RUMINAL FIBER VALUE OF COTTON LINTERS AND EFFECT ON DIGESTIBILITY AND FEEDLOT PERFORMANCE BY LAMBS

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ABSTRACT

Two experiments, with growing sheep, were conducted to determine the effects of feeding cotton linters (CL) on digestibility and feedlot performance and hematological, pathological and histopathological variables. Experiment 1. Five growing lambs were used in a digestibility and nitrogen (N) balance study. Treatments consisted of control (basal diet) with 25% cottonseed hulls (CSH) and four diets composed of 60% control plus 40% roughage. The 40% roughage of the four diets consisted of CSH or three different mixtures of CL and CSH in the ratios of 1 part CL plus 5 parts CSH (1 + 5 mix), 2 parts CL + 5 parts CSH (2 + 5 mix) and 3 parts CL + 5 parts CSH (3 + 5 mix). Lambs consuming 1 + 5 mix, 2 + 5 mix, 3 + 5 mix or CSH alone exhibited similar N retention, percent N intake retained, dry matter digestibility (DMD) and organic matter digestibility (OMD). Lambs fed the control diet, as would be expected, resulted in greater ($P < .01$) values for the four variables studied than lambs on other treatments. Experiment 2. Seventy-two growing-finishing lambs were provided a sorghum based supplement (.75 kg. daily) plus roughage ad libitum to determine the effect on intake, gains and feed efficiency. Roughage sources were: A) corn silage; B) CSH; C) 1 + 5 mix and D) 2 + 5 mix. Lambs consuming the CL + CSH mixtures demonstrated average daily gains (ADG) and feed efficiency (F/G) similar to those consuming corn silage or CSH. However, lambs on corn silage had lower ($P < .05$) average daily feed (ADF) consumptions than any of the other treatments. Similar ADF values were observed for lambs on the CSH and 1 + 5 mix treatments. However, lower ($P < .05$) ADF consumption was observed for the 2 + 5 mix compared to the CSH group but similar to the 1 + 5 mix. Blood samples were taken from five randomly selected lambs on each treatment. Analysis showed no treatment differences for hemoglobin (Hb), percent packed cell volume (PCV), red blood cells (RBC), total leucocytes (WBC), differential leucocytes, plasma alkaline phosphatase (PAP) or plasma glutamic oxaloacetic transaminase (GOT). These data would tend to suggest that CL can be used as a partial substitute of the roughage (CSH) without affecting any of the variables evaluated in these experiments.

INTRODUCTION

Roughages are feedstuffs consisting of bulky and coarse particles of plants or plant parts. These materials are termed fibrous (containing over 18% crude fiber) and are composed of hard to digest carbohydrates, mainly cellulose and lignin (Ensminger and Olentine, 1978). The cell walls of plant materials, which are comprised essentially of hemicellulose, cellulose, lignin and protein, supply varying nutritional availablities to the ruminant (Van Soest, 1967). Baker and Harris (1947) reported lignin to be a physical barrier between the more digestible cellulose and cellulolytic microorganisms.

Many different types or sources of roughages have been used in ruminants to maintain proper rumen function. However, animal performance results have been quite variable and many attempts have been made, by different treatment methods and chemical reagents, to improve the digestibility of those feedstuffs considered less digestible, such as cotton gin trash and various crop residues (Klopfenstein, 1978; Arndt and Richardson, 1982). Chemical treatment usually improves digestibility of roughage by solublizing hemicellulose, and increasing the rate and extent of cellulose and hemicellulose digestion (Klopfenstein, 1978). Lignin content is generally not reduced by chemical treatment (Klopfenstein et al., 1972) but rather the increase in digestibility is attributed to breaking bonds between lignin and other carbohydrates.

