INFLUENCE OF GRAIN SOURCE (WHEAT VS. CORN) ON RUMINAL AND POSTRUMINAL STARCH AND AMINO ACID DEGRADATION IN HEIFERS USING A MOBILE DACRON BAG TECHNIQUE

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Story in Brief

Two heifers fitted with ruminal and duodenal T-type cannulas were used to estimate starch and amino acid digestibility of wheat and corn at different sites in the gastrointestinal tract using the mobile nylon bag technique. Approximately 3 grams of each sample (wheat or corn) was placed into 3.0 by 5.0 cm nylon bags. Bags were suspended in the rumen for 15 hr, incubated for 3 hr in a pepsin-HCL solution, placed into the duodenal cannula and recovered from feces. For corn but not wheat, starch disappearance during ruminal incubation and postruminal passage increased as particle size was reduced. Ruminal disappearance of protein from corn and wheat was 5.2% and 58.7%. However, total tract disappearance of protein from corn and wheat was similar. Postruminal disappearance, as a fraction of dietary protein for threonine and sulfur-amino acids, was 46% and 19% lower for wheat than for corn. Results indicate that the first limiting amino acids for ruminants can change with grain source. Hence, amino acid balance, in addition to ruminal protein escape must be considered in diet formulation.

(Key Words: Mobile Dacron Bag, Starch, Amino Acid.)

Introduction

Several variables determine the usefulness of cereal grains for livestock. One of these variables is the rate and extent at which nutrients are hydrolyzed into simpler, more useful forms to be utilized by the animal. With dairy cows, the rate and amount of starch digestion can have an direct effect on milk fat production. Increasing the rate of starch digestion in the rumen can lower ruminal pH and decrease fiber digestion by ruminal microbes.

Little information is available on ruminal digestibility of wheat starch. Waldo (1973) suggested that 94% of wheat starch was fermented in the rumen, compared to 74% for ground corn. Turgeon et al. (1983) reported that ruminal digestion of starch was 52% for whole corn and 61% for cracked corn. Post-ruminal starch digestion values were 40 and 33%, so that total tract starch digestibilities were 91.5 and 94.3%, respectively.

The rate and extent of protein degradation, and, more specifically, amino acid degradation are other important factors. In early lactation, amino acid supply to the small intestine may limit production. The depression in milk production observed in some studies where wheat is fed as the main concentrate (Faldet et al, 1986; Nalsen et al., 1987) may be the result of extensive degradation of wheat protein in the rumen which limits supply of feed amino acids to the small intestine.

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The objective of this experiment was to compare the extent of starch and amino acid degradation of wheat and corn in the rumen and intestines of cattle.

Materials and Methods

Two Hereford heifers fitted with permanent ruminal and duodenal T-type cannulas were fed a wheat or corn-based concentrate mixture plus sorghum silage. The two rations consisted of 55% concentrate and 45% forage on a dry matter basis. Heifers were fed twice daily and adapted to the diet for 7 days.

Bags were constructed of dacron and measured 3.0 by 5.0 cm with a mesh size of 60 to 70 microns. Corn and wheat samples were ground using a 2-mm screen and sieved to obtain particle sizes of $<$ 250 microns, 250 to 500 microns, 500 to 1000 microns, 1000 to 2000 microns and $>$ 2000 microns. These were used to determine the impact of particle size on starch degradation. To evaluate amino acid degradation, wheat and corn samples ground through the 2-mm screen were used. Approximately 3.0 grams of each sample (wheat or corn) were placed in nylon bags which were double sewn and glued. Edges were melted to prevent unraveling. Four bags containing each grain sample (wheat or corn) at each particle size were used to determine ruminal starch degradation, while two bags containing each grain sample were used to determine intestinal starch degradation. Amino acid degradation from wheat and corn in the rumen and intestinal tract was compared using 1 bag of each sample at the respective sites. Bags containing the wheat samples were placed in the rumen of the heifer fed the wheat-based ration and bags containing corn samples in the rumen of the heifer fed the corn-based ration. Nylon bags were inserted into nylon stockings with approximately 7 bags placed in each leg and separated from each other with twist ties. Bags were incubated in the rumen for 15 hours. After ruminal incubation, the nylon bags were soaked in a pepsin-HCL solution (1 gram pepsin per liter; 0.1 N HCL) for 3 hours at 37 C. The solution was adjusted to pH 2. Bags then were placed into the T-type duodenal cannulas and recovered from the feces. The bags were thoroughly washed and dried in a forced-air oven at 60 C for 48 hours. The MacRae and Armstrong procedure was used for starch analysis, and 6 N HCL hydrolysates were used for amino acid analyses.

Results and Discussion

Ruminal and total tract starch disappearance was greater ($P<.002$) for wheat than corn (Table 1). The magnitude of difference was largest for particles greater than 500 microns, while differences were minor for particles less than 500 microns.

