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Energy content of reduced-fat dried distillers grains with solubles for lactating dairy cows

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ABSTRACT

Eight Holstein and 8 Jersey multiparous, lactating cows were used to complete 56 energy balances to determine the energy content of reduced-fat dried distillers grains with solubles (RFDDGS). A repeated switchback design was used to compare treatments with and without RFDDGS. Diets consisted of 24.2% corn silage, 18.4% alfalfa hay, 6.94% brome hay with either 22.9% rolled corn or 14.8% soybean meal (control), or 8.95% rolled corn, 28.8% RFDDGS, and 0% soybean meal [Co-P; dry-matter (DM) basis]. The inclusion of RFDDGS did not affect DM intake, averaging 21.4 ± 0.53 kg of DM for all cows, but milk production tended to increase from 29.8 to 30.9 ± 1.46 kg/d for control and Co-P treatments, respectively. Milk fat percentage and energy-corrected milk did not differ between treatments, averaging 4.33 ± 0.14% and 34.1 kg/d, respectively. Milk protein was significantly decreased by the Co-P treatment (3.56 and 3.41 ± 0.08% for control and Co-P treatments), but protein yield was not affected. Milk energies were 1.40 Mcal/d greater with Co-P. Energy lost as methane was reduced by 0.31 Mcal/d with the addition of RFDDGS to the diet. Heat loss averaged 29.9 ± 0.55 Mcal/d and was not different between diets. Average energy retained as tissue energy was −2.99 ± 0.93 Mcal/d and did not differ between treatments. Intake of digestible and metabolizable energy were not different between the control and Co-P treatments, averaging 2.68 and 2.31 Mcal/kg of DM, respectively. The net energy of lactation values of control and Co-P diets were calculated to be 1.43 and 1.47 Mcal/kg of DM, respectively. These energy estimates suggest greater energy content of diets containing RFDDGS than diets containing a mixture of corn and soybean meal in lactating dairy cows.

Key words: dairy cow, energy balance, indirect calorimetry, reduced-fat dried distillers grains with solubles

INTRODUCTION

Dry distillers grains with solubles (**DDGS**), a by-product of ethanol production from corn grain, is most commonly produced in the midwestern United States and often included in dairy rations. In recent years, technology has been developed to remove a portion of the oil so that it may be used in biodiesel production. This process results in a reduced-fat dried distillers grains with solubles (**RFDDGS**; Berger and Singh, 2010). This RFDDGS has been used as a protein and energy source in lactating dairy cow diets, with fat concentrations low enough to reduce the risk of milk fat depression that may be associated with diets high in fat (Bauman and Griinari, 2003). The nutritional value of RFDDGS has not been investigated to the extent of full-fat DDGS, and the effects of RFDDGS on energy utilization of lactating cows has not yet been evaluated. When replacing forages, corn, soybean meal, and soy products, the inclusion of RFDDGS has been reported to have no effect on milk fat percentage (Castillo-Lopez et al., 2014), or to increase milk fat percentage with no negative effect on milk production (Mjoun et al., 2010). Given that the fat content is decreased, it is speculated that the energy content of RFDDGS is also less than DDGS. As a consequence, the determination of the energy value of diets containing RFDDGS will allow for more precise formulation of diets for lactating dairy cows. The objective of this study was to use total collection and indirect calorimetry techniques to investigate the effect of including RFDDGS on energy and N utilization in lactating cow diets when replacing corn grain and soybean meal. It was hypothesized that diets containing RFDDGS would contain less energy, and as a result, cows consuming RFDDGS would produce less milk.

MATERIALS AND METHODS

Experimental Design

Sixteen multiparous Holstein (n = 8) and Jersey (n = 8) cows averaging 93 ± 20 DIM at the beginning of the

