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Effects of intake of linseed oil or tallow on nutrient digestion and nitrogen balance of beef steers consuming diets based on dry-rolled corn

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ABSTRACT

Lipids can have detrimental effects on the ruminal microbiota and, subsequently, diet digestibility. We evaluated effects of amount and source of dietary lipid on nutrient digestibility, ruminal fermentation, and N balance in cattle consuming diets based on dry-rolled corn. Five steers (BW = 392 ± 15 kg) fitted with ruminal, duodenal, and ileal cannulas were used in a 5 × 5 Latin square with 12-d periods. Diets contained no added lipid or 4 or 8% added lipid from either a tallow or linseed oil. Linseed oil tended ($P = 0.08$) to decrease DMI compared with tallow. Greater amounts of lipid tended to decrease ruminal digestion of DM ($P = 0.07$), OM ($P = 0.14$), and NDF ($P = 0.05$). Microbial efficiency (g of microbial N/kg of OM fermented) tended to increase ($P = 0.10$) with added lipid, but microbial N flow to the duodenum was not affected ($P \geq 0.19$) by amount or source of lipid. Ruminal pH ($P \geq 0.83$), ammonia ($P \geq 0.33$), and total organic acid content ($P \geq 0.54$) were not affected by diet lipid. Added dietary lipid tended ($P = 0.10$) to decrease ruminal acetate concentrations. Addition of a more unsaturated lipid (linseed oil) decreased ($P = 0.05$) total-tract NDF digestibility compared with a more saturated lipid (tallow), and addition of lipid tended to decrease digestion of DM ($P = 0.13$) and NDF ($P = 0.08$) compared with control. Linseed oil decreased ($P < 0.01$) fecal N and tended to reduce ($P = 0.08$) urinary N.

Key words: cattle, lipid, nitrogen balance, nutrient digestibility

INTRODUCTION

Cattle performance is often limited by energy available for productive purposes (Lofgreen and Garrett, 1968; NASEM, 2016). Lipid is an essential nutrient that can increase diet energy density, palatability, and mixing characteristics (NASEM, 2016). However, lipids can have deleterious effects on ruminal microbiota that can reduce ruminal fermentation of nonlipid energy sources (Jenkins, 1993; Zinn et al., 1994; Hess et al., 2008). Zinn et al. (1994) reported that lipid reduces ruminal fermentation of structural carbohydrates but has limited effect on fermentation of nonstructural carbohydrates. Yet, others (Hess et al., 2008) have concluded that deleterious effects of lipid on nonstructural carbohydrate fermentation may differ by extent of lipid saturation. Many studies have evaluated effects of increased lipid intake on diet digestion among ruminants fed forage- (Doreau et al., 1991; Scholljegerdes et al., 2004; Pavan et al., 2007), barley- (Zinn, 1989a), and wheat-based (Bock et al., 1991) diets; however, few data are available on effects of increased lipid intake and extent of lipid saturation on nutrient digestion and N balance among cattle fed corn-based diets. Ostensibly, the paucity in information related to effects of lipid supplementation on nutrient digestion in cattle fed corn-based diets contributed to the conclusion that "estimates of the effects of lipid supplementation on digestion characteristics, particularly of structural carbohydrates, would be useful for improving the accuracy of the Beef Cattle Nutrient Requirements model" (NASEM, 2016). Thus, our objective in this study was to determine the effects of amount and source of lipid supplementation on nutrient digestibility, ruminal fermentation, and nitrogen balance in cattle fed diets based on dry-rolled corn.

MATERIALS AND METHODS

Animals and Diets

All experimental protocols and animal husbandry procedures were approved by the South Dakota State University Institutional Animal Care and Use Committee. Five ruminally, duodenally, and ileally cannulated steers (BW = 392 ± 15 kg) were allowed ad libitum access to water and housed in individual pens (1.7 × 2.4 m) in a temperature-controlled room (21°C) under 16 h of light (0500 to 2100 h) and 8 h of darkness. Cattle were placed in a 5 × 5 Latin square. Treatments were provided across 12-d periods that consisted of 7 d of adaptation to diets, and samples were collected during the subsequent 5 d. Treatments consisted of 5 diets based on dry-rolled corn (Table 1) that differed in amount and source of added lipid. Treatments were

