Brief Communication Communication brève

Trace mineral concentrations in Canadian beef calves at weaning

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Abstract

Objective

To describe the copper and selenium statuses of beef calves at weaning.

Animal

Calves (n = 1998) were sampled from 106 Canadian cow-calf herds in the fall of 2021.

Procedure

Serum samples from calves were tested for copper, selenium, and molybdenum concentrations.

Results

Although the percentages of calves classified as selenium deficient (< 0.025 ppm) were relatively low (0.5% western Canada, 3% eastern Canada), 53% of calves from western Canada and 77% of calves from eastern Canada were classified as having less than adequate selenium concentrations (< 0.08 ppm). Copper deficiency (< 0.5 ppm) was common in calves from both western (17%) and eastern (14%) Canada. High molybdenum concentrations (> 0.10 ppm) were identified in 6% of calves from western Canada and 7% of calves from eastern Canada.

Conclusion

Selenium concentrations were higher in calves from western Canada than from those in eastern Canada ($P < 0.001$). Copper and molybdenum concentrations were not significantly different between western and eastern Canada. Less-than-adequate serum copper was the most common deficiency identified in Canadian beef calves at weaning.

Clinical relevance

Trace minerals are important for immune system function in calves at weaning. Selenium concentrations in calves at weaning were lower than in cows from the same herds collected at pregnancy testing 2 y earlier. Copper deficiency was also identified, though less frequently than for mature cows. Supplementation programs for calves should be customized based on testing and recognize both regional and age differences in risk.

Résumé

Concentrations d'oligo-éléments minéraux chez les veaux de boucherie canadiens au sevrage

Objectif

Décrire les statuts en cuivre et en sélénium des veaux de boucherie au sevrage.

Animal

Des veaux (n = 1998) ont été échantillonnés dans 106 troupeaux de type vache-veau canadiens à l'automne 2021.

Procédure

Des échantillons de sérum de veaux ont été testés pour déterminer les concentrations de cuivre, de sélénium et de molybdène.

Résultats

Même si les pourcentages de veaux classés comme déficients en sélénium (< 0,025 ppm) étaient relativement faibles (0,5 % dans l'ouest du Canada, 3 % dans l'est du Canada), 53 % des veaux de l'ouest du Canada et 77 % des veaux de l'est du Canada étaient classés comme ayant moins des concentrations de sélénium moins qu'adéquates (< 0,08 ppm). Une carence en cuivre (< 0,5 ppm) était courante chez les veaux de l'ouest (17 %) et de l'est (14 %) du Canada. Des concentrations élevées de molybdène (> 0,10 ppm) ont été identifiées chez 6 % des veaux de l'ouest du Canada et 7 % des veaux de l'est du Canada.

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Conclusion

Les concentrations de sélénium étaient plus élevées chez les veaux de l'ouest du Canada que chez ceux de l'est du Canada ($P < 0{,}001$). Les concentrations de cuivre et de molybdène n'étaient pas significativement différentes entre l'ouest et l'est du Canada. Un taux de cuivre sérique nettement insuffisamment était la carence la plus courante identifiée chez les veaux de boucherie canadiens au sevrage.

Pertinence clinique

Les oligo-éléments sont importants pour le fonctionnement du système immunitaire des veaux au sevrage. Les concentrations de sélénium chez les veaux au sevrage étaient inférieures à celles des vaches des mêmes troupeaux collectées lors des tests de gestation deux ans plus tôt. Des carences en cuivre ont également été identifiées, quoique moins fréquemment que chez les vaches matures. Les programmes de supplémentation pour les veaux doivent être personnalisés en fonction des tests et reconnaître les différences de risque selon la région et l'âge.

