Proceedings of the 2006 Cornell Nutrition Conference, pp. 135-139

EFFECT OF FERMENTABLE FIBER AND PROTEIN SOURCE ON FEED INTAKE AND EFFICIENCY OF GROWING LAMBS

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INTRODUCTION

Feed refusals from the Cornell dairy were used for many years as the primary feed for sheep in the barn. In addition to the cost of hauling the forage from the dairy to the sheep farm, feeding this day-old, complete mixed, silage-based diet to sheep caused three primary health problems: 1) listeriosis; 2) copper toxicity; and 3) increased exposure to *Mycobacterium avium* subsp. *paratuberculosis*, the organism that causes Johne's Disease). In 2004 we decided to switch to primary feeds for the ewe flock.

Based upon experiments to quantify the minimum fiber requirement for lambs (Hogue, 1987; Hogue, 1991; Thonney and Hogue, 1999) and experience designing diets for feedlot cattle, we developed a new set of guidelines to balance diets for ruminants based upon minimum levels of fermentable NDF (FDNF) and maximum levels of nonstructural carbohydrates (NSCHO). Those guidelines were used to develop a complete mixed concentrate diet that we self-fed to lambing and lactating ewes to take the place of expensive hay. The diet also took advantage of the relatively inexpensive high concentration of protein in by-product feeds that supplied some of the fermentable fiber.

The ewes' lambs also had access to the self-fed, high fiber ewe diet with corn gluten feed for supplemental protein. The ewe diet contained so much fermentable fiber that lamb growth could have been slowed and the feed could have been used less efficiently than for a diet designed for lambs that contained less fiber or a traditional soybean meal source of supplemental protein. Therefore, an experiment was conducted to compare the feed intake and efficiency of lambs fed three 14.5% CP diets similar in calculated digestible dry matter but differing in calculated FNDF and source of supplemental protein.

MATERIALS AND METHODS

The formulas for the experimental diets are given in Table 1 with the composition of the mineral and vitamin premix given in Table 2. The **soy hull diet** was a corn-based feed with 20% soy hulls and 10% soybean meal. This was representative of the standard diet fed to lambs at the Cornell Sheep Farm. The **high fiber diet** was composed of 35% corn, 34% corn gluten feed, and 23% soy hulls. This was the diet that had been self-fed to ewes. The corn **gluten feed diet** was a simple, corn-based diet with 37% corn gluten feed to replace the soy hulls and the much more expensive

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soybean meal in the soy hull diet. The three cracked-corn-based diets also contained limestone, 2% vitamin-mineral premix, and 2% vegetable oil to minimize dust.

Table 1. Formulas of experimental diets.

	Diet		
Ingredient, % of DM	Soy hull	High fiber	Corn gluten feed
Corn grain	63.6	35.0	54.5
Corn gluten feed		34.0	37.0
Soy hulls	20.0	23.3	
Soybean meal	10.0		
Limestone	2.0	3.3	4.1
Vitamin-mineral premix	2.2	2.2	2.2
Vegetable oil	2.2	2.2	2.2
Total	100.0	100.0	100.0

Figure 1. Lambs in their experimental pens.

The experiment was a randomized complete block design using Dorset and Finn × Dorset lambs. Gender was confounded with barn location to create the two blocks. A big and a small lamb were assigned to each pen to reduce pen-to-pen variation (Figure 1).

After weaning at 6 to 10 weeks of age and a 3-day adjustment to the pens, lambs were fed the diets for 42 days. Fresh water was provided and feed was added daily to each feeder to ensure that feed was available at all times. Lambs were weighed at the start of the experiment and weekly. Linear regression of weight on days was used to compute initial weight, final weight, and average daily gain.

Pens were the experimental units and results were reported on a per lamb basis. Diets were analyzed by wet chemistry methods by Dairy One (Ithaca, NY).

Analysis of variance was used to partition the variance between blocks and diets and the two degrees of freedom for the effect of diet were separated into two orthogonal contrasts comparing: 1) the high fiber diet

Table 2. Mineral & vitamin premix specifications (mix was 2% of diet dry matter)

Nutrient or ingredient	Units	Diet	Premix
Ammonium chloride	%	0.75	37.5
Salt	%	0.50	25.0
Deccox 6% premix	%	0.11	5.5
Mineral oil	%	0.01	0.5
Cobalt	ppm	0.14	7.2
Manganese	ppm	29.84	1492.0
Molybdenum	ppm	1.00	50.0
Selenium	ppm	0.30	15.0
Iodine	ppm	0.80	40.0
Vitamin A	kIU/kg	1.00	50.0
Vitamin D	kIU/kg	0.22	11.1
Vitamin E	IU/kg	14.99	749.6

with the average of the soy hull and corn gluten feed diets; and 2) the soy hull diet with the corn gluten feed diet.

