New Standardized Methods for Metals in Cannabis

Jenny Nelson[1], Craig Jones[1], Sam Heckle[2], Leanne Anderson[2], Ed McCurdy[3]

1 Agilent Technologies, Inc., 5301 Stevens Creek Blvd, Santa Clara, CA 9505,

2 CEM Corporation, 3100 Smith Farm Road, Matthews, NC 28104

3 Agilent Technologies LDA (UK) Ltd, Cheadle Royal Business Park, Stockport, Cheshire. SK8 3GR, UK

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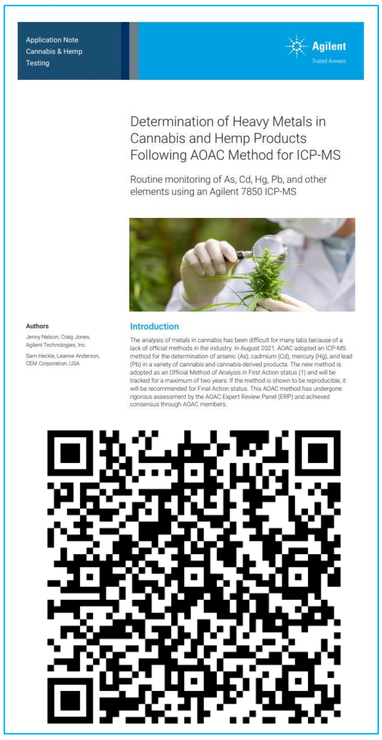
Introduction

The analysis of metals in cannabis has been difficult for many labs because of a lack of official methods in the industry. In August 2021, AOAC adopted an ICP-MS method for the determination of arsenic (As), cadmium (Cd), mercury (Hg), and lead (Pb) in a variety of cannabis and cannabis-derived products. The new method is adopted as an Official Method of Analysis in First Action status. This AOAC method has undergone rigorous assessment by the AOAC Expert Review Panel (ERP) and achieved consensus through AOAC members.

The authors have also worked with ASTM and the D37 Cannabis community to develop the first ASTM standard test method for the analysis in Metals in Cannabis.



Experimental

Instrumentation

The 7850 ICP-MS, with the Ultra High Matrix Introduction (UHMI) system and ORS^4 collision/reaction cell (CRC), was used for the analysis. The Agilent SPS 4 autosampler was used. The 7850 was configured as follows:

- Micro Mist glass concentric nebulizer
- Quartz spray chamber
- Quartz torch with 2.5 mm id injector
- Nickel-plated copper sampling cone and a nickel skimmer cone

Table 1. Agilent 7850 ICP-MS operating conditions.

Parameter	Value
RF Power (W)	1600
Sampling Depth (mm)	10
Carrier Gas (L/min)	0.80
Dilution (UHMI) Gas (L/min)	0.15
UHMI Setting	4
Helium Cell Gas (mL/min)	4.3
KED (V)	3.0

Standard and samples

To verify the sample preparation digestion process and the accuracy of the ICP-MS method, four NIST SRMs were analyzed. The SRMs included NIST 1547 Peach Leaves, NIST 1573a Tomato Leaves, NIST 1575 Pine Needles, and NIST 1515 Apple Leaves. The AOAC method is suitable for the analysis of the range of cannabis and hemp-based products that are listed in Table 2. A sample from each category was analyzed for a spiking study in this work.

Table 2. Types of cannabis and hemp samples that can be analyzed by the AOAC ICP-MS method. The samples in bold were used in the spiking study.

Sample Category	Sample
Inhaled	**Hemp flower**
	Cannabinoid (CBD) vape oil
	Hemp isolate extract
Oral	Full spectrum softgel capsules
	Full spectrum tincture
	Isolate tincture
	CBD coffee grounds
	Hemp butter
	Hemp seed oil
	CBD beef jerky
	CBD hard candy
	CBD pineapple drink
Topical	Full spectrum balm
	Pain relief cream
	CBD balm
	CBD topical oil
	Hemp soap
Manufacturing	Hemp biomass
	Spent hemp biomass
	Trichomes
	CBD crude extract
	CBD distillate
	CBD isolate

Sample preparation

Calibration standards were prepared using a mix of 1% HNO_3 and 0.5% HCl.

- A variety of cannabis and cannabis-containing samples (NC, USA)
- Approximately 0.5 g of cannabis plant or cannabis product were weighed into TFM MARSXpress Plus vessels (CEM).
- 9 mL HNO_3 and 1 mL HCl were added.
- A MARS 6 microwave digestion system (CEM) was used to digest the samples and method blanks.

