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Element concentrations in livers and kidneys of ranch mink

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Abstract. Reference ranges for element concentrations in livers and kidneys of "healthy" mink of known age, sex, and coat color and fed a conventional diet were determined. After euthanasia and removal of the pelts, liver and kidney samples were collected from 174 mink and analyzed for 22 elements using inductively coupled argon plasma emission spectroscopy. The diet of the mink was also analyzed for element concentrations. Descriptive statistics of element concentrations for livers and kidneys of the mink are given and compared with dietary element concentrations.

Knowledge of normal tissue element concentrations for animals is essential for detection of abnormal concentrations that may be indicative of disease problems. Tissue samples from animals presented for postmortem examination are frequently analyzed for element content to assist pathologists in diagnosing conditions involving mineral toxicoses or deficiencies. Normal tissue element concentrations are also useful to toxicologists, nutritionists, biologists, and producers. Little information exists on element concentrations in tissues of "normal" mink. The purpose of this study was to formulate liver and kidney element profiles for "healthy" mink fed a conventional mink farm diet.

Materials and methods

During the 1986 mink pelting season (November 24 to December 5), livers and kidneys were collected from 44 male and 130 female natural dark and pastel ranch mink varying from 7 mo to 3 yr, 7 mo in age. After euthanasia with CO, gas and removal of the pelts, the tissues were collected and

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Table 1. ICP detection limits for elements in mink feed and tissues.

Mineral	Tissue (ppm)	Feed (ppm)
Aluminum (Al)	1.0	3.0
Arsenic (As)	1.0	3.0
Boron (B)	1.0	3.0
Barium (Ba)	0.1	0.3
Calcium (Ca)	1.0	3.0
Cadmium (Cd)	0.1	0.3
Cobalt (Co)	0.1	0.3
Chromium (Cr)	0.2	0.6
Copper (Cu)	0.05	0.15
Iron (Fe)	0.5	1.5
Mercury (Hg)	2.0	6.0
Potassium (K)	500	1,000
Magnesium (Mg)	0.1	0.3
Manganese (Mn)	0.1	0.3
Molybdenum (Mo)	0.2	0.6
Sodium (Na)	0.1	0.3
Phosphorus (P)	1.0	3.0
Lead (Pb)	1.0	3.0
Antimony (Sb)	1.0	3.0
Selenium (Se)	4.0	15.0
Thallium (T1)	5.0	15.0
Zinc (Zn)	0.05	0.15

Table 2. Composition, nutrient analysis, and element concentrations of mink diet.

Ingredients	Percentage
Cereal*	20
Chicken (whole, ground)	24
Fish (cod, haddock, and flounder trimmings)	15
Lungs and trimmings (beef)	12
Liver (beef)	10
Water	19
Nutrient analysis?	
Moisture	67.4
Protein	12.4
Fat	8.4
Ash	2.8

Element concentration (ppm as fed)‡

Al	39	Co	ND	mg	718
As	ND§	Cr	ND	Mn	22
B	3.0	Cu	6.5	Mo	ND
Ba	3.3	Fe	91	Na	1,800
Ca	7,500	Hg	ND	P	5,000
Cd	ND	K	19,100	Pb	ND
Sb	ND				
Se	ND				
T1	ND				
Zn	41				

* XK-40 mink cereal, XK Mink Foods, Inc., Thiensville, WI.

† Analysis by National Environmental Testing, Inc., Bartlett, IL.

‡ Analysis by Inductively Coupled Plasma-Atomic Emission Spectroscopy, MSU Animal Health Diagnostic Laboratory, East Lansing, MI.

§ Not detected (for detection limits, see Table 1).

Table 3. Concentration of cadmium in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No. analyzed	No. detected	Cd (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	0	–	–	–	–
			Female	42	0	–	–	–	–
		Pastel	Male	6	0	–	–	–	–
			Female	29	0	–	–	–	–
	1 yr, 7 mo	Dark	Female	30	1	0.3	0.3	0.3	–
	2 yr, 7 mo	Dark	Female	11	1	0.1	0.1	0.1	–
		Pastel	Female	7	5	0.1	0.1	0.1	–
	3 yr, 7 mo	Pastel	Female	11	8	0.19 ± 0.099	0.1	0.3	52.86
Kidney	7 mo	Dark	Male	38	4	0.15 ± 0.058	0.1	0.2	38.49
			Female	42	8	0.1	0.1	0.1	–
		Pastel	Male	6	1	0.1	0.1	0.1	–
			Female	29	9	0.1	0.1	0.1	–
	1 yr, 7 mo	Dark	Female	30	20	0.25 ± 0.136	0.2	0.8	54.29
	2 yr, 7 mo	Dark	Female	11	11	0.382 ± 0.087	0.3	0.6	22.89
		Pastel	Female	7	7	0.386 ± 0.107	0.3	0.6	27.72
	3 yr, 7 mo	Pastel	Female	11	11	0.464 ± 0.186	0.2	0.8	40.09

