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FINAL REPORT

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Optimizing the utilization of sorghum stovers by ruminant livestock for small holders in West African Sahel

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I. INTRODUCTION

The final report is submitted to the Grant Officer, Office of Procurement, Washington, DC 20523, in compliance with the grant obligation stipulated in Section IE.2.(c) of the Attachment I on schedule. Upon request, the grant originally obtained for one year, was extended an additional year. The grant ended on December 31, 1990.

The final report will have two components, technical and financial. It will cover the project's major accomplishments, the problems and delays encountered and their resolutions, and the favorable developments that took place despite initial difficulties. In conclusion, it will be indicated how remaining analytical work will be carried out and a follow-up project will be considered.

II. TECHNICAL COMPONENT

1. Background

Part of this research was undertaken in the West African Sahel because in that region of Africa, very little effort has been made (a) to overcome the negative effects of the seasonal fluctuations on the nutritional status of peasants' livestock; and (b) to correct the nutritional deficiencies including the deficiency of digestible protein. The research was undertaken in Burkina Faso. It was possible because among the chemicals commonly used to improve digestibility of straws, urea was the only one which was available in that country and at a cost that would be affordable to most small farmers. It was undertaken, now, because in the current stage of this technology it was scientifically sound to hypothesize that urea treatment of the sorghum stovers will markedly increase nitrogen content of the dry stovers and have a beneficial effect on the degradability of stovers' cell wall components by the African goats' rumen microorganisms.

Therefore, the objectives of the project were:

1. To determine the right combinations of postharvest time, moisture content and urea concentration for improving nutritive value of sorghum stover.

2. To determine **in vitro** cell wall digestibility and cell wall component degradability as affected by urea treatment.

3. To determine nutrient digestibility and feed efficiency of urea-treated sorghum stovers fed to growing goats.

4. To compare nutritive value of sorghum stovers ensiled with urea in upright and in trench silos.

5. To determine the cost/benefit ratio of urea-treated sorghum stovers ensiled in low cost ground trench silo fed to goats.

6. To establish the basis for the follow-up step which should be the adaptation of this technology to Burkinabe farming conditions and its adoption by small Burkinabe farmers.

2. Major Accomplishments

The funding resources were utilized to meet the project's objectives and to support:

(a) The development and successful defense of two theses.

(1) In vitro improvement of sorghum stovers nutritive value for sheep and goats; 82 pages; August 1990; Student: Dembele Boubacar, from Mali; Major Professor: Suchet L. Louis; Degree granted: M.S. by Tuskegee University.

(2) Influence of urea treated straws on growth and digestibility in small ruminants; 79 pages; June 1990; Student: Charles L. Ouedraogo; Major Professor: Aime J. Nianogo; Degree granted: Rural Development Engineer by University of Ouagadougou.

(b) The presentation of one paper at the National Meeting of the American Society of Animal Science, Ames, Iowa; July 1990; Title: Effect of postharvest time, moisture and urea on nutritional quality of ensiled sorghum stovers in vitro (see Appendices; Presenter: Dembele Boubacar; Paper No. 779.

(c) Submission and preparation of 3 papers for publication. (See Appendices)

(1) Nianogo, A., C. Ouedraogo, S. Louis and S. Solaiman. In situ disappearance of various natural and cultivated straws. Bulletin of Animal Health and Production in Africa. (1990). (Accepted).

(2) Dembele, B., S. Solaiman and S. L. Louis. Effect of urea treatment, moisture and post harvest time on composition and digestion of sorghum stovers **in vitro.** Journal of Small Ruminant Research. 1991 (In preparation).

(3) Nianogo, A., S. L. Louis, C. Ouedraogo and S. Solaiman Effect of urea treatment on digestibility and utilization of sorghum straw. Bulletin of Animal Health and Production in Africa. (1991) (Submitted).

Moreover, the project's resources were used to improve the Animal Science facilities at the Gampela Experiment Station, Institut de Developpement Rural, University of Ouagadougou and some equipment and materials were purchased for the nutrition laboratories at both Tuskegee University and University of Ouagadougou.

As a result of this project, scientific collaboration has developed and persists between researchers of both institutions.

3. Main Results

3.1. Results Meeting Objective No. One

3.1.1. Objective One

To determine the right combinations of post harvest time, moisture content and urea concentration for improving sorghum stovers nutritive value.

3.1.2. Results

A. Nutrient Content (Tables I, II and III)

The addition of urea at ensiling has a marked influence on the nutrient content of the sorghum stovers, particularly at the 2% level. The most striking effects are observed for crude protein and cell wall components.

Table I. Sorghum Stovers Nutrient Content (%) As Influenced by Urea Treatment

	UREA CONCENTRATION (%)			
NDF	79.88 ± .63[a]	79.38 ± .42[a]	78.22 ± .52[b]	77.79 ± .52[b]
ADF	51.53 ± .50[a]	51.31 ± .48[a]	50.65 ± .31[b]	50.53 ± .25[b]
CELL	34.48 ± .51[bc]	35.25 ± .42[a]	35.13 ± .52[ab]	34.31 ± .46[c]
HEM	28.35 ± .49[a]	28.08 ± .59[ab]	27.57 ± .50[b]	27.17 ± .46[bc]
CP	7.38 ± .20[d]	12.01 ± .47[c]	15.63 ± .57[b]	18.66 ± .06[a]

[a,b,c,d] Means within row with different supercripts are significantly different at $P<0.05$.

Table II. Sorghum Stovers Nutrient Content (%) As Influenced by Post Harvest Time

	POST HARVEST TIME (WEEKS)		
	0	2	4
NDF	77.91 ± .59[c]	78.89 ± 0.40[b]	79.58 ± 0.43[a]
ADF	50.33 ± 0.29[b]	51.35 ± 0.25[a]	51.33 ± 0.45[a]
CELL	34.42 ± 0.44[b]	35.54 ± 0.31[b]	34.42 ± 0.43[b]
HEM	27.59 ± 0.48[b]	27.54 ± 0.40[b]	28.25 ± 0.49[a]
CP	13.52 ± 1.09[b]	12.80 ± 1.05[c]	13.95 ± 1.31[a]

[a,b,c,d] Means within row with different superscripts are significantly different at $P<0.05$.

Table III. Sorghum Stovers Nutrient Content (%) As Influenced By Moisture Level

	MOISTURE LEVEL	
	40	60
NDF	78.41 ± 0.44[b]	79.18 ± 0.36[a]
ADF	51.12 ± 0.28[a]	50.89 ± 0.31[a]
CELL	35.48 ± 0.26[a]	34.03 ± 0.33[b]
HEM	27.28 ± 0.48[b]	28.30 ± 0.32[a]
CP	12.24 ± 0.79[b]	14.60 ± 1.00[a]

[a,b,c,d] Means within row with different superscripts are significantly different at $P<0.05$.

The post harvest time (PHT) has a definite effect on the nutrient content, particularly on the cell wall content which tends to be higher after 4 weeks than at the time of grain harvest.

The moisture content of ensiling has also a positive effect, while crude protein content increased at 60% compared to 40% moisture, the cellulose content is lowered.

B. In vitro Dry Matter Digestibility (IVDMD) (Table IV)

The study indicated that there was no species difference ($P>0.05$) in IVDMD. In this study, the difference in IVDMD was not significant ($P>0.05$) for sheep and goats and even though the control feeds were low in crude protein (7.38%) and high in fiber (79.88 and 51.53% for NDF and ADF, respectively). The mean IVDMD was 53.18 and 52.19% for sheep and goats respectively.

(a) Sheep

In vitro dry matter digestibility was influenced by urea, moisture levels and by post harvest times. The increase in urea concentration from 0 to 3% w/w increased ($P<0.001$) the percentage of IVDMD above the control. The means were 44.13, 56.63, 62.60 and 49.93% for 0, 1, 2 and 3% urea levels, respectively. This may be the result of the solubilizing effect of urea on cell walls. The chemical analysis indicated a decrease of NDF, ADF and hemicellulose with the increase in urea levels. The crude protein content also increased and, therefore, more nitrogen was available to microorganisms for the hydrolyzing activities. However, a concentration of urea higher than 2% did not further increase *in vitro* dry matter digestibility. In the 3% urea treated stovers, the IVDMD was lower than for either 2% or 1% urea treated. The means were 49.93% for the 3% urea and 62.60 and 56.04% for 2 and 1%, respectively. The lower IVDMD with 3% urea treatment is probably the effect of excessive production of ammonia produced by urea hydrolysis which exceeded the capacity of microorganisms. However, the *in vitro* dry matter digestibility at 3% urea level was still higher ($P<0.01$) than that observed in the control (49.93 vs 44.13%). The IVDMD was lower ($P<0.001$) in stovers containing 40 than 60% moisture (50.63 vs 55.72%). This may be due to the complete hydrolysis of urea with 60% moisture. When urea is converted into ammonia, urea-NH_3 will act as an NH_3 treatment to solubilize cell walls and therefore increase its digestibility.