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Balanced nutrition, including appropriate trace mineral concentrations, is necessary for animal health and productivity. Previous studies demonstrated both the extent and effect of trace mineral deficiencies, particularly copper and selenium deficiencies, in beef cows in western Canada (1–4) and across Canada (5), but there is very little research looking at the problem in beef calves at weaning age. The few Canadian studies that examined micronutrient deficiencies in beef calves focussed on liver samples from postmortem examinations and serum vitamins A and E statuses in neonates (6,7). To date, there are no published reports describing trace mineral status in beef calves near the time of weaning.

The trace mineral status of calves at weaning is of particular interest because of its importance to immune system function (8). The stress associated with weaning can reduce the effectiveness of the calf's immune system, increase the risk of respiratory disease, and reduce antibody production after vaccination (8,9). Copper and selenium are 2 of the trace minerals most likely to be deficient in Canadian calves and are also very important for immune system function. For example, the copper-dependent enzyme superoxide dismutase and the selenium-dependent enzyme glutathione peroxidase protect cells, including neutrophils, from the metabolic products of oxidative stress (8).

The objective of this study was to survey the statuses of copper and selenium in calves at weaning as part of a national cow-calf herd productivity network. The resulting information can be used to explore potential regional differences in the risks of less-than-adequate or deficient status and to assist veterinarians and producers to better target supplementation.

This study was approved by the University Animal Care Committee and Research Ethics Board at the University of Saskatchewan (Saskatoon, Saskatchewan; Protocol # 2014003). All participants in the Canadian Cow-Calf Surveillance Network (C3SN) were eligible for the study. Cow-calf producers had been recruited to C3SN in 2018 (5). Cow-calf herds that conducted pregnancy checking, had > 40 breeding animals, and had access to email met the inclusion criteria for the network. Baseline management information was collected for each herd at recruitment.

Blood samples were collected in the fall of 2021, near the time of weaning, by a veterinarian selected by the herd owner. Veterinarians were asked to submit a systematic random sample of 20 calves in each herd, regardless of herd size (*e.g.,* every 10th calf in a herd of 200). Following collection in plain serum tubes, vials of clotted blood were sent to the laboratory in insulated coolers using the fastest available commercial courier option (interval of 1 to 4 d, based on point of origin). Twenty samples per herd were analyzed for trace mineral concentrations by Prairie Diagnostic Services Inc. (Saskatoon, Saskatchewan). The laboratory methods were reported (5).

Briefly, 0.5 mL of serum was added to a microwave vessel containing 2.5 mL double-distilled water, 1.5 mL trace mineral grade nitric acid, and 0.15 mL internal standard [1 ppm yttrium (Y) and indium (In)]. Samples were digested in a MARS 5 Digestion Microwave System (CEM Corporation, Matthews, North Carolina, USA) and diluted to 15.0 mL with double-distilled water in a trace mineral-free tube. Analysis was completed using a Thermo Scientific iCAP Q inductively coupled plasma mass spectrometer (ICP-MS) (Thermo Fisher Scientific, Waltham, Massachusetts, USA) with standard curves for copper (Cu), selenium (Se), and molybdenum (Mo). Duplicates were analyzed for each sample where sufficient serum was available.

Serum concentrations were categorized as "deficient" and "less than adequate" for copper and selenium and "high" for molybdenum based on published reference values (Table 1) (10). The resulting trace mineral concentrations were summarized for the study and then compared among herds from eastern and western Canada using mixed linear models, after log-transforming concentrations, when appropriate, to account for right skew and accounting for clustering by herd. As a sensitivity analysis to check for the potential confounding effect of any hemolysis during collection or transport, models for copper and selenium were adjusted for serum iron concentrations. However, all adjusted values were < 5% different from the original estimates and were therefore not reported.