RESULTS AND DISCUSSION

The chemical compositions of the diets are shown in Table 3. The diets were slightly lower than the 15% crude protein for which they were formulated, but the concentration of protein was similar in each diet. As expected, the NDF concentration was highest in the high fiber diet. Because corn gluten feed is high in phosphorus, the high fiber diet and the corn gluten feed diet contained the higher levels of calcium for which they were formulated to protect ram lambs against urinary calculi. The other components varied slightly with the feed ingredient composition of the diets but they were within recommended levels (National Research Council, 1985).

Table 3. Analyzed composition of experimental diets.

		Diet		
Component	Unit	Soy hull	High fiber	Corn gluten feed
Crude protein	%	14.4	14.6	14.2
NDF	%	22.2	32.2	21.0
Calcium	%	1.20	1.52	1.82
Phosphorus	%	0.31	0.53	0.57
Magnesium	%	0.18	0.29	0.27
Potassium	%	0.64	0.84	0.67
Sodium	%	0.37	0.35	0.36
Iron	ppm	199.5	225.5	164.5
Zinc	ppm	23.0	48.5	40.0
Copper	ppm	7.0	7.5	7.5
Manganese	ppm	50.0	40.5	40.0
Molybdenum	ppm	1.6	3.2	2.8

The estimated digestible dry matter (DDM), neutral detergent dry matter (NDF), and fermentable NDF (FNDF) of each diet is shown in Table 4. DDM, without discounting for high intakes (Van Soest et al., 1992) and NDF values were computed from published values of individual ingredients. FNDF was computed for each ingredient by subtracting indigestible NDF (INDF) from NDF. INDF was the difference between indigestibility (100 – DDM) and metabolic fecal losses which were assumed to be 10% of the dry matter for each ingredient (Van Soest, 1994)

Table 4. Numbers of lambs and estimated digestible dry matter (DDM), neutral detergent dry matter (NDF), and fermentable NDF (FNDF) of the diets.

	Diet		
Item	Soy hull	High fiber	Corn gluten feed
Number of pens	13	10	12
Ewes	6	6	6
Rams	7	4	6
DDM, % DM	78.5	77.1	77.5
NDF, % DM	22.4	32.9	21.1
FNDF, % DM	16.2	29.9	17.5

There were no metabolic disturbances among lambs fed any of the diets, indicating that sufficient FNDF was in each diet for proper rumen function. Growth and feed intake results are shown in Table 5. As expected by the random assignment of lambs to diets, initial weights were similar across diets. Although lambs fed the soy hull diet gained faster and had heavier weights, the effect of diet on growth was not significant. Lambs fed the high fiber diet consumed more dry matter either per day (P = 0.01) or as a proportion of body weight (P < 0.001) and grew less efficiently (P < 0.001) than lambs fed the other diets. There was no significant difference in growth, feed intake or feed efficiency between lambs fed the soy hull diet or the corn gluten feed diet.

Traditional models have included NDF (Mertens, 1987) and DDM or functions of DDM such as NE_m (Fox et al., 1992) to predict feed intake. The dry matter intake of the high fiber diet in our experiment was much higher than that of the soy hull or corn gluten feed diets even though the three diets had similar predicted DDM. Furthermore, the traditional models of feed intake would have predicted lower – not higher – dry matter intake for the high fiber diet. In contrast, increased NDF digestibility [fermentability] resulted in higher feed intakes in dairy cows consuming diets with the same level of NDF (Oba and Allen, 1999). The dramatic intake-enhancing effect of diets high in FNDF was previously observed in sheep (Thonney and Hogue, 1999) and supports the conclusion that ruminant diets can not be balanced properly by assuming a given intake level independent of feed ingredients to be included in the diet.

Table 5. Effect of fiber level and protein source on growing lambs.

	Diet				*P*-value for orthogonal contrast	
Item	Soy hull	High fiber	Corn gluten feed	SEM	High fiber vs others	Soy hull vs corn gluten feed
Initial weight, kg	20.6	20.8	20.6	0.51	ns	ns
Final weight, kg	33.4	32.5	32.7	0.68	ns	ns
Gain, g/day	305	280	289	10.7	ns	ns
DMI, kg/day	0.992	1.069	0.953	0.0297	0.010	ns
Gain/DMI	0.307	0.263	0.303	0.0074	<0.001	ns
DMI, % BW	3.69	4.09	3.63	0.083	<0.001	ns

CONCLUSIONS

This experiment demonstrated that high fiber ewe diets consumed by lambs can increase intake by 12% and reduce feed efficiency by about 14%, but with limited effect on growth, and that protein from corn gluten feed can replace more expensive protein from soybean meal for weaned lambs. The high feed intake of lambs fed the high fiber diet with the same estimated DDM of the soy hull and corn gluten feed diet confirms that ingredient composition of the diet influences dry matter intake so that diets can not be properly balanced assuming a given level of intake.

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