Cotton linters (CL), the short fibers removed from cottonseed as the first step in processing, are used for making a variety of chemical and non-chemical products. Current uses of CL are for mattress material, ammunition and marginally for livestock, the use of which was pioneered in feedyards on the high plains. Jones et al. (1976) reported energy digestibility of CL for ruminants to be 47%, yielding 1850 kilocalories per kg. of dry matter. Several researchers have indicated CL are comprised primarily of pure cellulose and contain very little hemicellulose or pectin (Schubert et al., 1973 and 1976; Orr, 1977). Several experiments indicate cotton fibers are almost completely solublized by rumen microorganisms **in vitro** (Hale et al. 1969; Millet et al., 1975).

The following experiments were conducted to determine the effects of feeding CL on: 1) digestibility of dry matter, organic matter and nitrogen (N) utilization; 2) average daily feed consumption (ADF), average daily gain (ADG) and feed efficiency (F/G); 3) its value as a roughage source (substitute) and 4) on hematological, pathological and histopathological variables when fed to lambs during a 120-day period.

EXPERIMENTAL PROCEDURE

Dilute sulfuric acid delinting of cottonseed (processed for planting) was engineered to produced large quantities of seed for commerical cotton producers (Cotton Incorporated, 1976). The cotton linters used in these studies were obtained by this new delinting method.

Experiment 1. Five growing wether lambs were individually housed in metabolism crates in a thermostatically controlled environment. Lambs were shorn and treated for internal parasites prior to the study. Clean fresh water was available ad libitum.

A complete diet was fed in which CL was used as a partial substitute for CSH. The control (basal) diet is shown in Table 1. Treatments differed in levels of CSH and CL-CSH mixtures. Treatments were: A) 100% control; B) 60% control + 40% CSH; C); D) and E) contained 60% control plus the following CL-CSH mixtures; 1 part CL-5 parts CSH, 2 parts CL-5 parts CSH and 3 parts CL-5 parts CSH, respectively. Standard total collection procedures for determining consumption and digestibility were used for feeding, excreta collection and chemical

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analysis of feed, feces and urine (AOAC, 1975). Criteria of evaluation were dry matter digestibility (DMD), organic matter digestibility (OMD), N retention and percent N retained.

Table 1. Composition of Basal Diet and Feedlot Lamb Supplement

	Percentages*	
Ingredient	Basal Diet, Exp. 1	Feedlot Lamb Supplement, Exp. 2
Cottonseed hulls	25.00	--
Ground sorghum	62.40	72.25
Soybean Meal	7.10	25.00
Molasses	3.00	--
Dicalcium Phosphate	2.00	2.00
Salt	0.50	--
Trace Mineralized Salt	--	0.50
Sodium Sulfate	--	0.25
Vitamin A+	1,506	4,455
Vitamin D+	440	1,100
Vitamin E+	33	240

*Dry matter basis
+IU/kg, International units/kilogram

A 5 x 5 latin square design was used with total collection of feces and urine. Each period consisted of a 10-day adaption followed by a 7-day collection period. One way analysis of variance and least significant differences were used to determine treatment responses (Steel and Torrie, 1960).

Experiment 2. Seventy-two growing-finishing lambs (31 kg) were used in a 120-day feeding study. Prior to initiation of the experiment, lambs were treated against internal parasites with one and one-half Tramisol ® bolus and received a 2.5 cc injection of Clostridium perfringens type C and D bacterin toxoid for prevention of enterotoxemia and a 2.5 cc injection of tylosin. Lambs were allowed a 14 day adjustment period to the control diet. Housing was provided in a building open to the south. Lambs were randomly assigned to the three replications of each treatment with six lambs per replication. Clean fresh water was provided ad libitum.

Lambs were provided once daily a .75 kg allotment of a sorhgum based concentrate supplement (Table 1). Roughage sources, provided ad libitum, were: corn silage, CSH, 1 part CL and 5 parts CSH (1 + 5 mix) and 2 parts CL and 5 parts CSH (2 + 5 mix), respectively for treatments A,B,C and D.

