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Effect of including canola meal and supplemental iodine in diets of dairy cows on short-term changes in iodine concentrations in milk

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ABSTRACT

The dietary requirement for iodine is based on thyroxine production, but data are becoming available showing potential improvements in hoof health when substantially greater amounts of I are fed. Feeding high amounts of I, however, can result in the milk having excessive concentrations of I. Canola meal contains goitrogenic compounds that reduce the transfer of I into milk. We hypothesized that including canola meal in diets would allow high supplementation rates of I without producing milk with unacceptable concentrations of I. Thirty midlactation Holstein cows were fed a diet with all supplemental protein from soybean meal (0% of diet dry matter as canola meal) or with all supplemental protein from canola meal (13.9% canola meal). A third treatment has a mix of soybean meal and canola meal (3.9% canola meal). Within canola-meal treatment, cows were fed 0.5 or 2.0 mg of supplemental I per kilogram of diet dry matter from ethylenediamine dihydroiodide. Cows were maintained on the canola treatment for the duration of the experiment but were changed from one I treatment to the other after 13 d of receiving the treatment. Milk I concentration before the treatments started (cows fed 0.5 mg/kg of I) averaged 272 μg/L and increased within 22 h after cows were first fed diets with 2 mg/kg of I. As inclusion rate of canola meal increased, the concentration of I in milk decreased linearly. After 12 d of supplementation, milk from cows fed 0.5 mg/kg of I had 358, 289, and 169 μg of I/L for the 0, 3.9%, and 13.9% canola-meal treatments. For cows fed 2.0 mg/kg of I, milk I concentrations were 733, 524, and 408 μg/L, respectively. Concentrations of I in serum increased with increased I supplementation, but the effect of canola meal was opposite of what was observed for milk I. Cows fed the highest canola-meal diets had the highest serum I whether cows were fed 0.5 or 2.0 mg/kg of I. Feeding dairy cows diets with 13.9% canola meal maintained milk I concentrations below 500 μg/L when diets were supplemented with 2 mg/kg of I.

Key words: iodine, canola meal, goitrogenic compound

INTRODUCTION

The NRC (2001) requirement for I is 0.015 mg/kg of BW or approximately 0.4 to 0.5 mg/kg of diet DM for a lactating cow. This requirement is based on thyroxine production. However, data, mostly with feedlot cattle, have shown increased resistance to foot rot when additional I was fed (Maas et al., 1984). The mode of action may involve improved phagocytic cell function (Siddiqui, 1993). Holstein steers fed 0.09 mg of I/kg of BW tended to have less digital dermatitis and smaller lesions than steers fed 0.009 mg of supplemental I/kg of BW following a challenge model designed to induce digital dermatitis (Gomez et al., 2014). In that study, steers fed extra I were also fed extra Co, Cu, Zn, and Mn.

Increasing the intake of I by dairy cattle may have benefits, but it also raises concerns. Increasing the concentration of I in diets of dairy cows will increase I concentration in milk (Norouzian and Azizi, 2013). This could reduce the prevalence of I deficiency in humans, but excess I in milk can contribute to I toxicity in humans (NRC, 2005). Definitive standards for maximum I concentrations in milk have not been established, but a maximum concentration of approximately 500 μg/L has been recommended (EFSA, 2013). When evaluating responses to supplemental I, supplementation rate is not the only factor that must be considered. Certain feeds, including canola meal, contain goitrogenic compounds (Tripathi et al., 2004), which affect the distribution of I within the body by inhibiting the Na–I transporter (De La Vieja et al., 2000). Cows fed diets that contain canola or rapeseed meal produce milk with lower concentrations of I than cows fed diets with other protein supplements (Laarveld et al., 1981b; Franke et al., 2009a; Norouzian and Azizi, 2013).

Increased supplementation rates for I may have some health benefits to the cow, but this must be tempered by

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potentially excessive I concentrations in milk and dairy products. We hypothesized that feeding a diet with canola meal would allow a high rate of I supplementation without producing milk with an unacceptable concentration of I. The objective of this experiment was to quantify the effects of canola-meal inclusion rate in diets fed to dairy cows on concentrations of I in serum and milk.

