

Heavy Metal Contamination of Red Pepper Spices and Hot Sauce

Introduction

The consumption of botanical products has increased over the past two decades as consumers trend to what are perceived to be natural and high quality botanical products. The primary regions of spice and tea production around the world have often been cited as having less stringent safety and quality standards in regards to consumer products. Products from these regions have been noted to contain a variety of adulterants and contaminants including wear metals and toxic elements.

The spice samples used were purchased at dollar stores, farmer's markets, chain stores, and online vitamin outlets. Products included organic products. Cryogenic grinding and microwave digestion were employed in sample processing. ICP-MS was used to determine the presence and level of heavy metal contamination and adulteration.

Methods & Materials

Samples

Whole and ground spice samples from seven spice families were purchased from several types of locations including online, health food stores, grocery stores, retail chain stores, and discount or dollar stores. The samples ranged in price from \$1 per bottle to more than \$20 per ounce. Some products were designated as 'organic'. In addition to the spices, related teas, sauces and dietary supplement capsules featuring spices were purchased for study. In this application note, the focus will be the concentration of the red pepper spices and products for heavy metal contamination.

- 13 Red Pepper Dry Spices: (\$1-\$16 / 100 g)
 - 2 'Chili' Pepper – No ingredients stated
 - 3 Cayenne Pepper – 1 Organic
 - 5 Paprika Pepper – 1 Organic
 - 3 Crushed Red Pepper Flakes – 1 Organic
- Red Pepper Products (Chili Powder & Hot Sauce):
 - 7 Chili Powders – 1 Organic (\$1-\$8 / 100 g)
 - 6 Hot Sauces – 1 Organic (Free - \$3 / 100 g)

Sample Preparation

Initial Sample Preparation:

- Whole spices were ground using Spex SamplePrep Freezer Mill.
 - Grinding Conditions:
 - 2 g of Spice
 - Program:
 - Pre-cool = 20 minutes
 - Grind for 5 cycles (2 min/cycle)
 - Each cycle = 2 minutes of cooling
 - Impact rate = 16 impacts/second
- Powdered or ground spices were tested as purchased.

Sample Digestion:

- Samples were digested using a CEM Mars 5 Microwave.
 - Microwave conditions:
 - Easy Prep vessels & XP vessels
 - 0.2 g sample
 - 10 mL HNO₃:
 - 1-2 drops HF in samples with high silica content
 - 15 minute ramp to 210 °C
 - 15 minute hold

Materials

- Spex CertiPrep Standards:
 - CLMS-1, CLMS-2, CLMS-3, CLMS-4 (Multi-Element Solution Standards 1-4)
- Reagents:
 - High Purity Nitric Acid
 - High Purity HF

Instrumentation

- Instrumentation Agilent ICP-MS 7700:
 - Meinhard nebulizer
 - Cyclonic spray chamber
- Analysis performed:
 - Normal mode: Air
 - Collision mode: Helium

Results & Discussion

Heavy metals found in spices could be contributed from a variety of sources. Some metals, such as lead oxides or lead chromates, can be intentional adulterations where as some other metals can be unintentional contamination from soil, pesticide applications, or processing issues.

Red Pepper Spices

The dry red pepper spices consisted of red pepper flakes, chili pepper powder and paprika. Lead levels in the dry red pepper ranged from a low of 0.5 µg/g for red pepper flakes to over 2 µg/g for a highly processed dollar store paprika. The highest levels of lead in the red pepper spices were found in the more processed ground chili peppers and paprika. The lowest lead levels were in the less processed red pepper flakes. Chromium levels also followed the pattern where the less processed samples had less than 1 µg/g of chromium, whereas the more highly processed cayenne pepper and dollar store paprika had the highest chromium levels up to 12 µg/g. (Fig. 1.)

