Short communication: Apparent ruminal synthesis of B vitamins in lactating dairy cows fed *Saccharomyces cerevisiae* fermentation product

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ABSTRACT

Apparent ruminal synthesis and duodenal flow of thiamin, riboflavin, niacin, vitamin B₆, folates, and vitamin B₁₂ were evaluated in an experiment using 15 ruminally and duodenally cannulated lactating Holstein cows fed a basal diet, according to a crossover design, supplemented or not with 56 g/d of *Saccharomyces cerevisiae* fermentation product. Duration of the treatment period was 28 d. The basal ration had 28% neutral detergent fiber, 30% starch and 16.5% crude protein; forages were corn silage (67% of forage dry matter) and alfalfa silage (33% of forage dry matter). Concentrations of B vitamins were analyzed in feed and duodenal digesta. Apparent ruminal synthesis of each B vitamin was calculated as the duodenal flow minus the intake. Under the present experimental conditions, a dietary supplement of *Saccharomyces cerevisiae* fermentation product had no effect apparent synthesis of B vitamins in the rumen or on the amounts of these vitamins reaching the duodenum and available for absorption by the dairy cow.

Key words: dairy cow, B vitamin, *Saccharomyces cerevisiae* fermentation product, duodenal flow

Short Communication

According to a meta-analysis, feeding *Saccharomyces cerevisiae* fermentation products (SCFP) increases milk, protein, and fat yields of dairy cows; the supplement increases DMI when fed in early lactation, whereas it decreases it during late lactation (Poppy et al.,

2012). Moreover, a SCFP supplement increases milk fat content (Li et al., 2016) or yield (Longuski et al., 2009) in cows fed highly fermentable diets, but not in cows fed less fermentable diets. It has been proposed that the effects of SCFP on production performance were due to modifications of rumen microbiota activity, such as an increase in microbial protein synthesis (Hristov et al., 2010), preferential growth of proteolytic (Wiedmeier et al., 1987; Yoon and Stern, 1996), or fiber-digesting (Wiedmeier et al., 1987) bacterial populations. Requirements of individual B vitamins differ among rumen bacteria populations (Scott and Dehority, 1965), affecting the amounts of vitamins available for the host. Consequently, the objective of the present project was to verify if feeding SCFP could change apparent ruminal synthesis (ARS) and duodenal flow (DF) of individual B vitamins in dairy cows.

Feed and duodenal digesta samples were collected during a research project conducted at Michigan State University following approval by the Institutional Animal Care and Use Committee (Allen and Ying, 2012). Fifteen multiparous Holstein cows from the Michigan State University Dairy Cattle Teaching and Research Center (East Lansing, MI), equipped with rumen and duodenal cannulas and housed in a tiestall facility, were used in this study. Animals were randomly assigned at 169 (SD = 84) DIM to treatment sequences in a crossover design, with 28-d treatment periods after a 14-d preliminary period when voluntary DMI was recorded. During preliminary and experimental periods, cows were offered the basal ration as TMR once daily at 110% of expected intake. The 2 treatments were the basal ration without (CON) or with SCFP (56 g/d; Diamond V XP Yeast Culture, Diamond V Mills Inc., Cedar Rapids, IA). The forage-to-concentrate ratio (% of DM) was 56:44; forages were corn (67% of forage DM) and alfalfa (33% of forage DM) silages (Table 1). Individual feed intake was recorded daily. Samples of all feed ingredients were collected daily from d 21 to 25 during each experimental period and pooled by period. Duodenal samples were collected every 15 h from d

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Table 1. Ingredients, chemical composition and B-vitamin concentrations of the basal ration¹

Composition	Value
Ingredient, % of DM	
Corn silage	37.1
Alfalfa silage	18.6
High-moisture corn	23.5
Soybean meal (48% CP)	10.8
SoyPlus ²	5.0
Mineral-vitamin mix ³	4.1
Limestone	1.0
Chemical composition	
DM, % as fed	49.6
OM, % of DM	92.6
NDF, % of DM	28.0
Forage NDF, % of DM	23.6
Forage NDF, % of NDF	84.3
Indigestible NDF, % of DM	11.6
Indigestible NDF, % of NDF	41.4
CP, % of DM	16.5
Starch, % of DM	30.1
Total cobalt, mg/kg of DM	1.35
B-vitamin concentrations, mg/kg of DM	
Thiamin	1.10
Riboflavin	29.07
Niacin ⁴	16.60
Vitamin B ₆ ⁵	7.98
Folates	0.69
Vitamin B ₁₂	ND ⁶

