Heavy Metals in Pet Food:
Changes in Heavy Metal Contamination in Pet Food Over the Past Decade

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Introduction

Pet food is a multi-billion dollar a year business that affects businesses and pet owners on a daily basis. Over the past decade, consumers have doubled their spending on pet related products. According to the American Pet Product Association (APPA), in 2009, pet owners in the US spent over $17 billion dollars on pet food. Along with this increased growth, there has been increased controversy. The melamine pet food scare of 2007 affected millions of people and their pets as well as the pet food industry. The supplementation of protein sources with materials containing melamine and cyanuric acid formed complex crystals that ultimately killed hundreds of pets and sickened many others. The pet food scare highlighted the potential for contaminants and controversial ingredients that could be contained in pet food. In addition to organic chemical contaminants and additives, there is also the possibility of toxic elemental contamination from protein sources, fillers and manufacturing processes. The search for 'healthy' pet food therefore goes beyond the choice of a name brand food, or seemingly nutritious ingredients on a label.

Ten years ago, SPEX CertiPrep first introduced its popular study on Heavy Metals in Pet Food at the 2010 Pittcon Conference. The purpose of this 2009 study was to examine pet foods from a variety of sources to determine if there were potentially toxic elements present in the foods and if higher priced food or higher quality ingredients equated to lower levels of toxic elements. A range of "budget" to "premium" grade pet food samples were donated by pet owners or purchased from several different stores. The food samples were ground in a cryogenic Freezer/Mill (dry samples) or blender (wet samples), digested with concentrated nitric acid, autoclaved for trace metals content by ICP-MS. Results were then compared to EPA Reference Dose (RfD) and World Health Organization Tolerable Daily Intake (TDI) values that are considered the daily oral exposure limits for the human population. Human limits were scaled to the weight of a medium to large breed dog (50 lbs) or average cat (10 lbs) to gain perspective of an animal's potential exposure. Many of the pet foods sampled showed significant concentrations of various toxic metals. In many cases, the concentrations exceeded the extrapolated human limit values calculated to pet-size dosages.

In the intervening ten years, the Food Safety Modernization Act was exacted and pet food became one of the targets of scrutiny. This new 2019 study revisits pet food brands first analyzed in 2009 and looks at new brands which that emerged after the 2007 pet food crisis and later enactment of FSMA to see if heavy metal contamination has significantly changed in the decade since the first study. Using updated cryogenic and microwave technology samples were tested by ICP and ICP-MS to determine heavy metal content and compared to our previous 2009 study.

Metods and Materials

Samples

- 2009: Original Study
  - 59 total samples: 31 dog food and 27 cat food samples
  - Dry and wet food
  - Range of ingredients and prices
  - Purchased from discount stores, pet stores, groceries, and donations from NJ area
- 2019: Ten Year Study
  - 61 total samples: 35 dog food and 26 cat food samples
  - All dry food
  - Range of ingredients and prices
  - Eleven brands purchased to be similar or the same brand and flavor of previous study
  - Purchased from discount stores, pet stores, groceries, and donations from NJ and NC area

Sample Preparation

Sample Digestion

- Samples were digested using a CEM Mars 6 microwave
  - Microwave conditions
    - Easy Prep vessels
    - 0.5 g sample
    - 10 mL in HNO_3
    - Pre-loaded food program

Materials

- SPEX SamplePrep Standards
  - CLMS-1, CLMS-2, CLMS-3, CLMS-4: Multi-Element Solution Standards 1-4
- Reagents
  - High Purity Nitric Acid

Instrumentation

- Perkin Elmer ICP-OES - Macroelements
- Agilent ICP-MS 7700 - Heavy Metals
  - Meinhard nubulizer
  - Cyclonic spray chamber
  - Analysis performed
    - Normal mode: Air
    - Collision mode: Helium

Method Design

Studies from 2009 and 2019 were set up in similar methods with updated grinding and microwave technologies to process the samples. Samples were ground using the SPEX SamplePrep 6875D Large Dual Freezer/Mill with 6885 Mid-size Poly-Vial (sample load 10 g-15 g).

