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Effect of rice bran oil supplementation on rumen fermentation, milk yield and milk composition in lactating dairy cows

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ABSTRACT

The objective of this study was to determine effects of rice bran oil (RBO) on feed intake, nutrient digestibility, ruminal fermentation, milk yield, and milk composition in lactating dairy cows fed at 0, 2, 4, and 6% in concentrate. Four crossbred (75% Holstein Friesian) lactating dairy cows with an average live weight of 399 ± 59 kg and 64 ± 10 days in milk were randomly assigned according to a 4×4 Latin square design. Cows were fed with total mixed ration (TMR), with a concentrate/roughage ratio of 60:40 and urea treated rice straw (5% urea) was used as a roughage source. Cows fed supplemental RBO were linearly decreased in feed intake expressed as kg/d and a percentage of BW. Increased level of RBO in concentrate linearly decreased digestibility of DM, OM, NDF and OM intake, but did not affect those of CP and ADF; however DMI and nutrient digestibility could maintain at 4% RBO supplementation as compared with control (0% RBO). RBO supplementation tended to increased in propionate concentration, which was highest in 4% RBO. Moreover, supplementing RBO linearly decreased in acetate concentration which resulted in a linearly decreased C2:C3 ratio and CH_4 production. Although supplementing with RBO had not affected on milk yield and milk composition, while milk fat yield and milk protein yield (kg/d) were linearly decreased. 3.5% FCM and milk fat tended to decrease when increasing level of RBO in the diet. In addition, increased RBO supplementation linearly decreased concentrations of both short- and medium-chain FA, and linearly increased the proportion of long-chain FA in milk fat and *cis*-9, *trans*-11 CLA, as well as tended to be increased in total CLA, which was highest in cow fed with 4%RBO. In conclusion, RBO can be used as a good source of additional energy for lactating dairy cows; however adding high level of RBO might have adverse effect on DMI and nutrient digestibility. Based on this study, feeding dairy cow with RBO should not exceed 4% in concentrate to obtain the most beneficial effect on nutrient utilization, rumen fermentation and dairy cow performance.

1. Introduction

Lipid is typically fed to ruminant to increase the energy density of the ration, as in the case of high-producing, early-lactation dairy cows and rapidly growing starter beef cattle. Moreover, lipid supplementation has other potential benefits, such as increased absorption of fat-soluble nutrients and reduced dustiness of feed (NRC, 2001). Supplemental lipids are used in diets for nutritional or economic reasons. Due to their high energy value, lipid supplements may contribute to meeting the energy requirements of animals; furthermore, it may be cheaper in some circumstances to provide energy as lipids rather than carbohydrates (Doreau and Chilliard, 1997).

Various forms of lipid are fed to dairy cattle, including vegetable oil, animal fat and "protected" fats (NRC, 2001). Vegetable oils are commonly added to ruminant diets to enhance the

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proportion of desirable unsaturated fatty acids in edible products (Raes et al., 2004), such as sunflower oil, soybean oil, linseed oil, corn oil, etc., which is rich in linoleic and linolenic acids. However, vegetable oil from different oilseed has different fatty acids compositions and accordingly has a different effect on animal performance and milk fatty acids profile. Feeding vegetable oils rich in linoleic acid have been demonstrated to be an effective strategy to enrich milk with conjugated linoleic acid (CLA). In contrast, feeding high amounts of oil in the diet could adversely affect animal performance (Gomez-Cortes et al., 2008). The used of free oil in high doses in the diet is not recommended in ruminants, because it might inhibit rumen microbial activity and affect milk production and composition (Jenkins, 1993). In most situations, total dietary lipid in ruminant diets should not exceed 6–7% of dietary DM (NRC, 2001). Feeding a higher concentration of lipid often results in a reduction of dry matter intake (Shingfield et al., 2006), and has the potential to inhibit ruminal fermentation (Jenkins, 1993).

Rice bran oil is one source of oil that can be used as a supplement for dairy cattle diets. It contains 25% saturated fatty acids and 75% unsaturated fatty acids, especially consists of high level of 38.4% oleic and 34.4% linoleic acids (Orthoefer, 2001). Thus, feeding dairy cows with rice bran oil may improve milk yield and milk fatty acids profile, especially CLA in milk. Therefore, the objective of this study was to investigate the effect of different level of supplementation rice bran oil on rumen fermentation, microorganisms, milk yield, milk composition and fatty acids profile in lactating dairy cows.