stored frozen (-6 C) until prepared for multielemental analysis by inductively coupled plasma atomic emission spectroscopy[a] (ICP), as described previously.[4] Samples of liver and kidney and the diet of the mink were analyzed for aluminum (Al), arsenic (As), boron (B), barium (Ba), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (MO), sodium (Na), phosphorus (P), lead (Pb), antimony (Sb), selenium (Se), thallium (T1), and zinc (Zn). The detection limits for the ICP analyses are listed in Table 1.

Results and discussion

The composition, nutrient analysis, and element concentrations of the diet fed to the mink are shown in Table 2. Of the 22 elements analyzed, 12 were detected in the diet (Table 2) and 10 in the liver and kidney tissue samples. The concentrations of the elements detected in the livers and kidneys are summarized according to age, sex, and coat color (Tables 3-12)

Iron was concentrated in the livers and kidneys of the mink (Table 13). The Fe concentration in the livers and kidneys of 7-month-old mink was about 4 times and 2 times that of the diet, respectively. Copper was also concentrated in the livers and tended to increase with age (Tables 5, 13). Copper did not accumulate or increase in concentration with age in the kidneys. In another study,[1] 7-month-old natural dark male mink fed a diet that contained 60.5 ppm Cu, 329.7 ppm Zn, and 327.7 ppm Fe (dry weight) for 5 months had mean liver Fe and Cu concentrations of 1,197 and 293 ppm

Table 4. Concentration of calcium in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	Ca (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	52.5 ± 8.30	29	66	15.81
			Female	42	71.0 ± 14.01	48	104	19.75
		Pastel	Male	6	64.7 ± 8.66	52	76	13.40
			Female	29	54.6 ± 7.12	40	74	13.04
	1 yr, 7 mo	Dark	Female	30	67.4 ± 11.31	46	96	16.77
	2 yr, 7 mo	Dark	Female	11	48.5 ± 4.61	42	56	9.52
		Pastel	Female	7	49.6 ± 9.40	39	66	18.96
	3 yr, 7 mo	Pastel	Female	11	48.8 ± 9.14	34	58	18.73
Kidney	7 mo	Dark	Male	38	62.6 ± 17.81	49	164	28.44
			Female	42	70.0 ± 14.53	45	142	20.74
		Pastel	Male	6	67.8 ± 6.68	63	80	9.84
			Female	29	54.5 ± 5.91	46	67	10.84
	1 yr, 7 mo	Dark	Female	30	70.4 ± 15.26	51	117	21.69
	2 yr, 7 mo	Dark	Female	11	75.2 ± 12.82	57	98	17.05
		Pastel	Female	7	128.4 ± 110.21	60	357	85.81
	3 yr, 7 mo	Pastel	Female	11	93.7 ± 32.27	69	187	34.43

Table 5. Concentration of copper in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	Cu (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	14.2 ± 8.48	4.4	43	59.89
			Female	42	15.4 ± 7.32	5.5	40	47.64
		Pastel	Male	6	13.2 ± 4.46	8.9	21	33.95
			Female	29	24.2 ± 9.29	9.7	42	38.43
	1 yr, 7 mo	Dark	Female	30	18.6 ± 8.18	6.5	48	43.99
	2 yr, 7 mo	Dark	Female	11	22.4 ± 12.15	9.3	52	54.27
		Pastel	Female	7	29.7 ± 9.18	22	48	30.89
	3 yr, 7 mo	Pastel	Female	11	38.4 ± 17.35	15	75	45.21
Kidney	7 mo	Dark	Male	38	4.2 ± 0.53	3.4	5.5	12.74
			Female	42	5.6 ± 1.15	4.1	10	20.36
		Pastel	Male	6	4.1 ± 0.45	3.5	4.6	11.02
			Female	29	4.6 ± 0.91	3.1	8.0	19.71
	1 yr, 7 mo	Dark	Female	30	5.4 ± 1.20	3.0	9.1	22.39
	2 yr, 7 mo	Dark	Female	11	4.2 ± 0.60	3.8	5.9	14.31
		Pastel	Female	7	5.4 ± 1.32	4.2	7.6	24.21
	3 yr, 7 mo	Pastel	Female	11	6.8 ± 1.19	4.8	8.5	17.60

(dry weight), respectively. Consumption of this diet supplemented with 200 ppm Cu (as $CuSO_4$) by mink for 5 months yielded a mean liver Cu concentration of 479 ppm but did not produce any observed toxic effects in the animals. Because the liver is the main organ involved in storage and metabolism of Cu, liver Cu concentration should be indicative of an animal's Cu status.