- Grinding Conditions
  - Pre-cool: 5 minutes
  - Run time: 2 minutes
  - Cool time: 1 minute
  - Cycles: 3
  - Rate: 12 cps

Results and Discussion

Heavy Metal Concentrations 2009

In 2009, there were significant amounts of toxic metals found in pet food with over 1 ppm of chromium (2.5 ppm) and lead (6 ppm). There was half to 1 ppm of antimony and cobalt. Some foods had ppm levels of nickel and tin showing large amounts of potential wear metal contamination. There was even uranium detected in several samples up to 1 ppm.

Heavy Metal Concentration 2019

Table 1. Toxic metals founds in 2009 and 2019 samples

Element	2009 Pet Food Min (ppb)	2019 Pet Food Min (ppb)	2009 Pet Food Max (ppb)	2019 Pet Food Max (ppb)
Aluminum	300	390	215000	86302
Arsenic	4	20	290	687
Beryllium	2	ND	74	114
Cadmium	2	ND	130	152
Cobalt	23	70	920	1343
Chromium	15	397	2500	34191
Mercury	ND	ND	55	146
Nickel	48	354	3200	5879
Lead	3	16	5900	515
Antimony	1	ND	970	318
Selenium	64	190	1500	1068
Tin	6	ND	9400	143
Thorium	ND	ND	90	147
Thallium	1	ND	10	28
Uranium	ND	ND	860	1699
Vanadium	5	43	7400	3339

The samples from 2019 still showed heavy metal contamination include twice the amount of uranium (1.7 ppm), and three times the amount of arsenic (0.7 ppm). Lead levels were significantly lower overall in the 2019 samples with a maximum of 0.5 ppm.

The 2019 samples did have more samples containing uranium than the ones found in the 2009 samples. In 2009, there was a high correlation between uranium, beryllium and thorium. Figure 1.

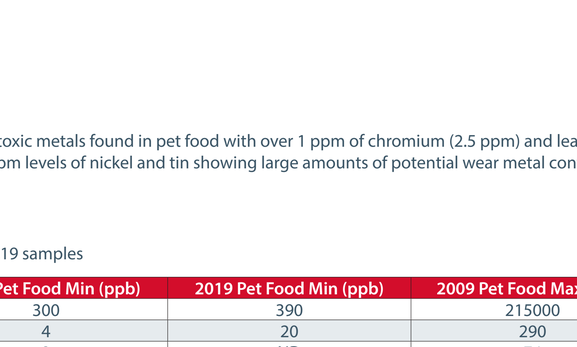

Figure 1. 2009 Uranium, Beryllium and Thorium comparison

In the 2019 samples, there were fourteen samples over 250 ppb. Most of the samples were dry dog foods with two dry cat foods measuring over 250 ppb. Nine samples contained over 500 ppb and four had over 1 ppm with the highest sample at 1.7 ppm.

The amount of exposure was calculated using average weights of a dog and cat being 50 lbs for a dog and 10 lbs for a cat. Serving sizes were cited by veterinary resources as approximately 3 cups of dry food dogs and 1/2 cup daily for cats. The reference dosages for humans at 50 lbs and 10 lbs were used to determine exposure limits.

Dog Food

Table 2. Reference dosages (RfD) calculated for 50 lb dog

Element	EPA Human RfD (µg/kg/day)	EPA Human RfD (per 50 lbs body weight)	WHO human TDI (µg/kg/day)	WHO Human TDI (per 50lbs body weight)
Arsenic	0.3	7	2.14	49
Beryllium	3	56	-	-
Cadmium	1	23	1	23
Mercury	0.1	2.3	0.4 to 2 µg/kg/day depending on type of Hg and literature source	9.08 (based on 0.4 µg/kg/day)
Nickel	20	454	12	272
Lead	-	-	3.6	82
Antimony	0.4	9	6	136
Thallium	0.1	2.3	-	-
Uranium	3	68	0.6	14

The exposure for many of the elements increased from 2009 to 2019. In 2009, arsenic was 33% over the limit for dogs and in 2019, it was 70% over the limit. Nickel exposure overages also increased from 22% over in 2009 to almost 46% over in 2019. Some exposures for lead and cadmium dropped from 2009 to 2019. Lead dropped from 17% over in 2009 to 11% over in 2019. Cadmium dropped from 28% to 19% over RfD.

