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Use of a corn milling product in diets for dairy cows to alleviate milk fat depression

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ABSTRACT

Various diet formulation strategies were evaluated to alleviate milk fat depression using a corn milling product (CMP) that contained approximately 28% crude protein, 34% neutral detergent fiber (NDF), and 12% starch (dry basis). The control diet comprised mostly corn silage, alfalfa silage, corn grain, and soybean meal and contained approximately 22% forage NDF (fNDF), 28% total NDF, and 33% starch. Another diet included 25% CMP that replaced corn grain and soybean meal and contained 27% starch and 33% NDF. Two other diets included 25 or 40% CMP that replaced forage and concentrate and contained 19 and 17% fNDF, 31 and 32% total NDF, and 30 and 28% starch, respectively. Diets were fed to 16 mid-lactation Holstein cows in 4 replicated 4 × 4 Latin squares. Milk fat percentage was low for the control diet (2.9%) but increased to 3.5% when cows were fed the diet with 25% CMP that replaced concentrate. Cows fed diets with 25 or 40% CMP that replaced forage and concentrate also had low milk fat percentages (3.0 and 2.9%, respectively). Intake was lowest for cows fed the control diet. Milk yield was reduced when CMP replaced only concentrate but because of the substantial increase in milk fat, the yield of energy-corrected milk was greater. Calculated energy use (maintenance + milk + body weight change) divided by dry matter intake was similar for the control and for the diet in which CMP replaced only concentrate, but it decreased linearly as increasing amounts of CMP replaced both forage and concentrate. A quadratic equation using the ratio of dietary starch to fNDF was the best predictor of milk fat percentage (ratios >1.4 were associated with reduced milk fat). Overall, CMP was effective at alleviating milk fat depression when it replaced corn grain but not when it replaced forage and concentrate.

Key words: milk fat depression, starch, nonforage fiber source, rumen acidosis

INTRODUCTION

The US corn refining industry used approximately 24.5 million tonnes of corn grain per year between 2004 and 2009 for the production of human foodstuffs such as sweeteners (USDA, 2010). Starch is the primary component used for human foodstuffs; therefore, the resulting corn milling product (**CMP**) is enriched with fiber and protein. These products can be added to diets simply to reduce diet costs or they can be included for nutritional reasons. In some diets with high starch concentrations, substituting these products for starchy grains could eliminate negative associative effects (Nousiainen et al., 2009) resulting in improved NDF digestibility, increased feed efficiency (FCM/DMI), and increased milk fat concentration (Allen and Grant, 2000; Boddugari et al., 2001). However, because starch is almost twice as digestible as NDF, on average (Weiss et al., 2009), replacing starch with NDF could reduce the energy concentration of the diet. When CMP replaces a portion of both forage and grain, the concentrations of forage NDF (**fNDF**) and starch will be reduced. This could result in increased DMI because reducing fNDF in diets can increase DMI, whereas DMI is rather insensitive to inclusion rates of nonforage fiber sources such as CMP (Allen, 2000). If digestibility is reduced because starch is replaced by NDF, the higher DMI may maintain energy intake. However, in studies in which CMP replaced both forage and starchy concentrates, inconsistent effects on DMI and feed efficiency have been reported (Boddugari et al., 2001; Mullins et al., 2010).

The objective of this study was to evaluate the use of a CMP to alleviate milk fat depression caused by a carbohydrate imbalance. We hypothesized that replacing corn grain with CMP would increase milk fat percentage but because NDF is less digestible than starch, feed efficiency would either not be affected or would decrease. We also hypothesized that when CMP replaced forage and corn grain, milk fat depression would be alleviated,

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DMI would increase but feed efficiency would probably decrease because NDF is less digestible than starch.

MATERIALS AND METHODS

Animals and Experimental Design

All procedures involving animals were approved by the Ohio State University Agricultural Animal Care Committee. Eight primiparous (DIM = 93; SD = 18) and 8 multiparous (DIM = 98; SD = 22) Holstein cows were used in a replicated (orthogonal) 4 × 4 Latin square experiment with 28-d periods. Within each parity group, cows were randomly divided into 2 groups of 4 and then each cow was randomly assigned to a treatment sequence within a square. Cows were housed in individual tie stalls, fed once daily for ad libitum intake (orts averaged 6% of as-fed amounts), and milked twice daily. Cows were weighed on d 2 and 3 of each period and on d 27 and 28 of period 4, and the 2 consecutive-day BW were averaged to calculate BW change during the period. Body condition was evaluated (1 = emaciated, 5 = obese) on d 2 of each period and on d 28 of period 4 by 2 independent evaluators.

