Extent and Rate of In Situ Ruminal Degradation of Protein Byproduct Feeds on a High Concentrate Diet

S.S. Swanek, C.R. Krehbiel, D.R. Gill, and B.A. Gardner

Story in Brief

The objective was to determine the extent and rate of in situ CP and DM disappearance of various byproduct protein feeds in steers consuming a high concentrate diet. Wheat middlings (WM), 48% soybean meal (SBM), 17% dehydrated alfalfa meal (DEHY), dry distillers grain (DDG), wet distillers grain without solubles (WDG), cotton seed meal (CSM), soybean hulls (SH), corn germ (CG), guar meal (GM), peanut meal (PM), crambe meal (CRM), extruded soybean meal (EXSBM), feather meal (FM), corn gluten feed (CGF) and sunflower meal (SFM) were the measured byproduct feeds. Feeds were randomly assigned to two of four steers and were incubated in the rumen for 0, 2, 4, 8, 12, 18, 24, and 48 h. Byproduct feeds were classified as high protein ($\geq$40% CP), medium protein (21-39% CP), or low protein ($\leq$20% CP) byproduct feeds. Rate and extent of CP and DM degradation varied considerably among the byproduct feeds. Of the high protein feeds, PM was the highest in rumen degradable protein (RDP), A fraction and DM degradability. Feather meal had the lowest RDP and DM degradability, and the highest C fraction. Of the medium protein byproducts, SFM and WDG were the highest in RDP. Wheat middlings and CGF had the highest RDP, A fraction and DM rumen degradation, and the slowest rates of B fraction and DM disappearance of the low protein byproduct feeds. Soybean hulls had the lowest RDP and DM degradability, and the highest C fraction.

Key Words: In Situ, Ruminal Degradation, Protein, Byproducts, High Concentrate

Introduction

Dietary protein is generally referred to as crude protein (CP) and can be defined as the N content of a feedstuff ´ 6.25. Two components of dietary CP are RDP and rumen undegradable protein (RUP). Rumen degradable protein provides peptides, free amino acids (AA), and ammonia for microbial growth and synthesis. Knowledge of the extent of degradation of protein sources is important in formulating diets with adequate RDP to support rumen microorganisms and sufficient RUP for enzymatic digestion by the host animal. When protein degradation in the rumen exceeds the microbes ability to assimilate N into microbial crude protein (MCP), excessive rumen ammonia concentrations can occur. Feedstuffs high in RUP have a more gradual release of ammonia (Veen, 1986). The goal of ruminant protein nutrition is to select complementary feed proteins that will provide adequate amounts of RDP to meet, and not exceed, microbial N requirements and to maximize MCP synthesis, while providing RUP with a complimentary AA profile to meet the host animals requirements.

Materials and Methods

In Situ Procedure. Four ruminally cannulated steers fed an ad libitum high concentrate diet (68% steam-flaked corn, 5% alfalfa hay, 5% cotton seed hulls, 5% molasses, 2.5% fat and 14.5% of a SBM based supplement containing 8.3% urea) were used to determine in situ CP and DM

disappearance. Byproduct feeds were randomly assigned to two of four steers except SBM, which was incubated in all four steers. Two grams of ground (2-mm screen) as-fed feed was placed in Dacron bags (5 ´ 13 cm, 53 ± 15 mm pore size; Ankom, Fairport, NY) and heat-sealed. Dacron bags were placed in replicate into a nylon mesh bag (36 ´ 42 cm) and suspended below the particulate mat layer in the rumen for 2, 4, 8, 12, 18, 24, or 48 h. Bags were placed in the rumen in reverse order so that all bags were removed from the rumen simultaneously. Bags were washed in cold water in a washing machine on the delicate setting (1 min rinse and 2 min spin) 10 times. Zero hour bags were not incubated in the rumen, but were included in the washing procedure. Bags were dried at 50°C for 48 h in a forced-air oven and weighed to determine DM disappearance. Nitrogen remaining in the bags was determined by a combustion method (Leco NS2000, St. Joseph, MI).

***Calculations*.** Extent of ruminal crude protein degradation was determined by the Mathers and Miller (1981) equation: Extent of CP degradation (percent) = $A + B \times [K_d /(K_d + K_p)]$, where A is the instantly soluble fraction of N (percentage of original N weighed into the bag) that disappeared at 0 h by the rinsing procedure. It includes NPN, rapidly soluble protein and protein particles that are smaller in size than the porosity of the Dacron bags. The C fraction is considered to be completely undegradable and is defined as the N remaining at 48 h (Nocek and English, 1986). The remaining is the B fraction and is considered to be potentially degradable true protein. Fraction A, plus the rumen degradable portion of the B fraction, is considered to be RDP. Rumen undegradable protein can be assumed to be 100-RDP. A constant rate of passage (K_p) from the rumen of .05 h^{-1} was used. The rate (K_d) of N disappearance from the rumen was estimated as the slope of the regression of the natural logarithm of the percentage of the nonsoluble N remaining vs incubation time in the rumen.

Statistical Analyses. Extent and rate of CP and DM disappearance were analyzed using the GLM procedure of SAS (SAS. Inst. Inc., Cary, NC). The model included steer and treatment. Treatment means were calculated using the LSMEANS option.