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experiment were used, with average BW of 693.8 ± 12.9 and 429.2 ± 13.0 kg, respectively. The experimental design and methodology were similar to that of Birkelo et al. (2004). Two treatments were compared in a 4-period repeated switchback (Cochran and Cox, 1957) within a split-plot design. Cows were randomly assigned 1 of the 2 dietary treatments (control or **Co-P**; Table 1), which alternated over 4 periods; thus, measurements were collected on each animal consuming each treatment during 2 nonconsecutive experimental periods. Animals were blocked by date of calving, and the subplot of this study was breed, which was duplicated. The objectives of the current study were not to examine and report breed effects, but those results were reported elsewhere (G. Garcia Gomez, A. J. Foth, T. Brown-Brandl, H. C. Freetly, and P. J. Kononoff; unpublished data). Two diets were formulated that differed in the proportion of RFDDGS (Poet Nutrition, Sioux Falls, SD) included in the formulation. Diets included the control, which did not contain any RFDDGS, and Co-P, in which the coproduct RFDDGS was included at 30% of the diet DM while partially replacing the corn and soybean meal in a similar strategy as Birkelo et al. (2004). Specifically, the proportion of forage was held constant between treatments, but they differed in concentrate formulation. In the Co-P diet, RFDDGS replaced all the soybean meal and approximately half of the ground corn of the control diet. Diets were balanced using the Cornell-Penn-Miner Dairy model (Boston et al., 2000) to contain similar concentrations of CP but they differed in predicted energy, as this is what was tested. The study was conducted over 16 mo because the blocks were not tested simultaneously, consequently forages varied by year. Diet compositions and nutrient analysis are presented in Table 1. Each experimental period was 35 d in duration with 28 d for ad libitum diet adaptation, followed by 7 d of collection and 95% ad libitum feeding to minimize refusals, similar to the methodology in Birkelo et al. (2004). During the 28-d diet adaptation, cows were fed for ad libitum consumption to allow for approximately 5% refusals. All cows were less than 90 d pregnant at the conclusion of the final experimental period. Cows were housed in a temperature-controlled barn at the Dairy Metabolism Facility in the Animal Science Complex of the University of Nebraska–Lincoln in individual tie-stalls equipped with rubber mats and milked at 0700 and 1800 h. After milking all cows were moved to an indoor drylot sand surfaced pen for exercise where they were held for approximately 1 h. All animal care and experimental procedures were approved by the University of Nebraska–Lincoln Animal Care and Use Committee. Control and Co-P diets contained corn silage, alfalfa hay, grass hay, and concentrate mixed as a TMR, which was mixed in a Calan Data Ranger (American Calan Inc., Northwood, NH). Cows were fed once daily at 0900 h.

Table 1. Ingredient composition of control and coproduct (Co-P) diets and analyzed chemical composition (mean ± SD) used to determine apparent digestibilities

Item	Diet	
	Control	Co-P
Ingredient, % of DM		
Corn silage	24.5	24.5
Alfalfa hay	18.4	18.4
Brome hay	6.94	6.94
Ground corn	22.9	8.95
RFDDGS[1]	—	28.8
Soybean meal	14.8	—
Ground soybean hulls	7.93	7.93
Soypass[2]	2.01	2.01
Calcium carbonate	0.89	0.89
Sodium bicarbonate	0.65	0.65
Calcium diphosphate	0.30	0.30
Salt	0.22	0.22
Magnesium oxide	0.18	0.18
Trace-mineral premix[3]	0.12	0.12
Vitamin premix[4]	0.12	0.12
Chemical composition,[5] % DM	1.71	1.67
CP	18.6 ± 0.77	19.0 ± 1.00
Ether extract[6]	2.26 ± 0.11	3.22 ± 0.18
NDF	36.7 ± 1.91	43.4 ± 1.37
Ash	7.66 ± 0.57	8.38 ± 0.62
Starch	26.4 ± 1.47	17.9 ± 1.31
NFC[7]	34.9 ± 2.00	26.1 ± 2.41
ME,[8] Mcal/kg	2.67	2.46
Gross energy, cal/g	3,970.8 ± 77.9	4,114.8 ± 92.4

[1]Reduced-fat dried distillers grains with solubles.

[2]LignoTech, Overland Park, Kansas.

[3]Contained 13.9% Ca, 0.03% P, 0.42% Mg, 0.20% K, 4.20% S, 0.08% Na, 0.03% Cl, 445 mg/kg of Fe, 60,021 mg/kg of Zn, 17,375 mg/kg of Cu, 43,470 mg/kg of Mn, 287 mg/kg of Se, 527 mg/kg of Co, and 870 mg/kg of I.

[4]Formulated to supply approximately 120,000 IU/d of vitamin A, 24,000 IU/d of vitamin D, and 800 IU/d of vitamin E in total ration.

[5]Determined from composite samples collected throughout the experiment and analyzed at the University of Nebraska–Lincoln, mean ± SD.

[6]Analyzed by Cumberland Valley Analytical Services, Hagerstown, Maryland.

[7]NFC = 100 − (% NDF + % CP + % fat + % ash) (NRC, 2001).

[8]Calculated using the Cornell-Penn-Miner Dairy model (Boston et al., 2000).

Individual feed ingredients were sampled (500 g) each day during the collection period and frozen at −20°C. They were later composited by period and a subsample sent to Cumberland Valley Analytical Services Inc. (Hagerstown, MD) for complete nutrient analysis of DM (AOAC International, 2000), N (Leco FP-528 N Combustion Analyzer; Leco Corp., St. Joseph, MI), NDF (Van Soest et al., 1991), ADF (method 973.18; AOAC International, 2000), sugar (DuBois et al., 1956), ether extract (2003.05; AOAC International, 2006), ash (942.05; AOAC International, 2000), and