Four diets were formulated to allow for various comparisons of interest. Forage for all diets consisted (DM basis) of 80% corn silage and 20% alfalfa silage (Table 1). Diet 1 contained (DM basis) 55% forage and no CMP (**0CMP**); diet 2 also contained 55% forage but included 25% CMP as a concentrate replacement (**25CMP-CR**). Diets 3 and 4 contained 25% CMP (**25CMP-FCR**) and 40% CMP (**40CMP-FCR**), respectively, as a forage and concentrate replacement (Tables 1 and 2). As the concentration of CMP increased from diet 1 to diets 3 and 4, dietary concentrations of fNDF, starch, and NFC decreased linearly and total NDF increased linearly (Table 3). All diets were formulated to meet NRC guidelines (Table 4-3; NRC, 2001) for minimum forage and total NDF and maximum NFC. The concentration of NFC in the 25CMP-FCR and 40CMP-FCR diets was less than the recommended maximum but the 0CMP diet slightly exceeded the NRC (2001) maximum (44.4% vs. 44.0%). These 4 treatments allowed us to determine the nutritional value of CMP when replacing mostly corn grain and soybean meal (diets 1 vs. 2) and to quantify the response to increasing concentration of CMP as concentrations of starch and fNDF decreased (diets 1, 3, and 4). The concentrate mixes (excluding the CMP) were pelleted. The CMP was stored in an open-walled shed protected from precipitation. The product was delivered every 3 wk and the experiment was conducted in January through April (average daily temperature 7.4°C, SD = 9.3°C, minimum and maximum average daily temperatures were −9 and 29°C) and no spoilage was evident.

Sampling and Analyses

Milk was sampled (a.m. and p.m.) on d 2, 8, 15, and 22 of each period and assayed for milk fat, protein, lactose (B2000 Infrared Analyzer, Bentley Instruments, Chaska, MN), and MUN (Skalar SAN Plus segmented flow analyzer, Skalar Inc., Norcross, GA) by DHI Co-

Table 1. Nutrient composition of the corn milling product and the silages (DM basis)[1]

Item	Corn milling product		Corn silage		Alfalfa silage	
	Mean	SD	Mean	SD	Mean	SD
DM, %	71.2	0.76	34.3	1.22	56.7	2.45
NE_L,[2] Mcal/kg	1.86	—	1.57	—	1.31	—
CP, %	27.7	0.93	6.85	0.40	19.7	0.42
NDF, %	34.2	0.86	39.1	1.28	43.5	0.77
IVNDFD,[3] % of NDF	70.6	2.69	54.0	1.47	41.8	1.22
Neutral detergent insoluble CP, %	3.69	0.37	0.68	0.10	2.75	0.12
Lignin, %	0.56	0.11	1.65	0.16	6.20	0.34
Starch, %	12.8	1.50	36.6	3.04	2.82	0.44
Long-chain fatty acids, %	2.54	0.25	2.76	0.04	2.16	0.15
Ash, %	7.32	0.17	3.65	0.27	10.3	0.10
Ca, %	0.08	0.01	0.15	0.02	2.42	0.03
P, %	1.06	0.04	0.23	0.04	0.26	0.01
K, %	1.75	0.01	0.85	0.07	0.96	0.02
Mg, %	0.39	0.02	0.12	0.01	0.19	0.01
Particle size, % of as-fed mass						
Top screen	—	—	4.5	1.5	10.5	5.7
Middle screen	—	—	68.6	2.9	42.4	1.5
Pan	—	—	26.9	1.7	47.1	4.2

[1]Mean and standard deviation calculated from results of 4 samples (1/period) that were each composited from 4 weekly samples.

[2]NE_L calculated using NRC (2001) with a constant discount of 8%.

[3]In vitro NDF disappearance during a 30-h incubation.