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Short communication: Iodine concentrations in serum, milk, and tears after feeding *Ascophyllum nodosum* to dairy cows—A pilot study

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ABSTRACT

Kelp (*Ascophyllum nodosum*) is rich in iodine and often fed by organic dairy producers as a mineral supplement to support animal health. A commonly held belief is that kelp supplementation decreases susceptibility to infectious bovine keratoconjunctivitis due to increased iodine concentrations in tears. Whereas serum and milk iodine concentrations are positively correlated and modulated by oral iodine supplementation, nothing is known about the iodine concentration of tears. Therefore, the 3 objectives of this pilot study were to determine (1) the iodine content of tears, milk, and serum of cows after being fed kelp for 30 d; (2) the trace mineral and thyroid status of cows before (d 0) and after being fed kelp for 30 d; and (3) the in vitro growth rate of bacteria in tears (*Moraxella bovis*) or milk (*Staphylococcus aureus*, *Escherichia coli*, *Streptococcus uberis*) collected from cows fed no kelp (d 0) or kelp (d 30). Cows (n = 3/treatment) were individually fed 56 g of kelp per day (n = 3/treatment) or not (n = 3/no treatment) for 30 d. Daily feed intake of the TMR was recorded and weekly TMR, kelp, milk, blood and tear samples were collected and analyzed for iodine. The feed samples were pooled and further analyzed for other minerals. On d 0 and 30, liver biopsies and blood samples were collected and analyzed for mineral content and thyroid hormone concentrations, respectively. An inhibition test used milk and tear-soaked plates from kelp-fed cows (d 0 and 30) as well as 1 and 7.5% iodine as positive and distilled water as negative control. As expected, serum iodine concentrations were positively correlated with milk and tear iodine concentrations. Whereas the iodine concentrations in serum increased significantly in the kelp-fed cows during the 30-d study, milk and tear iodine concentrations increased only numerically in these cows compared with the control group. Liver mineral profiles were comparable between groups and generally did not change over the course of the study. Thyroid hormones remained overall within the reference range throughout the trial. Neither milk nor tears from kelp-fed cows inhibited in vitro growth of any of the plated bacteria. In summary, serum iodine concentration was correlated with the iodine concentration in milk and tears and feeding kelp increased only the serum iodine levels of cows in this trial. Bacterial growth was not inhibited in milk and tears of kelp-fed cattle in vitro, and prevention of infectious bovine keratoconjunctivitis would not be based solely on increased iodine concentrations in tears.
Key words: tears, iodine, kelp, *Ascophyllum nodosum*, infectious bovine keratoconjunctivitis

Short Communication

Organic producers are using different preventive approaches to support animal health because their treatment options are limited (AMS, 2015). Feed supplementation with kelp (*Ascophyllum nodosum*), a brown seaweed, as a mineral source is practiced by well over 50% of organic dairy producers (Antaya et al., 2015; Sorge et al., 2016). Many organic dairy producers believe that feeding kelp will improve the health of their animals because kelp is rich in iodine and other important trace minerals (Antaya et al., 2015). The positive effect of kelp on health is mostly focused on improved udder health, reproduction, and particularly the prevention of infectious bovine keratoconjunctivitis, which is also called pink eye (Olree and Dettloff, 2010; Antaya et al., 2015). In particular, the latter observation is explained by the assumption that an increased concentration of iodine in tears will decrease the growth of *Moraxella bovis* or *Moraxella bovoculi*, the causative agents of pink eye. However, although feeding kelp indeed increases the iodine concentration in hair (Olree and Dettloff, 2010) and milk of cows (Antaya et al.,

