Short communication: Effects of prepartum diets supplemented with rolled oilseeds on Brix values and fatty acid profile of colostrum

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ABSTRACT

The objective of this study was to evaluate effects of oilseeds supplemented in prepartum diets on colostrum quality. Thirty-nine dry pregnant Holstein cows (14 primiparous and 25 multiparous cows) were blocked by body condition score and parity and assigned to 1 of 3 experimental diets containing rolled oilseeds at 8% of dietary dry matter (canola seed or sunflower seed) or no oilseed (control) at 35 d before the expected calving date. Canola seed is high in oleic acid and sunflower seed is high in linoleic acid content. Colostrum samples were collected at the first milking after calving, and concentrations of nutrient composition, fatty acid profile, and Brix value (an indicator IgG concentration) were determined. Cows fed sunflower seeds before calving produced colostrum with greater crude protein content (15.0 vs. 12.9%), colostral Brix values (24.3 vs. 20.3%), and conjugated linoleic acid concentration (18:2 *cis*-9,*trans*-11; 0.64 vs. 0.48%) compared with those fed canola seed. Positive effects of feeding sunflower seed might be mediated by ruminal metabolism of linoleic acid and subsequent enhanced production of conjugated linoleic acid. Oilseed supplementation in prepartum diets of dairy cows also altered fatty acid profile of colostrum in a way to reflect fatty acid profile of the supplemented oilseeds except for oleic acid. In conclusion, prepartum feeding of sunflower seed increased colostral Brix value, an indicator of colostral IgG concentration, compared with that of canola seed, but its mode of action and effects on health and productivity of calves need to be investigated.

Key words: colostrum, sunflower seed, canola seed, fatty acid profile, Brix

Short Communication

Elevated blood fatty acid concentration and accumulation of lipids in the liver during the periparturient

period exert significant effects on health and milk production of dairy cows (Drackley, 1999). Prepartum fat supplementation was proposed as a nutritional strategy to prime cows for fat mobilization during the periparturient period and to reduce accumulation of lipids in the liver. In the literature, prepartum fat supplementation decreased plasma fatty acid concentration (Andersen et al., 2008; Ballou et al., 2009), plasma BHB concentration (Ballou et al., 2009; Damgaard et al., 2013), and liver triglyceride accumulation (Grum et al., 1996; Andersen et al., 2008; Damgaard et al., 2013) during the periparturient period. However, positive effects of prepartum fat supplementation on health and productivity of dairy cows have not been consistent and sometimes have been detrimental (Duske et al., 2009; Karimian et al., 2015), and its efficacy is still controversial. Although cows have been the primary research focus in those recent studies evaluating effects of prepartum fat supplementation, it is also expected to affect colostrum composition, fatty acid profile, and possibly IgG concentration. However, little data exist on the effects of prepartum nutritional management on colostrum quality. As such, the objective of the current study was to evaluate effects of prepartum supplementation of oilseeds differing in fatty acid profile on colostrum quality.

The animal study was conducted at the Dairy Research Unit of the University of Alberta, Edmonton, and all animal experimental procedures were according to the guidelines of the Canadian Council on Animal Care (2009; Ottawa, Ontario, Canada) and approved by the University of Alberta Animal Care and Use Committee for Livestock.

Thirty-nine nonlactating pregnant Holstein cows (14 primiparous and 25 multiparous cows), a subset of animals from a larger study (Salehi et al., 2016), were used. Cows were blocked by BCS and parity, and assigned to 1 of 3 experimental diets containing rolled oilseeds at 8% of dietary DM (canola seed or sunflower seed) or no oilseed (control) at 35 d before the expected calving date (Table 1). Canola seed is high in oleic acid and sunflower seed is high in linoleic acid content (Salehi et al., 2016). Cows were housed individually in tiestalls, fed once daily at 0800 h, and had unrestricted access to

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water. Diets were offered ad libitum as a TMR. Detailed experimental diets and experimental procedures are described in the companion paper (Salehi et al., 2016). Colostrum samples were collected at the first milking after calving, and analyzed for concentrations of fat, CP, and lactose by infrared spectroscopy (MilkoScan 605; Foss Electric, Hillerød, Denmark; AOAC International, 2002) at the Central Milk Testing Laboratory (Edmonton, Alberta, Canada). A Brix refractometer (Atago Co., Ltd., Tokyo, Japan) was used to estimate concentration of IgG (Bielmann et al., 2010; Quigley et al., 2013). Colostrum samples were also analyzed for fatty acids profile. Fatty acids in colostrum samples were extracted as described by Folch et al. (1957). The fatty acid profile of extracted lipids was assessed by gas chromatography as previously described by Cruz-Hernandez et al. (2007).

