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Digestion and metabolism of diets containing increasing levels of corn germ[1]

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SUMMARY

A novel germ fraction is being generated by the BFrac™[4] process. The 20% fat, dry, flowable material is a potential source of concentrated energy to include in Northern Plains feedlot diets. A metabolism study with wethers was conducted to evaluate how ruminants would respond to this additional fat intake in finishing diets. Total collections of urine and feces were conducted on 23 wethers fed pelleted, high-corn content, iso-nitrogenous diets that included 0, 10, 20, or 30% germ. Each 6-d collection period followed 21 d adaptation periods. Increasing BFrac™ germ content caused ($P < 0.01$) an increase in DMI and a linear ($P < 0.001$) decrease in DM digestibility, probably due to the effect of DMI. There was a quadratic ($P < 0.01$) increase in EE digestibility, plateauing at 10% germ. Dietary DE, kcal/g declined linearly ($P < 0.01$) but DE intake (kcal/d) increased linearly ($P < 0.05$) because of higher DMI. There was no ($P > 0.15$) dietary effect on N digestibility, but there was a linear ($P < 0.01$) reduction in N retained. The increase in DE intake and decrease in N balance suggest that diets containing 20% or 30% germ had an antagonistic impact on metabolism.

INTRODUCTION

Co-products generated by the ethanol industry make feedstocks available for cattle feeding that are high in oil and/or protein at relatively low cost for the nutritive value they contain. The lower cost incentivizes feeding at elevated levels. To optimize use of these co-products, it would be useful to have a greater knowledge regarding practical upper limits for oil and protein inclusion in ruminant diets. The germ stream from the BFrac™ process is rich in oil (20%) and compatible with most feedlot feed handling equipment. We used sheep as a ruminant model to evaluate how high oil inclusion (from germ) affects utilization of high grain content diets.

MATERIALS AND METHODS

The four dietary treatments represented germ inclusion levels of 0, 10, 20, and 30% in high concentrate diets (Table 1). Germ replaced corn and SBM on an iso-nitrogenous basis. To maintain an appropriate Ca:P ratio, the high phosphorus content of germ forced inclusion of increasing levels of limestone that replaced corn. Complete diets, formulated to meet nutrient requirements were fed in pelleted form.

The digestion study involved a 21-d adaptation to diets and a 6-d total collection period. There were 24 lambs (BW = 90 ± 2.5 lb) stratified by weight across the four dietary treatments (Table 1). Lambs were fed ad libitum. Total collection of feces and urine was achieved using metabolism crates in a climate-

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[1] This project funded by the Department of Energy and the Beef Nutrition Program.

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controlled room with a 12-h light/dark schedule. Daily feed, feces, and urine samples were pooled (10% aliquots) within lamb and were analyzed in the Ruminant Nutrition labs, SDSU, for DM, CP, NDF, ADF, ash, EE, and GE. One lamb was removed from the 20% germ diet for health reasons unrelated to diets.

Table 1. Metabolism study diets[a]

	% Germ			
Item	0	10	20	30
Beet pulp	10.00	10.00	10.00	10.00
Corn	79.70	70.50	61.56	52.63
Germ	0	10.00	20.00	30.00
SBM, 44%	8.30	6.95	5.34	3.72
Limestone	1.45	2.00	2.55	3.10
Ammonium Cl	0.25	0.25	0.25	0.25
TM salt	0.30	0.30	0.30	0.30
CP, %[b]	11.72	11.58	11.48	11.66
EE, %[b]	3.92	6.59	6.77	8.72
GE, Mcal/kg[b]	4.168	4.188	4.252	4.308

[a] Dry matter basis. Included supplemental Vitamins A, D, and E. Contained 30 g lasalocid/T.

[b] Laboratory determinations.