Table IV. *In vitro* Dry Matter Digestibility in Sorghum Stovers as Influenced by Post Harvest Time, Moisture and Urea Treatment (Sheep vs Goats)

	SHEEP MEAN	GOAT MEAN	DIFFERENCE	SE±
UC (%)				
0	44.13	41.92	2.21	1.73
1	56.04	53.27	2.77	2.64
2	62.60	60.35	2.25	2.55
3	49.93	52.78	-2.85	2.29
PHT (WEEKS)				
0	54.48	55.52	-1.04	2.51
2	52.00	51.98	0.02	2.79
4	53.04	48.73	4.31	2.44
MOISTURE %				
40	50.63	45.07	5.56*	1.70
60	55.72	59.09	-3.37	1.98

UC = UREA Concentration
PHT = Post Harvest Time
MC = Moisture Concentration
* = Difference was significant (P<.02)

The *in vitro* dry matter digestibility was higher when stovers were cut immediately after grain harvest than 2 or 4 weeks later. The difference between IVDMD or sorghum stovers cut at 2-week versus 4-week PHT was not significant even though the 4-week PHT tended to have a low IVDMD. This may be due to the decrease of the nutritive value of the stovers with time of post harvest. The means were 54.48, 52.00 and 53.04 for 0-, 2-, and 4- week

PHT, respectively. No significant difference was observed in IVDMD between stovers cut immediately ($P<0.05$) and those cut 4 weeks later. *In vitro* dry matter digestibility of stovers cut 2-week PHT was lower ($P<0.01$) than at 0- week PHT but not different from IVDMD at 4-week PHT.

(b) Goats

The increase in urea concentration (from 0 to 2%) significantly increased IVDMD ($P<0.001$). The means were 41.92, 53.27 and 60.35% for 0, 1 and 2% urea levels, respectively. In goats, as well as in sheep, sorghum stovers treated with 3% urea did not show any additional increase in IVDMD with urea treatment above 2%. This was probably the effect of excess ammonia produced from the hydrolyzed urea. In the presence of 40% moisture, IVDMD of stovers was lower ($P<0.001$) than for 60% moisture. The means were 45.05 and 59.09%, respectively. The increase in digestion with 60% moisture could be the result of complete hydrolysis of the urea in the ensiled stovers. The study indicated that IVDMD decreased with the length of post harvest time ($P<0.001$). The IVDMD was high (55.52%) when stovers were cut immediately after grain had been harvested. At 4-week PHT the percentage of IVDMD became lower ($P<0.01$) than when stovers were cut at 2-week PHT (48.73 vs 51.98). The increase in post harvest time may have decreased the nutritive decreased crude protein and increased NDF and ADF content value of sorghum stovers. This is probably a result of decreased crude protein and increased NDF and ADF content.

3.2 Results Meeting Objective No. Two

3.2.1. Objective No. Two

To determine *in vitro* cell wall digestibility and degradability as affected by urea treatment.

3.2.2. Results

A. Kinetics of Digestion

Kinetics of digestion were calculated from the Potentially Digestible Cell Wall (PDCW). The PDCW was obtained by subtracting the mass of indigestible cell wall (cell wall remaining after 96 hours incubation) from the mass of cell wall remaining at different times of incubation (0, 12, 24, 36, 48 and 72 hours).

(a) Sheep

The mean retention time (MRT), the half life ($T_{1/2}$) and the digestion rate (k) data are presented in Tables V, VI and VII.

1. Mean Retention Time (MRT)

The study indicated that PHT did not significantly influence ($P>0.05$) the mean retention time of sorghum stovers for sheep. Samples containing 40% moisture had lower MRT ($P<0.05$) than those containing 60% moisture. This result did not support the finding for IVDMD that the zero week PHT and 60% moisture content showed the highest digestibility. The urea treatment decreased the MRT ($P<0.01$) compared to the control. This suggests that urea would increase digestibililty, subsequently intake. The difference in MRT for urea treatments (1, 2 and 3% w/w) was not significant ($P>0.05$).

2. Half-life

From this study, post harvest time did not have a significant influence ($P>0.05$) on half-life of sorghum stovers using sheep *in vitro* experiment. *In vitro* half-life times were different ($P>0.05$) with different levels of moisture and urea. The half-life time of the rumen content was higher for 60 than for 40% moisture content (24.43 and 17.53 hours, respectively). This result did not agree with the IVDMD which showed a higher digestibility with 60 compared to 40% moisture. Urea treatments decreased the half-life time ($P<0.01$). The calculated half-life time of the control stovers was significantly greater ($P<0.007$) than urea treated stovers. The means were 29.14, 19.15, 16.27 and 19.39 hours for the 0, 1, 2 and 3% urea treated stovers respectively. The difference between urea treatments was not significant ($P>0.05$). The urea treatment decreased the half-life time of sorghum silage and, therefore, may increase the total digestibility over the control.

3. Digestion Rate (k)

Rates were assumed the same through the entire gastrointestinal tract. The factors studied in this experiment did not show any significant influence of treatment on the digestion rate ($P>0.05$). The highest and lowest rates were observed in stovers cut at 0- and 4-week PHT, respectively. Stovers cut immediately after harvest may have a higher digestibility compared to the later cut stovers. Silage at the 60% moisture level had a lower k compared to the 40% moisture content. This result did not support findings from IVDMD that stovers with 60% moisture had a better

digestibility than those with 40% moisture. The urea treatment did not significantly increase (P>0.05) k, however, the rate tended to be highest with 2% urea treated samples. The means were 4.5, 5.04, 8.5 and 4.8% for the control, 1, 2 and 3% respectively. Similar results were obtained with IVDMD where the highest digestibility was observed with the 2% urea treatment.

Table V. **In Vitro dry matter digestibility and kinetics of digestion of sorghum stovers as influenced by urea treatment using sheep.**

		UREA CONCENTRATION (%)			
		0	1	2	3
IVDMD	(%)	44.13 ± 1.18[d]	56.04 ± 1.13[d]	62.60 ± 1.29[a]	49.93 ± 1.20[c]
MRT	(hr)	38.81 ± 3.26[a]	25.97 ± 2.88[b]	24.02 ± 2.94[b]	24.53 ± 2.74[b]
$T_{1/2}$	(hr)	29.14 ± 2.52[a]	19.15 ± 2.84[b]	16.27 ± 3.11[b]	19.61 ± 2.74[b]
K	(%)	4.50 ± 1.88[a]	5.04 ± 1.03[a]	8.50 ± 3.17[a]	4.79 ± 0.82[a]

[a,b,c,d] Means within row with different superscripts are significantly different at P<0.05.

Table VI. **In vitro Dry Matter Digestibility and Kinetics of Digestion of Sorghum stovers as Influenced by Post Harvest Time Using Sheep.**

		POST HARVEST TIME (WEEKS)		
		0	2	4
IVDMD	(%)	54.48 ± 1.83[a]	52.00 ± 1.60[b]	53.04 ± 1.34[ab]
MRT	(hr)	31.59 ± 2.13[a]	25.00 ± 3.25[a]	28.39 ± 3.19[a]
$T_{1/2}$	(hr)	23.87 ± 2.13[a]	19.00 ± 2.72[a]	20.25 ± 2.71[a]
k	(%)	5.31 ± 1.43[a]	5.25 ± 0.87[a]	6.56 ± 2.46[a]

[a,b,c] Means within row with different superscripts are significantly different at P<0.05.

(b) Goats

MRT, $T_{1/2}$ and k results for goats are presented in Tables VII, VIII and IX.