Of the 125 C3SN producers who provided calving records in the summer of 2021, 106 provided blood samples in the fall of 2021 for trace mineral studies from calves near the time of weaning. Participating herds from western Canada were located in northern BC (7%, 7/106), Alberta (32%, 34/106), Saskatchewan (18%, 19/106), and Manitoba (15%, 16/106). Participating herds from eastern Canada were located in Ontario (12%, 13/106), Quebec (12%, 13/106), and the Maritimes (4%, 4/106). Sales of at least some seedstock were reported by 38% (40/106). The median number of weaned

Table 1. Summary of selenium, copper, and molybdenum concentration data for serum samples collected from beef calves at or near the time of weaning in the fall of 2021 ($n = 1998$ calves, N = 106 herds).

Selenium less than adequate (< 0.08 ppm)	% calves < adequate selenium	% of herds with ≥ 1 calf < adequate	Mean herd prevalence < adequate[a] (SD)
Western provinces: 2021	52.8% (799/1512)	83% (63/76)	0.53 (0.40)
Eastern provinces: 2021	76.7% (373/486)	90% (27/30)	0.79 (0.34)
Selenium deficient (< 0.025 ppm)	% calves deficient selenium	% of herds with ≥ 1 calf deficient	Mean herd prevalence deficient[a] (SD)
Western provinces: 2021	0.5% (7/1512)	3.9% (3/76)	0.005 (0.026)
Eastern provinces: 2021	3.3% (16/486)	20% (6/30)	0.044 (0.138)
Copper less than adequate (< 0.6 ppm)	% calves < adequate copper	% of herds with ≥ 1 calf < adequate	Mean herd prevalence < adequate[a] (SD)
Western provinces: 2021	38.1% (576/1512)	93% (71/76)	0.38 (0.27)
Eastern provinces: 2021	35.8% (174/486)	87% (26/30)	0.35 (0.28)
Copper deficient (< 0.5 ppm)	% calves deficient copper	% of herds with ≥ 1 calf deficient	Mean herd prevalence deficient[a] (SD)
Western provinces: 2021	17.1% (258/1512)	74% (56/76)	0.17 (0.23)
Eastern provinces: 2021	14.2% (69/486)	57% (17/30)	0.13 (0.19)
Molybdenum high (> 0.10 ppm)	% calves high molybdenum	% of herds with ≥ 1 calf high	Mean herd prevalence high[b] (SD)
Western provinces: 2021	5.5% (83/1512)	21% (16/76)	0.06 (0.19)
Eastern provinces: 2021	7.0% (34/486)	30% (9/30)	0.07 (0.20)

SD — Standard deviation.
[a,b] Herd prevalence was calculated as the number of calves in each herd below ([a]) or above ([b]) the specified threshold as a proportion of the 20 calves sampled per herd.

Table 2. Summary of trace mineral concentration data for serum samples collected from beef calves near the time of weaning in the fall and early winter of 2021 ($n = 1998$ calves, N = 106 herds).

			Mean serum concentration (95% CI)		
Year of collection	No. herds	No. samples	Selenium (ppm)	Copper (ppm)	Molybdenum (ppm)
Western provinces 2021	76	1512	0.077 (0.071, 0.084)	0.616 (0.586, 0.648)	0.017 (0.014, 0.021)
Eastern provinces 2021	30	486	0.056 (0.049, 0.064)	0.634 (0.584, 0.688)	0.025 (0.018, 0.035)

95% CI — 95% confidence interval.

calves reported by participating herds was 134 (5th, 95th percentile: 34, 540), with 183 (5th, 95th percentile: 55, 562) for herds from the west and 73 (5th, 95th percentile: 28, 207) for herds from the east. The median age at sampling for herds was 226 d (5th, 95th percentile: 151, 313 d) for calves from cows and 224 d (5th, 95th percentile: 147, 305 d) for calves from heifers.

The percentage of calves outside the thresholds used by the diagnostic laboratories in Canada, the percentage of herds with ≥ 1 calf beyond the thresholds, and the mean herd prevalence of samples beyond the thresholds are reported in Table 1. Number of herds tested; number of calves sampled; and serum concentrations of copper, selenium, and molybdenum are summarized in Table 2.