The statistical analysis used was appropriate for a completely random designed experiment with 6 replicates per treatment. Since DMI was affected by diet, and DMI affects digestion kinetics, all variables except DMI were evaluated in a model using DMI as a covariate. Responses were tested for linear and quadratic aspects using polynomial contrasts. Pairwise comparisons of least squares means were accomplished using a protected ($P < 0.05$) Fischers t test.

RESULTS AND DISCUSSION

As was observed in a related cattle feeding study, germ content caused a linear increase in DMI (Table 2). Dry matter, organic matter, and GE digestibility (expressed as DE) all declined linearly ($P < 0.01$) with increasing dietary germ content (Table 2). These responses were not due to changes in protein or fiber digestibility as those digestion coefficients were not affected by diet.

The EE digestibility increased between 0 and 10% germ diets and then plateaued, resulting in a quadratic response ($P < 0.01$). The initial increase in EE digestibility was probably due to 1) dilution of endogenous EE losses, and 2) higher digestibility of EE in germ than in basal feed ingredients. The latter point should have caused EE digestibility to increase more at higher dietary germ levels, but that did not occur. An upper limit on fat digestion may have prevented this. Even so, total fat absorption (g/d) increased linearly ($P < 0.001$) with higher germ diets with values of 24, 49, 48, and 74 g/d, respectively.

The increased EE digestion (absolute quantity) and higher DMI caused daily DE intake to increase in spite of reduced digestion coefficients. The apparent DE intakes were 2.47, 2.79, 2.70, and 3.20 Mcal/d, respectively. The response was linear ($P < 0.05$) and suggests a more positive energy balance with increasing dietary germ. However, N retention (NR) decreased linearly ($P < 0.01$) with increasing germ. Since diets were iso-nitrogenous and N digestibility was not affected, this reduction in NR suggests that either energy or amino acids were limiting lean growth. Protein deficiencies typically cause reductions in DMI. In this situation, DMI increased, suggesting that limited amino acid supply was not involved.

An alternative hypothesis is that large amounts of fatty acid absorption may force ruminants to increase de novo production of oxaloacetic acid (OAA) or glycerol to accommodate storage of these fatty acids as triglycerides. Labile amino acids may have been drawn upon to meet this demand, resulting in a reduction in amino acids available for growth. This theory could explain the reduced N retention in this experiment and would be consistent with the reduced ribeye area observed in the steer feeding experiment. This metabolic adjustment would increase metabolic heat production, which might have been reflected in the linear increase ($P < 0.01$) in feed/gain in the finishing steer experiment.

Table 2. Influence of dietary germ level on feed utilization[1]

	% Germ						
	0	10	20[2]	30	SEM	*P* < [3]	L, Q[4]
DMI, g/d‡	674[a]	775[a]	755[a]	935[b]	61.7	0.01	L
DE, kcal/g	3.62[b]	3.59[b]	3.57[b]	3.48[a]	0.025	0.01	L
Digestibility, %							
DM	87.96[c]	85.77[b]	84.59[b]	81.68[a]	0.596	0.001	L
OM‡	89.74[c]	88.36[b]	87.10[b]	84.34[a]	0.501	0.001	L
NDF	67.8	67.2	67.8	62.0	3.41	NS[5]	
ADF	70.8	69.8	70.4	64.5	4.16	NS	
EE	81.9[a]	88.2[b]	86.6[b]	88.9[b]	1.06	0.01	Q
N	77.8	77.4	76.2	76.0	0.72	NS	
N retention, g/d‡	4.43[c]	4.64[c]	3.13[b]	2.08[a]	0.449	0.01	L

[1] Least square means.

[2] n = 5. In all other treatments n = 6.

[3] Probability value for diet.

[4] L or Q indicates linear or quadratic responses, respectively.

[5] Not significant.

[a,b,c] Means differ ($P < 0.05$).

‡ DMI : 10 & 20 v 30 ($P < 0.09$).
OM digestion : 0 v 10 ($P = 0.08$).
N retention : 0 v 20 ($P = 0.08$).