others (Ibrahim *et al.*, 1987) found no effect of urea treatment and ensiling on SS dry matter digestion. Under our conditions the values obtained may be due to both the addition of readily digestible ingredients, and to positive effects of these ingredients on digestibility of the straw.

Results of species effect on digestion (**Table 7**) differ from those reported by Huston *et al.*, (1988) ; these authors found a higher DM digestion coefficient for goats fed with wheat straw. However, level of supplemental concentrate was much lower (0 to 60 $g{\cdot}day^{-1}{\cdot}animal^{-1}$) in the latter study. With medium or high quality hay, sheep are often better at digesting DM than goats (Huston *et al.*, 1988).

Results of the digestion trial may indicate that there is no effect of straw treatment to be expected when straw is included in well balanced rations, and contributes for less than 55% of DM intake. In this study, diets were isonitrogenous, thus eliminating the improved N supply usually expected with urea treatment or supplementation as a potential factor for microbial activity in the rumen. Furthermore, diet S_1 contained preformed protein (cottonseed meal) instead of urea. Under such circumstances, there is more risk of N being lost in the form of urea (from ammonia absorbed from the rumen) with diets containing non protein N than with S_1: cottonseed meal is believed to provide 43% rumen undegradable protein (NRC, 1989).

4.2. Growth trial

As indicated in the result section, intake of straw may have been low in this study, considering that straw was the item being evaluated. Jarrige (1988) recommended that concentrate should not exceed 20–25% of total DM offered if one seeks to improve intake of straw. However, large amounts of concentrates were offered here in order to overcome low nutrient concentration in the straw. Because the animals used in this study were young and growing, high nutrient requirements were expected.

The DM intake obtained in this study (4.364% of body weight) was lower than that recommended by N.R.C (1984) for similar weights in temperate environments (5–6% body weight) but higher than that recommended by Rivière (1978) for tropical environments (1.8 to 3% body weight). However, DM intakes in this study were similar to those [82.4 to 95.9 $g{\cdot}(kg^{0.75})^{-1}$] observed by Ouibga (1985) for sheep fed with diets comparable to ours. Dry matter intake in the

Table 6. Effect of ration and species on digestibility of selected nutrients — *Influence de la ration et de l'espèce sur la digestibilité de quelques nutriments*.

Parameter	Ration			Effect of species (probability)	Standard error
	S_1	S_{u1}	S_{ue1}		
DM	51.98[a]	59.24[a]	55.64[a]	NS	2.43
OM	53.43[a]	62.56[a]	58.33[a]	NS	2.37
CP	51.44[a]	53.32[a]	59.32[a]	NS	3.34
NDF	42.55[a]	42.59[a]	30.72[a]	NS	3.00
ADF	47.28[a]	50.51[a]	45.46[a]	NS	2.90

[a] Means bearing no common superscript differ (P<.05); NS = not significant; **DM** = dry matter; **OM** = organic matter; **CP** = crude protein; **NDF** = neutral detergent fiber; **ADF** = acid detergent fiber.

Table 7. Combined effect of species and ration on nutrients digestibility — *Influence de l'espèce et de la ration sur la digestibilité.*

Component	Sheep			Goats			Standard error
	S_1	S_{u1}	S_{ue1}	S_1	S_{u1}	S_{ue1}	
DM	57.44[a]	55.04[a]	58.39[a]	46.52[a]	63.43[a]	52.94[a]	2.43
OM	58.96[a]	59.24[a]	61.17[a]	47.90[a]	65.88[a]	55.50[a]	2.37
NDF	49.28[a]	38.14[a]	32.43[a]	35.82[a]	47.05[a]	29.00[a]	3.00
CP	55.74[a]	46.21[a]	58.45[a]	47.14[a]	60.44[a]	59.87[a]	3.34
ADF	50.35[a]	47.42[a]	48.62[a]	44.21[a]	57.59[a]	42.29[a]	2.90

[a] Means bearing no common superscript differ (P<0.05).

