

<b>Classification</b>	<b>ID</b>	<b>Revision</b>	<b>Effective Date</b>
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### Ovine Metal & Mineral Data (where known)

Metals and 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	Ovine Normal Range (adults and growing lambs)	Ovine Normal Range (neonates)	Units	Deficient	High	Toxic
Cobalt	Serum	0.18 – 2.0	0.18 – 2.0	ng/mL	-	-	-
Copper	Serum	0.75 – 1.70	0.75 – 1.70	µg/mL	< 0.40	-	> 2.00
Iron	Serum	90 – 270	90 – 270	ug/dl	< 60	-	-
Manganese	Serum	1.0 – 6.0	1.0 – 6.0	ng/mL	-	-	-
Molybdenum	Serum	1.0 – 50	1.0 – 50	ng/mL	-	-	> 100
Selenium	Serum	60 – 200	50 – 100	ng/mL	< 30	-	-
Selenium	Blood	120 – 350	120 – 350	ng/mL	< 50	-	-
Zinc	Serum	0.55 - 1.2	0.55 - 1.2	µg/mL	< 0.40	-	> 30.0
Arsenic	Blood	0.01 - 0.08	0.01 - 0.08	µg/mL	-	-	> 5.0
Cadmium	Blood	< 0.20	< 0.20	µg/mL	-	-	-
Lead	Blood	< 0.25	< 0.25	µg/mL	-	> 0.70	> 1.0
Thallium	Blood	-	-	µg/mL	-	-	-

#### Liver (*Dry weight basis*) – Determined gravimetrically

Analyte	Ovine Normal Range (adults and growing lambs)	Ovine Normal Range (neonates)	Units	Deficient	High	Toxic
Cobalt	0.08 - 0.35	0.08 - 0.35	ug/g dwt	< 0.02	-	> 20.0
Copper <sup>1</sup>	200 - 600	200 - 600	ug/g dwt	< 16	-	> 1000
Iron	250 - 1000	250 - 1000	ug/g dwt	< 100	-	-
Manganese	3.5 - 20	3.5 - 20	ug/g dwt	-	-	-
Molybdenum	0.9 - 7.5	0.9 - 7.5	ug/g dwt	-	-	> 30.0
Selenium	0.8 - 3	0.8 - 3	ug/g dwt	< 0.4	-	> 60.0
Zinc	80 - 300	80 - 300	ug/g dwt	< 60	-	> 1600
Arsenic	< 0.2	< 0.2	ug/g dwt	-	> 4	> 10
Cadmium	< 1.4	< 1.4	ug/g dwt	-	6 - 36	> 50
Lead	< 0.8	< 0.8	ug/g dwt	-	> 5	> 10
Thallium	< 0.05	< 0.05	ug/g dwt	-	-	> 0.16
Dry wt. fraction	25 - 34	18 - 29	%			

<sup>1</sup>Copper sensitivity varies widely with breed. Diagnosis of copper poisoning requires measuring copper concentration in the kidney cortex or histopathology revealing hemoglobinuric nephrosis.

**Kidney Cortex (Dry weight basis)** – Determined gravimetrically

Analyte	Ovine Normal Range	Units	Deficient	High	Toxic
Cobalt	0.20 - 1.00	ug/g dwt	< 0.05	-	> 120
Copper	16 - 22	ug/g dwt	< 16	-	> 40.0
Iron	120 - 800	ug/g dwt	< 100	-	-
Manganese	3.2 - 10	ug/g dwt	-	-	> 20.0
Molybdenum	1.5 - 1.6	ug/g dwt	-	-	> 200
Selenium	3.6 - 12.0	ug/g dwt	< 2.4	-	> 24.0
Zinc	80 - 160	ug/g dwt	< 60	-	> 960
Arsenic	-	ug/g dwt	-	-	-
Cadmium	-	ug/g dwt	-	-	-
Lead	-	ug/g dwt	-	-	-
Thallium	-	ug/g dwt	-	-	-
Dry wt. fraction	25 - 34	%			

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

Analyte	Ovine Safe Range	Units	Deficient	High	Toxic
Cobalt	0.10 - 0.25	ug/g	< 0.06	4 - 20	> 30
Copper <sup>1</sup>	5 - 10	ug/g	< 0.5	10 - 20	> 20
Iron	50 - 280	ug/g	< 40	-	> 390
Manganese	40 - 100	ug/g	< 8	400 - 500	> 3000
Molybdenum <sup>1</sup>	0.5 - 3.5	ug/g	-	4 - 24	-
Selenium	0.40 - 1.00	ug/g	< 0.10	3.00 – 5.00	> 5.0
Zinc	50 – 100	ug/g	< 20	800 - 1000	> 2000
Arsenic	-	ug/g	-	-	-
Cadmium	< 1.0	ug/g	-	> 5	-
Lead	< 1.0	ug/g	-	> 3	> 5.0
Thallium	< 0.5	ug/g	-	1.5 - 50	-
Cu:Mo <sup>1</sup>	20:1 – 2:1		-		-

<sup>1</sup>Recommended copper level in ovine total diet is 5 – 10 ug/g IF the molybdenum concentration is 0.05 – 1.0 ug/g. The Cu:Mo ratio should be between 20:1 and 2:1.