Trouble Digesting Your Milk? An Examination of Heavy Metals in Alternative Dairy Milks

2024 Winter Conference on
Plasma Spectrochemistry
January 15-20, 2024

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Introduction

Plant-based milks are becoming increasingly popular alternatives to dairy milk. While some plant-based milks, such as soy and almond, have become mainstream, more and more alternative milks, such as coconut and oat milk are also increasing in popularity. These non-dairy milks are derived from nuts, seeds, and other plant-based sources. These 'milks' are appealing because they follow consumer trends for dairy-free, lactose-free, and vegan products.

All plants are grown in soil, which has a naturally occurring concentration of metals. Many plants and nut trees are effective bioaccumulators of inorganic compounds. Plants uptake metals from soils via the root and vascular system and can concentrate elements in the leaf, fruit, and flower. As these plants are processed into downstream products (such as non-dairy milks), plants grown in contaminated soil can accumulate heavy metals, increasing a consumer's heavy metal exposure. The heavy metals known as the big four (As, Pb, Cd, Hg) are of particular concern due to their potential toxicity. In this study, metal concentrations are measured and compared for plant-based milks and cow's milk. The metals are measured after microwave digestion and ICP-MS analysis of the milks.

Methods and Materials

Samples (digested in triplicate using CEM MARS™ 6):

- NIST SRM 1575A Pine Needles
- Cow's 2% Milk
- Cow's Whole Milk
- Almond Milk
- Soy Milk
- Oat Milk
- Coconut Milk
- Hemp Milk

*Three different brands were tested for almond, soy, oat, and coconut milks.

Digestion Method:

1. Weigh 2 g of sample or 0.25 g of SRM in a MARSXpress™ Plus TFM vessel.
2. Add 5 mL HNO_3 + 1 mL HCl of trace level grade acids to vessel.
3. Cap vessel and place in turntable.

Digestion parameters:

Method	Control Type	Sample Type	Power (W)	Ramp (min)	Temp (°C)	Hold (min)
Classic	Ramp to Temp	Organic	1600	20	210	15

All digests were clear and colorless.

Digests were analyzed using an Agilent 7850 ICP-MS.

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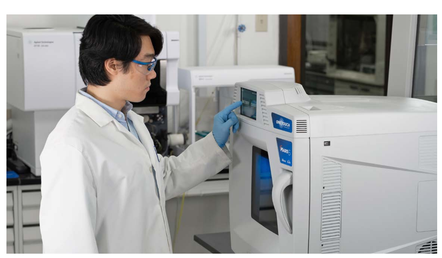

Results

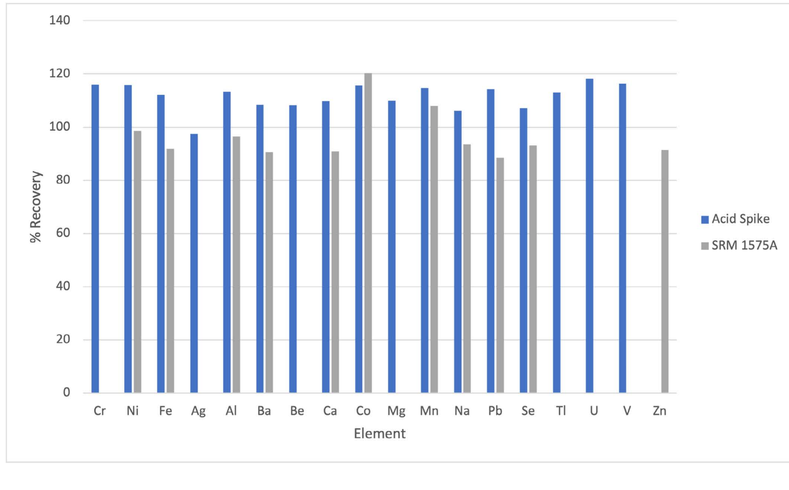

Figure 1. % Recovery for 10 ppb Spiked Acid Blanks with SPEX CLMS-2 and NIST SRM 1575A Pine Needles (n=3)

Table 1. Average Elemental Concentrations (ppb) of Cow's Milk and a Variety of Plant-based Milks (n=3)

Milk	As	Cd	Hg	Pd	Cr	Fe	Ni
2% Cow's	0.502	n.d.	0.183	0.382	0.996	345	13.9
Whole Cow's	0.526	0.0143	0.109	0.347	n.d.	239	8.51
Almond 1	1.53	0.217	0.0733	0.580	15.0	1340	38.7
Almond 2	1.84	2.57	0.0980	1.11	23.5	1060	62.7
Almond 3	3.31	0.197	0.0660	2.54	5.54	3660	44.8
Soy 1	2.71	2.85	0.124	1.53	94.9	6120	141
Soy 2	2.17	3.72	0.158	2.12	1.21	6130	198
Soy 3	1.99	3.46	0.139	0.957	9.03	5770	154
Oat 1	3.10	1.87	0.196	1.11	60.3	7170	410
Oat 2	4.91	0.856	0.156	0.696	7.99	1140	195
Oat 3	2.03	3.12	0.127	2.02	138	1640	139
Coconut 1	1.71	0.713	0.107	0.650	11.6	2170	141
Coconut 2	4.36	1.26	0.163	2.44	16.6	2630	49.3
Coconut 3	3.43	0.158	0.107	2.98	15.1	4240	24.5
Hemp	15.5	0.999	0.242	0.554	49.4	7470	1.64

Conclusions

Proper monitoring and analysis of elemental impurities in milk products is imperative for ensuring consumer safety. Efficient sample preparation providing homogenous solutions for analysis plays a vital role in this process. In this study, strong recoveries for both SRM and high-spiked acid samples showed suitability of digestion and analysis protocols. Of the milks studied, it was found that cow's milk had lower levels of As, Cd, and Pb than the plant-based milks. Furthermore, metals found in processing, such as Cr, Ni, and Fe were found to be in higher abundance in the plant-based milks. Overall, variability between the different brands tested was minimal, and for all milks tested, the metal content detected was within regulation.