1. Mean Retention Time (MRT)

The MRT was not influenced (P>0.05) by post harvest time whether stovers were cut immediately or up to 4 weeks after grain harvest. The urea treatment did not significantly influence (P>0.05) MRT when it was applied at the rate of 0, 1, 2 or 3% (w/w). However, the MRT tended to be higher for the control stovers compared to the urea treatment. The means were 34.36, 28.55, 25.51 and 27.13% for the control, 1, 2 and 3%, respectively. The increase of moisture level from 40 to 60% increased (P<0.01) the MRT 24.95 and 32.82, respectively.

2. Half-Life

Post harvest time or UC did not influence (P>0.05) the half-life time of rumen content. These results were contrary to the findings for IVDMD where post harvest time and urea level influenced IVDMD. The half-life time was lower (P<0.01) for the 40% than for 60% moisture level and the means were 16.20 and 26.49 hours, respectively. This effect of moisture levels was also obtained in sheep.

3. Digestion Rate (k)

The study indicated that postharvest times, moisture and urea concentrations used did not affect the digestion rate of the ensiled sorghum stovers (P>0.05). The rates obtained for the control tended to be lowest for the

urea treatments. The moisture level of 60% had a higher k compared to the 40%. The mean digestion rates were 6.12 and 4.14% for 60 and 40% moisture levels, respectively. The fecal and feed samples that were sent by mail from Burkina Faso to Tuskegee were intercepted by USDA Quarantine Service. It took two months to clear the shipment because of unexpected delay from getting clearance. This problem is responsible for the delay experienced to date in the analysis of the sample ytterbium and other nutrients. Although it was anticipated that the analysis would be completed by the end of 1990, the results were not acceptable. Therefore, the passage rate results will not be presented in the Final Report. The analysis of the sample ytterbrium will be repeated and the results will be published in a second paper.

VII. In Vitro Dry Matter Digestibility and Kinetics of Digestion of Sorghum Stovers as Influenced by Moisture Level Using Sheep and Goats.

		SHEEP		GOAT	
		MOISTURE %		MOISTURE%	
		40	60	40	60
IVDMD	(%)	50.63 ± 1.19^{b}	55.72 ± 1.32^{a}	45.07 ± 1.21^{b}	59.09 ± 1.48^{a}
MRT	(hr)	25.65 ± 2.00^{b}	31.01 ± 2.65^{a}	24.95 ± 1.97^{b}	32.82 ± 1.86^{a}
$T_{1/2}$	(hr)	17.53 ± 1.90^{b}	24.55 ± 2.45^{a}	16.20 ± 2.08^{b}	26.49 ± 2.21^{a}
k	(%)	5.94 ± 0.96^{a}	5.48 ± 1.72^{a}	8.71 ± 1.46^{a}	4.10 ± 1.09^{a}

^{a,b,c,d} Means within row with different superscripts are significantly different at $P<0.05$.

Table VIII. *In vitro* Matter Digestibility and Kinetics of Digestion of Sorghum Stovers as Influenced by Urea Treatment Using Goats.

	UREA CONCENTRATION (%)			
	0	1	2	3
IVDMD (%)	41.92 ± 1.27[c]	53.48 ± 2.39[b]	60.35 ± 2.20[a]	52.78 ± 1.95[b]
MRT (hr)	34.36 ± 2.80[a]	28.55 ± 2.99[a]	25.51 ± 2.30[a]	27.13 ± 3.20[a]
$T_{1/12}$ (hr)	27.90 ± 2.99[a]	21.63 ± 3.00[a]	16.92 ± 3.71[a]	18.93 ± 3.71[a]
k (%)	4.83 ± 1.27[a]	4.33 ± 0.81[a]	7.42 ± 2.09[a]	9.79 ± 0.25[a]

[a,b,c,d] Means within row with different superscripts are significantly different at $P<0.05$.

Table IX. In Vitro Dry Matter Digestibility and Kinetics of Digestion of Sorghum Stovers as Influenced by Post Harvest Time Using Goats

	UREA CONCENTRATION (%)		
	0	2	4
IVDMD (%)	55.52 ± 1.72[a]	51.98 ± 2.28[b]	48.73 ± 2.04[c]
MRT (hr)	28.90 ± 2.07[a]	26.64 ± 2.64[a]	31.13 ± 2.84[a]
$T_{1/2}$	21.40 ± 2.69[a]	20.20 ± 3.25[a]	22.44 ± 2.90[a]
k (%)	4.94 ± 0.48[b]	7.75 ± 0.80[a]	6.53 ± 2.31[a]

[a,b,c,d] Means within row with different superscripts are significantly different at $P< 0.05$.

3.3 Results Meeting Objective No. Three

3.3.1. Objective No. Three

To determine nutrient digestibility and feed efficiency of urea treated sorghum stovers fed to growing goats.

3.3.2. A. *In vivo* Digestibility

Influence of 2% urea treatment of stovers *in vivo* digestibility and growth in sheep and goats.

The supplement composition varied with the rations but all contained molasses, cotton seed meal (CSM) and Dolicos hay. The main difference was in the amount of CSM utilized. The experimental ration (ensiled stovers) had three times less CSM, which means much cheaper in concentrate than the control. All rations were formulated to be theoretically isocaloric and isonitrogenous. All animals received salt blocks. The price of Dolicos hay did not influence the cost of ration that much.

In the Final Report, the cost of rations and cost of gain will not be presented as anticipated because of lack of sufficient data. Such data will be obtained in the next round of repeated experiments. Instead, we will discuss and assess the economic advantage of using top dressing with urea versus ensiled with urea.

There was no significant difference between Ration 2 and Ration 3. Ensiling sorghum stovers with 2% urea and the addition of urea did not improve the voluntary feed intake which was higher on untreated stovers. This result agrees with that of other findings. The decrease in voluntary feed intake may result from a reduction of palatability due to urea. Voluntary feed intake of DM, OM, NDF, ADF and CP was statistically identical between sheep and goats. On the other hand, consumption of

NDF was significantly higher (P<.02) in sheep than in goats (.028 vs. .022g/kgw$^{.75}$) respectively.

Table X. Composition of Experimental Rations

INGREDIENTS	Ration 1 %	Ration 2 %	Ration 3 %
Sorghum Stovers	62	62	--
Stovers ensiled w/Urea	- -	- -	61
Urea	- -	1.28	- -
Molasses	18	20	22
Cottonseed Meal	10	4	3
Dolicos Hay	10	12	14
T	60.98	61.02	60.21
CP	9.26	9.28	9.52

Ration 1: Stovers with supplement as described below.
Ration 2: Stovers (S29) with 2% added urea and supplement
Ration 3: Stovers (S29) ensiled with 2% urea and with supplement.

Table XI. Effect of Ration on Voluntary Feed Intake

	Ration 1 (Not Ensiled)	Ration 2 (Urea Added)	Ration 3 Ensiled (W/Urea)	SE±
	g/kgw$^{.75}$	g/kgw $^{.75}$	g/kgw$^{.75}$	
DM	55.9^{a}	42.3^{b}	39.4^{a}	.003
OM	51.0^{a}	39.3^{b}	37.0^{b}	.002
NDF	30.0^{a}	16.8^{b}	16.2^{b}	.002
ADF	20.6^{a}	14.0^{b}	13.6^{b}	.001
CP	5.7^{a}	4.6^{b}	4.3^{b}	.001

P<.05

Table XII. Effect of Rations on Apparent Digestibility

	Ration 1 (Not Ensiled)	Ration 2 (Urea Added)	Ration 3 (Ensiled w/Urea)	SE±
Parameters	%	%	%	
DM	51.9[a]	59.2[a]	55.6[a]	2.4
OM	53.4[a]	62.5[a]	58.3[a]	2.3
NDF	42.5[a]	42.5[a]	30.7[a]	3.0
ADF	47.2[a]	50.5[a]	45.4[a]	2.8
CP	51.4[a]	53.3[a]	59.3[a]	3.3

There was no statistical difference in digestibility of nutrients DM, OM, NDF, ADF and CF among the three rations. However, for most the nutrients measured, their digestibility tends to be higher in Ration 2 and Ration 3. Others found similar results *in vivo* with 4% urea treatment of sorghum stovers. This result may stem from the fact that there was no treatment effect on NDF nor in the voluntary intake of the straw. It is apparent that although the differences were not statistically significant, there was a sustained trend for the DM, OM, NDF, ADF and CP digestibilities for being high in the ensiled with urea and urea added treatment than in the control. The lack of significant difference is certainly due to the high level of individual variations, evidenced by high (SE) standard errors. This trial should be repeated to statistically confirm the trends.