Results and Discussion

Calibration and calibration verification

Representative calibration curves for As, Cd, Hg and Pb are shown in Figure 1. All show excellent linearity across the calibration range. A summary of the calibration data for As, Cd, Hg, and Pb, including detection limits (DLs) and background equivalent concentrations (BECs) is given in Table 3. The Limits of Quantitation (LOQ) were calculated from 3 x standard deviation (low-level spike) x 100 (dilution factor). The LOQs were within the AOAC SMPR of ≤10 ppb in the original sample.

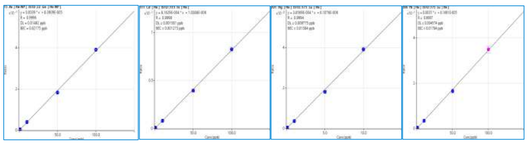


Figure 1. Calibration Curves for As, Cd, Hg, Pb.

Table 3. Calibration data, DLs, BECs, and LOQs for As, Cd, Hg, Pb.

		From ICP-MS MassHunter Calibrations			Calculated
Mass		R	DL (ppb)	BEC (ppb)	Limit of Quantitation (LOQ), µg/kg
75	As*	1.000	0.0158	0.0142	9.18
111	Cd	1.000	0.0026	0.0015	6.25
201	Hg	1.000	0.0068	0.0120	2.16
208**	Pb	1.000	0.0010	0.0150	7.85

*Data for As using half mass correction. ** Pb results were based on the sum of the signals measured at mass 206, 207, and 208.

SRM recoveries

To check the effectiveness of the sample digestion process and the accuracy of the ICP-MS method, each of the four NIST SRMs was prepared in triplicate. Each of the three preparations of the SRMs was analyzed three times using the 7850 ICP-MS. As shown in Table 4, the mean concentrations were in good agreement with the certified concentrations, where values were provided, meeting the AOAC method SMPR acceptance criteria of 80–120%. Blank cells indicate the absence of a certified or reference value.

Table 4. Mean concentrations (ppm) of three repeat measurements of four plant-based SRMs, including comparison with reference values, and recoveries for certified elements. Blank cells indicate the absence of a reference or certified value.

	NIST 1547 Peach Leaves				NIST 1573a Tomato Leaves			
Element	Measured Conc (ppm, µg/kg)*		Certified Conc (mg/kg)	Recovery (%)	Measured Conc (ppm, µg/kg)*		Certified Conc (mg/kg)	Recovery (%)
	Mean	SD			Mean	SD		
75 As	**0.06**	**0.01**	**0.06**	**99**	**0.109**	**0.021**	**0.112**	**97**
111 Cd	**0.025**	**0.001**	**0.026**	**96**	**1.39**	**0.01**	**1.52**	**91**
201 Hg	**0.034**	**0.003**	**0.031**	**108**	**0.032**	**0.002**	**0.034**	**96**
Pb**	**0.78**	**0.02**	**0.87**	**90**	**0.555**	**0.098**		
52 Cr	1.04	0.08	1R	(104)	2.09	0.51	1.99	**105**
55 Mn	95.4	3.3	98	97	238.67	34.91		
59 Co	0.068	0.004	0.07R	(97)	0.504	0.014	0.57	**88**
60 Ni	0.79	0.01	0.69	114	1.50	0.03	1.59	**94**
63 Cu	3.31	0.08	3.7	89	4.25	0.34	4.7	**90**
66 Zn	16.38	0.56	17.9	92	26.19	0.27	30.9	**85**
78 Se	0.108	0.032	0.12	90	0.062	0.009	0.054	**114**
107 Ag	0.006	0.000			0.023	0.002	0.017R	**(135)**
137 Ba	128	4	124	103	60.07	0.56	63R	**(95)**
	NIST 1575 Pine Needles				**NIST 1515 Apple Leaves**			
Element	**Measured Conc (ppm, µg/kg)***		**Certified Conc (mg/kg)**	**Recovery (%)**	**Measured Conc (ppm, µg/kg)***		**Certified Conc (mg/kg)**	**Recovery (%)**
	Mean	**SD**			**Mean**	**SD**		
75 As	**0.047**	**0.008**	**0.039R**	**(121)**	**0.029**	**0.009**		
111 Cd	**0.210**	**0.006**	**0.233**	**90**	**0.014**	**0.003**	**0.013**	**108**
201 Hg	**0.0380**	**0.0010**	**0.0399**	**96**	**0.0420**	**0**	**0.0432**	**98**
Pb**	**0.144**	**0.002**	**0.167R**	**(86)**	**0.41**	**0.01**	**0.47**	**86**
52 Cr	3.4	0.9	3R	(113)	0.46	0.23	0.3R	**(153)**
55 Mn	434	12	488R	(89)	49.2	1.1	54.1	**91**
59 Co	0.060	0.005	0.061R	(98)	0.086	0.005	0.09R	**(96)**
60 Ni	1.43	0.10	1.47R	(97)	0.787	0.024	0.936	**84**
63 Cu	3.22	0.30	2.8	115	4.79	0.13	5.69	**84**
66 Zn	32.01	0.77	30.9	104	10.14	0.29	12.45	**81**
78 Se	0.110	0.007	0.099R	(111)	0.118	0.024		
107 Ag	0.0167	0.004			0.006	0.001		
137 Ba	4.99	0.08	6	83	45.06	1.52	48.8	92