Data were analyzed using the MIXED procedure of SAS (version 9.3, 2011; SAS Institute Inc., Cary, NC) and means were compared using orthogonal contrasts to test the effects of prepartum oilseed (oilseed vs. no oilseed control) and type of oilseed (canola vs. sunflower) supplementation. The statistical model included prepartum dietary treatment and parity as the main effects and the interaction of prepartum dietary treatment by parity when it was significant. All data are reported as mean $\pm$ standard errors; significance was declared at $P \leq 0.05$, whereas $P > 0.05$ but ≤ 0.10 was considered trends.

Cows fed sunflower seeds before calving produced colostrum with higher CP content (15.0 vs. 12.9%; $P = 0.05$) and greater colostrum Brix values (24.3 vs. 20.3%; $P < 0.01$; Table 2), an indicator of colostrum IgG concentration, compared with those fed canola seed. Colostrum IgG concentration was not measured directly, but estimated from Brix values in the current study. It has been shown that the Brix readings are highly correlated with IgG concentration determined by radial immunodiffusion assay (Bielmann et al., 2010), and the colostrum Brix reading of 21% is used to identify colostrum with IgG concentration of 50 g/L or greater (Quigley et al., 2013). Estimated colostrum IgG concentrations (estimated using the equation: $-61.896 + 5.666 \times \text{Brix } \%$; Quigley et al., 2013) were 58.2, 53.1, and 75.8 g/L, respectively for control, canola, and sunflower treatments.

Sunflower seed, which increased colostrum Brix values, is greater in linoleic acid concentration than canola seed (Salehi et al., 2016). In agreement with our findings, Lessard et al. (2004) reported that feeding a prepartum diet containing micronized soybean, which is high in linoleic acid, increased colostrum antibody responses to ovalbumin challenge compared with diets containing whole flaxseed or calcium salts of palm oil. Greater

Table 1. Ingredients and nutrient composition of prepartum experimental diets¹

Item	Prepartum dietary treatment		
	Control	Canola	Sunflower
Ingredients, % of DM			
Barley silage	60.0	60.0	60.0
Alfalfa hay	10.0	10.0	10.0
Ground barley grain	10.0	10.0	10.0
Soybean hulls	10.0	6.2	3.4
Canola meal	5.0	0.8	3.6
Canola seed	0.0	8.0	0.0
Sunflower seed	0.0	0.0	8.0
Vitamins and minerals	5.0	5.0	5.0
Nutrient composition, % of DM (unless otherwise noted)			
CP	14.2	13.8	14.4
NDF	42.0	41.3	40.1
Starch	11.6	10.0	9.8
Ether extracts	2.7	7.4	6.2
NE _L , Mcal/kg	1.40	1.61	1.55

¹Adapted from Salehi et al. (2016).

antibody responses to linoleic acid feeding may be mediated by CLA. The positive effects of feeding CLA on serum IgG concentration were documented for rats (Sugano et al., 1998), pigs (Corino et al., 2001), and goats (Castro et al., 2006). Furthermore, Corino et al. (2009) reported that feeding CLA beginning 7 d before parturition increased colostrum IgG concentration in sows, and speculated that CLA is involved in production of interleukins, which regulate immunoglobulin synthesis.

Griinari and Bauman (1999) showed that CLA in ruminant milk derives from incomplete biohydrogenation of linoleic acid in the rumen, either directly or indirectly via absorption of 18:1 *trans*-11 followed by desaturation to 18:2 *cis*-9,*trans*-11 (Griinari et al., 2000). We found that sunflower seed treatment increased concentration of 18:2 *cis*-9,*trans*-11 in colostrum compared with canola seed treatment (0.64 vs. 0.48%; $P = 0.02$). Our findings, along with evidence in the literature, collectively indicated that prepartum feeding of sunflower seed increased CLA production, and possibly led to enhanced IgG concentration in colostrum estimated by Brix values. However, Garcia et al. (2014) recently reported that feeding SFA (Energy Booster 100; Milk Specialties, Dundee, IL) during the late gestation period decreased CLA concentration in colostrum, but increased colostrum IgG concentration of parous dairy cows compared with Ca salts of fatty acids (Megalac-R; Church & Dwight, Princeton, NJ). Reasons for the discrepancies are not known, and the possible role of CLA in colostrum IgG production warrants further investigation. Future studies should determine colostrum yield as well as IgG concentration to quantify IgG production accurately.

In the current study, we also found that prepartum supplementation of oilseeds decreased fat content of colostrum in primiparous cows, but not in multiparous cows. We found an interaction effect between treatment and parity on DMI, in which oilseed supplementation did not affect DMI of primiparous cows whereas it decreased DMI of multiparous cows (Salehi et al., 2016). However, oilseed treatments increased plasma fatty acid concentration at 3 wk before calving and 1 wk after calving to a similar extent for both multiparous and primiparous cows (Salehi et al., 2016). As such, it is not known why prepartum oilseed supplementation decreased fat concentration of colostrum only in primiparous cows.

