

Effect of Cane Molasses on Absorptive Capacity of Rumen Papillae in Dairy Cows During the Dry Period and Early Lactation

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Introduction

Improvements in energy intake for dairy cows during the periparturient period have repeatedly resulted in improved performance for milk yield and reduced metabolic disorders in early lactation. These results are likely due to the increase in energy intake thus reducing the duration of negative energy balance immediately postpartum for the dairy cow. The increase in rumen organic matter fill promotes rumen mat formation while maintaining the position of the abomasum reducing incidence of displaced abomasum. Molasses addition at 3% of dry matter concentration to diets for lactating dairy cattle improved intake by 10%, milk yield by 4%, and milk protein yield by 8% in a recent study (Broderick and Radloff, 2004, *J. Dairy Sci.* 87:2997). Accompanying the improvements in production were decreased rumen ammonia concentration and milk urea nitrogen content, thus increasing the desirability of the milk for cheese production. Combining the improvement in early lactation performance due to increased energy intake with the increased intake from molasses addition to lactating dairy cattle diets could be very advantageous. Diets for dry dairy cows, beginning 60 d prior to projected calving date, have not been investigated with regards to molasses inclusion and potential benefits during the postpartum period until recently. In previous research at Kansas State University, dairy cattle were offered one of two diets, no molasses or 3% blackstrap molasses on a dry matter basis during the 60 d dry period. Upon parturition a common lactating diet was fed to investigate the impact of treatment during the dry period on DMI and milk yield during early lactation.

	Control	Molasses
Intake, kg/day		
Far-off	14.9	15.6
Close-up	16.7	18.5
Lactating	24.3	25.7
Milk yield, kg/day	46.4	50.8

Inclusion of molasses in the far off and close up dry cow diets at approximately 3% dry matter basis, improved intake during the close up period by 10.7% for multiparous cows. The increase in intake was not transient since the increase was maintained throughout the 30 d close-up period. During the initial 75 days of lactation, intake was

increased 6% for multiparous cows while yield of energy corrected milk and milk components were greater for cows offered diets containing molasses during the dry period. We hypothesized that the sucrose contained in the molasses enhanced butyrate (a volatile fatty acid; VFA) production within the rumen promoting rumen epithelial development and increasing VFA absorption from the

rumen. As the diet changed from a dry cow diet to a lactating cow diet, the rumen epithelium was more adapted to absorb VFA when available. The increased absorptive capacity resulted in improved energy status of the dairy cow during early lactation and improve performance. The increase in intake during the periparturient period improved the energy status of the dairy cow during early lactation as indicated by improved performance. While milk yield for the entire lactation was not followed, it is reasonable that peak milk was higher for cows with improved early lactation performance and thus milk yield would be greater during the entire lactation. In addition, an uneventful transition into lactation is desired. Prevention of metabolic disorders associated with the periparturient period is important to the longevity of the dairy cow which reduces input costs for replacements through reduced culling in addition to reduced costs associated with corrective intervention. These results reveal the importance of diets for non lactating dairy cows towards upcoming lactation and that liquid molasses inclusion into diets for dry cows can improve performance. Diets containing large amounts of forage, such as dry cow diets, conceivably benefit from reduced feed waste with the addition of liquid molasses, a benefit not evident in animal performance.

Marketing liquid molasses to dairy operations to enhance palatability is commonplace however, in our current research we hypothesized that addition of liquid molasses may influence rumen epithelial development during the period prior to parturition providing an innovative marketing approach for inclusion into dry cow diets. Our major goal of the proposed research study was to investigate the effect of liquid molasses addition to far-off and close-up dry cow diets on 1) rumen epithelium condition and presence of a specific receptor important in mediating the growth and development of rumen epithelium, glucagon-like peptide 2 receptor (GLP-2R) and 2) to determine the potential change in VFA absorption rate with molasses addition.

Results

Production, ruminal fermentation and VFA absorption data:

Six multiparous Holstein cows with rumen cannulas were used in a randomized complete block design to evaluate ruminal absorptive capacity in response to the addition of cane molasses to diets during a 60-d dry period. The chemical composition of the cane molasses used during this trial is represented in Table 1. A control diet without molasses or a diet containing molasses was individually fed during the far-off period (Table 2 and 3, d -60 to -30) and the close-up period (Table 4 and 5, d -29 to 0 relative to projected calving date). Molasses was 3.3% of DM in the far-off molasses diet and in the close-up molasses diet. During lactation all cows were individually fed a common lactation diet (Table 6 and 7). Cane molasses was included at 1.0% of DM in this common diet.