MATERIALS AND METHODS

Cows and Treatments

Thirty Holstein cows (DIM at start of experiment was 150 ± 42) were assigned to 5 blocks based on parity (1 block of first parity and 4 blocks of >1 parity) and milk yield (block average milk yields ranged from 33 to 48 kg/d). The experiment was a split plot design with 3 whole-plot treatments and 2 split-plot treatments arranged as a 2 × 2 Latin square (2 dietary treatments × 2 periods). The whole-plot treatments (Table 1) were inclusion rate of canola meal (**CM**): 0% CM, all supplemental protein from soybean meal (**SBM**); 3.9% CM (30% of supplemental CP from CM and 70% from SBM); and 13.9% CM (100% of supplemental CP from CM). The 3.9% treatment represents an inclusion rate that is typical for premixes (i.e., ca. 1 kg/cow per day). The canola meal was generic canola meal (solvent extracted) with a guaranteed analysis of 36% CP and 3% crude fat (88% DM basis) and an assayed (AOCS, 2011) glucosinolate concentration of 8.5 mmol/kg of DM. The split-plot treatments were 0.5 or 2 mg/kg of supplemental iodine (from ethylenediamine dihydroiodide). The rate of 0.5 mg/kg of I is approximately the NRC (2001) requirement, and 2 mg/kg of I is approximately the rate used by Gomez et al. (2014) that resulted in reduced hoof lesions. This design was used because we thought carryover effects were more likely with the CM inclusion treatments than with the iodine treatments. Starting dates were staggered for logistical reasons. Two blocks (multiparous) of cows were moved into the tie-stall barn, fed the diet with 0% CM and 0.5 mg/kg of supplemental I for 7 d, and then abruptly changed to their treatment diets. One week later, the remaining 3 blocks of cows were moved into the tie-stall barn, fed the diet with 0% CM plus 0.5 mg/kg of I for 7 d, and then abruptly changed to their treatment diets. Cows remained on their treatment diets for 13 d, and then cows were abruptly switched to the other iodine treatment (cows remained on the whole-plot treatments for the duration of the experiment). Half the cows started on the low-I treatment and then switched to the high-I treatment, and half the cows followed the opposite sequence. The second period lasted 13 d. On d 14 of the second period all cows were moved to a common freestall pen and fed a common diet (no CM and 0.3 mg/kg of supplemental I from pentacalcium orthoperiodate) for 14 d.

All cows were fed once daily for ad libitum consumption (while in the tie stalls, feed refusal averaged 7% of feed delivered) and milked twice daily (milk yields were measured electronically). Cows were fed at approximately 0400 h each day and milked at approximately 0200 and 1400 h. The milking procedure included a 4% hypochlorite teat predip followed by wiping the teat with a clean, cloth towel. A 1% iodine-based teat postdip (FS-103X, IBA Inc., Millbury, MA) was applied to all teats after each milking. The use of an iodine-based postdip in this manner should not influence milk I (Borucki Castro et al., 2012). When cows were in the tie stalls, individual feed delivery and feed refusals were weighed and recorded daily. Feed intake when cows were in the freestall pens was not recorded. Cows were weighed in the morning (approximately 3 h after feeding) at the end of each period.

Sampling and Analytical Methods

All milk samples for I assay were taken from the 0200 h milking. Milk was sampled for I assay 4 h before initiation of treatments (all cows were fed 0% CM plus 0.5 mg/kg of I treatment at that time) and then in each period at 22, 46, 94, 190, and 286 h (d 12) after treatment diets were first offered to the cows. Blood was sampled on d 12 of each period approximately 4 h after feed was delivered. Milk was sampled 44 and 212 h (9 d) after cows were first fed the common lactation diet at the end of the experiment (i.e., 44 and 212 h after treatments ceased). On d 7 of each period, milk from both milkings was sampled and analyzed for milk fat, protein, lactose (B2000 Infrared Analyzer, Bentley Instruments, Chaska, MN), and MUN (Skalar SAN Plus segmented flow analyzer, Skalar Inc., Norcross, GA) by DHI Cooperative Inc. (Columbus, OH).

Silages and grain mixes were sampled every 10 d (3 samples of each component) and sent to Cumberland Valley Analytical Services (Hagerstown, MD) for nutrient analysis using standard wet chemistry methods (CVAS, 2014). Dried ground samples of silages and concentrate mixes were assayed for I (Wahlen et al., 2005) by Michigan State University Veterinary Diagnostic Laboratory (East Lansing, MI). The canola meal and the concentrate mixes were assayed for glucosinolates by HPLC (AOCS, 2011) by Bioprofile Testing Laboratories (St. Paul, MN).

Milk and serum iodine was analyzed using a modified colorimetric microplate method (Hedayati et al., 2007). Standard, blank, or sample (50 μL) in triplicate