¹Adapted from Allen and Ying (2012).²West Central Soy (Ralston, IA).³Vitamin-mineral mix contained (DM basis) 17.6% sodium bicarbonate, 15.1% magnesium sulfate, 7.5% salt, 6.0% dicalcium phosphate, 2.5% trace mineral premix, 0.4% vitamin A, 0.4% vitamin D, 0.2% vitamin E, and 50.2% dry ground corn as a carrier.⁴Sum of nicotinic acid and nicotinamide.⁵Sum of pyridoxamine, pyridoxal, and pyridoxine.⁶ND = not detected.

21 to 25 of each experimental period. The 8 samples collected were then pooled by cow and by period. All samples were stored at -20°C before processing. Experimental procedures, measurements, and analyses were described by Allen and Ying (2012).

Concentrations of B vitamins in feed and duodenal digesta were analyzed at the Sherbrooke Research and Development Centre (Agriculture and Agri-Food

Canada, Sherbrooke, QC, Canada) as described by Castagnino et al. (2016a). Thiamin, riboflavin, niacin, and vitamin B₆ were quantified by HPLC (Varian Pro-Star, Lake Forest, CA) equipped with a solvent delivery system (model 210), an autosampler (model 410), and a fluorescence detection system (model 363). Folates were determined with a microbiological microtiter plate test (VitaFast Folic Acid, R-Biopharm Inc., Marshall, MI) and vitamin B₁₂ was analyzed by radio-assay [SimulTRAC-S Vitamin B₁₂ (⁵⁷Co)/Folate (¹²⁵I), MP Biomedicals, Solon, OH]. Dietary Co concentrations were determined by atomic absorption spectrometry with flame stoichiometric air-acetylene at 240.7 nm, as described by Castagnino et al. (2016b). Samples were analyzed in duplicate (except folates, for which samples were analyzed in triplicate), and a coefficient of variation of less than 10% was accepted between replicates.

Individual B-vitamin concentrations in the experimental TMR were the summation of each B-vitamin concentration in dietary ingredients (Table 2) multiplied by the proportion of these ingredients in the TMR, on a DM basis. Daily intakes of individual vitamins were calculated as the concentration of each vitamin in the TMR multiplied by cow DMI. Calculations of DM DF were described by Allen and Ying (2012). The duodenal flow of each B vitamin was calculated as B-vitamin concentrations in duodenal sample multiplied by the daily DM flowing through the duodenum. Apparent ruminal synthesis was calculated as DF minus the daily intake of each vitamin.

Daily intake, DF, and ARS for each vitamin, expressed in milligram per day or milligram per kilogram of DMI, were analyzed using the MIXED procedure of SAS (version 9.4; SAS Institute Inc., 2012), in which period and treatment were considered as fixed effects and cow as a random effect. Differences were declared significant at $P < 0.05$ and as a tendency at $0.05 \leq P \leq 0.10$.

In the present experiment, DMI and DF did not differ between treatments ($P \geq 0.36$); DMI and DF were 22.4 and 23.1 (SE = 0.85) kg of DM/d and 16.4 and

Table 2. Concentrations of B vitamins (mg/kg of DM) for ingredients used in the basal ration (mean $\pm$ SD; n = 2)

Item	Thiamin	Riboflavin	Niacin ¹	Vitamin B ₆ ²	Folates	Vitamin B ₁₂
Corn silage	1.40 $\pm$ 0.011	33.21 $\pm$ 2.462	7.70 $\pm$ 0.282	17.39 $\pm$ 0.785	0.10 $\pm$ 0.015	ND ³
Alfalfa silage	0.39 $\pm$ 0.073	50.25 $\pm$ 6.045	21.01 $\pm$ 1.646	10.35 $\pm$ 4.424	0.38 $\pm$ 0.101	ND
High-moisture corn	0.64 $\pm$ 0.020	15.28 $\pm$ 8.066	11.92 $\pm$ 2.852	2.11 $\pm$ 1.247	0.07 $\pm$ 0.013	ND
Soybean meal (48% CP)	4.69 $\pm$ 0.025	12.47 $\pm$ 1.190	30.57 $\pm$ 3.614	3.08 $\pm$ 0.495	3.28 $\pm$ 0.120	ND
SoyPlus ⁴	0.82 $\pm$ 0.030	19.36 $\pm$ 0.857	25.13 $\pm$ 1.255	1.67 $\pm$ 0.148	3.20 $\pm$ 0.331	ND

¹Sum of nicotinic acid and nicotinamide.²Sum of pyridoxamine, pyridoxal, and pyridoxine.³ND = not detected.⁴West Central Soy (Ralston, IA).