2. Materials and methods

2.1. Animals, diets and management

Four, multiparous mid-lactation crossbred dairy cows (75% Holstein Friesian) with an average of 399 ± 59 kg BW and 64 ± 10 DIM, were randomly assigned according to a 4×4 Latin square design. The treatments were as follows; concentrate with 0, 2, 4, and 6% rice bran oil (RBO) respectively. Cows were fed with total mixed ration (TMR), with a concentrate/roughage ratio of 60:40 and urea treated rice straw (5% urea) was used as a roughage source. All cows were housed in individual pens and received free access to water and a mineral-salt block. The experiment was run in four periods, each experimental period lasted for 21 days. The first 14 days of each period were for treatment adaptation and for feed intake measurements, while during the last 7 days feed, feces, refusals and milk were sampled for subsequent chemical analyses. Chemical composition and components of the experimental diets are shown in Table 1.

Table 1
Feed ingredients and chemical composition used in the experimental diets.

Item	Rice bran oil				UTRS[a]
	0	2	4	6	
Ingredients, %					
Rice bran oil (RBO)	0.0	2.0	4.0	6.0	
Cassava chip	51.0	51.0	49.0	47.0	
Fine rice bran	9.0	9.0	9.0	9.0	
Coconut meal	16.0	17.0	17.0	17.0	
Palm meal	14.0	13.0	13.0	13.0	
Urea	3.0	3.0	3.0	3.0	
Molasses	5.0	3.0	3.0	3.0	
Sulfur	0.5	0.5	0.5	0.5	
Mineral mixture	1.0	1.0	1.0	1.0	
Salt	0.5	0.5	0.5	0.5	
Chemical compositions, % of DM					
DM	87.5	87.0	85.2	83.5	70.3
OM	91.7	92.3	91.8	90.9	88.7
CP	17.2	17.2	17.1	17.0	4.8
EE	4.2	7.4	8.9	10.8	1.6
NDF	29.1	30.3	28.7	29.0	66.3
ADF	16.4	14.4	14.8	15.9	48.8

DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.
[a] UTRS = urea treated rice straw (5% urea).

2.2. Data collection, sampling procedures and chemical composition analysis

Feed intakes were measured and refusals recorded. Body weights were measured daily during the sampling period prior to feeding. Feeds were sampled daily during the collection period and were composited by period prior to analyses. Feed and fecal samples were collected during the last 7 days of each period. Fecal samples were collected by rectal sampling. Composited samples were dried at 60 °C and ground (1 mm screen using Cyclotech Mill, Tecator, Sweden) and then analyzed for DM, EE, ash and CP content (AOAC, 1990), NDF and ADF (Goering and Van Soest, 1970) and acid-insoluble ash (AIA). AIA was used to estimate digestibility of nutrients (Van Keulen and Young, 1977).

Cows were milked twice daily, and milk yield was recorded at each milking of each period. Milk samples were composted daily, according to yield, for both the morning and evening milking, preserved with 2-bromo-2 nitropropane-1, 3-dial, and stored at 4 °C until analysis for fat, protein, lactose, total solids and solid-not-fat content (AOAC, 1990) by infrared methods using Milko-Scan 33 (Foss Electric, Hillerod, Demark). Milk urea N (MUN) was determined using Sigma kits #640 (Sigma Diagnostics, St. Louis, MO) (Valadares et al., 1999). One part of each milk sample was dried by a freeze dry method (Heto PowerDry LL3000 Freeze Dryer; Thermo Fisher Scientific, Tehovec-Mukarov, Czech Republic) and analyzed for fatty acid content. Total lipids were saponified and methylated according to the procedure of Metcalfe et al. (1966) followed by gas liquid chromatography (Nelson, 1975).

Rumen fluid samples were collected at 0 and 4 h-post feeding at the end of each period. Approximately 200 ml of rumen fluid was taken from the middle part of the rumen by a stomach tube connected with a vacuum pump. Rumen fluid was immediately measured for pH and temperature using portable pH and temperature meter. Rumen fluid samples were then filtered through four layers of cheesecloth. Samples were used for NH_3-N analyses where 5 ml of H_2SO_4 solution (1 M) was added to 50 ml of rumen fluid. The mixture was centrifuged at 16,000×*g*. for 15 min and the supernatant stored at −20 °C prior to NH_3-N analysis using the micro Kjeldahl method (AOAC, 1990) and VFA analyses using a HPLC (Samuel et al., 1997).

Samples of jugular blood (about 10 ml) were drawn into serum separation tubes at the same time as rumen fluid sampling and centrifuged for 10 min at 5000×*g*. The supernatant was decanted and frozen (−20 °C) until it was analyzed for