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Quantification of toxic trace metals in commercial pet foods using atomic absorption spectroscopy

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Abstract
This study aimed to determine the concentrations of lead (Pb), cadmium (Cd), and chromium (Cr) in commercial pet foods available in Raipur, Chhattisgarh, using Atomic Absorption Spectroscopy (AAS) after a wet digestion method. The analytical data revealed that all three investigated heavy metals were detected in each commercial dry pet food sample. Lead concentrations ranged from 0.12-0.17 mg/kg, cadmium 0.010-0.016 mg/kg, and chromium 0.593-0.679 mg/kg. Among the analyzed samples, dog food contained the highest concentrations of lead (0.17 mg/kg) and cadmium (0.016 mg/kg), whereas cat food exhibited the highest chromium concentration (0.679 mg/kg). Fish food contained intermediate concentrations of lead and chromium but the lowest cadmium concentration. Levels of lead and cadmium measured in pet food were well below international safety limits. Lead was less than 2% of the maximum limit, and cadmium was just 1.6% of the limit. There is no set limit for chromium, but the levels found in this study were within the range of typical scientific reports and did not indicate any serious contamination.

Keywords: Dry pet food, lead, cadmium, chromium, international safety limit

Introduction
In the last few decades, humans have changed their relationship with pets, treating them as part of the family and becoming more aware of their health, nutrition, and safety (Dodd *et al*., 2021) [2]. Commercial pet food is currently available, made from proteins, grains, vegetables, fats, vitamins, minerals, and additives to provide age-specific nutritional needs for pets. But despite strict standards, it may contain undesirable contaminants such as toxic trace metals due to raw materials, contamination, processing, packaging or storage (Kim *et al*., 2018) [8]. Among the most concerning pollutants are toxic trace metals such as lead, cadmium, and chromium. These occur naturally in the environment, do not biodegrade, and can accumulate and bioaccumulate in the body (Jaishankar *et al*., 2014) [7]. Eating contaminated commercial pet food over time leads to a slow buildup of toxic metals in animals. The damage often isn't noticeable until it's already significant. So, regularly monitoring toxic metals in pet food is crucial for animal health and meeting safety standards. In India, there isn't enough data on lead, cadmium, and chromium levels in pet food sold in Raipur, Chhattisgarh, which raises safety concerns. This study aims to measure these trace heavy metals in commercial pet food using atomic absorption spectroscopy.

Samples selected for study

The following kibble pet food samples were taken for this study:

Dog food –formulated for the domestic dog (Canis lupus familiaris).

Cat food – formulated for the domestic cat (Felis catus).

Fish food – commercial feed intended for ornamental or aquarium fishes.

Material & Methods
All the standard solutions were prepared from analytical-grade compounds from Merck. All the glassware used was of Borosil. Before all chemical analyses, the reagent bottles, beakers, measuring cylinder, and volumetric flasks were cleaned by soaking overnight in 2N hydrochloric acid, rinsed with water, and oven-dried at 60°C. Nitric acid (65% Merck) and de-ionized water were used for sample preparation. Atomic Absorption Spectrometer (AA240-Varian) was used for analysis.

Sample Collection and Preparation
Commercial dog, cat, and fish food samples were collected from authorized pet shops and retail outlets in Raipur. All samples were transported to the Central Laboratory Facility, Chhattisgarh Council of Science and Technology (CCOST), where they were processed under controlled laboratory conditions. The samples were dried, homogenized, and digested using a wet acid digestion procedure based on the United States Environmental Protection Agency (US EPA Method 3050B).

Sample Analysis
The digested solutions were diluted up to 50 ml than filtered with Whatman filter paper and analyzed using a Varian AA240 Flame Atomic Absorption Spectrophotometer.

Table 1: Operating conditions of the AAS for the determination of the selected elements

Elements	Wavelength	Current (mA)	Burner height (mm)	Slit width (nm)	Fuel gas flow (L/min)	Type of oxidant
Pb	283.3	10	7	0.7	2.0	Air-acetylene
Cd	228.8	04	7	0.7	2.0	Air-acetylene
Cr	357.9	07	7	0.2	2.0	Air-acetylene

Result & Discussion

The analytical results revealed that all three investigated heavy metals were detected in each commercial pet food sample.

Table 2: Concentration of Pb, Cd and Cr in commercial pet foods

Type of food	Elements detected (mg/kg)		
	Pb	Cd	Cr
Dog food	0.17	0.016	0.593
Fish food	0.16	0.010	0.669
Cat food	0.12	0.013	0.679

Lead concentrations ranged from 0.12 to 0.17 mg/kg, cadmium concentrations from 0.010 to 0.016 mg/kg, and chromium concentrations from 0.593 to 0.679 mg/kg. Among the analyzed samples, dog food contained the highest concentrations of lead (0.17 mg/kg) and cadmium (0.016 mg/kg), whereas cat food exhibited the highest chromium concentration (0.679 mg/kg). Fish food contained intermediate concentrations of lead and chromium but the lowest cadmium concentration.

Lead (Pb)

Lead in commercial pet foods ranged from 0.12–0.17 mg/kg, with dog food highest and cat food lowest. This is <2% of the FEDIAF limit of 10 mg/kg, so normal feeding poses no significant lead exposure risk. These results align with recent global studies by Davies *et al*. (2022) [10] and Di Donato *et al*. (2021) [1], which also found lead well below regulatory limits. Overall, improved ingredients and manufacturing over the past 10 years have greatly reduced lead contamination in pet food across Europe, North America, and Asia.

Cadmium (Cd)

Cadmium in commercial pet foods ranged from 0.010–0.016 mg/kg. Dog food had the highest level and fish food the lowest, with cat food at 0.013 mg/kg. All levels were well below the 1.0 mg/kg international limit the highest was only 1.6% of it showing negligible contamination and compliance with safety standards. These results match Bampidis *et al*. (2021) and Di Donato *et al*. (2021) [1], who also found very low cadmium in European and commercial dog and cat foods, suggesting modern manufacturing has significantly reduced cadmium contamination.

Chromium (Cr)

Chromium in commercial pet foods ranged from 0.593–0.679 mg/kg. Cat food had the highest level, followed by fish food, and dog food was lowest. While higher than lead and cadmium, these values are within the normal 0.3–2.5 mg/kg range reported in previous studies. There's no universal maximum limit for total chromium in pet food. Since the method measured total chromium and food chromium is usually the safe Cr (III) form with very little toxic Cr (VI), the levels found do not indicate a toxicity concern.

Conclusion

The study of commercial pet foods sold in Raipur, Chhattisgarh found only trace levels of lead, cadmium, and chromium. Lead and cadmium were well within international safety limits, and chromium levels matched those reported in earlier research. Overall, the products are safe regarding these toxic trace metals. The results also provide useful baseline data for future monitoring, regulation, and research on pet food quality in India.

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