Table 3. Heavy metal exposure for 3 cups of dog food

	Arsenic	Cadmium	Mercury	Nickel	Lead	Antimony	Uranium
Dog-1	33	9	0.1	763	32	5	15
Dog-2	28	8	ND	442	19	2	28
Dog-3	26	16	ND	351	17	2	21
Dog-4	125	10	1.1	416	38	2	9
Dog-5	53	16	1.3	404	119	16	7
Dog-6	54	16	1.0	626	155	18	10
Dog-7	152	14	0.8	645	37	7	46
Dog-8	83	25	0.1	635	46	13	216
Dog-9	206	11	1.8	361	54	4	34
Dog-10	39	10	ND	846	47	48	58
Dog-11	16	5	ND	821	20	3	4
Dog-12	111	11	0.3	354	40	8	34
Dog-13	133	42	0.4	583	154	15	280
Dog-14	64	21	ND	408	69	8	166
Dog-15	107	12	0.5	349	43	4	16
Dog-16	93	10	0.2	345	44	8	4
Dog-17	69	13	0.0	371	25	9	95
Dog-18	46	26	ND	504	25	6	90
Dog-19	18	ND	0.3	339	14	3	33
Dog-20	54	11	0.1	446	41	4	103
Dog-21	104	21	ND	390	34	8	456
Dog-22	73	16	ND	556	55	8	192
Dog-23	54	12	ND	369	45	5	236
Dog-24	124	16	0.1	319	33	7	322
Dog-25	168	15	0.5	309	37	9	510
Dog-26	49	14	ND	405	73	5	9
Dog-27	56	18	ND	402	72	4	7
Dog-28	33	25	BD	590	80	5	5
Dog-29	21	40	0.1	632	20	3	4
Dog-30	70	27	0.2	474	23	1	5
Dog-31	57	14	0.4	609	52	96	4
Dog-32	64	11	ND	499	38	2	8
Dog-33	100	17	ND	812	76	5	19
Dog-34	58	22	0.2	1764	97	5	14
Dog-35	94	28	0.1	1067	28	8	321
Mean	**75**	**17**	**0.5**	**549**	**51**	**10**	**97**
EPA	**7**	**23**	**2.3**	**454**		**9**	**68**
WHO	**49**	**23**	**9.8**	**272**	**82**	**138**	**14**
% Over	**70**	**19**	**0.0**	**46**	**11**	**0**	**32**

Cat Food

Table 4. Reference dosages (RfD) for 10 lb cat

Element	EPA Human RfD (µg/kg/day)	EPA Human RfD (per 10 lbs body weight)	WHO human TDI (µg/kg/day)	WHO Human TDI (per 10lbs body weight)
Arsenic	0.3	1.4	2.14	9.72
Beryllium	2	9	-	-
Cadmium	1	4.5	1	4.5
Mercury	0.1	0.5	from 0.4 to 2 µg/kg/day depending on type of Hg and literature source	1.82 (based on 0.4 µg/kg/day)
Nickel	20	91	12	55
Lead	-	-	3.6	16
Antimony	0.4	1.8	6	27
Thallium	0.1	0.5	-	-
Uranium	3	14	0.6	2.7

The cat food found similar increases from 2009 to 2019 with arsenic rising from 25% over to 48% over, nickel rose from 33% to 68% and for the first time we had uranium in the cat food in the 2019 samples. As with the dog food lead levels dropped from 17% to 12% over.

Conclusions

The ten years between the two pet food studies did not show any major drops in heavy metal contamination despite the enactment of the FSMA. Some of the lead levels have dropped but other potentially toxic metals have increased including arsenic, nickel and uranium. The 2019 samples showed uranium in cat food, unlike the 2009 study that only had uranium found in the dog food. There are many studies regarding heavy metals and toxic metals in human foods that go undetected so it is no wonder that pet food is still not heavily tested for metals contamination.