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Short communication: Feed iodine concentrations on farms with contrasting levels of iodine in milk

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ABSTRACT

In a previous study, milk iodine concentration from 501 farms across Canada was found to vary considerably and appeared to be influenced by feeding practices. Farms with contrasting levels of milk iodine from a subset of 200 participating farms were used to determine the relationship between milk iodine concentration and the concentration of this mineral in different feeds and complete diets given to lactating dairy cows. The 30 farms with the lowest levels of iodine in milk (low group) and the 30 farms with the highest levels (high group) were selected. Samples of bulk tank milk, all feed ingredients, and water were collected. Additionally, each farmer completed a questionnaire providing information on feeding management. The iodine offered on each of the farms was estimated from the amount of the feed in the diet recommended by the Ration'L software (Valacta, Ste-Anne-de-Bellevue, QC, Canada) and the iodine concentration in the feed sampled and analyzed using inductively coupled plasma mass spectrometry. The dietary concentration of iodine offered daily was 33% lower for the low group compared with the high group; that is, 1.20 ± 0.099 versus 1.81 ± 0.195 mg/kg of dry matter (DM), respectively. Milk iodine concentrations averaged 146 ± 13.9 μg/kg for the low group and 487 ± 44.6 μg/kg for the high group. A linear relationship was found between dietary iodine concentration and milk iodine level, as follows: milk iodine (μg/kg) = 145 (±66.9) + 113 (±39.4) dietary iodine concentration (mg/kg DM). However, the low R^2 value (0.15) indicates that other factors, such as milking management and the presence of goitrogens, may have affected the concentrations of iodine in milk. Forages supplied approximately 17% of iodine requirements in the average lactating cow diet. Therefore, variations in the iodine content of forages are unlikely to cause iodine overfeeding. In contrast, 27% of the mineral mix samples presented iodine concentrations >100,000 μg/kg of DM (and up to 322,000 μg/kg of DM). More than 85% of the farms tested were feeding iodine levels higher than the dietary iodine recommendations (0.5 mg of iodine/kg of DM). Iodine supplements should be used with caution in lactating cow diets.
Key words: food safety, milk quality, dairy cow

Short Communication

Cow milk has become one of the most important sources of iodine for human nutrition in several developed countries (Dahl et al., 2003; Li et al., 2006; Schöne et al., 2009). However, the tolerable iodine intake level could easily be exceeded with high milk iodine concentrations (Scientific Committee on Food, 2002; Flachowsky, 2007; Flachowsky et al., 2007). In humans, a rapid increase in iodine intakes increases the risk of iodine toxicity in susceptible individuals and young children (Roti and Uberti, 2001). Therefore, the European Food Safety Authority (2005) suggested that the maximum iodine content in dairy cattle rations be set at 4,000 μg/kg of feed (as fed, 88% DM). The European Union Regulation EC 1459/2005 (European Union, 2005) followed the proposal and lowered the maximum iodine concentration in dairy feedstuffs from 10,000 to 5,000 μg/kg (as fed, 88% DM).

A Health Canada study on retail milk found that the average iodine content of Canadian milk is high: 393 ± 150 μg/kg (A. Robichaud, unpublished results). These levels of iodine are in the same range as those found in 2007 in 500 samples of bulk tank milk from farms across Canada (304 ± 188 μg/kg; Borucki Castro et al., 2010). These findings indicate that most of the iodine in the milk delivered to the consumer is already present at the farm gate. In our previous study, one of the factors associated with farms presenting high milk iodine levels was the type of ration used, together with other factors of milking management. The transfer of iodine from feeds to milk ranges from 7 to 27%, depending on the amount fed to the animal (Kaufmann et al., 1998; Norouzian et al., 2009; Moschini et al., 2010). Special caution is required in diet formulation of lactating dairy cows because feeding iodine in excess will immediately result in higher concentrations of iodine in

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milk. Forages, which constitute 50% or more of the DM consumed by the cow, are assumed in diet formulation databases (e.g., NRC, 2001) to contain no iodine. The objective of this study was to investigate the iodine content in forages and other dairy cow feedstuffs, and to determine their contribution to the total iodine consumed by the animal. Furthermore, based on the analysis of the levels of iodine in bulk-tank milk and on the different feeds sampled, the relationship between the total iodine offered and the levels of iodine in milk was determined.