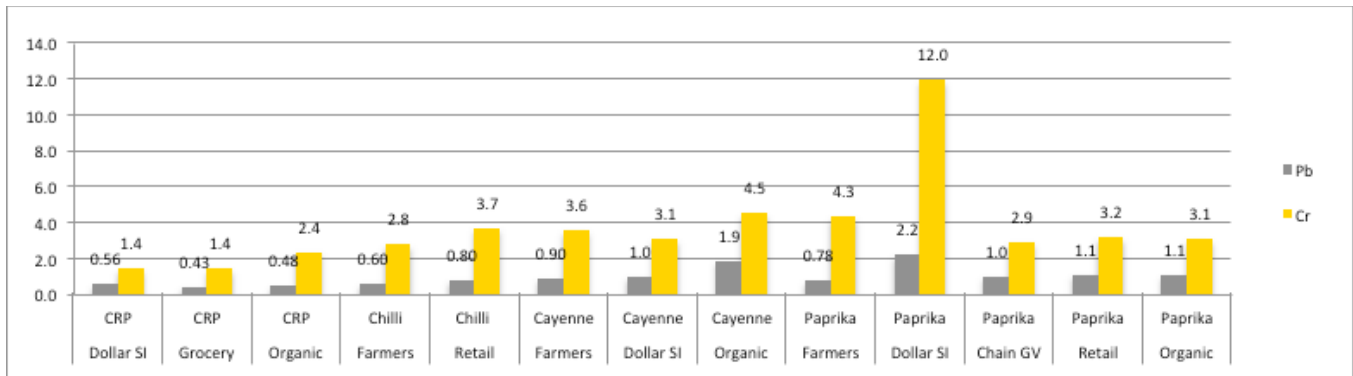


Figure 1. Lead and chromium concentrations in dry red pepper spices ($\mu\text{g/g}$).

Arsenic and cadmium were found at notable levels in three of the paprika samples including a retail paprika ($0.5 \mu\text{g/g}$ Cd), Organic paprika ($0.7 \mu\text{g/g}$ Cd & $0.3 \mu\text{g/g}$ As) and the dollar store paprika ($0.75 \mu\text{g/g}$ Cd & $0.75 \mu\text{g/g}$ As). Mercury was either not detected in samples or was found to be less than $0.1 \mu\text{g/g}$. (Fig. 2).

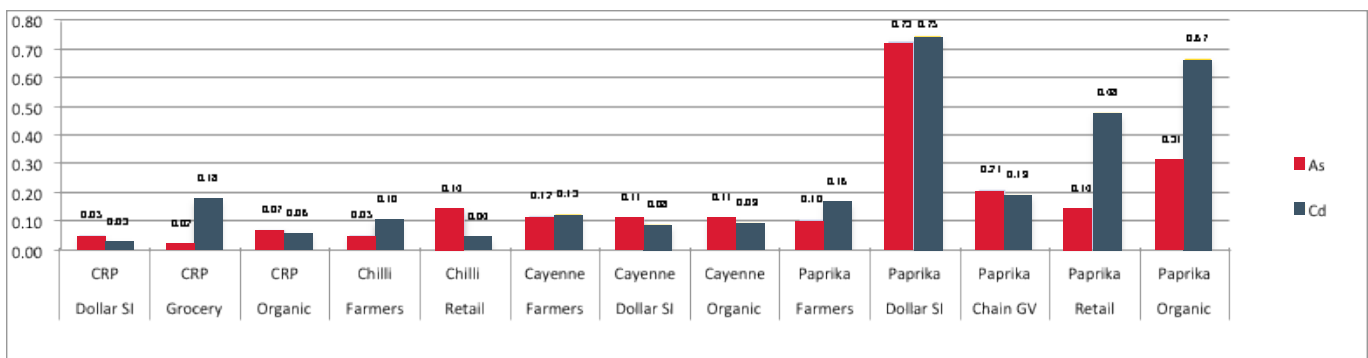


Figure 2. Arsenic and cadmium concentrations in dry red pepper spices ($\mu\text{g/g}$).

The red pepper products consisted of blended 'chili' powder spices of unknown composition and red pepper hot sauces. The most prevalent heavy metal for the red pepper products was chromium up to $7 \mu\text{g/g}$ in a dollar store chili powder. Levels of chromium ranged from 3.1 to $7.0 \mu\text{g/g}$. Arsenic and cadmium were highest in the same dollar store chili powder which contained the highest chromium levels ($1.2 \mu\text{g/g}$ Cd & $0.4 \mu\text{g/g}$ As). Lead was also found in this same sample at just less than $1 \mu\text{g/g}$. The highest lead content of the mixed chili powders was in the organic chili powder ($1.6 \mu\text{g/g}$). (Fig. 3).