Cadmium was not detected in the diet or in the livers of the 7-month-old mink but was present in low concentrations in the kidneys of some 7-month-old mink and livers of some l-year, 7-month-old mink. The Cd concentration increased notably with age in both the livers and kidneys of the mink (Table 3). These results are consistent with reports in the literature that indicate Cd tends to concentrate in the viscera of vertebrates, especially in the livers and kidneys of carnivores, resulting in higher Cd concentrations in older animals.[5,10]

Although Hg was not detected in the diet, livers, or kidneys of the mink in the present study, Hg concentrations of 0.28[2] and 0.2-0.7[12] ppm in livers and 0.68[1] and 0.5-l.0[11] ppm in kidneys have been reported for ranch mink fed conventional diets. Liver and kidney Hg concentrations of 55.6 and 37.7 ppm, respectively, were noted for mink that died from consumption of a conventional mink diet supplemented with 5 ppm methylmercury for 29 days.[2]

There are several reports in the literature of liver and/or kidney values for heavy metals in wild mink.[3,6-11,13,14] The concentrations reported in these

Table 6. Concentration of iron in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	Fe (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	387 ± 107.5	186	727	27.79
			Female	42	461 ± 89.7	328	882	19.45
		Pastel	Male	6	297 ± 41.9	261	374	14.12
			Female	29	305 ± 52.9	187	429	17.35
	1 yr, 7 mo	Dark	Female	30	392 ± 98.9	217	558	25.23
	2 yr, 7 mo	Dark	Female	11	338 ± 76.8	219	449	22.70
		Pastel	Female	7	374 ± 156.1	208	658	41.68
	3 yr, 7 mo	Pastel	Female	11	312 ± 78.8	154	425	25.24
Kidney	7 mo	Dark	Male	38	169 ± 38.6	88	330	22.84
			Female	42	183 ± 34.9	134	279	19.02
		Pastel	Male	6	159 ± 10.0	141	167	6.30
			Female	29	184 ± 37.3	123	243	20.28
	1 yr, 7 mo	Dark	Female	30	206 ± 41.4	133	299	20.07
	2 yr, 7 mo	Dark	Female	11	152 ± 42.0	82	237	27.60
		Pastel	Female	7	141 ± 36.6	81	188	25.98
	3 yr, 7 mo	Pastel	Female	11	180 ± 55.9	76	267	31.08

Table 7. Concentration of magnesium in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	Mg (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	138 ± 15.9	91	181	11.49
			Female	42	140 ± 10.5	119	169	7.46
		Pastel	Male	6	154 ± 9.3	141	165	6.07
			Female	29	152 ± 11.7	131	172	7.68
	1 yr, 7 mo	Dark	Female	30	148 ± 12.6	128	182	8.57
	2 yr, 7 mo	Dark	Female	11	135 ± 9.3	119	149	6.86
		Pastel	Female	7	144 ± 13.8	126	166	9.62
	3 yr, 7 mo	Pastel	Female	11	151 ± 17.7	128	177	11.71
Kidney	7 mo	Dark	Male	38	134 ± 7.7	112	154	5.71
			Female	42	140 ± 8.1	120	159	5.79
		Pastel	Male	6	145 ± 8.0	136	157	5.50
			Female	29	137 ± 7.2	120	149	5.26
	1 yr, 7 mo	Dark	Female	30	143 ± 55.7	100	433	39.02
	2 yr, 7 mo	Dark	Female	11	130 ± 5.3	118	139	4.06
		Pastel	Female	7	137 ± 6.5	129	149	4.76
	3 yr, 7 mo	Pastel	Female	11	128 ± 7.1	118	139	5.56

