In Situ Starch and Nitrogen Degradation of Feedstuffs for Use as Supplements to Wheat Forage

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Story in Brief

This experiment examined the in situ degradation characteristics of starch and nitrogen in common grain sources, by-product feeds and fresh wheat forage. These feedstuffs are or could be used in supplements formulated for cattle grazing wheat. We used an in situ bag technique in five fistulated heifers. Feedstuffs were incubated for up to 60 h to estimate degradation fractions. Feedstuffs were different in the readily soluble fraction for both starch and nitrogen. Additionally, the fraction that degrades at a measurable rate was different among feedstuffs for both starch and nitrogen. The degradation rate constant for starch and the lag time for nitrogen degradation was affected by feedstuff. Matching the degradation parameters of the feedstuff's starch and nitrogen to those of wheat forage are important considerations when formulating supplements for wheat forage.

Key Words: Degradation Fractions, Grain, By-products

Introduction

Supplementation of cattle grazing wheat pastures can provide several benefits. Horn et al. (1995) observed increased performance and increased stocking density of wheat pastures. Additionally, supplementation allows for inclusion of ionophores, bloat prevention and other compounds into the diet of grazing animals. Wheat pasture provides a unique forage that is high in available nitrogen. Johnson (1976) discussed the interaction of carbohydrate solubility and non-protein nitrogen utilization in the ruminant. Wheat forage in the vegetative state contains approximately 25 to 30% crude protein. Soluble nitrogen makes up 30 to 40% and non-protein nitrogen 10 to 20% of the total nitrogen (Johnson et al., 1974). In theory, if the profiles of carbohydrate and nitrogen solubility can be matched, bacterial fermentation and growth may be optimized. Optimization of bacterial fermentation may increase energy supplied to the animal, increase bacterial yield and thus improve animal production.

Materials and Methods

We utilized five ruminally fistulated heifers (1300 lb mean BW) in an incomplete randomized design. Heifers grazed winter wheat for 2 wk prior to the first sampling in January and continued to graze the same pasture through the second sampling in March. We utilized ten feedstuffs including, corn, hard red winter wheat, hard white winter wheat, white endosperm milo, bird resistant milo, corn gluten feed, steam crimped barely, soybean hulls, wheat middlings, and fresh wheat forage. The corn, wheat, milos, and corn gluten feed were ground with a hammer mill through a 5 mm screen. Wheat forage was harvested the day before the start of the incubations and was cut into 2-cm length pieces. In situ procedures were as follows. Duplicate dacron bags were filled with 5-g samples of air-dried feedstuffs or 40 g of wheat forage. All bags of an individual feed type were placed in a mesh bag and soaked in 39^{o}C water for 15 min to remove water-soluble components. Five bags per feedstuff were removed, which represented 0 h. The remaining bags were inserted into the ventral rumen. Five randomly selected feedstuffs were incubated in each heifer, and all feedstuffs were incubated in two heifers. Bags were incubated for 2, 4, 6, 9, 12, 24, 36, 48, or 60 h. Appropriate bags were removed at each time period, rinsed in ice-cold water and frozen for subsequent washing. Rinsing procedures were similar to those of Coblentz et al. (1997). After rinsing, all bags were dried to a constant weight in a 50^{o}C forced-air oven. Bags and contents were weighed individually, then composited by heifer, feed, and time and analyzed for starch and nitrogen.

Starch and nitrogen pools were partitioned into three fractions as described by Coblentz et al. (1998). Those fractions are the A fraction which is considered to be immediately soluble; the B fraction which is starch or nitrogen degraded at a measurable rate; and the C fraction which is considered undegradable in the rumen. Determination of these fractions was performed using PROC NLIN of SAS (SAS Inst. Inc., Cary, NC). Data were fit to the model described by Coblentz et al. (1998). The model calculates fractions B and C, lag time, and degradation rate constant (K_d). Fraction A was calculated by difference [total N or starch – (B+C)], and maximum theoretical extent of degradation by difference [total N or starch – C) (Coblentz et al., 1998).

Kinetic data were analyzed using the GLM procedure of SAS with least squares means calculated. Source of variation included in the model was feedstuff. We considered heifer the experimental unit for this analysis.

