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R.H. Pritchard
South Dakota State University

J.W. McCarthick
South Dakota State University

J. Knock
South Dakota State University

D.L. Boggs
South Dakota State University

C.J. Mueller
South Dakota State University

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R. H. Pritchard[2], J. W. McCarthick[3], J. Knock[4], D. L. Boggs[5], and C. J. Mueller[6]

Department of Animal and Range Sciences, South Dakota State University*

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SUMMARY

The feeding value of dried distillers grains plus solubles (DDGS) is a combination of its contributions to protein nutrition as well as caloric intake of cattle. When DDGS is included in diets at levels where dietary CP has been met, the feeding value would primarily be a function of caloric density. A replicated 4 x 4 metabolism study was conducted to measure the caloric value of DDGS at high inclusion levels. Diets were formulated to contain 0, 12, 24, or 36% DDGS. These finishing diets were fed to yearling steers during a 21 d adaptation prior to total fecal and urine outputs collection for 5 d. Increasing dietary DDGS caused increased ($P < 0.01$) energy density of diets. Organic matter digestibility was not affected ($P > 0.15$), but NDF digestibility improved ($P < 0.01$). Apparent N digestibility increased ($P < 0.01$) with no additional N retention ($P > 0.15$). Apparent DE increased ($P < 0.01$) with each incremental increase in DDGS, but metabolizable energy (ME) plateaued at 12% DDGS. The relationship of urine energy:urine N was altered ($P < 0.01$) by increasing dietary DDGS level. Once dietary CP requirements were met, DDGS had a ME value similar to the corn and SBM mixture it replaced.

INTRODUCTION

The feeding value of distillers grains is an enigma because it is a significant source of protein and energy. A typical response to improved protein nutrition is improved energetic efficiency. It becomes difficult therefore to use production scale experiments to differentiate the ME content of DDGS and its influence on DMI. Knowing the ME content of DDGS would be beneficial when pricing DDGS into least cost formulations at higher levels once dietary CP has been met.

MATERIALS AND METHODS

Yearling crossbred steers (n = 8; BW 975 lb) were used to determine the ME content of DDGS in high grain content diets. Diets (Table 1) were formulated to provide a dose titration of 0, 12, 24, and 36% DDGS. The DDGS was substituted for rolled corn and soybean meal. Diets were offered ad libitum.

The experiment was designed as a replicated Latin square. In each 28 d period, adaptation occurred over 21 d. Total collections of feces and urine occurred over 5 d and there were 2 d for transition. One steer

[1] This project funded by the South Dakota Corn Utilization Counsel and the Beef Nutrition Program.
[2] Distinguished professor.
[3] Graduate student.
[4] SDSU undergraduate student, currently working for Trans-Ova, Sioux Center, IA.
[5] Professor, currently at Kansas State University.
[6] SDSU graduate student, currently asst. professor at Oregon State University.

had to be removed from the study after Period 2. His records were deleted from all periods resulting in 7 observations per treatment.

Table 1. Diet formulations[1]

	Diet DDGS, %			
Treatment	0	12	24	36
Cottonseed hulls	10.00	10.00	10.00	10.00
Rolled corn	74.00	68.00	56.00	44.00
Soybean meal	6.00	0.00	0.00	0.00
Distillers grains	0.00	12.00	24.00	36.00
Supplement[2,3]	10.00	10.00	10.00	10.00
DM, %[4]	89.81	90.07	90.69	91.31
CP, %[4]	10.77	10.95	13.54	16.11
NDF, %[4]	18.03	22.06	26.26	30.46
GE, Kcal/g[4]	4.087	4.167	4.251	4.334

[1] DM basis.
[2] Due to pelleting concerns, 50% of the supplement consisted of rolled corn.
[3] Provides vitamins and minerals to meet or exceed nutrient requirements (NRC, 1996).
[4] Based on laboratory analysis of samples during collections.

Complete diets were mixed prior to collection periods. During diet preparation each ingredient was sampled 4 times for determining composition. Total diet composition and relevant variable intakes were reconstructed from ingredient analyses, mixing records, and orts composition. During collection periods, steers were housed in digestion stalls that accommodated total feces and urine collections. Feces and urine outputs were recorded and sampled daily. Aliquots of daily samples were used to make 5 d composites for analyses.

In all samples, N was determined as Kjeldahl N and gross energy (GE) was determined by bomb calorimetry. To determine GE of urine, urine was first lypholyzed onto a cotton matrix. Dry matter content of feed and fecal samples was determined by drying components at 60^{o}C until a constant weight was achieved. Composition values (CP, NDF, GE, etc.) were corrected to DM determined at 100^{o}C. Calculation of ME did not include any correction for gaseous energy losses.

Statistical analysis was accomplished using the PROC MIXED module of SAS where main effects included square, period, diet, and square x diet. Steers within square was assigned as a random effect. Least squares means generated by this model were separated by Fischers t test.

RESULTS AND DISCUSSION

Diets fed closely approximated targeted DDGS inclusion levels (Table 2). Dietary CP was slightly lower than anticipated because of the low CP content of the corn used in this experiment. Dietary CP, GE, NDF, and ash content increased ($P < 0.01$) with increasing DDGS content as would be anticipated. As is typical in these types of experiments, intake was low relative to expected levels for these diets and cattle. That probably leads to an over estimate of digestion coefficients than would be realized at higher intakes.

Digestibility of DM and OM were similar among diets (Table 3). Digestibility of NDF and CP increased ($P < 0.01$) with increasing dietary DDGS. Both of which were expected. The NDF of DDGS would be more digestible than the NDF of the cottonseed hulls (CSH) used as the roughage source. Increasing DDGS effectively diluted out the indigestible NDF contribution from CSH. A similar outcome occurs for CP as metabolic fecal N is diluted out by increasing digestible CP intake associated with increased dietary DDGS.