B. Growth Trial

Table XIII. Composition of Growth Ration for Lambs.

INGREDIENTS	Ration 1 %	Ration 2 %	Ration 3 %
Sorghum Stovers	40	38.22	--
Stovers ensiled w/Urea	--	--	40
Urea	--	0.78	--
Molasses	12	12.5	12
Cottonseed Meal	10	10	10
Dolicos Hay	18	24	22
TDN	69.7	69.7	60.21
CP	9.26	16.5	16.34

The composition of the growth ration differs from the digestibility rations in two points. (1) The Dolicos is replaced by wheat bran in the concentrate and (2) the ingredient percentages are not the same for the purpose of meeting growth requirements. Everything else remained the same.

TABLE XIV. Effects of Rations on Voluntary Intake in the Lamb (average) grams/kgw$^{.75}$

NATURE OF FEEDS	Ration1	Ration 2	Ration 3	SE±
(a) Sorghum Stovers (Straw only)	17.9	24.7	20.1	1.35
(b) Concentrate/Supplement only (Within the total feed consumed)	79.4	72.8	79.0	1.73
(c) **Total Feeds Consumed**[1]	86.6	89.8	91.5	4.25

[1] Do not add up

No significant difference was obtained among the rations as for the voluntary feed intake. The supplement consumption had definitely an influence on the consumption of straw. Indeed, in the growth trial, the average consumption of concentrate varied from 77 to 85%, much more than it was foreseen (60%). It was observed that the concentrate were consumed quite rapidly and first, whereas the straw was refused at about 42%. Since straw and concentrate were not mixed and were offered separately, the selection in favor of concentrate was possible.

TABLE XV. Effect of Rations on Growth of Lambs (kg)

Weight (kg)	Ration1	Ration 2	Ration 3	SE±
Initial	13.5[b]	14.2[b]	17.3[a]	0.00
Final	17.9[b]	18.8[b]	20.7[a]	0.69

N = 24 lambs Trial period = 8 weeks

Table XVI. Effect of Ration on Weight Gain (g/day).

Weeks	Ration1	Ration 2	Ration 3	SE±
1 - 4	89.9	90.5	77.8	6.77
5 - 8	78.4	82.5	61.7	5.78

Since the initial weight (IW) in Ration 3 was significantly higher than in the other two, the IW was used as covariant in the related statistical analysis. The lack of statistical difference obtained may result from high intake of concentrate (70% of total intake), eliminating, de facto, any possible

effect of urea on growth while improving the feeding quality of the sorghum stovers.

Even though the results appear interesting for an animal production perspective, an economic assessment or a cost/benefit analysis is necessary to better appreciate these results.

3.4. Results Meeting Objective No. Four

3.4.1. Objective No. Four

To compare nutritive value of sorghum stovers with urea in upright and in trench silos.

3.4.2. Results

The nutritive value of sorghum stovers silage from trench silo was compared to that of sorghum stovers with added urea. No upright silo was used. This objective was slightly modified in order to design a feeding condition which was most likely to occur in the African villages. This study was carried out in completely balanced ration in both the digestibility and growth trials.

Table XVII. Composition of Ration in Digestibility Trials.

Ingredients	Ensiled with Urea	Not Ensiled with Added Urea
Sorghum Stovers	- -	62.0
Stovers Ensiled with Urea	61.0	- -
Urea	- -	1.28
Molasses	22.0	20.0
Cottonseed Meal	3	4
Dolicos	14	12

Table XVIII. Nutritive Value of Sorghum Stovers Ensiled with Urea and Not Ensiled but with Added Urea

Parameters		Ensiled with Urea	Not Ensiled with Added Urea
		%	%
TDN	%	60.21	61.02
CP	%	9.52	9.28
MO	%	93.21	91.60
ADF	%	35.85	35.65
NDF	%	43.79	47.89
ADL	%	4.78	7.81
DMO	%	58.33[a]	62.56[a]
DGP	%	53.32[a]	59.32[a]
DNDF	%	30.72[a]	42.59[a]
DADF	%	45.46[a]	50.51[a]

D = Digested

Table XIX. Composition of Growth Ration for Goats.

Ingredients	Ensiled with Urea	Not Ensiled with Added Urea
	%	%
Sorghum Stovers		38.22
Stovers Ensiled with Urea	40.0	
Urea	- -	0.78
Cotton Seed Meal	16.0	14.5
Cottonseed	10.0	10.0
Molasses	12.0	12.5
Wheat Bran	22.0	24.0
TND %	70.23	62.70
CP %	16.34	16.25

Table XX. Food Intake and Growth Data for Growing Goats

	Ensiled with Urea	Not Ensiled with Added Urea
	$\bar{X}$	$\bar{X}$
Food Intake g/kg$^{3/4}$	91.52[a]	89.89[a]
Total Weight Gain grams	61.70[a]	82.54[a]

Not statistically significant at 5%

From the limited result presented above and given the modification in the design in regard to this specific objective, it ensues that the dry sorghum ensiled with urea was as good as the dry sorghum fed not ensiled but with added urea. Although individual variations in the data were in part responsible for non-statistical differences, the feeding of complete concentrate based rations might have masked the "sorghum treated urea effect" on the small ruminants' weight gain. Therefore this segment of the research is being repeated in Burkina Faso. This experiment is being done in a way that the goats would consume more treated or untreated stovers than in previous trials.

3.5. Results Meeting Objective No. Five

3.5.1. Objective No. Five

To determine the cost/benefit ratio of urea-treated sorghum stovers ensiled in low cost ground trench silo fed to goats.

3.5.2. Results

Two large size trench silos were dug side by side. One was constructed in cement blocks, the "concrete silo" and the other remained as dug, the "dirt silo".

The following data were obtained on the silo performance and cost. The cost is expressed in CFA Francs (US $1.00 = CFAF $250.00).

Table XXI. Silo Performance and Cost at Gampela Experiment Station/University of Ouagadougou, Burkina Faso

Items	Concrete Silo	Dirt Silo
Estimated Volume (Cubic metric)	45	45
Dry Matter Ensiled:		
Estimated amount, kgs.	1,932	2,425
Losses, kg	265	478
Losses, %	13.72	19.71
Amount Recovered, kg	1,667	1,947
Construction Cost:		
Digging, CFA Francs	30,000	30,000
Cement, block, labor, (CFA Francs)	170,000	None
Total	200,000	30,000

For comparison purposes, if we disregard the cost of urea addition, the labor cost for cutting, chopping and transporting the stovers, filling the silos with chopped stovers, and the fuel cost, we found that the silage from dirt silo cost 5.5 times less than from the concrete silo. The quality of the silage as feed, being equal, from both types of silos, it is recommended that the dirt silo be promoted in the villages. However, if dirt silo is to be promoted, the following recommendations must be followed to avoid some problems:

1. The dirt silo suffered some degree of erosion due to rain, particularly on the edges. If not

protected from erosion, it must be re-emptied from accumulated dirt in order to bring the silo back to its original depth and volume. If not done, the silo would accept less chopped stovers. If not protected from run off, the silo would become unusable within two years (after two rainy seasons). That could add to the cost of the dirt silo.

2. In the dirt silo, all silage piled to a depth inferior to 1 m was found dry (85% dry matter) and spoiled (white dusty mold). At about 30 cm from the top, the silage looked good. Apparently, the soil was dry enough to cause the removal of moisture from the stovers.

   On the contrary, the concrete silo caused less spoilage in general, except in the 30 cm from the top.

   At this stage of the investigation, some data are lacking in order to make conclusive recommenda tions by comparing the concrete silo with the dirt silo. However, given (a) the percentage of recovery, 86.29% versus 80.29%; (b) the cost (1.00 vs. 0.15); and (c) the equal silage quality, the use of dirt silo for small farmers is recommended.

3.6. Results Meeting Objective No. Six

3.6.1. Objective No. Six

To establish the basis for the follow-up step which should be the adaptation of this technology to Burkinabe farming conditions and its adoption by small Burkinabe farmers.

3.6.2. Results

At this stage, the gathering of economic data is largely insufficient. Therefore, it is not yet possible to test the new technology that has been developed.