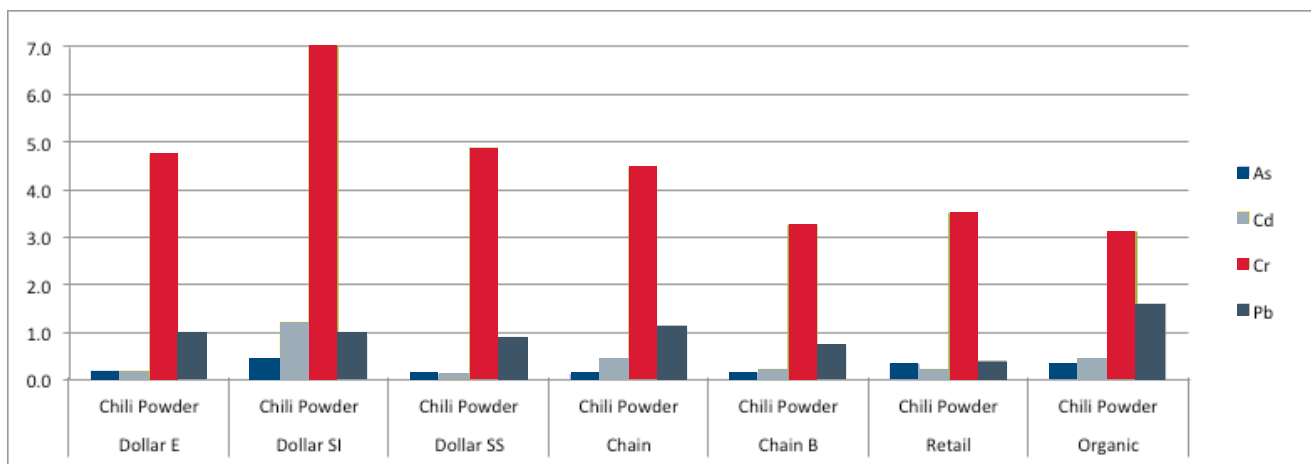


Figure 3. Heavy metals in 'chili' powder blends ($\mu\text{g/g}$).

Between all the dry spices and red pepper products, some of the highest lead levels, in terms of exposure, were in the commercially prepared red pepper sauces. Some of sauces were packaged in individual servings of about 10 g per packet. The serving size of two packets or 20 g was used to compare heavy metal concentrations. Two packets of the Chinese fast food hot sauce contained 20.6 μg of lead and 63 μg of chromium which would contribute to almost 30% of an adult's allowable daily limit for each element. Lead and chromium were consistently found in all the hot sauces tested. Some of the samples also included measurable amounts of arsenic and cadmium. (Fig. 4).

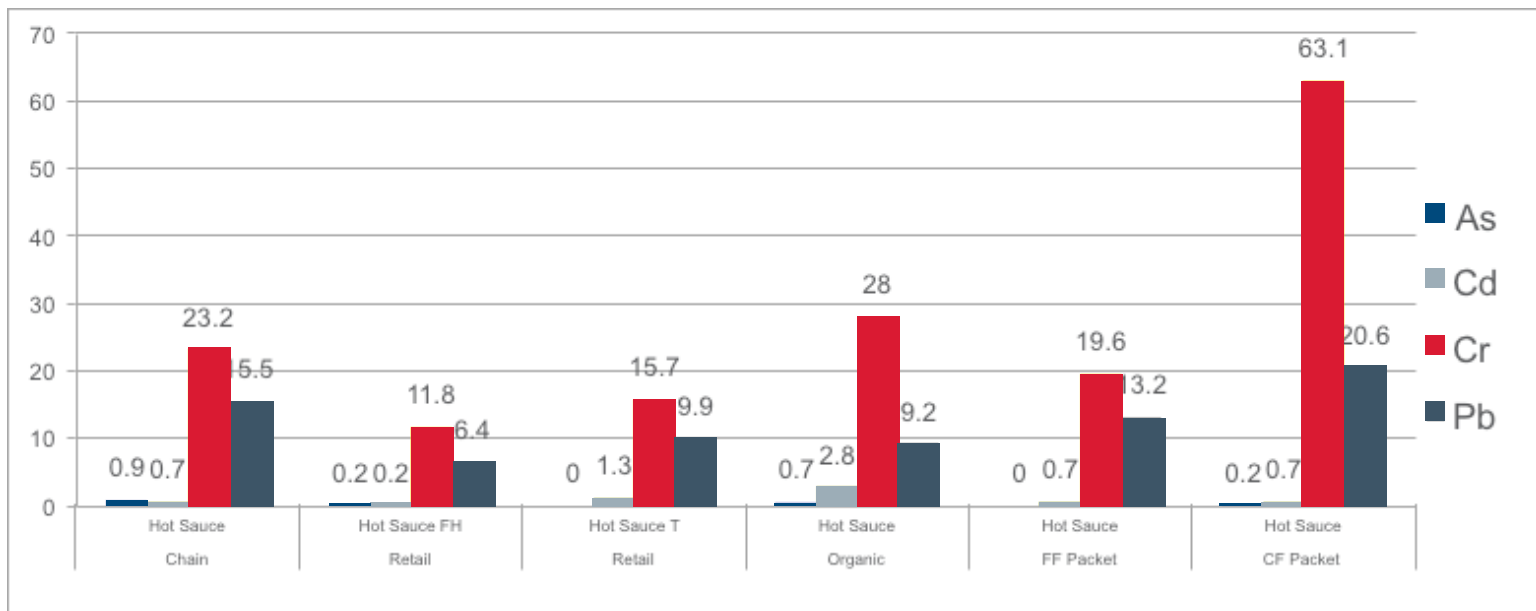


Figure 4. Heavy metal concentrations in hot sauce ($\mu\text{g}/20\text{g}$ serving = 2 fast food packets).