Table 2. Diet composition with increasing levels of DDGS

	Diet DDGS, %					
	0	12	24	36	SEM	P Value
Actual DDGS, %	0.0 ± 0	12.2 ± 0.09	24.3 ± 0.13	36.3 ± 0.16		
DMI, kg/d	7.85	8.44	7.71	7.12	0.683	NS[1]
CP, %	10.63[a]	11.02[b]	13.46[c]	16.10[d]	0.134	0.01
OM, %	95.80[b]	96.00[b]	95.47[a]	95.35[a]	0.114	0.01
NDF, %	18.5[a]	22.4[b]	26.8[c]	31.2[d]	0.39	0.01
ADF, %	10.1[a]	10.8[b]	12.3[c]	13.8[d]	0.16	0.01
ASH, %	4.20[a]	4.00[a]	4.53[b]	4.65[b]	0.114	0.01
GE, Mcal/kg	4.089[a]	4.172[b]	4.239[c]	4.316[d]	0.014	0.01

[1] NS = $P > 0.15$.
[a,b,c,d] Means differ; P values noted on tables.

Table 3. Digestibility of diet fractions with increasing levels of DDGS

	Diet DDGS, %					
	0	12	24	36	SEM	P Value
Digestibility						
Dry matter, %	71.0	72.0	73.4	73.3	1.26	NS[1]
Organic matter, %	72.5	73.3	75.0	74.7	1.24	NS
NDF, %	25.3[a]	36.7[b]	49.0[c]	54.5[d]	2.01	0.01
ADF, %	25.4[a]	31.5[a]	39.2[b]	46.0[b]	2.55	0.01

[1] NS = $P > 0.15$.
[a,b,c,d] Means differ; P values noted on tables.

There were linear ($P < 0.01$) increases in N intake, apparent N digestibility, and urinary-N excretion in response to increasing dietary DDGS (Table 4). If digestible CP intake is in excess of requirements it will be excreted in the urine. There were no increases in N intake or urinary N output between 0 and 12% DDGS. There was only a small increase in dietary CP content between these diets due to variable composition of ingredients that probably affected the outcome. Increases in urinary N output with no concurrent improvement in N retention for diets 24 and 36% DDGS (Table 4) suggest that the 12% DDGS diet met dietary CP requirements.

Table 4. Nitrogen digestion and retention with increasing levels of dietary DDGS

	Diet DDGS, %					
	0	12	24	36	SEM	P Value
Nitrogen						
Intake, g/d	134[a]	149[ab]	166[bc]	183[c]	13.7	0.05
App. dig., %	63.7[a]	65.3[a]	71.7[b]	75.5[c]	0.97	0.01
UN, g/d	56.0[a]	49.8[a]	74.2[b]	102.5[c]	5.95	0.01
NR, g/d	28.8	47.3	45.1	35.8	9.02	NS[1]

[1] NS = $P > 0.15$.
[a,b,c] Means differ; P values noted on tables.
UN = urinary N; NR = N retention.

Gross energy intake was similar among diets. There was an increase ($P < 0.01$) in DE as DDGS content increased (Table 5). The 36% DDGS had 9% more DE than the 0% DDGS diet. The ME content of diets increased ($P < 0.05$) over the control when 12% DDGS was fed; but there were no subsequent increases in ME at 24 and 36% DDGS. The improvement in ME corresponded to the diet that met CP requirements. Once the CP requirement was met, DDGS had an energy value similar to the corn-SBM blend that it replaced. That ME determination does not include any correction for gaseous energy losses, which would theoretically be higher as the NDF content of diets increased with increasing DDGS content.

Table 5. Energy partitioning of the diets with increasing levels of DDGS

	Diet DDGS, %					
	0	12	24	36	SEM	P Value
GE intake, Mcal/d	32.038	35.191	32.613	30.775	2.8420	NS[1]
DE, Mcal/kg	2.878[a]	2.985[ab]	3.098[bc]	3.138[c]	0.0536	0.01
ME, Mcal/kg	2.778[a]	2.904[b]	2.976[b]	2.971[b]	0.0547	0.05

[1] NS = $P > 0.15$

[a,b,c] Means differ; P values noted on tables.

The energy content of urine can be estimated as 60 kJ/g N based upon the typical non-amino acid N content of urine. In this presumption, the principle, energy containing, nitrogenous component of urine would be hippuric acid and urea. Table 6 shows urinary energy losses based upon bomb calorimetry as well as urinary energy losses estimated from N content. When urinary energy (UE) was estimated from N content, the values exceeded bomb calorimetry values by 6.8, 6.4, 14.0, and 26.0% for diets 0, 12, 24, and 36% DDGS respectively. This may reflect a significant increase in NH_4^+ excretion at higher DDGS inclusion levels. Normally, NH_4^+ excretion is in response to maintaining acid base balance. Excess amino acid uptake and/or elevated NDF fermentation associated with higher DDGS content diets may evoke such a response.

Table 6. Urine energy content and output with increasing levels of dietary DDGS

	Diet DDGS, %					
	0	12	24	36	SEM	P Value
UE[1], Mcal/d	0.752[ab]	0.672[a]	0.935[b]	1.167[c]	0.0789	0.01
UE[2], Mcal/d	0.803[a]	0.715[a]	1.066[b]	1.471[c]	0.0854	0.01

[1] Determined using isoperibol calorimeter

[2] Calculated using the formula 60 kJ/g N (Blaxter, 1989)

[a,b,c] Means differ; P values noted on tables.

The results of this experiment suggest that DDGS has an available energy content similar to corn. It also provides evidence that production studies that suggest a higher energy value for DDGS may actually be showing a metabolizable protein response.