Table 3. Intake of B vitamins (expressed in mg/d), duodenal flow and apparent ruminal synthesis (ARS; expressed as mg/d and as mg/kg of DMI) of cows fed *Saccharomyces cerevisiae* fermentation product (SCFP) or the basal control diet only (CON)

Vitamin	Treatment LSM, mg/d				Treatment LSM, g/kg of DMI			
	CON	SCFP	SEM	P-value	CON	SCFP	SEM	P-value
Thiamin								
Intake	24.7	25.4	0.95	0.40				
Duodenal flow	63.9	64.5	4.10	0.90	2.82	2.79	0.125	0.84
ARS	39.2	39.1	3.44	0.97	1.71	1.68	0.125	0.84
Riboflavin								
Intake	652	672	24.6	0.36				
Duodenal flow	884	906	48.4	0.56	39.3	39.1	1.23	0.90
ARS	232	235	32.0	0.90	10.19	10.03	1.229	0.90
Niacin ¹								
Intake	373	383	14.4	0.47				
Duodenal flow	2,128	2,186	190.8	0.65	95.2	93.8	7.32	0.66
ARS	1,756	1,804	184.2	0.68	78.6	77.2	7.33	0.66
Vitamin B ₆ ²								
Intake	178	183	7.40	0.53				
Duodenal flow	54.0	52.1	5.96	0.83	2.38	2.22	0.23	0.65
ARS	-124	-131	6.8	0.48	-5.60	-5.76	0.234	0.65
Vitamin B ₉								
Intake	15.5	15.9	0.60	0.42				
Duodenal flow	89.6	89.3	10.50	0.98	3.92	3.79	0.401	0.74
ARS	74.1	73.4	10.22	0.94	3.22	3.10	0.401	0.74
Vitamin B ₁₂								
Intake ³	ND ³	ND	—	—				
Duodenal flow	10.8	10.3	0.77	0.39	0.48	0.44	0.029	0.13
ARS	10.8	10.3	0.77	0.39	0.48	0.44	0.029	0.13

¹Sum of nicotinic acid and nicotinamide.²Sum of pyridoxamine, pyridoxal, and pyridoxine.³Not detected.

17.0 (SE = 0.92) kg of DM/d, for CON and SCFP, respectively. Intake of individual B vitamins was similar in basal diets for both treatments ($P \geq 0.36$). Neither B-vitamin DF nor ARS, expressed in milligrams per day or in milligrams per kilogram of DM, were affected by SCFP ($P \geq 0.13$; Table 3).

Samples of SCFP were not available when the vitamin analyses were conducted. Based on the product Profile Sheet (<https://store.buchanancellers.com/inet/storefront/getpdf.php?recid=223>), except for vitamin B₁₂, the amount of individual B vitamins provided by 56 g/d of SCFP would represent less than 2% of total daily intake of each vitamin from the basal diet. Nevertheless even if B-vitamin supply would have been greater for cows fed SCFP, the supplement had no effect on B-vitamin DF.

Production responses following SCFP supplementation vary according to DIM (Poppy et al., 2012) and dietary NDF concentrations (Robinson and Erasmus, 2009), and are likely explained by changes in fermentation and microbial populations in the rumen. In the present experiment, however, neither rumen fermentation, nor nutrient ruminal digestibility (Allen and Ying, 2012), nor the relative abundance of 12 ruminal microbial species (Mullins et al., 2013) differed between CON and SCFP. Using DMI recorded during the preliminary

period as a covariable, Allen and Ying (2012) reported that SCFP increased the rate of starch digestion in the rumen of cows with lower DMI (DMI during the preliminary period below 26 kg/d), but had the opposite effect in cows with higher DMI. Nevertheless, even when conducting statistical analyses according to the model described by Allen and Ying (2012), neither treatment effects nor interactions between DMI during the preliminary period and treatment were significant for all the studied vitamins (data not shown). Consequently, under the present experimental conditions, where the SCFP supplement had no effect on the ruminal fermentation pattern (Allen and Ying, 2012; Mullins et al., 2013), it also had no effect on B-vitamin supply for the dairy cows.

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