Results and Discussion

Starch. The in situ starch degradation characteristics are presented in Table 1. We categorized our feedstuffs into grain and by-product categories. The grains were characterized by higher amounts of initial starch (over 60%) and by-products lower initial starch (less than 35%). However, the by-products starch that was present was highly soluble with an A fraction mean of 85.16. The grain sources tended to be more variable in A fraction starch, that ranged from 81.9 to 24.6. All of these grains were ground with the exception of the steam crimped barley which was incubated as-is which would have naturally reduced its A fraction. Feedstuff had an effect on fraction A ($P<.01$). The B fractions in all samples varied inversely to the A fractions. Similar to the A fraction, B fraction showed a feedstuff effect ($P<.01$). The C fraction or ruminally undegradable fraction of all feedstuffs were not different and tended to be very low. Theoretical extent of degradation was not different among feedstuffs and averaged 98.94%. Lag times were also not different among the feedstuffs, however large differences did exist between feedstuffs. Rate of degradation (K_d) was different among feedstuffs ($P<.01$). Generally, grains had faster degradation rates than did by-products feeds.

Table 1. In situ starch degradation characteristics of feeds

	A*	B*	C	Extent	Lag time	K_d*
	----------------------% DM---------------------				(h)	(/h)
Ground corn	50.20	48.55	1.25	98.75	.663	.116
Hard red winter wheat	74.01	25.30	.68	99.32	0.0	.300
Hard white winter wheat	81.94	18.07	.00001	99.99	2.00	.300

White endosperm milo	57.76	38.84	3.40	96.60	15.29	.061
Bird resistant milo	33.34	64.98	1.68	98.32	8.55	.020
Steam crimped barley	24.62	74.59	.79	99.22	14.91	.158
Soybean hulls [a]	-	-	-	-	-	-
Corn gluten feed	78.38	20.93	.69	99.31	9.18	.223
Wheat middlings	91.94	8.06	0.0	100	3.36	.280
Wheat forage	59.07	40.93	0.0	100	6.91	.086
SEM	5.33	5.58	1.14	3.08	4.92	.026
*Significant treatment effect of feedstuff (P<.01) [a]Analysis excluded						

Nitrogen. The in situ nitrogen degradation characteristics are presented in Table 2. Grain feedstuffs had only slightly lower initial nitrogen values (2.14% N) than did by-product feedstuffs (2.61% N). The A fraction of N was different (P<.01) among the feeds. Generally, by-product feedstuffs had greater proportion of N in the A fraction as compared to the grain feedstuffs. The B fraction was also different (P<.01) between feeds. Grains generally had higher proportions of B fraction N than did by-products. The C fraction and theoretical extent of degradation were similar among the feedstuffs. Fraction C was generally small and extent of degradation averaged 98.09%. Lag time was affected by feedstuff (P<.04). The longest lag times were observed in steam crimped barley and soybean hulls. Both of these feedstuffs are high in fiber, and both were un-ground. In the case of the barley, the outer covering of the seed could cause an increased lag time; whereas, in the soybean hulls the waxy nature of the hull could cause an increase in lag time.

Table 2. In situ nitrogen degradation characteristics

	A*	B*	C	Extent	Lag time*	K_d
	-----------------------% DM----------------------				(h)	(/h)
Ground corn	42.34	55.33	2.33	97.67	5.65	.101
Hard red winter wheat	27.37	72.63	3×10^{-8}	100	3.93	.138
Hard white winter wheat	28.18	71.07	.75	99.25	3.73	.191
White endosperm milo	32.34	63.21	4.45	95.55	7.39	.036
Bird resistant milo	30.69	67.27	2.05	97.95	8.55	.010
Steam crimped barley	46.85	52.55	.60	99.40	23.95	.129
Soybean hulls	59.01	38.44	2.55	97.45	24.72	.107
Corn gluten feed	77.50	18.71	3.8	96.20	4.57	.187
Wheat middlings	61.09	38.71	.20	99.80	5.29	.211
Wheat forage	84.45	14.25	1.30	98.70	.89	.100
SEM	4.31	4.07	1.08	1.08	4.75	.040
*Significant treatment effect of feedstuff (P<.04)						

Implications

The selected feedstuffs varied greatly in degradation characteristics for both starch and nitrogen. Selection of feedstuffs for inclusion in supplements must take into consideration the desired production level of the animal and current feeding regime. Interactions between the supplemental constituents and the grazed forage must also be considered.

Literature Cited

Coblentz, W.K. et al. 1997. J. Dairy Sci. 80:700.

Coblentz, W.K. et al. 1998.J. Dairy Sci. 81:150.

Horn, G.W. et al. 1995. J. Anim. Sci. 73:45.

Johnson, R.R. et al. 1974. Okla Agr. Exp. Sta. Res. Rep MP-92:37.

Johnson, R.R. 1976. J. Anim. Sci. 43:184.