Five lambs were randomly selected from each treatment before slaughter for use in blood analyses. Blood samples were collected via jugular puncture using vacutainer collection tubes containing EDTA as an anti-coagulant. Analyses conducted on the blood samples included plasma alkaline phosphatase (PAP) and glutamic oxaloacetic transaminase (GOT), hemoglobin (Hb), packed cell volume (PVC), red blood cells (RBC), total leucocytes (WBC) and differential leucocytes. Differential leucocytes were determined by the coulter counter method. Spectrophotometry was used to determine Hb. The microhematocrit method was used to determine PCV. Red blood cells (RBC) and WBC were determined using a hemocytometer and a microscope (Seiverd, 1964).

An accredited veterinary pathologist observed at time of slaughter, the spleen, brain, heart, thyroid, salivay glands, adrenal glands, bladder and lungs for any abnormalities. Tissue samples of each of these organs were taken and microscopic cross-sectional analysis performed.

A complete randomized design was used. One-way analysis of variance and least significant differences were used to test for treatment differences (Steele and Torrie, 1960). Criteria for evaluation were average daily gain (ADG), average daily feed (ADF) consumption, roughage valuę and hematological, pathological and histopathological examination of the lambs.

RESULTS AND DISCUSSION

Experiment 1. Results of the digestibility and N balance studies are shown in Table 2. Nitrogen (N) retention and percent N intake for lambs consuming the CL-CSH mixtures were similar to lambs consuming the CSH as roughage. Lambs consuming the control diet exhibited greater ($P < .01$) N retention and percent N intake retained than all other treatments.

Dry matter digestibility (DMD) and OMD were parallele for all treatments. The CSH diet and all CL-CSH mixtures were similiar in digestibilities. Lambs on the control diet demonstrated higher ($P < .01$) digestibilities than CSH and CL-CSH mixtures as was expected. The digestibilities reported for the complete diets used in this experiment were indicative of the high in vitro digestibility of CL reported by Hale et al. (1969) and Millet et al. (1975). These data indicate that CL could be a valuable substitute for CSH as a feedstuff for growing lambs.

Experiment 2. Lamb performance data from the growing-finishing experiment are shown in Table 3. Lambs consuming both CL-CSH mixtures had similiar ADG, and F/G as compared to corn silage and CSH treatments. Lambs consuming the corn silage treatment had lower ($P < .05$) ADF consumption than lambs on the three other treatments. Significantly, less ($P < .05$) of the 2 + 5 mix was consumed than the CSH treatment. Similar ADF consumptions were observed for the 1 + 5 mix and CSH treatments as well as the 1 + 5 mix and 2 + 5 mixtures exhibiting similar results.

Blood data are presented in Table 4. Lambs consuming either the 1 + 5 mix or 2 + 5 mix did not exhibit any significant differences in any of the blood variables tested. Futhermore, no abnormalities were noted from visual appraisal of organs at time of slaughter or after microscopic examination of cross-sectional tissue samples.

Only a small amount of literature is available on the animal use of CL. However, in vitro data (Hale et al., 1969; Millet et al., 1975; Jones et al., 1976) parallels the data reported in this study. Under these experimental feedlot conditions CL obtained by the dilute sulfuric acid process served as an equal substitute for a portion of the roughage (CSH or corn silage) in growing-finishing lambs diets. Equivalent values, for N utilization and digestibility of DM and OM, were also noted when lamb diets containing CSH were partially substituted with CL. Furthermore, substitution of 11.4% of the roughage in lamb diets with CL resulted in equal performance.

Table 2. Intake and Apparent Digestibilities Experiment 1.

