

Effect of Corn Particle Size, Moisture Level and Frequency of Feeding on Performance and Nutrient Utilization by Lactating Dairy Cows

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Introduction

Corn processing can be important for improving ruminal starch utilization as well as overall starch digestion. The objective of this experiment was to evaluate the effect of moisture level and particle size of corn grain on milk production, nutrient utilization and ruminal fermentation. An additional objective was to evaluate once or twice daily feeding of high energy diets to relatively high producing dairy cows.

Materials and Methods

Thirty-six Holstein cows were assigned to six squares according to their lactation number and the presence of a rumen cannula. Eighteen cows were assigned to the six different treatments and were fed once daily. Within this group of 18 cows, six had a rumen fistula and were used to evaluate nutrient digestibilities and ruminal fermentation. The remaining 18 cows were similarly assigned, except that they were fed twice daily. Cows were randomly assigned to each of the treatments in a 6 x 6 Latin square design replicated three times for each frequency of feeding. Periods were 21-d long; the first 14-d were considered as an adaptation period, and the last 7-d constituted the sampling period. Six diets, fed as TMR, were identical except for the corn portion of the diet. Corn treatments tested were dry shelled corn (DSC), high moisture ear corn (HMEC) and high moisture shelled corn (HMSC), either coarsely (CG) or finely (FG) ground. The six dietary treatments were DSC-CG, DSC-FG, HMEC-CG, HMEC-FG, HMSC-CG and HMSC-FG.

Diets were formulated to contain 50% DM, 1.69 Mcal NEL/kg DM, 17.5% CP, 32.8% NDF, 19.7% ADF and 37.2% NSC. Forage to concentrate ratio was 45:55. Dry matter content of the grain was: 88.9%, DSC; 70.0%, HMEC; and 68.1%, HMSC. Mean particle size (mm) for the corn treatments were 3.28, DSC-CG; 1.11, DSC-FG; 4.43, HMEC-CG;

1.32, HMEC-FG; 3.78, HMSC-CG; and 1.02, HMSC-FG.

Ytterbium was used as an external marker to estimate apparent total tract digestibility. Purine derivatives measured in a urinary spot sample were used as an indirect method for estimating rumen microbial protein synthesis.

Results and Discussion

Cows fed once daily. Production of milk was not affected by treatment (Table 1). Percentage of milk fat and milk fat yield trended lower ($P = .09$) for the high moisture corn and for the finely ground corn. Milk protein content and yield were not affected by treatment. Dry matter, OM, NDF and ADF digestibilities were not affected by treatment, but digestibilities of starch and free glucose were highest with the finely ground high moisture corn treatments. The allantoin: creatinine ratio was highest for the HMSC-FG treatment, indicating greater microbial protein production in the rumen.

Cows fed twice daily. Milk yield was significantly higher with the HMSC treatments, and milk fat test was lower (Table 1). Fine grinding of corn tended to reduce fat test across all treatments. Fine grinding increased the digestibility of starch, and tended to increase the allantoin:creatinine ratio. Ruminal pH was lowest for the HMSC treatments.

Effect of feeding frequency. Production of fat corrected milk was increased ($P < .07$) (Table 2), along with total milk fat production ($P < .07$) when cows were fed twice rather than once daily.

Conclusions

Feeding HMSC compared to HMEC resulted in higher milk production and slightly lower milk fat

percentage, reflecting the higher energy content of HMSC. The digestibility of starch + free glucose was improved by feeding high moisture corn and by fine grinding. Higher starch digestibility tended to increase

microbial growth in the rumen. Feeding twice daily rather than once daily tended to increase milk production, but had little effect on nutrient utilization.

Table 1. Performance of cows.