Conclusions

The red pepper spice and product samples we tested all contained some notable amounts of heavy metals. The most prevalent heavy metals found were lead and chromium. The dry spices had the highest concentrations of both lead and chromium but the exposure to these concentrations was minimized by the typical serving of these dry spices. However, the hot sauces which did have lower overall concentrations of heavy metals, in comparison with the dry spices, had high exposure levels when looked at within the context of serving size. In the case of some of the hot sauce packets, two packets would contain over a quarter of an adult's exposure to chromium and lead for the day.

Red pepper, when compared to our other study spices, contained some of highest overall concentrations of heavy metals only exceeded by some cinnamon and turmeric samples for the highest levels of lead. Red pepper and chili powder blend samples did contain the highest amounts of arsenic and cadmium found in all the spices. The only heavy metal not found in significant concentrations in red pepper spices was mercury. (Fig. 5).

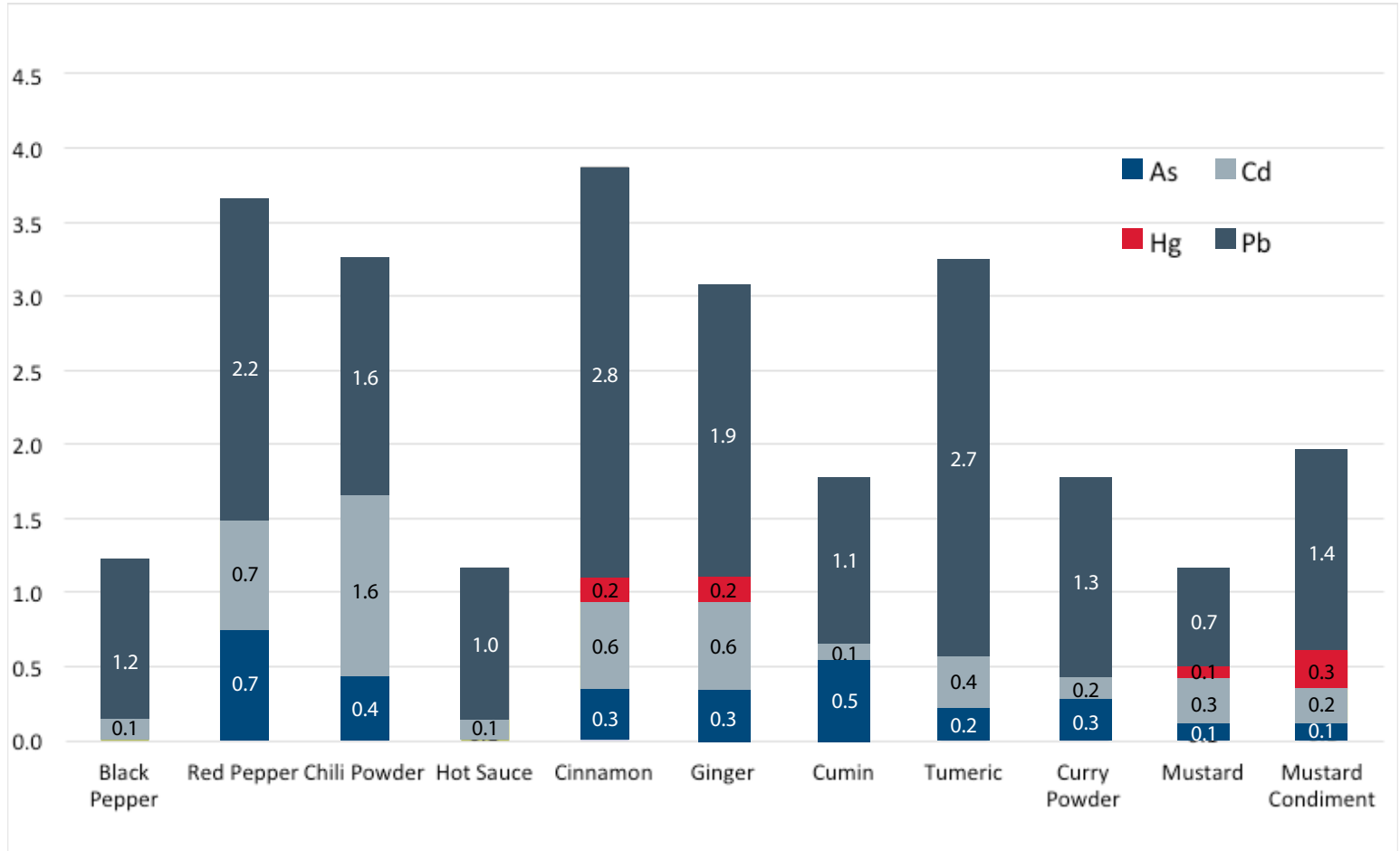


Figure 5. Comparison of overall concentration of heavy metals in spice sample groups (µg/g).