Results

Extent and rate of CP and DM degradation are presented in Tables 1, 2 and 3 for high protein, medium protein and low protein byproducts feeds, respectively.

High Protein Byproduct Feeds. Peanut meal had the highest RDP, A fraction and rumen DM degradation. Feather meal had the lowest RDP and rumen DM degradation, and the highest C fraction. Peanut meal and FM had the lowest B fraction values and the slowest rates of B fraction and DM disappearance. Guar meal had the highest rate of DM disappearance.

Medium Protein Byproduct Feeds. Sunflower meal and WDG had the greatest RDP values. Sunflower meal had the highest A fraction, while CG had the lowest. Corn germ had the highest B fraction and rate of B fraction disappearance, while SFM had the lowest B fraction. Dry matter degradability was the lowest for CRM and highest for the distiller's grains, wet being the highest followed by dry. Corn germ had the fastest rate of DM disappearance, whereas CRM had the highest C fraction.

Low Protein Byproduct Feeds. Wheat middlings and CGF had the greatest RDP, A fraction and rumen DM degradation, and the slowest rates of B fraction and DM disappearance. Soybean hulls were the lowest in RDP and DM degradation, and had the highest C fraction.

Table 1. Extent and rate of degradation of high protein byproduct feeds

Byproduct feed	SBM	CSM	GM	PM	EXSBM	FM	SEM
CP, %	51.0	44.6	43.0	48.3	47.3	86.2	
RDP, %	71.1[a]	66.6[ab]	63.7[b]	95.8[c]	53.0[b]	21.0[d]	.052
A fraction, %	39.1[a]	39.5[a]	38.5[a]	80.1[b]	26.3[c]	18.8[c]	.026
B fraction, %	59.0[a]	51.3[a]	48.3[ab]	18.4[b]	58.2[a]	12.8[b]	.099
C fraction, %	1.9[a]	9.2[a]	13.2[a]	1.5[a]	15.6[a]	68.4[b]	.080
Rate of B fraction disappearance, %/h	1.72[a]	1.83[a]	1.81[a]	.33[b]	2.07[a]	.23[b]	.005
Rumen DM degradation, %	77.7[a]	57.5[b]	65.8[c]	90.6[d]	61.2[bc]	23.4[e]	.012
Rate of DM disappearance, %/h	1.16[a]	1.04[a]	2.10[b]	.43[c]	.99[a]	.27[c]	.001

[a,b,c,d,e]Means within row lacking common superscript differ P<.05.

Table 2. Extent and rate of degradation of medium protein byproduct feeds

Byproduct feed	DDG	CG	CRM	SFM	WDG	SEM
CP, %	27.5	22.2	32.5	29.0	32.0	
RDP, %	74.4[a]	62.9[b]	68.0[ab]	83.3[c]	79.3[c]	.023
A fraction, %	49.5[a]	31.5[b]	46.7[a]	63.3[c]	54.6[d]	.012
B fraction, %	42.6[a]	63.7[b]	39.1[a]	30.2[c]	39.8[a]	.025
C fraction, %	7.9[ab]	4.8[a]	14.2[b]	6.6[a]	5.6[a]	.024
Rate of B fraction disappearance, %/h	1.26[ab]	1.96[b]	1.30[ab]	.61[a]	1.14[ab]	.002
DM rumen degradation, %	78.5[a]	49.8[b]	43.3[c]	57.0[d]	87.3[e]	.015
Rate of DM disappearance, %/h	.81[a]	1.81[b]	.70[a]	.46[a]	.34[a]	.008

[a,b,c,d,e]Means within row lacking common superscript differ P<.05.

Table 3. Extent and rate of degradation of low protein byproduct feeds

Byproduct feed	WM	DEHY	SH	CGF	SEM
CP, %	17.4	17.2	12.7	18.6	
RDP, %	89.5[a]	73.9[b]	59.2[c]	91.7[a]	.010
A fraction, %	73.7[a]	53.5[b]	41.2[b]	78.9[a]	.027
B fraction, %	21.2[ac]	33.7[ab]	37.9[b]	16.1[c]	.046
C fraction, %	5.1[a]	12.8[a]	20.9[b]	5.0[a]	.025
Rate of B fraction disappearance, %/h	.39[a]	1.33[b]	.93[b]	.28[a]	.002
DM rumen degradation, %	68.5[a]	57.4[b]	27.4[c]	68.7[a]	.012

Rate of DM disappearance, %/h	.27[a]	.89[b]	.99[b]	.25[a]	.002
[a,b,c]Means within row lacking common superscript differ P<.05.					

Implications

Considerable variation can be found in the rate and extent of CP and DM degradation of various byproduct protein feedstuffs available in Oklahoma. Selecting complementary protein sources to optimize RDP and ruminal efficiency, and maintain a balanced RUP AA profile is critical to protein nutrition. Further research needs to evaluate roughage:concentrate and their effect on the extent and rate of CP and DM degradation.

Literature Cited

Mathers, J.C. and E.L. Miller. 1981. Br. J. Nutr. 45:587.

Nocek, J.E. and J.E. English. 1986. J. Dairy Sci. 71:2051.

Veen, W.A.G. 1986. Neth. J. Agric. Sci. 34:199.

2001 Oklahoma Agriculture Experiment Station

[2001 Research Report | Animal Science Research Reports | Animal Science]