As it is explained in detail below, the setback was that the cost of weight gain due to urea treated and untreated stovers could not be correctly estimated due to inadvertent consumption of concentrate rations by the goats. Although no extension of the project is granted, we have already repeated the growth trial with proper feeding conditions of treated and untreated straws. By this summer, we hope to obtain sufficient economic data. Consequently, the rational basis for the follow-up experiment will be established for both the adaptation of the new technology and its adoption by small Burkinabe farmers.

4. Problems Encountered and Solutions

4.1. Shipment of Feed and Fecal Samples From Burkina Faso to Tuskegee

All experimental samples destined to Tuskegee were previously dried at 100^0 Celsius, autoclaved, and sealed in ziplock plastic bags. Both Tuskegee and IDR insured that procedures were followed. However, because a shipment document was not received by USDA for these samples, they were confiscated for several weeks. This unexpected delay was responsible for prolonging the time for laboratory analysis and caused a waste of money. A laboratory technician was hired specifically to analyze these samples which were not available. After more than 3-4 months, the samples were released but the technician had left Tuskegee for another opportunity. Moreover, no one knows what effect the prolonged storage might have on the yitterbium analysis.

4.2. *In vivo* Digestion Trial

In order to calculate the digestion coefficients for different nutrients, daily feed intake and fecal output per animal are needed, as well as chemical composition of the feeds and feces. These digestion data had to come from the University of Ouagadougou. The data of chemical composition of feeds were sent to Tuskegee but was determined on "yitterbium marked" stovers, because the same animals served in two experiments:

the digestion and the passage rate. It happened that the marked feeds, which resulted from feeds previously washed with water according to a standard procedure, served in the chemical analysis and not unmarked, unwashed ones. Therefore, it becomes difficult to use the data in the calculation of digestion. At present, unmarked feeds (sorghum stovers) are not available in our laboratory at Tuskegee. We are now awaiting unmarked sample or chemical analysis for unmarked stovers to be sent to us from Burkina Faso. Using chemical analysis of washed stovers may bias the results. The final results for these trials will not be known at the moment.

4.3. Passage Rate Experiment

In order to calculate the passage rate kinetics, samples received from Burkina Faso have been analyzed for yitterbium. However, results did not come out, as expected. Therefore, we are currently repeating all yitterbium analyses and the passage rate result will be reported later in a paper.

III. FINANCIAL COMPONENT

Period: 9/15/88 - 12/31/90 **TU-A/C: 270-VAA-4720-4100**

Salaries	$ 22,929.94
Fringes	1,676.29
Consultant	1,525.00
Supplies	8,454.20
Other Expenses	205.00
Travel	14,134.56
Equipment	3,995.23
Indirect Cost: On-Campus Off-Campus Expenses	16,536.82
Salaries	6,365.00
Other Expenses	14,135.00
Indirect Cost Off-Campus	4,920.00
Total	$ 94,877.54

IV. CONCLUSION

Since 1983, Tuskegee University and the University of Ouagadougou have signed a cooperative linkage agreement. In 1986, such linkage was updated to include a broader scope of cooperation. The goat nutrition research is one of the few projects, tried under this linkage and successfully implemented. Urea treated sorghum stovers in Burkina Faso is a new technology which has great future, not only in that country, but also in the whole Sub-Region of the Sahel.

Given the problems encountered due to the inherent nature of this international research, the growth trial was repeated in order to complete this investigation . Additional results will be obtained this summer.

V. APPENDICES

1. Papers Submitted and In Preparation

1.1. Nianogo, A. J., S. L. Louis, S. G. Solaiman, C. L. Ouedraogo and A. Siaway. 1991. Effect of urea treatment on digestibility and utilization of sorghum straw. Bulletin of Animal Health and Production in Africa. (submitted).

1.2. Dembele, B., S. G. Solaiman, S. L. Louis and A. J. Nianogo. 1991. Effect of urea treatment, moisture and post harvest time on composition and digestion of sorghum stovers *in vitro*.

1.3. Nianogo, A., C. Ouedraogo, S. Louis and S. Solaiman. 1990. *In situ* disappearance of various natural and cultivated straws. Bulletin of Animal Health and Production in Africa (submitted).

2. Abstract of papers presented at Animal Science meetings

2.1. Effect of postharvest time, moisture and urea on nutritional quality of ensiled sorghum stovers *in vitro*. August 1990 Iowa State University.

2.2. Effect of urea treatment on digestibility and utilization of sorghum stovers in sheep and goats. August 1991, Laramie, University of Wyoming.

V. APPENDICES

1. Papers Submitted and In Preparation

1.1. Nianogo, A. J., S. L. Louis, S. G. Solaiman, C. L. Ouedraogo and A. Siaway. 1991. Effect of urea treatment on digestibility and utilization of sorghum straw. Bulletin of Animal Health and Production in Africa. (submitted).

EFFECT OF UREA TREATMENT ON DIGESTIBILITY AND UTILIZATION OF SORGHUM STRAW.

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ABTRACT

Nine male goats and 9 castrated lambs were randomly divided into 3 groups of 3 animals to receive one of three experimental diets in a digestion trial. Diet S1 provided chopped sorghum straw (SS), 28% concentrate (C) and 10% Dolichos lab-lab hay (D). Diet S_{u1} provided SS containing 2% urea, 25.28% C and 10% D, and diet S_{ue1} provided SS treated to contain 2% urea and ensiled for 28 days, plus 25% .

Twenty four lambs where randomly divided into 3 groups of 8 animals to receive one of three diets in a 56-day growth trial; Diet S2 provided SS plus 60% C; diet S_{u2} provided SS containing 2% urea plus and 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 ($P<0.05$) daily intake of DM, OM, CP and NDF for S_1 than for S_{ue1} and S_{u1}. Dry matter intake was 55.93; 39.42 and 42.34 g/Kg MBW for S_1, S_{u1} and S_{ue1}, respectively. Dry matter intake was slightly higher for lambs (50 g/Kg$^{0.75}$) than for goats (42 g/Kg$^{0.75}$). There was no effect of dietary treatments on apparent nutrient digestibility.

During the growth trial intake of straw varied from 17.97 (S2) to 24.78g/kg$^{0.75}$ (S_{ue2}), but differences were not significant. Total feed intake and

feed efficiency were only slightly affected by dietary treatments. Average feed intake was 4.364% body weight. High concentrate intakes may have upset the effect of urea treatment and silo fermentation in this study.

INTRODUCTION

Ruminant livestock in most sahelian countries rely on natural pastures for survival; however, crop residues contribute for about 25% of feeds ingested by ruminants in Burkina Faso (M.A.E. 1990). The only concentrates used for ruminants are agroindustrial by-products (peanut and cottonseed meals, cottonseeds, molasses, brewers grain, and wheat bran), and the supply is limited. Furthermore, there is an increase in land occupation in favor 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, crops residues have been shown to contain low amounts of digestible nitrogen and energy (Tagel-Din et al, 1989), 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 NDF content (resulting in high cell wall rigidity), and poor N content. Several treatments have been applied to try and 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; Dolgberg 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 (Mamidou, 1989; Zan, 1989; Adu et al, 1990).

Results of cereal straw treament with urea N appear to vary greatly. Urea supplementation usually result in higher dry matter intake and digestibility (Dolgberg et al, 1981; Ibrahim et al, 1987), 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; Poulya, 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 (Adu, 1990) to decrease. The effect of straw treatment on digestion and utilization at high levels of concentrate is still unclear.

Two trials were conducted to determine the effect of urea treatment and ensiling of sorghum straw (to be supplemented 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).

MATERIALS AND METHODS

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 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; approximately 30 cm of dirt was layed on the plastic sheet; the straw was opened after 30 days of fermentation.

Digestion trial:

Nine castrated Sahelian goats averaging 25.9 kg body weight and 36 months of age and 9 Mossi lambs averaging 33.3 Kg body weight and 26 months of age were utilized for a digestion trial. All 18 animals were treated for internal and external parasites prior to the study. Within each species, animals were randomly divided into 3 groups to receive one of 3 experimental rations (Table 1):

S_1: chopped sorghum straw (SS) plus 38 % concentrates and 10 % Dolichos lab-lab hay;

S_{u1}: SS with 2% urea plus 39% concentrates and 12 % Dolichos L. hay;

S_{ue1}: SS with 2% urea top dressed, plus 38% concentrates and 14% Dolichos L. hay.