The farms for this study were selected based on milk iodine concentrations recorded in a previous study (Borucki Castro et al., 2010). Of the 200 dairy farms that had been sampled in the province of Quebec (Canada), 30 farms with the highest iodine levels (high group) and 30 farms with lowest iodine levels (low group) were chosen. Samples of the feed ingredients and TMR fed to lactating cows were collected, together with water and milk samples from the bulk tank. In addition, farmers were asked to complete a questionnaire to characterize their farms' feeding programs and milking management. Of the 60 farms targeted, 54 were sampled and 52 completed the questionnaire. All of the selected farms were clients of the dairy herd improvement program run by Valacta Dairy Production Centre of Expertise (Ste-Anne-de-Bellevue, QC, Canada), and the samples were collected by Valacta representatives during regular visits between April and June 2008.

Milk samples were analyzed at Health Canada (Longueuil, QC, Canada) in a laboratory accredited by the Standards Council of Canada. Total iodine concentration (organic and inorganic) was determined using the method of Benkhedda et al. (2009) by inductively coupled plasma mass spectrometry (7500 series model, Agilent Technologies, Santa Clara, CA) optimized for raw milk samples. Prior to analysis, samples were digested in a closed microwave system with a mixture of perchloric and nitric acids. The detection limit was 12 ng/g for a 0.5-g sample, with precisions of 4.0 and 2.2% obtained for 10 replicate measurements of 50 and 1,000 ng/g standards, respectively.

Descriptive statistics, regression analysis, and group differences (low vs. high) were determined using *t*-tests and ANOVA with the Data Analysis Toolpak of Microsoft Office Excel (Microsoft Corp., Redmond, WA). Feed ingredients are presented in this paper using descriptive statistics and graphical distribution. Feeds were classified according to the way they were reported in the questionnaires (i.e., as registered supplements, custom-made concentrates, or mineral mixes). Bulk-tank milk iodine was related to dietary iodine concentration in the lactating cow group, which was calculated for each of the farms based on (1) the amount of feed offered (Valacta Ration'L formulation software) and (2) the iodine concentration of the different feeds sampled and analyzed by Health Canada's laboratory. Farms were grouped according to iodine concentration in the diet (mg/kg of DM) compared with the level recommended by the NRC (2001; 0.5 mg/kg of DM). Five groups were formed: (1) 100% of the recommended value (0.30 to 0.74 mg/kg of DM); (2) twice the recommended value (0.75 to 1.24 mg/kg of DM); (3) 3 times the recommended value (1.25 to 1.74 mg/kg of DM); (4) 4 times the recommended value (1.75 to 2.24 mg/kg of DM); and (5) 5 times the recommended value or more (>2.25 mg/kg of DM).

In total, 96% of the samples received were successfully analyzed; 38% were forages (hay, silage, and haylage), 22% were supplements, 20% mineral mixes, 13% grain samples, 4% soybean products, and 3% samples of TMR. Iodine levels in forages, grains, and soy products are presented in Table 1. Iodine levels in plant sources are highly variable; they depend on proximity to the sea, plant species and strain, and climatic and seasonal conditions (Underwood and Suttle, 1999). As an example, the variation between cyanogenic and noncyanogenic strains of white clover grown in the same area of New Zealand varied from 200 to 40 μg/kg of iodine, respectively. The iodine in the plant appears to be linked to the plant's capacity to absorb and retain the iodine from the atmosphere (stomata) and from the soils. Iodine in grasses ranged from 80 to 690 μg/kg, with marked species and seasonal differences in iodine content (Alderman and Jones, 1967). Attempts to correlate soil with plant iodine levels have not been successful; iodine's availability from the soil to the plant is generally low (Fuge, 2005). In the present study, the iodine concentrations found in forages fell within the range of values reported in previous studies for pastures (Alderman and Jones, 1967) and agreed with iodine levels found in conserved forages in other countries (112 μg/kg of DM for hay, 213 μg/kg of DM for grass silage, and 110 μg/kg of DM for maize silage; Trávníček et al., 2004).

Based on the mean iodine levels observed in forages, as well as on calculations for a typical lactating cow diet, these feedstuffs (Table 1) would supply approximately 17% of the iodine required by the cow (NRC, 2001). Note that using the mean could give a biased estimation because the range of values found was broad for most of the feeds presented. Cereals and oilseed meals are considered poor sources of iodine (Underwood and Suttle, 1999). The average values found in this study for grains and soy products (Table 1) were similar to the values published in nutrient composition tables in France (Sauvant et al., 2004). The ranges reported by McDowell (2003) and Underwood and Suttle