Table 8. Combined effect of species and ration on weight changes — *Évolution pondérale par espèce et par lot.*

Parameter	Sheep			Goats			Standard error
	S_1	S_{u1}	S_{ue1}	S_1	S_{u1}	S_{ue1}	
Initial Weight (kg)	34.86[a]	34.1[a]	30.93[ab]	28.29[bc]	23.27[bc]	26.35[bc]	1.09
Daily Gain (g)	-183.3[a]	-91.11[a]	-86.67[a]	-173.33[a]	-37.78[a]	-115.56[a]	23.22

* [a,b,c] Means bearing no common superscript differ (P<0.05).

growth trial was also higher than that observed for the digestion trial.

Since straw digestion was not improved by urea-treatment or by ensiling, treatment effect on gain and feed conversion was not likely. However, lambs fed with S_{ue2} tended to have lower conversion rates than others, due to high DM intake and low gain, although differences were not significant.

Average daily gains (ADG) observed in this study are higher than the 30.08 $g \cdot d^{-1}$ observed with lambs of the same breed and age at the same location (Gampela Experimental Station). The latter were on a regimen which included 7 h of pasture a day, and 5 to 10% of DM requirements as concentrates (Nianogo, 1990). Gains observed in this study were also higher than those observed with lambs of the same age group on a semi-intensive regimen with 7 $h \cdot d^{-1}$ of pasture plus 15, 30 or 45% concentrate supplementation; such lambs gained 54.13; 67.86; and 64.84 $g \cdot d^{-1}$, respectively (Nassa, 1990). However, overall ADG (74.24 g) was below those reported by Ouibga in 1985 (83–133 $g \cdot d^{-1}$).

To conclude, high intake of concentrate might have masked the effect of urea treated straw in the growth trial. Effect of urea treatment or ensiling may be benefical only when straw is the only feed, or when concentrate supplementation is minimal.

Table 9. Intake of total dry matter as affected by ration — *Évolution de la consommation totale d'aliment.*

Feedstuff		Week	Ration			Standard error
			S_2	S_{u2}	S_{ue2}	
All feed	g·d^{-1}	1–2	647.2	690.95	729.3	24.91
		3–4	648.8	663.75	723.8	27.15
		5–6	715.2	787.35	944.6	43.60
		7–8	761.60[b]	849.1[ab]	1003.1[a]	43.57
		1–4	648	677.35	726.55	25.86
		5–8	738.4	818.25	973.85	43.22
		1–8	693.2	747.8	830.2	33.09
	g·(kg$^{0.75}$)$^{-1}$	1–8	86.63	89.89	91.52	4.25
Straw	g·d^{-1}	Mean	143.83	205.92	187.10	17.46
	g·d^{-1} (kg$^{0.75}$)$^{-1}$	Mean	17.97	24.78	20.14	1.35
Concentrate	(% consumed)		79.38	72.81	79.03	1.73

[ab] Means bearing no common superscript differ ($P<0.05$).

Table 10. Growth performance as affected by diet — *Influence de la ration sur les performances de croissance.*

Parameter	Ration			Standard error
	S_2	S_{u2}	S_{ue2}	
Initial Weight (kg)	13.52[b]	14.20[b]	17.32[a]	0.60
Weight at week 4 (kg)	16.04[b]	16.74[b]	19.50[a]	0.61
Weight at 56 days (kg)	17.91[b]	18.83[b]	20.78[a]	0.69
ADG week 1–4 (g·j^{-1})	89.91[a]	90.54[a]	77.86[a]	6.77
week 5–8 (g·j^{-1})	66.96[a]	74.55[a]	45.54[a]	8.04
week 1–8 (g·j^{-1})	78.44[a]	82.54[a]	61.70[a]	5.78
Weight gain (kg gain·kg feed^{-1})				
week 1–4	0.0698	0.0670	0.0579	0.0056
week 5–8	0.0425	0.0457	0.023	0.0047
week 1–8	0.0553	0.0553	0.0378	0.004

ADG = average daily gain

[ab] Means bearing no common superscript differ ($P<0.05$).

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