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Short communication

Effects of crude glycerin on milk composition, nutrient digestibility and ruminal fermentation of dairy cows fed corn silage-based diets

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ABSTRACT

The objective of the current study was to evaluate the effects of increasing levels of crude glycerin on dry matter intake, nutrient digestibility, ruminal parameters, blood metabolites, milk yield and composition of dairy cows fed corn silage-based diets. Twenty-four Holstein cows (16 non-cannulated and 8 rumen-cannulated; 184 ± 50 days in milk [DIM] and 594 ± 39 kg of body weight [BW]) were assigned to a replicated 4 × 4 Latin square design experiment, consisting of 14 days for adaptation to diets and 7 days for sampling. Cows were assigned to receive one of the diets: 0 (Control), 70, 140 or 210 g of crude glycerin/kg of diet dry matter (DM). Dry matter intake and milk yield linearly decreased with the inclusion of crude glycerin. However, crude glycerin did not affect milk composition. Total-tract digestibility of DM, crude protein (CP) and ether extract (EE) linearly increased, and neutral detergent fiber (NDF) digestibility linearly decreased according to dietary inclusion of crude glycerin. Feeding crude glycerin changed volatile fatty acid concentrations: linearly increased propionate, quadratically affected butyrate, and linearly decreased acetate concentrations, resulting in lower acetate to propionate ratio. Total volatile fatty acid was not affected by crude glycerin. Ruminal NH_3-N linearly decreased according to crude glycerin dietary levels. Crude glycerin linearly increased blood glucose concentration. Inclusion of high levels of crude glycerin (210 g/kg) in diets of mid-lactating cows, increased dry matter digestibility and ruminal propionate concentrations, but negatively affected dry matter intake and milk yield.

Abbreviations: BCFA, branched chain fatty acids; BUN, blood urea nitrogen; BW, body weight; CP, crude protein; DIM, days in milk; DMI, dry matter intake; EE, ether extract; aNDF, neutral detergent fiber with residual ash; NFC, non-fiber carbohydrate; VFA, volatile fatty acids.

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1. Introduction

The growth of the biofuel industry has increased the demand for corn, affecting prices and the livestock sector (USDA, 2014). Therefore, new alternative feed sources are required in order to reduce animal feed costs. Crude glycerin is a by-product obtained from oil processing in the biodiesel industry, wherein for each liter of biodiesel produced, 0.1 l of crude glycerin is formed (Dasari et al., 2005). Crude glycerin contains 800–880 g of glycerol/kg (Donkin, 2008) and glycerol or purified glycerin (>95% glycerol) has been used to prevent metabolic problems in transition cows (Goff and Horst, 2003; Piantoni and Allen, 2015).

Crude glycerin can be converted into volatile fatty acid (VFA) in rumen, mainly into propionate (Wang et al., 2009), or can be absorbed through the rumen epithelium and oxidized in the liver, increasing the energy available for animal utilization (Remond et al., 1993). Several studies have reported that replacing corn with glycerin increased the ruminal molar proportion of propionate (De Frain et al., 2004; Shin et al., 2015; Boyd et al., 2013).

There is a lack of data examining crude glycerin as a primary energy source ingredient in rations of dairy cows, mainly in dietary levels higher than 100 g/kg (dry matter [DM] basis). Thus, the objective of the present study was to evaluate the effects of increasing dietary levels of crude glycerin (up to 210 g/kg diet DM) on dry matter intake (DMI), nutrient digestibility, ruminal parameters, blood metabolites, milk yield and composition of lactating dairy cows fed corn silage-based diets. Our hypothesis was that cows fed crude glycerin could maintain milk yield and composition without impairing DMI and nutrient digestibility.

2. Materials and methods

Experimental procedures were approved by the Ethics Committee of the School of Veterinary Medicine and Animal Science of the University of São Paulo (approval number 3058/2013).

2.1. Animals, diets and experimental design

Twenty-four multiparous Holstein cows (184 ± 50 days in milk [DIM] and 594 ± 39 kg body weight [BW], mean ± SD), 16 non-cannulated and 8 rumen cannulated, were assigned to a replicated 4 × 4 Latin square design experiment with 21 day periods (14 day of adaptation and 7 day of sampling). The cows were grouped according to milk yield and then assigned to each square according to BW, except for 2 squares that were formed by the rumen cannulated cows. Thus, 24 repetitions per treatment were used for statistical analysis. The animals were assigned within each square to receive one of the following diets: 0 (Control), 70, 140 or 210 g of crude glycerin/kg of diet DM. Diets were formulated according to NRC (2001), and ingredients and chemical composition are described in Table 1. The crude glycerin contained 806 g/kg of glycerol, 63 g/kg of ash and 124.6 g/kg of water, and was obtained from soybean oil (ADM, Rondonopolis, Brazil). The crude glycerin was mixed into the concentrate before the morning feeding. Cows were individually fed twice daily (50% of total diet DM in each feeding) at 0700 and 1300 h to supply 105–110% of expected feed intake (on as fed-basis). The feed was individually

Table 1
Ingredients and chemical composition of experimental diets.

Item, g/kg of diet DM	Glycerin inclusion, g/kg of DM			
	0	70	140	210
Corn silage[a]	501.4	500.3	505.9	504.0
Ground corn	300.5	219.2	125.1	45.0
Soybean meal	162.1	174.6	192.8	204.8
Crude glycerin[b]	0.0	69.9	140.2	210.2
Mineral premix[c]	29.8	29.8	29.8	29.8
Urea	5.30	5.30	5.30	5.30
Ammonium sulphate	0.90	0.90	0.90	0.90
Composition				
Dry matter	586.4	587.6	585.0	586.6
Neutral detergent fiber	301.1	290.5	281.9	271.0
Non fiber carbohydrate[d]	455.7	464.1	468.1	468.1
Crude protein	162.3	160.7	161.2	159.5
Ether extract	31.1	31.2	31.0	31.2
Ash	66.3	70.1	74.3	78.0
Net energy[e] (Mcal/kg DM)	1.74	1.75	1.75	1.75

[a] Composition: 293.0 of dry matter (DM); 70.5 of crude protein (CP); 556.7 of neutral detergent fiber (NDF); 29.7 of ether extract (EE) and 38.6 of ash.
[b] Composition: 806 g/kg of glycerol, 63 g/kg of ash and 124.6 g/kg of water, obtained from soybean oil (ADM, Rondonopolis, Brazil).
[c] Contained per kg: 88.0 g of Ca; 42.0 g of P; 18.0 g of S; 45.0 g of Mg; 123.0 g of Na; 14.0 mg of Co; 500.0 mg of Cu; 20.0 mg of Cr; 1050.0 mg of Fe; 28.0 mg of I; 1400.0 mg of Mn; 18.0 mg of Se; 2800.0 mg de Zn; 80.0 mg of Biotin; 200.000,00 UI vitamin A; 40.000,00 UI vitamin D; 1.200,00 UI vitamin E.
[d] Non fiber carbohydrate = 1000–([CP - CP of urea + urea] + NDF + EE + ash), Hall (2000).
[e] Estimated using the NRC (2001) model.