Table 8. Concentration of manganese in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	Mn (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	1.31 ± 0.360	0.4	2.0	27.38
			Female	42	1.54 ± 0.428	0.6	2.5	27.64
		Pastel	Male	6	1.45 ± 0.105	1.3	1.6	7.23
			Female	29	1.78 ± 0.291	1.2	2.5	16.24
	1 yr, 7 mo	Dark	Female	30	1.79 ± 0.350	1.2	2.6	19.53
	2 yr, 7 mo	Dark	Female	11	1.63 ± 0.224	1.3	2.0	13.77
		Pastel	Female	7	1.97 ± 0.345	1.6	2.5	17.50
	3 yr, 7 mo	Pastel	Female	11	1.97 ± 0.410	1.5	2.8	20.78
Kidney	7 mo	Dark	Male	38	0.85 ± 0.147	0.6	1.5	17.30
			Female	42	0.94 ± 0.121	0.6	1.2	12.86
		Pastel	Male	6	0.88 ± 0.075	0.8	1.0	8.52
			Female	29	0.83 ± 0.088	0.7	1.0	10.66
	1 yr, 7 mo	Dark	Female	30	0.83 ± 0.158	0.4	1.1	19.02
	2 yr, 7 mo	Dark	Female	11	0.71 ± 0.083	0.6	0.8	11.72
		Pastel	Female	7	0.79 ± 0.107	0.6	0.9	13.61
	3 yr, 7 mo	Pastel	Female	11	0.78 ± 0.098	0.6	0.9	12.55

Table 9. Concentration of phosphorus in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	P (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	2,384 ± 318.4	1,200	3,000	13.35
			Female	42	2,502 ± 208.9	2,100	3,000	8.35
		Pastel	Male	6	2,633 ± 206.6	2,300	2,900	7.84
			Female	29	2,548 ± 186.4	2,200	2,900	7.31
	1 yr, 7 mo	Dark	Female	30	2,620 ± 267.0	2,100	3,100	10.19
	2 yr, 7 mo	Dark	Female	11	2,318 ± 166.2	2,100	2,700	7.17
		Pastel	Female	7	2,486 ± 285.4	2,100	2,800	11.48
	3 yr, 7 mo	Pastel	Female	11	2,673 ± 322.8	2,300	3,300	12.08
Kidney	7 mo	Dark	Male	38	2,692 ± 140.2	2,300	3,100	5.21
			Female	42	3,138 ± 186.0	2,800	3,600	5.93
		Pastel	Male	6	3,250 ± 164.3	3,100	3,500	5.06
			Female	29	2,869 ± 169.2	2,600	3,200	5.90
	1 yr, 7 mo	Dark	Female	30	2,837 ± 181.0	2,400	3,200	6.38
	2 yr, 7 mo	Dark	Female	11	2,545 ± 129.3	2,400	2,800	5.08
		Pastel	Female	7	2,600 ± 81.6	2,500	2,700	3.14
	3 yr, 7 mo	Pastel	Female	11	2,855 ± 186.3	2,500	3,200	6.5

Table 10. Concentration of potassium in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	K (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	1,495 ± 239.1	1,100	2,100	16.00
			Female	41	1,672 ± 739.5	590	3,000	44.24
		Pastel	Male	6	1,233 ± 163.3	1,100	1,500	13.24
			Female	29	1,231 ± 284.0	712	1,900	23.06
	1 yr, 7 mo	Dark	Female	15	1,420 ± 259.7	1,100	2,200	18.29
	2 yr, 7 mo	Dark	Female	11	1,065 ± 234.0	702	1,400	21.97
		Pastel	Female	7	1,008 ± 284.9	660	1,500	28.27
	3 yr, 7 mo	Pastel	Female	11	1,237 ± 410.2	674	1,800	33.17
Kidney	7 mo	Dark	Male	38	1,574 ± 280.4	**904**	2,300	17.81
			Female	42	1,890 ± 786.7	704	3,300	41.62
		Pastel	Male	6	1,233 ± 136.6	1,000	1,400	11.08
			Female	29	1,215 ± 233.9	624	1,600	19.24
	1 yr, 7 mo	Dark	Female	15	1,406 ± 253.3	989	1,900	18.02
	2 yr, 7 mo	Dark	Female	11	1,266 ± 224.4	751	1,500	17.73
		Pastel	Female	7	1,454 ± 480.2	780	2,300	33.02
	3 yr, 7 mo	Pastel	Female	11	1,202 ± 400.2	517	1,700	33.30