ITEM	Treatments				
	A Control	B 40% CSH	C 40% 1+5	D 40% 2+5 mix	E 40% 3+5 mix
Dry Matter intake (g/day)	700	700	700	700	700
N retention (g/day)	$4.3^a \pm 1.11$	$1.2^b \pm .72$	$1.7^b \pm .81$	$2.0^b \pm .90$	$1.8^b \pm .57$
Percent N intake retained	$36.8^a \pm 2.62$	$14.4\ ^b \pm .98$	$18.7^b \pm 1.34$	$21.9^b \pm 1.41$	$19.1^b \pm 1.37$
Digestibility (%) dry matter	$76.4^a \pm 4.21$	$59.9^b \pm 1.47$	$66.2^b \pm 2.22$	$65.4^b \pm 2.07$	$65.4^b \pm 1.94$
Organic matter	$77.9^a \pm 6.02$	$60.6^b \pm 3.21$	$67.0^b \pm 4.19$	$65.9^b \pm 4.11$	$64.9^b \pm 3.73$

[a,b]Means within a row followed by different superscripts are different ($P < .01$).
[1]Means $\pm$ SE for $n = 3$.

Table 3. Intake and Performance of Growing-Finishing Lambs, Experiment 2.

Criteria	Treatments			
	A Corn silage	B Cottonseed Hulls	C 1+5 mix	D 2+5 mix
No. Lambs	18	18	18	18
Initial wt (kg)	30.3	30.6	30.6	30.8
Final wt (kg)	45.30	47.5	47.0	45.7
Days of feed	120	120	120	120
Average daily feed (kg/day)	$1.0\ ^a \pm .003$	$1.9\ ^c \pm .02$	$1.8^{b,c} \pm .03$	$1.7\ ^b \pm .06$
Average daily gain (kg/day)	$.13\ ^a \pm .002$	$.14\ ^a \pm .007$	$.14\ ^a \pm .003$	$.12\ ^a \pm .002$
Feed efficiency (F/G)	$5.2\ ^a \pm .78$	$8.2\ ^a \pm .85$	$7.7\ ^a \pm 1.40$	$7.5\ ^a \pm 2.06$

[a,b,c]Means within a row followed by different superscripts are different ($P < .05$).
[1]Means $\pm$ SE for $n = 3$.

Table 4. Analyses on Blood Variables, Experiment 2.

ITEM	Treatments*			
	A	B	C	D
Alkaline phosphatase, IU/1	199 $\pm$32.53	177.2 $\pm$16.46	215.6 $\pm$16.46	241.2 $\pm$31.32
Glutamic oxaloacetic transaminase,IU/1	69.4 $\pm$ 7.82	51.8 $\pm$ 2.65	62.0 $\pm$ 4.30	71.8 $\pm$ 7.41
Red blood cells, million/mm^3	8.57 $\pm$ .492	10.76 $\pm$ 1.025	9.47 $\pm$ .434	10.41 $\pm$ .553
Total leucocytes, thousand/mm^3	7.72 $\pm$ 1.022	7.12 $\pm$ .857	8.28 $\pm$ 1.37	7.84 $\pm$ 1.109
Hemoglobin, g/100ml	11.06 $\pm$ .252	11.36 $\pm$ .264	11.36 $\pm$ .264	11.2 $\pm$ .405
Packed cell volume, %	40.2 $\pm$ .80	42.4 $\pm$ 1.66	43.0 $\pm$ 1.816	42.8 $\pm$ 2.29
Polymorpho-nuclear, %	31.0 $\pm$ 5.88	31.6 $\pm$13.18	19.2 $\pm$ 1.88	24.8 $\pm$ 5.57
Lymphocytic,%	66.2 $\pm$ 5.68	50.8 $\pm$18.28	75.4 $\pm$ 1.435	73.0 $\pm$ 5.07
Eosinophils, %	1.8 $\pm$ .916	.6 $\pm$ .4	4.8 $\pm$ 1.772	1.6 $\pm$ .6
Monocytic, %	1.0 $\pm$ .447	17.2 $\pm$15.71	.8 $\pm$ .374	.6 $\pm$ .245

*No differences ($P > .05$).
+Mean $\pm$SE for $n = 5$.

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