Rumen absorptive capacity was measured on d -60, -30, -3, 2, 16, 30, 44, 58, and 72 relative to calving by bolus dosing a 1-L solution containing 2 mol valerate

and 4 g Co-EDTA adjusted to pH 6.0 with NaOH. Ruminal fluid was collected over an 8-h period to determine liquid passage rates and valerate disappearance. Valerate absorption was greater ($P = 0.02$) during the close-up than the far-off period but did not differ for cows fed control (31.2%/h) or molasses (32.8%/h) diets. During lactation, valerate absorption did not differ for cows previously fed control (35.3%/h) or molasses (43.2%/h). Ruminal liquid volume, dilution rate, and outflow were similar between diets during the dry period. Total VFA concentration during the dry period (Table 8 and 9) did not differ between cows fed control or molasses nor did molar percentage of acetate, propionate, butyrate, or isovalerate. Total VFA concentration and molar percentage of propionate were greater whereas acetate molar percentage was less during the close-up period (Table 9) versus the far-off period (Table 8). The DM intake and milk yield data from this study is illustrated in Table 10. DMI was greater ($P = 0.002$) during the close-up period for cows fed molasses diets. DMI during lactation tended ($P = 0.08$) to be greater and milk production was greater ($P = 0.02$) for cows previously fed molasses diets. Inclusion of cane molasses in diets for non-lactating cows did not significantly improve ruminal absorptive capacity but had positive effects on DMI and milk production.

Ruminal biopsy sample analysis:

Biopsies of rumen papillae were conducted on day -60, -31, -4, 1, 14, 27, 39, 52, and 65 by exteriorization of the ventral sac and sharp dissection of an area (approximately 2.5 x 2.5 cm) using Mayo scissors as to not invade the muscular layer. The biopsy site was sutured using catgut like material as a prophylactic to preserve the integrity of the rumen epithelium. Biopsies were immediately frozen in liquid nitrogen and stored for determination of GLP-2R mRNA abundance with real-time PCR techniques and GLP-2R protein concentrations with Western blotting techniques. We observed a significant diet x period interaction (Figure 1, $P = 0.03$) for GLP-2R mRNA concentration in the rumen papillae samples obtained with our biopsy technique. The interaction was caused by molasses addition in the dry cow diets dramatically increasing GLP-2R mRNA levels prior to parturition with no change in samples obtained from the control diet. Following parturition, GLP-2R mRNA levels in samples obtained from cows fed molasses in the dry period moderated and levels in the control group increased during early lactation. We feel these disparate changes may be an important mediator of changes in rumen epithelial growth and development.

In addition to measuring the mRNA levels, we have successfully detected the GLP-2R protein on Western blots (Figure 2). These data aid in confirming the changes we observed with the GLP-2R mRNA data. In addition, the detection of both the GLP-2R mRNA and protein on tissue obtained with biopsy from the rumen wall is very novel and will increase our understanding of factors important for the growth and development of rumen epithelium. Increased understanding of these factors will increase our ability to manipulate the efficiency of nutrient absorption out of the rumen and subsequently, enhance production efficiency.

Conclusions

Addition of cane molasses to dry cow diets significantly improved dry matter intake during the close up period. During lactation, dry matter intake and milk yield tended to be greater for cows fed cane molasses during the dry period. These data indicate maintenance of intake during the dry period can positively impact performance during lactation. In addition, valerate absorption, as a measure of absorptive capacity, was greater during the close up period compared to the far off period. Disparate response in VFA absorption and liquid dilution rate for gestating dry cows compared to lactating cows indicated changes in absorptive capacity relative to parturition.

Table 1. Molasses Chemical Composition

Nutrient	% Dry matter
Dry matter	68.9
Crude protein	4.86
Crude fat	5.62
Ash	18.4
Sucrose	34.8
Glucose	5.1
Fructose	5.8
Calcium	0.97
Phosphorus	0.74
Potassium	3.03

Table 2. Far-off Diet

Ingredient	Control	Molasses
	----- % DM -----	
Prairie hay	57.5	56.6
Corn silage	12.6	12.4
Wet corn gluten feed	9.8	9.6
Soybean meal, solvent	7.1	7.0
Alfalfa hay	6.8	6.7
Whole cottonseed	3.4	3.0
Corn grain, ground	1.3	-
Molasses, sugarcane	-	3.3
Vitamins / minerals	1.5	1.5