Table 11. Concentration of sodium in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	Na (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	1,571 ± 139.3	1,000	1,800	8.87
			Female	42	1,583 ± 116.7	1,300	1,800	7.37
		Pastel	Male	6	1,683 ± 75.3	1,600	1,800	4.47
			Female	29	1,555 ± 127.0	1,300	1,800	8.17
	1 yr, 7 mo	Dark	Female	30	1,513 ± 113.7	1,300	1,800	7.51
	2 yr, 7 mo	Dark	Female	11	1,573 ± 127.2	1,300	1,800	8.09
		Pastel	Female	7	1,529 ± 281.2	1,000	1,900	18.39
	3 yr, 7 mo	Pastel	Female	11	1,340 ± 275.9	735	1,500	20.59
Kidney	7 mo	Dark	Male	38	2,037 ± 119.5	1,700	2,200	5.87
			Female	42	1,888 ± 77.2	1,800	2,100	4.09
		Pastel	Male	6	1,783 ± 116.9	1,600	1,900	6.56
			Female	29	1,945 ± 118.3	1,700	2,200	6.08
	1 yr, 7 mo	Dark	Female	30	1,823 ± 138.2	1,500	2,000	7.58
	2 yr, 7 mo	Dark	Female	11	1,964 ± 156.7	1,700	2,200	7.98
		Pastel	Female	7	1,943 ± 97.9	1,800	2,000	5.02
	3 yr, 7 mo	Pastel	Female	11	1,809 ± 192.1	1,500	2,000	10.62

Table 12. Concentration of zinc in the livers and kidneys of male and female natural dark and pastel mink of different ages.

Organ	Age	Color	Sex	No.	Zn (ppm wet weight) Mean ± SD	Minimum	Maximum	CV
Liver	7 mo	Dark	Male	38	24.9 ± 4.19	15	34	16.80
			Female	42	29.4 ± 6.19	19	43	21.09
		Pastel	Male	6	28.3 ± 3.27	24	32	11.53
			Female	29	27.1 ± 3.09	21	34	11.43
	1 yr, 7 mo	Dark	Female	30	27.4 ± 4.74	21	40	17.29
	2 yr, 7 mo	Dark	Female	11	25.4 ± 3.72	19	30	14.68
		Pastel	Female	7	28.1 ± 3.13	25	33	11.13
	3 yr, 7 mo	Pastel	Female	11	30.3 ± 6.25	21	40	20.63
Kidney	7 mo	Dark	Male	38	18.1 ± 1.96	13	22	10.87
			Female	42	22.4 ± 4.28	17	34	19.10
		Pastel	Male	6	17.5 ± 1.87	15	20	10.69
			Female	29	17.4 ± 1.43	14	20	8.19
	1 yr, 7 mo	Dark	Female	30	19.9 ± 2.49	15	26	12.52
	2 yr, 7 mo	Dark	Female	11	17.1 ± 0.83	16	19	4.86
		Pastel	Female	7	18.4 ± 1.72	16	20	9.32
	3 yr, 7 mo	Pastel	Female	11	17.5 ± 1.44	15	20	8.21

Table 13. Element concentrations in the diet, livers, and kidneys of 7-mo-old mink.*

Element	Dietary concentration (ppm as fed)	Mean liver concentration (ppm wet weight)	Liver/diet ratio	Mean kidney concentration (ppm wet weight)	Kidney/diet ratio
Al	39	ND†	-	ND	-
B	3.0	ND	-	ND	-
Ba	3.3	ND	-	ND	-
Ca	7,500	60.4	0.008	63.6	0.008
Cu	6.5	17.1	2.62	4.81	0.74
Fe	91	389	4.27	178	1.96
K	19,100	1,464	0.08	1,581	0.08
Mg	718	143	0.20	138	0.19
Mn	22	1.53	0.07	0.88	0.04
Na	1,800	1,577	0.88	1,946	1.08
P	5,000	2,482	0.50	2,929	0.58
Zn	41	27.3	0.67	19.5	0.48

* Liver and kidney values are based on the mineral concentrations for all (male, female, dark, and pastel) 7-mo-old mink (n = 115).
† Not-detected (see Table 1 for detection limits).

studies are variable and frequently associated with specimens obtained from areas of heavy metal contamination or from mink suspected of showing heavy metal poisoning. Little information exists in the literature on tissue concentrations of other elements for mink. Although the concentration of some elements was below the quantifiable limits of the ICP analysis employed in this study, the values presented should serve as a useful addition to the literature and provide reference information for diagnosticians and researchers for evaluating liver and kidney element concentrations in mink.

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Sources and manufacturers

a. ICP, Jarrell-Ash model 955 Plasma Atomcomp Direct Reading Spectrometer System, Applied Chemical Corp., Waltham, MA.

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