Whereas absolute deficiency of serum selenium (< 0.025 ppm) was relatively rare, a substantial percentage of calves had less than adequate serum selenium concentrations (< 0.08 ppm). The mean concentration for serum selenium of the calves tested (Table 2) was also less than the laboratory-recommended adequate concentration of 0.08 ppm (10). Serum selenium concentration was 1.39 times higher (95% CI: 1.18 to 1.63, $P < 0.001$) in calves from western Canada than in those from eastern Canada. However, whereas average serum concentration for calves from western Canada approached the cutoff to be considered adequate (Table 2), the average concentration for the calves was 21% lower than for cows from the same network (0.098 ppm) (5).

The percentages of animals classified as selenium-deficient were similar for the calves reported in this study and cows sampled in 2019 from the same network of herds for both east and west [Table 1 (5)]. In contrast, the percentage of calves considered to have less than adequate selenium for western herds was more than 50% higher than the percentage for cows (33.8%) from the same network in 2019 [Table 1 (5)]. This is an important finding because veterinarians and herd owners from western Canada who have previously assessed selenium concentrations in cows might not recognize the calves could be in greater need of selenium supplementation. This would be of particular concern in drought years when vitamin E in grass is low, as vitamin E and selenium work together to manage oxidative stress (8,9).

Consistent with previous reports in mature cows (1–3,5), copper deficiency was the most common trace mineral abnormality identified in this study. The percentages of calves that were deficient and less than adequate for serum copper were very similar between eastern and western Canada (Table 1). Mean serum concentrations in western herds were not statistically different from those in eastern herds, unlike the regional differences observed for mature cows (5). Average serum copper concentrations (Table 2) were 6 to 8% higher than previously reported for cows from the same network in 2019 for both western (0.568 ppm) and eastern herds (0.595 ppm) (5). Similarly, the percentage of calves classified as deficient (Table 1) was more than 30% lower than that reported from this network for cows in 2019, for both western (29%) and eastern herds (21%) (5).

Serum molybdenum can be an important contributor to secondary copper deficiency. Serum concentration of molybdenum for calves from western Canada was 0.68 times (95% CI: 0.47 to 1.03, $P = 0.07$) that for calves from eastern Canada. The percentages of calves with high serum molybdenum (> 0.10 ppm) were similar for eastern and western Canada (Table 1). However, serum concentrations of molybdenum were lower in calves than in cows, and the percentage of calves with high serum molybdenum was $< 1/2$ the percentage of the cows from this network [Table 1 (5)].

Although serum samples do not reflect the most sensitive indicator of copper status and can be influenced by recent intake of selenium (11,12), collecting serum and reporting the proportion of deficient samples is a practical option for herd screening and large-scale surveillance studies. Although the sensitivity of serum for detecting low animal status is limited compared to liver biopsies when serum results are lower than normal according to established guidelines, the results are a specific indication of risk (3) and can inform the need for enhanced supplementation. Low copper concentrations at the time of weaning could have implications for immune function and response to vaccines when weaned calves are arriving at feedlots. Experimental studies have shown that copper repletion in deficient feedlot steers can take from 14 to 42 d, depending on trace mineral supplementation strategies in the feeding period (13). This could mean that, during the high-risk period for respiratory disease, some calves will have an impaired immune response due to ongoing copper deficiency. Although copper and selenium are important trace minerals for calf health, zinc is also important to immune system function. However, zinc concentrations were not reported due to the additional complexities of interpreting serum concentrations, particularly in stressed animals (11,12).

In summary, selenium concentrations appeared to be slightly lower in calves than previously established concentrations in adult cows, and copper concentrations appeared to be slightly higher in calves near weaning than in cows at pregnancy testing. Copper was the most common deficiency of beef calves at weaning across all regions in this study. Low selenium concentrations were more prevalent in eastern than western Canada, whereas serum copper and molybdenum concentrations were more consistent across regions in this study. CVJ

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