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Table 1. Composition of diets based on dry-rolled corn (DRC)

	Dietary treatment[1]				
Item, % DM unless otherwise noted	**Control**	**4S**	**4U**	**8S**	**8U**
Ingredient					
DRC	67.4	62.2	62.2	57.0	57.0
Alfalfa hay	10.0	10.0	10.0	10.0	10.0
Linseed meal	10.8	12.0	12.0	13.2	13.2
Linseed oil	0.0	0.0	4.0	0.0	8.0
Tallow	0.0	4.0	0.0	8.0	0.0
Cane molasses, liquid	10.0	10.0	10.0	10.0	10.0
Limestone	1.2	1.2	1.2	1.2	1.2
Salt	0.5	0.5	0.5	0.5	0.5
Mineral mix[2]	0.1	0.1	0.1	0.1	0.1
Chemical composition[3]					
OM	93.7	93.9	93.4	93.5	93.5
N	2.3	2.2	2.4	2.3	2.4
DIP[4]	7.7	7.8	7.8	7.9	7.9
Starch	36.5	33.8	32.5	31.3	33.5
NDF	19.4	18.7	18.0	20.9	18.7
Total fatty acids	3.5	6.8	7.2	10.1	10.9
NE_m,[4] Mcal/kg	1.98	2.09	2.09	2.21	2.21
NE_g,[4] Mcal/kg	1.33	1.41	1.41	1.50	1.50

[1]Treatments delivered no additional fat (control), 4% (4S) or 8% (8S) additional fat from tallow, or 4% (4U) or 8% (8U) additional fat from linseed oil.

[2]Designed to provide to diet (DM basis) 100 mg/kg of Fe, 40 mg/kg of Mn, 60 mg/kg of Zn, 20 mg/kg of Cu, 1 mg/kg of I, 0.2 mg/kg of Se, 0.2 mg/kg of Co, 2,200 IU of vitamin A/kg, 275 IU of vitamin D/kg, and 50 IU of vitamin E/kg.

[3]Analyzed values.

[4]DIP = degradable intake protein. Predicted from tabular values (NRC, 2000).

designed to deliver no additional lipid (control) or 4 or 8% additional lipid from tallow (predominantly saturated lipid) or linseed oil (predominantly unsaturated lipid). The fatty acid composition of lipid sources is shown in Table 2, and diet fatty acid compositions are shown in Table 3. Although both lipid sources contained considerable amounts of unsaturated fatty acids, tallow had a greater ratio of saturated:unsaturated than linseed oil (1.1 vs. 0.1 for tallow and linseed oil, respectively). Additionally, tallow contained 4.8-times more C16:0 fatty acids and 5.4-times more C18:0 fatty acids, and linseed oil contained 409-times more C18:3 fatty acids than tallow, which had only small amounts C18:3 (0.13% of total fatty acids).

Diets were offered (DM basis) at 105% of the average DMI over the previous 4 d and were fed in equal amounts every 12 h (0700 and 1900 h). Five grams of TiO_2 was added to each 12-h feed offering as an indigestible nutrient flow marker beginning on d 5 and continued to the end of each period.

Cattle were moved to metabolism stalls (0.66 × 1.83 m) on d 8 to allow total collection of urine and feces from d 8 to 11 for measure of nutrient digestion and N balance. Diet (100 g/d) and ort samples (10%, if present) were collected from d 7 to 10 to correspond to urine and fecal

Table 2. Fatty acid (FA) profile of 2 dietary lipid sources

	Lipid source	
FA, % of total	**Tallow**	**Linseed oil**
C10:0	0.07	0.00
C12:0	0.09	0.01
C14:0	3.49	0.05
C16:0	25.12	5.21
C16:1	2.51	0.07
C18:0	20.38	3.78
C18:1	41.62	21.47
C18:2	2.04	13.95
C18:3	0.13	54.57
C20:0	0.15	0.15
C20:1	0.20	0.03
C20:2	0.08	0.05
C22:0	0.03	0.16
C22:1	0.02	0.04
C24:0	0.02	0.12
SFA	49.35	9.49
MUFA	44.35	21.61
PUFA	2.25	68.57