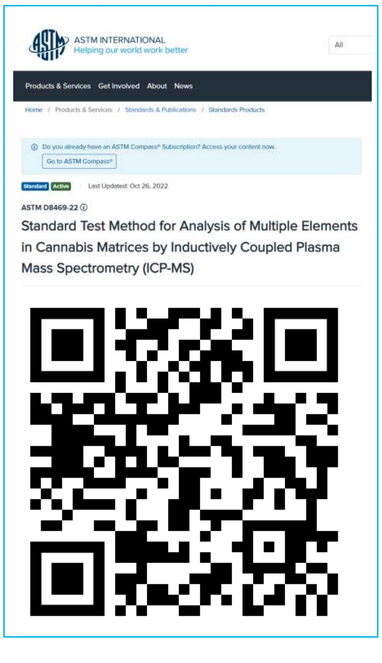
Spike recoveries

A spike recovery test was carried out to check the accuracy of the 7850 ICP-MS method. Table 5 shows the results for all SMPR elements spiked at three concentration levels (low, medium, and high) for four cannabis samples (from Table 2).

Mass	Element	Native Level in Matrix ppb, µg/kg	Recovery %		
			Low Spike ≥10 to 100 ppb	Medium Spike >100 ppb to 1 ppm	High Spike >1 to 10 ppm
Flower (Inhaled)					
75	**As**	91.2	87	95	**107**
111	**Cd**	209	99	101	**100**
201	**Hg**	16.9	95	94	**102**
208	**Pb**	306	66	109	**100**
Hemp Butter (Oral)					
75	**As**	0.48	108	103	**102**
111	**Cd**	0.16	98	100	**95**
201	**Hg**	<LOQ	103	104	**101**
208	**Pb**	3.73	95	102	**98**
Pain Relief Cream (Topical)					
75	**As**	11.8	64	97	**100**
111	**Cd**	2.26	93	99	**98**
201	**Hg**	6.86	78	89	**103**
208	**Pb**	12.4	69	100	**102**
CBD Crude Extract (Manufacturing)					
75	**As**	3.15	88	99	**100**
111	**Cd**	1.11	98	97	**98**
201	**Hg**	5.76	85	91	**94**
208	**Pb**	188	63	89	**100**

Table 5. Mean recovery results of As, Cd, Hg, and Pb in cannabis sample digests. Mean calculated from three separate digests, each measured in triplicate. The recoveries for As, Cd, Hg, Pb in all the cannabis samples were within the AOAC SMPR recovery requirements of 60–115% for low spikes, and 80–115% for medium and high spikes.

In addition to the quantitative analysis, IntelliQuant data was also acquired to provide semiquantitative results for other elements. Some plant materials can accumulate high enough levels of less typical elements to cause unexpected and unusual interferences. One example is if the rare earth elements (REEs) are present at high enough concentration in a sample they can form doubly charged ion (REE^{2+}) interferences on trace Zn, As, and Se. From this data, and many other cannabis samples we have analyzed, we often see Rare Earth Elements (REE) present, as shown in figure 2.



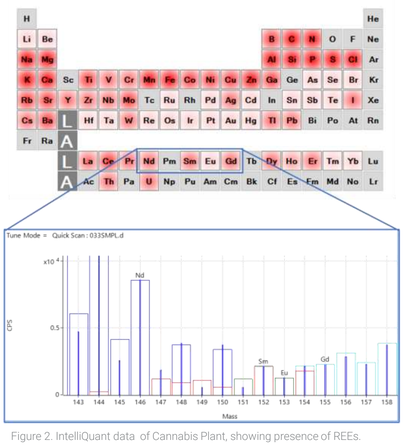


Figure 2. IntelliQuant data of Cannabis Plant, showing presence of REEs.

Conclusions

- The first standard test methods have been completed with both ASTM and AOAC.
- Both methods are for the determination of As, Cd, Hg, and Pb and additional optional elements in cannabis samples.
- The accuracy of the methods was evaluated by analyzing four plant-based SRMs and conducting a spike recovery test at different concentration levels for As, Cd, Hg, and Pb in four cannabis samples.

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