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

The animals were adjusted to digestion cages and to their respective diets during a 4-week period. They were weighed at the beginning and end of the 6-day collection period. During the collection period, feed intake was monitored, a fecal output and samples of feed offered and orts were collected. Fecal samples were first frozen; they were then mixed together for 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 (1984) and for cell wall contents as described by Robertson and Van Soest (1982). 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) and neutral detergent fiber (NDF).

Growth trial:

Twenty four Mossi lambs averaging 15 Kg body weight and 6 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 3

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[1]Kaya salt licks provided 76% NaCl, 20 %, 2% Mg sulfate, 1% Fe sulfate, 0.4% Mn, 0.5% Cu sulfate, 0.1% Zn sulfate, 0.01% Co sulfate and 0.004% Ca sulfate.

[2]Vitamin mix provided 420,000 IU vitamin A, 1.05 mg vitamin D3, 46,2 mg vitamin E, 42% mg vitamin B1, 21mg vitamin B6, 12.6mg pyridoxal phosphate, 42mg Ca pantothenate, 42mg Cu sulfate, [illegible] mg Co sulfate, 3.16mg Mg sulfate, 7.44mg Mn sulfate, and 6.79mg Zn sulfate.

groups to be fed one of three experimental diets (Table 2):

S_2: 40% untreated, chopped sorghum straw (SS) plus 60% concentrates.

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

S_{u2}: 40% sorghum straw, mixed with 2% urea plus 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 and were adjusted to their respective diets during a 14-day pretrial period.

Feed offerings were readjusted at the end of week four, following body weight changes.

Samples of straws and concentrates were analyzed for DM, CP, NDF, ADF, 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 group 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.

RESULTS

Digestion trial:

Partial compositional analyses of diets and orts are shown in Table 3. Diets were similar in terms of DM, OM and CP content. NDF content was highest

(57.11%) for S_1 and lowest (43.79%) for S_{u1}. 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, CP and NDF were higher ($P < 0.05$) for S_1 than for S_{ue1} and S_{u1}. Dry matter intake was 55.93; 39.42 and 42.34 g/Kg MBW for S_1, S_{u1} and S_{ue1}, respectively. Absolute intake of DM, OM, NDF and CP were higher ($P < 0.05$) for lambs than for goats; however, diffences between species were not significant on a metabolic weight basis. Avegare DM intake was 50 g/Kg MBW for lambs, and 42 g/Kg MBW for goats.

As for the effect of treatment combination on intake, differences were found only for CP and NDF. Lambs fed S_1 had the highest NDF and CP intakes, goats fed Sue1 had the lowest NDF intake, and lambs fed S_{u1} had the lowest CP intake.

Animals consumed 0.12 to 0.17 liters of water/Kg MBW, or 2.83 to 3.36 l/gm DM consumed. Differences were not significant.

Digestibility coefficients (Tables 7 and 8): 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 with goats fed S_{ue1} and lowest coefficient was observed with goats fed S_1; there were more variation among goats fed different diets than among lambs.

Weight changes (Table 9): nearly all animals lost weight during the

collection period. Differences in weight loss were not significant.

Growth trial:

Feed intake (Table 10) increased from week one to eight; average intakes of straw during the 8 week experimental period were 17.97, 20.14 and 24.75 g/kg MBW for S_2, S_{u2} and S_{ue2}, respectively. Concentrates were entirely consumed; however, an average of 42% of straws were refused. Instead of the predicted 60% concentrates, the average percentage of concentrates consumed ranged from 72.61 (S_{u2}) to 79.38% (S_2).

Total dry matter intake averaged 86.63, 91.52 and 89.89 g/kg MBW for S_2, S_{ue1} and S_{u2}, respectively. This represents an average of 4.364 % of body weight.

Growth performance appears in Table 11. Weight gain decreased slightly between the first and the second 4-week period. Average daily gains (ADG) were 78.44, 61.70 and 82.54gm for S_2, S_{ue2} and S_{u2}, respectively; these values were not significantly different.

Feed efficiency ratio (kg gain/kg feed) was lowest for Sue2 (0,0379) and similar for S_2 and S_{u2} (0,0553).

DISCUSSIONS

Digestion trial:

Dry matter intake in the digestion trial was comparable to values reported

by others on caged lambs (Zan, 1989; Hébié, 1989). The reason for weight losses observed during the digestion trial are unclear.

Digestibility coefficients osbserved in this study were higher than those reported with lambs receiving untreated straw alone (Hébié, 1989); Digestibility coefficients were 48.79, 51.07, 12.78, and 44.07% respectively for DM, OM, MAT and NDF (Hébié, 1989). Hébié (1989) 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; 56.60% with straw ensiled with 4% urea and supplemented with 25% cottonseed meal (DM basis). Ouedraogo (1990) found that treatment of SS with 4% urea increased in situ DM disappearance. These 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.

Results of species effect on digestion differ from those reported by Huston et al (1988); these authors found higher DM digestion coefficient with goats fed wheat straw. However, level of supplemental concentrate was much lower in the latter (0 to 60 g/day/animal) 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 contribute 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).

Growth trial:

As indicated in the results section, intake of straw may have been low in this study, considering that straw was the item being evaluated. Jarrige (1980) recommended that concentrate offered 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. The animals used in this study were young and growing, and 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 Rivierre (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 gm/Kg MBW) observed by OUIBGA (1985) with sheep fed diets comparable to ours. Dry matter intake in the growth trial was also higher than that observed for the digestion trial.

Since straw digestion was not improved by urea-treatment or or by

ensiling, treatment effect on gain and feed conversion was not likely. However, lambs fed Sue2 tended to have poorer conversion rates than others, due to high DM intake and low gain, although differences were not significant.

Average daily gains observed in this study are higher than the 30.08 gm/day 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 hours 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 hours/day plus 15, 30 or 45% concentrate supplementation; such lambs gained 54.13; 67.86; and 64.84g/day, respectively (Nassa, 1990). However, overall ADG (74.24 gm) was below those reported by OUIBGA in 1985 (83-133 gm/day).

High intake of concentrate may have helped to mask the effect of straw treatment in the growth trial. Effect of urea treatment or ensiling may be beneficial only when straw is the only feed, or when concentrate supplementation is minimal.

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Table 1 : Composition of experimental rations for digestion trial*.

Ingredient	S_1	S_{u1}	S_{ue1}
Chopped sorghum straw	62.00	-	-
Chopped sorghum straw ensiled with 2 % urea	-	-	61.00
Chopped sorghum straw with 2% urea added	-	61.00	-
Sugarcane molasses	18.00	20.00	22.00
Cottonseed meal	10.00	1.00	3.00
Dolichos L. hay	10.00	12.00	11.00
Total	100.00	100.00	100.00
EXPECTED [illegible]	[illegible]	51.02	60.21
EXPECTED crude protein	9.25	9.28	9.[illegible]2

* S_1= chopped sorghum straw, plus concentrates; S_{u1}= chopped sorghum straw with 2% urea added, plus concentrates; S_{ue1}= chopped and urea treated and ensiled sorghum straw, plus concentrates.

Table 2 : Composition of experimental rations for trial II*.

Ingredient	RATION I: S_2	RATION II: S_{uw2}	RATION III: S_{u2}
Chopped sorghum straw with 2% urea added	-	-	10.0
Chopped sorghum straw	10	-	-
Sorghum straw ensiled with urea	-	10	
Cottonseed meal	20	16	11.5
Whole cottonseed	10	10	10
Molasses	12	12	12.5
Wheat bran	18	22	21
Total	100	100	100
Expected TDN	69.73	70.23	69.70
Expected CP	16.1	16.31	16.25

* S_2= chopped sorghum straw, plus concentrates; S_{u2}= chopped sorghum straw with 2% urea added, plus concentrates; S_{uw2}= chopped and urea treated and ensiled sorghum straw, plus concentrates.