Table 3. Far-off Diet Nutrient Analysis

Ingredient	Control	Molasses
	-----%DM-----	
DM, %	73.2	73.3
CP, %	12.4	12.2
NDF, %	53.7	52.4
ADF, %	33.4	32.6
NE _L , Mcal/kg	1.25	1.29
Calcium, %	0.51	0.52
Phosphorus, %	0.34	0.35
Potassium, %	1.67	1.73

Table 4. Close-up Diet

Ingredient	Control	Molasses
	-----%DM-----	
Alfalfa hay	9.0	9.0
Prairie hay	36.8	36.8
Corn silage	13.1	13.1
Wet corn gluten feed	12.0	12.0
Corn grain	16.4	13.1
Molasses	-	3.3
Soybean meal, solvent	5.8	5.8
Whole cottonseed	5.0	5.0
Fish meal	1.3	1.3
Vitamins / minerals	1.4	1.4

Table 5. Close-up Diet Nutrient Analysis

Ingredient	Control	Molasses
	-----%DM-----	
DM, %	70.9	71.6
CP, %	14.0	13.9
NDF, %	46.9	45.8
ADF, %	26.5	25.9
NE_L, Mcal/kg	1.41	1.42
Calcium, %	0.43	0.46
Phosphorus, %	0.39	0.39
Potassium, %	1.42	1.55

Table 6. Lactation Diet

Ingredient	%DM
Alfalfa hay	15.3
Corn silage	22.0
Wet corn gluten feed	20.4
Corn grain	20.4
Molasses	1.0
Soybean meal, expeller	7.6
Whole cottonseed	8.5
Fish meal	2.1
Vitamins / minerals	2.8

Table 7. Lactation Diet Nutrient Analysis

Ingredient	Lactation
DM, %	62.5
CP, %	18.8
NDF, %	35.8
ADF, %	19.7
NE_L, Mcal/kg	1.63
Calcium, %	0.94
Phosphorus, %	0.51
Potassium, %	1.19

Table 8. Rumen VFA Concentration: Far-off Period

Item	Control	Molasses	SEM	P value
Total VFA, mM	89	84	7.5	0.55
Acetate, %	70.8	68.1	1.3	0.25
Propionate, %	16.2	17.8	1.2	0.44
Butyrate, %	11.1	12.3	0.4	0.12

**Table 9. Rumen VFA
Concentration: Close-up Period**

Item	Control	Molasses	SEM	P value
Total VFA, mM	104	93	10.5	0.40
Acetate, %	67.6	66.5	1.8	0.67
Propionate, %	18.9	19.3	1.6	0.75
Butyrate, %	12.4	12.3	0.9	0.96

Table 10. DMI and Milk Yield

Item	Control	Molasses	SEM	P value
DMI, kg/day				
-60d to -30d	13.0	13.1	0.97	0.956
-29d to 0d	12.1	13.6	1.19	0.002
1d to 75d	23.3	26.5	2.56	0.081
ECM, kg/day	38.7	45.9	4.94	0.067
ECM/DMI	1.69	1.78	0.03	0.161

Figure 1. GLP2R mRNA Expression

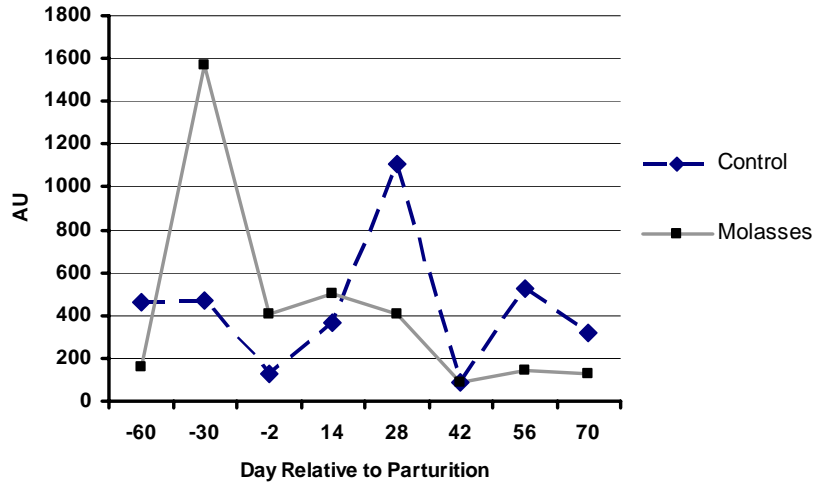


Fig. 2. GLP2R Western Blot