	DSC CG	DSC FG	HMEC CG	HMEC FG	HMSC CG	HMSC FG	SEM	Trt P
Once daily feeding								
Milk, kg/d	37.7	37.2	34.9	36.3	37.9	36.2	1.57	0.26
Milk fat, %	3.60	3.58	3.49	3.29	3.49	3.25	0.14	0.09
Milk protein, %	3.02	3.05	3.08	2.96	3.03	3.13	0.05	0.12
Intake, kg/d								
Dry matter	25.8	24.7	23.3	22.8	24.6	24.9	1.58	0.25
Starch ¹	9.13	8.73	8.26	8.09	8.73	8.86	0.56	0.25
Digestibility, %								
Dry matter	62.6	69.3	64.9	67.9	67.4	68.5	2.39	0.31
Starch ¹	80.4 ^c	88.1 ^{bc}	85.5 ^{cd}	90.2 ^{ab}	84.1	91.8 ^a	1.37	<.01
Fecal starch ²	18.8 ^a	13.7 ^b	14.8 ^b	10.7 ^c	15.7 ^b	9.32 ^c	0.79	<.01
Urine constituents								
A:C ratio	2.67 ^{bc}	2.54 ^{bc}	2.34 ^c	2.96 ^{ab}	2.79 ^{ab}	3.10 ^a	0.20	0.01
Rumen								
pH	6.12	6.09	6.10	5.99	5.96	5.94	0.09	0.09
NH ₃ , mM	10.2 ^a	9.32 ^a	8.74 ^{ab}	6.79 ^c	7.43 ^{bc}	6.98 ^c	0.61	<.01
Tot VFA, mM	121.7	125.0	122.6	127.5	28.2	130.9	3.84	0.30
C ₂ :C ₃ ratio	3.19 ^a	3.05 ^a	3.15 ^a	2.95 ^a	2.84 ^{ac}	2.47 ^{bc}	0.24	0.04
Twice daily feeding								
Milk, kg/d	37.2 ^c	38.9 ^{abc}	38.0 ^{bc}	37.8 ^c	39.3 ^{ab}	40.3 ^a	1.19	<.01
Fat, %	3.82 ^a	3.67 ^{ab}	3.78 ^{ab}	3.72 ^{ab}	3.59 ^b	3.31 ^c	0.12	<.01
Protein, %	3.10	3.08	3.03	3.09	3.11	3.09	0.04	0.46
Intake, kg/d								
Dry matter	26.3	26.8	25.2	25.2	25.8	25.4	1.87	0.69
Starch ¹	9.31	9.47	8.94	9.53	9.16	9.03	0.76	0.81
Digestibility, %								
Dry matter	65.6	65.9	62.7	66.6	67.1	69.2	2.45	0.55
Starch ¹	84.4 ^c	86.5 ^{bc}	83.2 ^c	89.7 ^{ab}	86.7 ^{bc}	91.2 ^a	1.48	0.01
Fecal starch ²	18.7 ^a	13.8 ^b	15.9 ^b	10.8 ^c	14.3 ^b	10.1 ^c	1.08	<.01
Urine constituents								
A:C ratio	2.58	2.69	2.93	3.36	2.78	3.04	0.22	0.17
Rumen								
pH	5.99 ^a	5.97 ^a	5.94 ^{ab}	5.81 ^{bc}	5.80 ^c	5.80 ^c	0.07	0.02
NH ₃ , mM	10.9 ^a	10.1 ^{ab}	8.88 ^{bc}	7.53 ^c	8.61 ^{bc}	7.04 ^c	0.67	<.01
Tot VFA, mM	127.8 ^c	132.2 ^{bc}	131.9 ^{bc}	135.9 ^{ab}	137.2 ^{ab}	140.2 ^a	3.10	0.02
C ₂ :C ₃ ratio	3.18 ^a	3.05 ^a	2.87 ^{ab}	2.5 ^{bc}	2.46 ^{bc}	2.13 ^c	0.24	<.01

¹Includes free glucose

²Includes free glucose, and is expressed as % of fecal DM.

Table 2. Effect of frequency of feeding.

	Fed once daily	Fed twice daily	SEM	Frequency <i>P</i>
Milk, kg/d	36.7	38.6	1.07	0.22
4% FCM, kg/d	33.6	36.5	1.11	0.07
Milk fat, %	3.45	3.65	0.09	0.15
Milk protein, %	3.04	3.07	0.04	0.48
Intake, kg/d				
Dry matter	24.3	25.8	1.54	0.51
Digestibility, %				
Dry matter	66.7	66.2	1.33	0.77
Urine constituents				
A:C ratio	2.74	2.90	0.14	0.39
Rumen				
pH	6.04	5.89	0.07	0.10
NH ₃ , mM	8.24	8.85	0.32	0.17
Tot VFA, mM	126.0	134.2	2.36	0.01
C ₂ :C ₃ ratio	2.94	2.70	0.18	0.35