Table 3: Partial compositional analysis of rations and orts for digestion trial

RATION		DM	OM	ASH	CP	ADF	NDF	ADL
S1	FED	96.30	91.40	8.60	9.17	38.55	57.11	7.07
	ORTS	97.68	90.43	9.57	8.57	11.28	65.15	9.02
Sa1	FED	96.09	91.60	8.40	69.37	35.65	17.89	7.81
	ORTS	96.38	88.88	11.12	6.61	41.21	62.87	8.38
Sac1	FED	96.91	93.21	6.88	9.58	35.85	43.79	1.7[illegible]
	ORTS	96.60	88.24	11.76	7.99	37.35	54.03	7.69

Table 4 : Effect of ration and species on intake for digestion trial

Parameter		RATION			EFFECT OF SPECIES[c]	Standard Error
		S1	Su1	Sue1		
DM	g/d	710.71[a]	529.55[b]	181.73[b]	0.0017	13.61
	$g/kg^{0.75}$	55.93[a]	42.34[b]	39.42[b]	N.S.	0.003
OM	g/d	675.14[a]	492.79[b]	452.79[b]	0.002	39.32
	$g/kg^{0.75}$	51.00[a]	39.38[b]	37.05[b]	N.S.	0.002
NDF	g/d	395.27[a]	211.31[b]	197.75[b]	0.0301	26.81
	$g/Kg^{0.75}$	30.01[a]	16.83[b]	16.22[b]	N.S.	0.002
CP	g/d	76.91[a]	57.88[b]	52.81[b]	0.0001	5.25
	$g/kg^{0.75}$	5.75[a]	4.63[b]	4.36[b]	N.S.	0.0003
ADF	g/d	272.86[a]	171.39[b]	168.76[b]	0.559	16.46
	$g/kg^{0.75}$	20.69[a]	14.00[b]	13.65[b]	N.S.	0.001
NDS	g/d	315.45[a]	318.22[a]	283.98[a]	0.0003	21.13
	$g/kg^{0.75}$	25.91[a]	25.45[a]	23.29[a]	0.024	0.001

[a,b]Means bearing no common superscript differ ($P < 0.05$).
[c]Probability of a greater F value; N.S. = not significant at $P < 0.05$.

Table 5 : Combined effect of ration and species on digestibility and intake of dietary components

		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] Means [illegible] [illegible] significant [illegible]

Table 6 : Water consumption by species and ration*

Parameter	SHEEP			GOATS		
	S1	Su1	Sue1	S1	Su1	Sue1
litre/day	2.18	1.91	1.6	1.73	1.59	1.55
litre/Kgl$^{0.75}$	0.17	0.14	0.12	0.15	0.15	0.13
litre/Kg DM	2.83	2.91	3.06	2.94	3.96	3.52

*No significant difference was observed at P< 0.05.

Table 7 : Effect of ration and species on digestibility of selected nutrients

Parameter	RATION			Effect of Species Probability	Standard Error
	S_1	S_{u1}	S_{ue1}		
DM	51.98[a]	59.24[a]	55.64[a]	N.S.	2.43
OM	53.43[a]	62.56[a]	58.33[a]	N.S.	2.37
NDF	42.55[a]	42.59[a]	30.72[a]	N.S.	3.00
CP	51.11[a]	53.32[a]	59.32[a]	N.S.	3.34
ADF	47.28[a]	50.51[a]	45.46[a]	N.S.	2.90

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

Table 8 : Combined effect of species and ration on nutrient digestibility

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]	2.34
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]	32.13[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 9 : Combined effect of species and ration on weight changes*

Parameter	SHEEP			GOATS			Standard Error
	S_1	S_{u1}	S_{ue1}	S_1	S_{u1}	S_{ue1}	
Initial weight (kg)	31.36[a]	31.1[a]	30.93[ab]	28.29[bc]	23.27[bc]	26.35[bc]	1.09
Daily gain	-183.3[a]	-91.11[a]	-86.67[a]	-173.33[a]	-37.78[a]	-115.56[a]	23.22

*[a-bc]Means bearing no common superscript differ ($P < 0.05$)

Table 10 : Intake of total dry matter as affected by ration

Feedstuff	Week	RATIONS			Standard error
		S_2	S_{ue2}	S_{u2}	
All feed	1-2, gm/day	617.2	729.3	690.95	24.91
	3-4, gm/day	648.8	723.8	663.75	27.15
	5-6, gm/day	715.2	914.6	787.35	43.60
	7-8, gm/day	761.60[b]	1093.1[a]	849.1[ab]	43.57
	1-4, gm/day	648	726.55	677.35	25.38
	5-8, gm/day	738.4	973.85	818.25	43.22
	1-8, gm/day	693.2	[illegible]	747.8	[illegible]
	1-8, gm/kgl$^{0.75}$	86.63	91.52	89.89	1.25
Straw	Mean. gm/day	143.83	187.10	205.92	17.46
	Mean (gm/day /kgl$^{0.75}$)	17.97	20.14	21.78	1.35
Concen-trate	% consumed	79.38	79.03	72.81	1.73

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

Table 11 : Growth performance as affected by diet*

Parameter	RATION			Standard error
	S2	Sa+2	Sa2	
Initial Wt.	13.52[b]	17.32[a]	14.29[b]	0.60
Wt. at week 4	16.01[b]	19.50[a]	16.74[b]	0.61
Wt. at 56 d.	17.91[b]	20.78[a]	18.33[b]	0.69
ADG, wk 1-4	89.91a	77.86a	90.54a	6.77
ADG, wk 5-8	66.96a	45.54a	74.55a	8.04
ADG, wk 1-8	78.44a	61.70a	82.54a	5.72
Gain/Feed:				
wk 1-4	0,0698	0.0579	0.0670	0.0056
wk 5-8	0.0125	0.023	0.0457	0.0047
wk 1-8	0.553	0.0378	0.0553	0.001

* Wt. = weight; wk = week.

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

1.2. Dembele, B., S. G. Solaiman, S. L. Louis and A. J. Nianogo. 1991. Effect of urea treatment, moisture and post harvest time on composition and digestion of sorghum stovers **in vitro.** (In preparation)

1.3. Nianogo, A., C. Ouedraogo, S. Louis and S. Solaiman. 1990. In situ disappearance of various natural and cultivated straws. Bulletin of Animal Health and Production in Africa (submitted).

DEGRADABILITE IN SITU DE QUELQUES PAILLES DE GRAMINEES NATURELLES ET DE RESIDUS DE RECOLTE*

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RESUME

Quatre caprins mâles castrés et fistulés au niveau du rumen ont été utlisés pour une étude de dégradabilité IN SITU de diverses pailles de graminées naturelles et de résidus de récolte. La dégradabilité de quelques constituants a été étudiée pour un temps de séjour de 24 heures dans le rumen. Pour la disparition de la matière sèche on obtient la classification suivante en allant du taux le plus élevé vers le taux le moins élevé: Maïs (34.56%), Andropogon gayanus, Sorgho rouge, Sorgho blanc, Brachiaria lata, Pennisetum pedicellatum, Panicum anabaptistum, Andropogon pseudapricus, petit mil.

INTRODUCTION

Dans les pays sahéliens les pailles sur pied et les résidus de récolte représentent l'essentiel de l'alimentation des ruminants pendant la longue période sèche de l'année. L'utilisation rationelle de ces pailles nécéssite une connaissance préalable de leurs caractéristiques. La présente

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étude a été entreprise en vue de comparer la dégradabilite IN SITU de pailles de graminées naturelles et de résidus de récolte.

MATERIELS ET METHODES

Quatre caprins mâles castrés, âgés de 2 ans et pesant 20 kg en moyenne, et fistulés au niveau du rumen ont été utilisés pour cette expérience. Ils ont reçu une ration équilibree [1] composee de son de blé (39.15 %) et de paille de sorgho (60.85 %). Chaque paille a été broyée pour donner des particules d'une longueur de 2 mm en moyenne ,et placée dans des sacs de nylon présentant des mailles de 40 µm de diamètre. Les sacs introduits dans le rumen sont retires après 24 heures, lavés à l'eau simple, puis rinçés à l'eau distillée et plaçés dans une étuve préchaufée à 105 °C pour une durée de 24 heures. Les pailles incubées et les résidus non dégradées ont été soumis à une analyses pour déterminer les teneurs en matière sèche (MS), matière azotée brute (MAB) et cendres [2], et en constituants pariétaux (NDF) [3].

Le pourcentage (D) de constituant disparu est détermine de la manière suivante :

$$D = 100 * (P0 - P1) / P0$$

où P0 est le poids de constituant incubé et P1 le poids de constituant résiduel.

Le traitement des données a été fait à l'aide du logiciel SAS [4] selon le test de Ryan-Einot-Gabriel-Welsh.

RESULTATS ET DISCUSSIONS

Composition chimique: les résultats présentés dans le tableau 1 révèlent une grande variation inter-espèces. Andropogon pseudapricus a la teneur la plus élevée (83,62 %) en parois totales (NDF); par contre le taux de matière azotée brute (MAB) le plus élevé est celui de Brachiara lata (5,32 %).