Prepartum oilseed supplementation increased the proportion of stearic acid (11.3 vs. 7.65%; $P < 0.0001$), linoleic acid (3.63 vs. 2.89%; $P < 0.001$), and linolenic acids (0.54 vs. 0.46%; $P = 0.03$) in the colostrum compared with control, but did not affect oleic acid concentration. These findings were consistent with the report of Santschi et al. (2009) and Garcia et al. (2014), where supplementation of linseed or Energy Booster (Milk Specialties) or Megalac-R (Church & Dwight) during the transition period was evaluated, respectively. It is noteworthy that prepartum fat supplementation did not affect oleic acid concentration of colostrum consistently whereas it affected concentrations of other long-chain fatty acids. Cows fed sunflower seed had greater proportions of medium- and short-chain fatty acids (<C18; 55.3 vs. 48.8%; $P = 0.01$) and linoleic acid (4.05 vs. 3.21%; $P < 0.01$), but lower proportions of stearic acid

(9.89 vs. 12.7%; $P < 0.01$), oleic acid (primiparous cows only; 20.5 vs. 26.3%; $P < 0.0001$), and linolenic acid (0.49 vs. 0.59%; $P = 0.02$) in the colostrum compared with those fed canola seed before calving. In general, the fatty acid profile of colostrum reflected the fatty acid profile of oilseeds supplemented in prepartum diets (Salehi et al., 2016). Type of oilseed supplemented in the current study affected fatty acid profile of colostrum to a greater extent than that reported by Garcia et al. (2014) possibly because dietary fat content was greater in our study than that of Garcia et al. (2014). These findings collectively suggest that the fatty acid profile of colostrum is easily affected by the amount and type of fat supplemented in prepartum diets. However, little data exists in the literature on how colostrum fatty acid profile affects health and productivity of calves.

In conclusion, prepartum feeding of sunflower seed increased colostrum Brix value, an indicator of colostrum IgG concentration, compared with feeding canola seed. As sunflower seed contains more linoleic acids than canola seed, we inferred that feeding sunflower seed increased endogenous CLA production, which may have increased colostrum IgG concentration. In addition, our findings suggest that the fatty acid profile of colostrum, except for oleic acid, reflects the fatty acid profile of oilseeds supplemented in prepartum diets.

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Table 2. Effects of prepartum dietary treatment on colostrum composition (means $\pm$ SE)

Item	Prepartum dietary treatment			P-value	
	Control	Canola	Sunflower	Fat vs. control	Canola vs. sunflower
Primiparous cows, no.	4	4	6	—	—
Multiparous cows, no.	9	9	7	—	—
Brix, % ¹	21.2 $\pm$ 0.92	20.3 $\pm$ 0.96	24.3 $\pm$ 0.88	0.29	<0.01
Fat, % ²					
Primiparous cows	7.08 $\pm$ 0.77	4.79 $\pm$ 0.77	3.46 $\pm$ 0.70	<0.01	0.21
Multiparous cows	3.82 $\pm$ 0.50	3.30 $\pm$ 0.57	4.00 $\pm$ 0.52	0.79	0.37
CP, %	12.7 $\pm$ 0.66	12.9 $\pm$ 0.69	15.0 $\pm$ 0.63	0.09	0.05
Lactose, %	3.04 $\pm$ 0.10	3.14 $\pm$ 0.11	2.85 $\pm$ 0.10	0.48	0.07
Fatty acid profile, g/100 g of total fatty acids					
<C18	58.6 $\pm$ 1.75	48.8 $\pm$ 1.75	55.3 $\pm$ 1.75	<0.01	0.01
C18:0	7.35 $\pm$ 0.63	12.7 $\pm$ 0.63	9.89 $\pm$ 0.63	<0.0001	<0.01
C18:1 ²					
Primiparous cows	22.5 $\pm$ 1.36	26.3 $\pm$ 1.36	20.5 $\pm$ 1.11	0.53	<0.0001
Multiparous cows	16.5 $\pm$ 0.91	24.5 $\pm$ 0.91	22.5 $\pm$ 1.03	0.13	0.99
C18:2	2.89 $\pm$ 0.14	3.21 $\pm$ 0.14	4.05 $\pm$ 0.14	<0.001	<0.01
C18:2 <i>cis</i> -9, <i>trans</i> -11	0.39 $\pm$ 0.04	0.48 $\pm$ 0.04	0.64 $\pm$ 0.04	<0.01	0.02
C18:3	0.46 $\pm$ 0.03	0.59 $\pm$ 0.03	0.49 $\pm$ 0.03	0.03	0.02
>C18	1.70 $\pm$ 0.14	2.07 $\pm$ 0.14	1.85 $\pm$ 0.14	0.16	0.28

¹Colostrum Brix reading.

²Treatment by parity interaction was significant ($P < 0.05$).

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