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2015), little information is available at present to assess the effect of kelp supplementation on cattle health. The only existing long-term study supplemented a different kind of kelp (*Macrocystis pyrifera*) and the authors were unable to find any "consistent differences which [could] be attributed to the rations fed. [. . .] The addition of kelp meal to normal rations for dairy heifers showed no particular benefits for growth, breeding efficiency, general health, physical condition, appetite, and size and condition of calves at birth" (Berry and Turk, 1944). To the best of our knowledge, no studies have been conducted to validate the effect of feeding kelp on the incidence of infectious bovine keratoconjunctivitis, let alone to measure the iodine concentration in tears. However, it is well established that iodine is crucial for animal health. Oral iodine supplementation is positively correlated with the iodine concentrations in serum and milk in cows (Schöne et al., 2009) and feeding iodine-rich kelp increases iodine levels in milk (Rey-Crespo et al., 2014; Antaya et al., 2015). Therefore, it is probable that the concentration of iodine in serum and tears could also be positively correlated. Increased iodine concentrations in tears may indeed improve the animal's ability to cope with *M. bovis* infections, just as increased iodine levels in the upper respiratory tract contributed to airway antiviral defenses (Derscheid et al., 2014). Therefore, the 3 objectives of this pilot study were to determine (1) the iodine content of tears, milk, and serum of cows after being fed kelp (56 g/d) for 30 d; (2) the trace mineral and thyroid status of cows before (d 0) and after being fed kelp for 30 d; and (3) the in vitro growth rate of bacteria in tears (*Moraxella bovis*) or milk (*Staphylococcus aureus*, *Escherichia coli*, *Streptococcus uberis*) collected from cows fed no kelp (d 0) or kelp (d 30). We hypothesize that the tear iodine concentration is affected by alimentary iodine uptake and is positively associated with serum and milk iodine concentration. Furthermore, we hypothesize that an increased iodine concentration would decrease the growth rate of *Moraxella bovis* in tears and that of *Staph. aureus*, *E. coli*, and *Klebsiella* in milk compared with the original iodine concentrations in tears and milk, respectively.

To address objectives 1 and 2, based on the results of Schöne et al. (2009), we expected a change in the serum iodine concentration from 66 to 131 μg/L (SD ~20) over the 30-d trial. Assuming 80% power and 95% confidence, at least 2 cows would be needed to show this difference in serum iodine concentration (objective 2). Therefore, 3 mid to late lactation Holstein Friesian cows of the University of Minnesota's Saint Paul campus dairy were enrolled per treatment to account for potential losses during the study and for potentially lower iodine concentrations in tears. The cows were healthy and had not received kelp or other additional iodine supplementation previously. The Holstein Friesian cows were randomly assigned to either the kelp (n = 3) or the negative control group (n = 3). The cows were fed an individually weighed TMR that was the same for all cows (Table 1). The kelp group was additionally fed 56 g/d of kelp (Kelp, Thorvin, New Castle, VA) that was manually top dressed and mixed into the TMR at 28 g in the morning and evening feeding. The 56 g/d responded to a recommended 0.5% of DMI (E. Chandler, Thorvin, personal communication). Each morning, the refusal was weighed to estimate the daily intake of each cow. Furthermore, each week, a small sample of the kelp fed as well as a grab sample of the TMR were collected and frozen. The weekly kelp and TMR samples were combined (separately) for subsequent mineral and iodine analysis.

Blood (10-mL serum Vacutainer, 21-gauge, 1.5-inch needles; BD, Franklin Lakes, NJ,) and tear samples were collected weekly from each cow (d 0, 7, 14, 21, and 30). To collect tears, the head of the cow was restrained with a halter, the third eye lid of the cow was prolapsed, and a Weck-Cel sponge (Weck-Cel, Merisol, Houston, TX) was gently held into the medial corner of the cow's eye to absorb approximately 1 mL of tear fluid per eye in the morning and afternoon after the cows returned from milking. The sponge was placed into a 2.5-mL Ep-

Table 1. Composition of TMR fed to all cows

Item	
Ingredient (% of DM)	
Alfalfa hay	12.73
Grass hay	2.73
Corn silage	33.64
Corn gluten feed	6.36
Corn grain, ground	10.91
Cottonseed, fuzzy (with linters)	5.00
Molasses, liquid	3.63
Protein mix[1]	23.64
Energy Booster[2]	1.36
Component	
DM (%)	59.30
CP (%)	16.50
NE_M (Mcal/kg)	0.81
NE_G (Mcal/kg)	0.52
ADF (%)	24.20
NDF (%)	33.70
Ca (%)	0.66
P (%)	0.40

[1]Protein mix included fine rolled corn (34.91%), canola meal (14.07%), soybean meal, 47% (12.80), SoyPass (11.31%; LignoTech, Rothschild, WI), dry distillers grain (10.69%), blood meal (4.28%), sodium bicarbonate (3.90%), calcium carbonate (3.68%), Ultramet (1.90%; Vita Plus Corp., Madison, WI, including liquid MetaSmart, Adisseo, Alpharetta, GA), potassium carbonate (1.08%), white salt (0.92%), magnesium oxide (0.43%), and Rumensin (0.03%; Elanco Animal Health, Greenfield, IN) on a DM basis.

[2]Energy Booster 100 (Milk Specialties, Eden Prairie, MN) is hydrogenated fat.