Disparition de la matière sèche (MS), de la matière organique (MO), et des parois totales: Là encore on note une grande variation entre espèces (tableau 1). L'analyse statistique montre que la paille de maïs avec 34,56 % de MS disparue est la mieux dégradée des 9 espèces étudiées. En revanche, les différences entre certaines espèces pour la disparition de la MS de la MO et des NDF sont très minimes. Des 3 constituants étudiés, la plus faible dégradation est observée pour les parois cellulaires. Ceci confirme bien que les fibres sont les éléments qui limitent le plus la dégradation des pailles par les microoganismes du rumen.

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TABLEAU I : Composition chimique des pailles et disparition des différents nutriments.

Espèces végétales	Composition chimique				Degradabilite		
	M S	M O	NDF	MAB	M S	M O	NDF
Maïs	96,31	94,36	78,58	4,6	34,56[a]	32,69[a]	22,27[a]
Andropogon gayanus	97,93	93,72	77,50	2,65	30,53[ab]	29,69[a]	18,58[ab]
Sorgho rouge	96,87	91,03	79,94	3,38	28,31[ab]	24,36[ab]	16,30[ab]
Sorgho blanc	87,55	91,65	82,53	3,85	24,04[bc]	20,37[bc]	16,41[ab]
Brachiaria lata	95,71	87,5	75,98	5,32	22,70[bc]	18,24[bcd]	9,51[bc]
Pennisetum pedicellatum	82,89	88,88	79,99	5,1	15,94[cd]	10,91[cd]	4,87[c]
Panricum anabaptistum	96,80	93,50	82,40	2,37	13,84[d]	12,35[cd]	5,52[c]
Andropogon pseudapricus	98,04	93,92	83,62	3,12	9,74[d]	9,05[d]	3,60[c]
Petit mil	83,58	90,23	79,73	3,48	9,56[d]	3,17[e]	___

Les moyennes figurant sur la même colonne et ne portant pas le même indice sont significativement différentes ($P < 0,05$).

2. Abstract of papers presented at Animal Science meetings

2.1. Effect of postharvest time, moisture and urea on nutritional quality of ensiled sorghum stovers *in vitro*. August 1990 Iowa State University.

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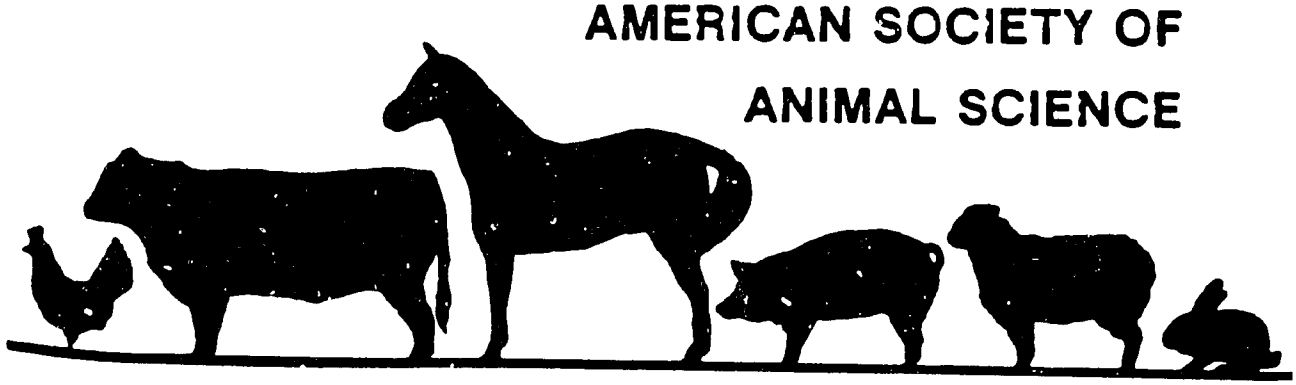

predominant on alfalfa; yeasts, molds, and enterobacteriaceae dominated on corn. Higher proportions of lactate-using yeasts were found on corn than alfalfa. Lactic acid bacteria comprised a small (10^4 to 10^5 CFU/g) proportion of the total (10^8) populations, with streptococci being the main epiphytic LAB group. Lactobacilli, pediococci, and leuconostoc were the minor groups, and their occurrence was variable, particularly on alfalfa. The cutting and maturity of alfalfa did not have a significant effect on the epiphytic microflora. The chopping process significantly increased the numbers of microorganisms on both alfalfa and corn, but wilting alfalfa did not affect the populations. When the second and fourth cutting alfalfa and the three corn hybrids were ensiled, dramatic changes occurred in the populations. The LAB grew extremely fast, and reached maximum numbers (approximately 10^9 CFU/g) at 3 d post-ensiling, while the numbers of enterobacteriaceae, yeasts, and molds showed a continuous reduction as ensiling progressed, and this was much more pronounced in alfalfa than corn.

KEY WORDS: Alfalfa, Corn, Microflora, Silage.

778 Top spoilage losses in horizontal silos: A research model. G. Ashbell, Volcani Center, Bet Dagan, Israel, and J. T. Dickerson and K. K. Bolsen*, Kansas State University, Manhattan.

Laboratory models of 208 l drums, 84 cm x 15 cm PVC pipes, and nylon net bags was used to study the top spoilage dynamic of corn silage. On September 12 1989 corn forage (full dent, 40.6% dry matter) was harvested, chopped, and packed (248 kg dry matter/m^3) in four drums, 16 PVC pipes, and 36 nylon bags. Each drum was divided by plastic netting into thirds, and three nylon bags were placed in the middle of each third. Four PVC pipes were placed in a drum a secured with excess fresh material. A perforated 2.54 cm PVC pipe was placed at the bottom of each drum and connected through an air-lock to drain effluent. Treatments were uncovered and covered with two sheets of 0.1 mm plastic secured with tape (four drums and eight PVC pipes / treatment). Drums and PVC pipes were stored outside. Temperature in the center of the drum, and precipitation were recorded daily for the first 2 weeks, and weekly thereafter. Duplicate PVC pipes were empted at 7, 67, 180 d, and drums at 180 d post-ensiling. Uncovered silages exhibited higher pH and dry matter losses in the top two thirds of all three models. Ash content was higher in the top one third of uncovered silages than in the pre-ensiled material. Chemical analyses of silages from corresponding nylon bags and drums were similar. Air penetration in the top third of covered PVC pipes, and a defect in sealing the bottom increased losses, and adversely affect silage quality near the bottom of the PVC pipes. Continued research and modification are needed to establish these models as reliable methods to characterize top spoilage losses in horizontal silos.

KEY WORDS: Top Spoilage, Model, Silage.

779 Effect of post harvest time, moisture and urea on nutritional quality of ensiled sorghum stovers in vitro. B. Dembele*, S. G. Solaiman, S. L. Davis and M. A. Maloney, Tuskegee University, Tuskegee, Alabama.

A series of in vitro fermentation experiments using rumen fluid from sheep and goats were conducted to evaluate the effect of post harvest time for ensiling the stovers (H) 0,2 and 4 weeks, moisture content (M) 40 and 60% on DM basis and urea (U) 0, 1, 2 and 3% on as fed basis on sorghum stovers ensiled for 30 days. Treatments were arranged in factorial fashion and experiment was replicated twice. Dry matter, CP and cell wall constituent as well as IVDMD and kinetics of cell wall digestion were measured. Crude protein was lowest ($P<.001$) and NDF was highest ($P<.001$) in stovers collected at 4 weeks after harvest. Crude protein increased ($P<.001$) whereas NDF and Hemicellulose decreased ($P<.001$) with addition of U and 60% M, with no changes in ADF, lignin and ash. In vitro DMD was affected ($P<.001$) by H, M and U. No species effect was observed ($P<.01$). Significant ($P<.01$) interaction among H, M and U existed. However 0 H, 60% M and 2% U resulted in highest ($P<.01$) IVDMD. Moisture and U had significant effect ($P<.01$) on rate of cell wall digestion (k). Digestion rates were improved by U treatment for 0, 2 and 4 weeks of H, and were higher ($P=.06$) for 40% M in sheep and goats. Urea treatment improved quality of sorghum stovers ensiled.

KEY WORDS. Post Harvest, Urea, Moisture, Sorghum Stovers, Silage

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