An interaction between grain source and particle size both for ruminal ($P<.05$) and total tract ($P<.01$) digestion was detected. Disappearance of starch from corn tended to be highest with particles less than 250 microns, both in the rumen and total tract, i.e. 32 and 100% respectively. Very little corn starch was degraded in the rumen when particles were greater than 1000 microns. In contrast, ruminal wheat starch degradation was highest for 500 and 1000 micron particles. Though there was no significant difference among particle sizes in total tract disappearance of starch from wheat, starch from particles less than 1000 microns tended to be more extensively degraded after passage

Table 1. Starch disappearance from corn and wheat particles in the rumen and total tract.

Particle size (microns)	Corn Grain		Wheat Grain		S.E.
	Rumen	Total Tract	Rumen	Total Tract	
	Disappearance (%)				
< 2000	8[b]	33[b]	28[a]	88	15.3
1000-2000	4[b]	47[b]	40[ab]	83	10.8
500-1000	17[ab]	58[b]	54[b]	97	10.8
250-500	25[ab]	94[a]	29[a]	96	10.8
>250	32[a]	100[a]	22[a]	96	15.3

[ab]Means in a column with different superscripts differ (P<.05).

through the total tract than for particles over 1000 microns in diameter. The relationship between particle size of the grain and pore size of the dacron material should be taken into consideration. This relationship may affect the amount of particles capable of filtering out of the dacron bags, and thus affecting calculated starch degradation.

The major site of degradation of protein differed between corn and wheat (Table 2). Very little corn protein was degraded in the rumen, as compared to the small intestine, i.e. 5.2 vs 90.5%, whereas disappearance of wheat protein was higher in the rumen than in the lower tract, i.e. 58.7 vs 40.0%. Though the major site of degradation differed for corn and wheat, total tract degradation of wheat protein tended to be more complete than corn protein.

Similar to protein disappearance, degradation of lysine, threonine, sulfur amino acids and essential amino acids from corn was higher in the small intestine than the rumen. Ruminal and total tract lysine disappearance was higher for wheat than corn, although postruminal disappearance was similar for the two grains. For wheat, similar quantities of threonine disappeared in the rumen (43.9%) and intestines (48.8%). In contrast, 75% of the threonine from corn was degraded in the lower tract. Unlike lysine and threonine, a larger quantity of sulfur amino acids from wheat escaped ruminal degradation, however, extensive postruminal degradation resulted in higher total tract disappearance of sulfur amino acids from wheat than corn. As with protein, total tract degradation of essential amino acids in wheat was more complete than in corn.

This study illustrates that wheat starch is more extensively degraded in the rumen than corn starch. This response may decrease ruminal fiber digestion and, without proper management, decrease fat test in lactating dairy cows. As with starch, ruminal degradation of protein and essential amino acids was higher for wheat than corn. Thus if these two grains are supplemented with protein to provide the same amount of protein in the diet, ruminal escape protein will be much lower with a wheat-based diet. Alternative protein supplements that are higher in ruminal undegradable protein than soybean or cottonseed meal

Table 2. Protein and amino acid disappearance from corn and wheat

	Corn	Wheat
Protein		
Feed, %	8.91	15.03
Ruminal disappearance, %	5.2	58.7
Postruminal disappearance, % of fed	90.5	40.0
Postruminal disappearance, g/100 g DM	8.06	6.01
Total tract disappearance, %	95.6	98.7
Lysine		
Feed, %	.20	.38
Ruminal disappearance, %	30.0	36.8
Postruminal disappearance, % of fed	55.0	55.3
Postruminal disappearance, g/100 g DM	.11	.21
Postruminal disappearance, g/100 g CP fed	1.2	1.4
Total tract disappearance, %	85.0	92.1
Threonine		
Feed, %	.28	.41
Ruminal disappearance, %	10.7	43.9
Postruminal disappearance, % of fed	75.0	48.8
Postruminal disappearance, g/100 g DM	.21	.20
Postruminal disappearance, g/100 g CP fed	2.4	1.3
Total tract disappearance, %	85.7	92.7
Sulfur amino acids		
Feed, %	.41	.39
Ruminal disappearance, %	24.4	10.3
Postruminal disappearance, % of fed	56.1	79.5
Postruminal disappearance, g/100 g DM	.23	.31
Postruminal disappearance, g/100 g CP fed	2.6	2.1
Total tract disappearance, %	80.5	89.7
Essential amino acids		
Feed, %	4.22	5.55
Ruminal disappearance, %	16.4	43.1
Postruminal disappearance, % of fed	72.0	51.7
Postruminal disappearance, g/100 g DM	3.04	2.87
Postruminal disappearance, g/100 g CP fed	34.1	19.1
Total tract disappearance, %	88.4	94.8

may be required to provide a ration similar or higher in rumen undegradable protein than a corn-based ration. Expressed per unit of dietary protein, quantities of threonine and sulfur amino acids would be much lower with a wheat-based than a corn-based diet. Thus, first-limiting amino acids might be expected to change with grain of the basal diet as discussed by Owens (1986).

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