

Classification	ID	Revision	Effective Date
C-TOX-A	72866	2	10/12/2021 2:39:30 PM

Bovine Metal & Mineral Data (where known)

Minerals measured by ICP/MS. Note that our reference data source has evolved from relying on Puls, Mineral Levels in Animal Health, 1994 to including 'The use of blood analysis to evaluate trace mineral status in ruminant livestock', 2011, by Tom Herdt and Brent Hoff, *Vet Clin Food Anim* 27:255-283. We continue to gathering population data for multiple species to adjust the adequate ranges.

Blood and Serum/Plasma

Analyte	Sample	Bovine Normal Range (adults and growing calves)	Bovine Normal Range (neonates)	Units	Deficient	High	Toxic
Cobalt	Serum	0.17 – 2.0	0.18 – 2.3	ng/mL	-	-	-
Copper	Serum	0.6 - 1.10	0.3 – 1.0	µg/mL	< 0.60	-	-
Iron	Serum	110 - 250	25 - 170	ug/dl	< 60	400 - 600	> 1800
Manganese	Serum	0.9 – 6.0	1.0 – 4.0	ng/mL	-	-	-
Molybdenum	Serum	2.0 - 35	1.0 - 15	ng/mL	-	-	> 100
Selenium	Serum	65 – 140	20 - 70	ng/mL	-	-	-
Selenium	Blood	120 – 300	100 - 250	ng/mL	< 80	-	> 14,000
Zinc	Serum	0.6 - 1.9	0.6 – 1.75	µg/mL	< 0.40	-	> 3.00
Arsenic	Blood	0.03 - 0.05	0.03 - 0.05	µg/mL	-	-	> 0.17
Cadmium	Blood	< 0.40	< 0.40	µg/mL	-	-	> 0.05
Lead	Blood	< 0.10	< 0.10	µg/mL	-	> 0.30	> 0.35
Thallium	Blood	-	-	µg/mL	-	-	-

Liver (As received basis) – wet weight

Analyte	Bovine Normal Range (adults and growing calves)	Bovine Normal Range (neonates)	Units	Deficient	High	Toxic
Cobalt	0.025 – 0.10	0.015 – 0.10	ug/g	< 0.005	-	> 5.00
Copper	12.5 - 150	31.25 – 162.5	ug/g	< 10	-	> 250
Iron	35 - 250	40 - 250	ug/g	< 30	-	> 8900
Manganese	1.25 – 3.75	0.88 – 3.75	ug/g	< 1	6.25 - 23	-
Molybdenum	0.25 – 1.00	0.15 – 0.75	ug/g	-	-	> 2.0
Selenium	0.18 – 0.63	0.38 – 0.88	ug/g	< 0.17	-	> 1.50
Zinc	22.5 - 100	30 - 100	ug/g	< 20	-	> 250
Arsenic	< 0.40	< 0.25	ug/g	-	> 1	> 2
Cadmium	0.02 - 1	< 1	ug/g	-	1.4 - 9	> 25
Lead	< 1	< 1	ug/g	-	> 2.0	> 5
Thallium	< 0.05	< 0.04	ug/g	-	0.64 - 92	-

Liver (Dry weight basis) – Determined gravimetrically

Analyte	Bovine Normal Range (adults and growing calves)	Bovine Normal Range (neonates)	Units	Deficient	High	Toxic
Cobalt	0.10 - 0.40	0.06 - 0.40	ug/g dwt	< 0.02	-	> 20.00
Copper	50 - 600	125 - 650	ug/g dwt	< 40	-	> 1000
Iron	140 - 1000	160 - 1000	ug/g dwt	< 120	-	> 35,600
Manganese	5 - 15	3.5 - 15	ug/g dwt	-	-	-
Molybdenum	1 - 4	0.6 - 3	ug/g dwt	-	-	> 8.0
Selenium	0.7 - 2.5	1.5 - 3.5	ug/g dwt	< 0.68	-	> 6.00
Zinc	90 - 400	120 - 400	ug/g dwt	< 80	-	> 1000
Arsenic	0.02 - 1.60	< 1	ug/g dwt	-	> 4	> 8
Cadmium	0.08 - 4	< 4	ug/g dwt	-	5.6 - 36	> 100
Lead	< 4	< 4	ug/g dwt	-	> 8.0	> 20
Thallium	< 0.2	< 0.2	ug/g dwt	-	0.64 - 92	-
Dry wt. fraction	25 - 34	18 - 29	%			

Kidney Cortex (Dry weight basis)

Analyte	Bovine Normal Range	Units	Deficient	High	Toxic
Arsenic	0.016 - 1.60	ug/g dwt	-	6 - 20	> 20
Cadmium	0.20 - 6.00	ug/g dwt	-	20 - 100	> 100
Lead	0.80 - 8.00	ug/g dwt	-	12 - 20	> 20
Thallium	0.20 - 0.24	ug/g dwt	-	1.28 - 136	-
Zinc	80 - 100	ug/g dwt	< 80	200 - 500	> 520
Dry wt fraction	25 - 34	%			

Bovine Feed (Total Diet) – Compare feed results to feed label claims

Analyte	Bovine Safe Range	Units	Deficient	High	Toxic
Cobalt	0.10 - 1.00	ug/g	< 0.06	4.0 - 20	> 30
Copper	10 - 25	ug/g	-	-	-
Copper - Adults	Max 80 - 100	ug/g	-	> 50	> 80
Copper - Calves	Max 50	ug/g	-	-	-
Iron	100 - 500	ug/g	< 40	1000 - 2000	> 4000
Manganese	40 - 200	ug/g	< 1.0	1000	> 2000
Molybdenum	0.5 - 3.5	ug/g	-	> 5	> 10
Selenium	0.30 - 1.00	ug/g	< 0.10	3.00 - 4.00	> 5.00
Zinc	50 - 100	ug/g	< 10	> 600	> 5000
Arsenic	< 10	ug/g	-	-	-
Cadmium	0.01 - 0.5	ug/g	-	5 - 50	> 50
Lead	< 1.0	ug/g	-	5 - 50	> 100
Thallium	< 0.5	ug/g	-	5 - 50	-
Cu:Mo	8:1 - 5:1		-		-