spex certiprep

App Note

Analysis of Elemental Content in Commercial Chocolate Bars

Abstract

Chocolate has been harvested for human consumption for thousands of years. The Mayans used cocoa beans as currency. Present day consumption of chocolate is measured on a global scale. In the US, Americans consume over 11 pounds of chocolate per person, per year.

Cocoa plants are native to tropical climates with high levels of humidity and rainfall. This climate increases the need for pesticide application to protect the cocoa bean crops. Heavy metals from pesticide and fertilizer applications can accumulate in the soil and add to the possible accumulation of those metals in the cocoa beans.

This study examined the elemental composition of several types of chocolate products from chocolate liquor to milk and dark chocolate bars.

Materials & Methods

Sample Preparation

Seven different chocolate products were examined: three dark chocolate bars, three milk chocolate bars and chocolate liquor. All of the chocolate bars were purchased in the United States. The suggested average serving size of all of the chocolate bars was 40 g. The nutritional and elemental information reported on the package was recorded for comparison to experimental results.

- 0.1 to 0.2 g of sample were digested using 10 mL High Purity Nitric Acid
- Digests were diluted 100x with water before analysis on ICP-MS

Spex CertiPrep standards were used to calibrate and quantitate sample results:

- Multi-element solution standards: CLMS-1, CLMS-2 and CLMS-3
- Instrument calibration standards: CL-ICV-1 and CL-ICS-1
- Instrument tuning solution: CL-TUNE-2

Analytical Conditions

- Instrument: DRC ICP-MS

- Instrument Conditions
  - RF Generator: 1000W
  - Plasma Gas Flow: 15 L/min
  - Aux. Gas Flow: 1 L/min
  - Nebulizer: 0.90 L
  - Sample Uptake: 1 mL/min
  - Spray Chamber: Cyclonic, glass
  - Injector Tube Diameter: 1.5 mm
  - Interface Cones: Pt
  - Quad. Rod Offset: 0 V
  - Dwell Time: 50 ms
  - Scan Mode: Peak Hopping
  - MCA Channels/Peak 1
  - Detector Mode: Pulse Counting

Results

Macro Elements

Eleven macro elements (Tables 1 and 2) were quantified in the chocolate samples. Potassium and phosphorus were found to be the most abundant of the elements studied. The highest concentration of potassium was 244 mg found in a 40 g serving.

A comparison was made of the concentrations of elements listed on the nutritional label of the chocolate bars. In general, only three elemental components were listed on most of the packaging (Table 2). These elements included sodium (reported in mg), iron and calcium (reported in percent of Daily Value or Reference Daily Intake (RDI)). Reported RDI values based on an adult diet of 2,000 calories per day are 1,000 mg of calcium and 18 mg of iron.

The nutritional information of the chocolate bars reported concentrations of calcium from 0-2% in the dark chocolate bars and 4-8% in milk chocolate bars. The highest levels of iron were reported in the dark chocolate bars ranging from 4-10% of the RDI. Milk chocolate bars report iron levels at 2-4% of the RDI. The analysis of the chocolate bars found levels of iron consistent with the levels reported on the packaging. Calcium levels were reported up to 80 mg per serving, but the highest detected level of calcium was 34 mg per serving. Two of the dark chocolate samples reported 0 mg of sodium per serving. All of the samples had a minimum of 11 mg of sodium.

Table 1. Macro elements.

Element	Min (µg/g)	Max (µg/g)
Al	10	30
Mg	500	1,500
K	2,500	6,100
Ni	0.93	2.9
S	360	900
P	1,100	2,200
Si	7.3	28
Zn	8.3	16

Table 2. Observed levels of select elements.

Element	Min (mg/40 g serving)	Max (mg/40 g serving)	Reported Range on Label (mg/40 g serving)
Fe	0.60	2.1	0.36-1.8
Ca	14	34	20-80
Na	11	15	0-28

Toxic Elements

Toxic elements, including heavy metals such as mercury, arsenic, lead, and cadmium (Table 3) were all detected in varying amounts in all of the chocolate products. The lowest concentration of elements was found in the chocolate liquor. The highest levels of heavy metals were generally found in the dark chocolate products. All brands of the chocolate bars studied had approximately 1 µg or more of lead with the highest concentration of lead of 3 µg found in one of the dark chocolate servings.

Table 3. Comparison of chocolate bars for toxic element content.

Element	Brand 1 Dark (µg/40 g serving)	Brand 2 Dark (µg/40 g serving)	Brand 3 Dark (µg/40 g serving)	Brand 4 Dark (µg/40 g serving)	Brand 5 Dark (µg/40 g serving)	Brand 6 Dark (µg/40 g serving)	Brand 7 Dark (µg/40 g serving)
Cd	3.0	3.8	5.3	0.90	1.5	1.0	0.20
Pb	3.0	2.8	0.87	1.0	2.2	1.5	0.40
Hg	2.0	0.10	0.04	4.0	0.22	0.060	0.40
As	0.39	0.98	2.0	0.40	0.37	0.30	0.050
U	0.14	0.040	0.020	0.04	0.040	0.04	0.010

Conclusions

Heavy metals were detected in all of the chocolate bar samples with the highest concentration of elements found in the dark chocolate bars. The labeling information reported levels of sodium, calcium and iron. The levels of iron detected did fall within the reported range, but there was some discrepancy between a few of the samples and the reported levels of sodium and calcium.

Additional Resources

To watch our webinar on Toxic Metals in Gourmet Foods, an analysis of trace metals in common gourmet foods including salt, chocolate and fish, visit our YouTube channel at www.youtube.com/spexcertiprep.

For additional product information, please contact us at +1.732.549.7144 or via email at USMet-CRMSales@spex.com.

spex.com

Phone: +1.732.549.7144 • +1.800.LAB.SPEX
Fax: +1.732.603.9647
spexsales@antylia.com

4772CM

Connect with us