Application Brief

Foods

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Characterizing the Elemental Content of Alternative Proteins Using ICP-MS

IntelliQuant screening in helium mode complements quantitative analysis using Agilent 7850 ICP-MS

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Figure 1. Insects such as crickets could be a sustainable alternative source of protein.

Alternative sources of protein

Demand for alternative (non-animal) protein sources is projected to increase rapidly due to increasing population, pressure on land use, public concern about health, and the environmental and animal welfare aspects of intensive livestock farming (*1*). Cultured meat is one possible protein source being investigated (*2*), while foods based on plant, fungi, algae, and insect protein (Figure 1) are also being developed or are already available.

The sample preparation methods, analytical techniques, and quality control (QC) protocols defined in existing food quality and safety regulations, such as FDA EAM 4.7, can be applied to novel foodstuffs (*2*). But new food types and manufacturing processes can lead to the presence of unexpected contaminants that may not be covered in existing regulations. ICP-MS is a valuable tool for food producers, regulators, and consumers, as it can provide full elemental characterization, as well as accurate quantitative determination of all regulated elements.

Elemental screening using ICP-MS with He mode to control polyatomic ion overlaps

Agilent ICP-MS instruments—whether single or triple quadrupole—include the unique combination of an exceptionally robust plasma (CeO/Ce ratio <1.5%), and the ORS^4 collision/reaction cell for the most effective interference control in helium (He) mode. The robust plasma provides unmatched matrix tolerance, ensuring long-term stability and minimal routine maintenance, while also increasing ionization, reducing the formation of many spectral overlaps, and minimizing matrix suppression.

The Agilent ORS^4 operates in He mode with kinetic energy discrimination (KED) to provide a simple, universal method to filter out matrix-derived polyatomic ions. He KED on the ORS^4 ensures consistent, accurate results in varied sample types, extending the number of trace analytes that can be measured reliably in unknown samples. He KED also gives access to many secondary or qualifier isotopes for data confirmation. In EAM 4.7, He KED is the only cell mode permitted for single quadrupole ICP-MS. Reaction gases are not allowed, because of the risk of errors due to spectral overlap from cell-formed reaction product ions.

Characterizing alternative proteins

In this work, an Agilent 7850 ICP-MS was used to analyze four commercially available alternative protein products:

- Cricket protein powder
- Reishi mushroom
- Almond flour
- Besan (chickpea) flour

The powdered samples were digested (0.5 to 50 g) in a microwave oven. A mix of HNO_3 and HCl was used to ensure stability of all the elements, including Hg. Potential Cl-based polyatomic interferences were removed in the standard He cell mode. The 12 elements defined in EAM 4.7 were quantified, together with the nutrient/mineral elements, Na, Mg, P, K, Ca, and Fe. The mineral elements are often measured using ICP-OES, but Agilent ICP-MS systems have an exceptionally wide detector dynamic range, so these high concentration elements can be measured in the same run as the trace analytes.

The results shown in Table 1 reveal large differences in the levels of some of the elements. For example, the reishi mushroom powder contained 15.5 mg/kg (ppm) Cr, compared to less than 0.2 ppm in the other samples.

Table 1. Agilent 7850 ICP-MS concentrations for EAM 4.7 specified elements (in bold) and mineral elements in four alternative proteins. Results in original dried sample in µg/kg (ppb) except where indicated.

Element	Cricket Protein	Reishi Mushroom	Almond Meal	Besan Flour
Na (mg/kg)	3440	19.7	5.14	23
Mg (mg/kg)	1160	439	2880	1030
P (mg/kg)	9180	1030	5580	2490
K (mg/kg)	10100	1860	7190	8610
Ca (mg/kg)	1190	709	2370	522
Cr	**173**	**15500**	**58.2**	**61.3**
Mn (mg/kg)	**36.6**	**82.4**	**25.3**	**14.7**
Fe (mg/kg)	53.3	226	40.9	55.5
Ni	**214**	**2590**	**716**	**2210**
Cu (mg/kg)	**29.1**	**4.71**	**10.8**	**8.34**
Zn (mg/kg)	**212**	**7.27**	**29.7**	**33**
As	**36.4**	**86.5**	**23.2**	**7.76**
Se	**387**	**47.2**	**26.3**	**133**
Mo	**730**	**75.7**	**439**	**679**
Cd	**11.8**	**138**	**12.1**	**0.709**
Hg	**2.87**	**52.2**	**1.58**	**1.14**
Tl	**3.19**	**2.18**	**3.3**	**0.867**
Pb	**80.5**	**209**	**12.2**	**14.2**

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The 18 quantitative elements represent a tiny fraction of the information available from an Agilent ICP-MS system operating in He KED mode. Built-in preset methods provided with Agilent ICP-MS MassHunter software include a He mode Quick Scan acquisition, which collects data for every mass, with only two seconds of additional acquisition time.

He mode attenuates all common polyatomic ion overlaps, so the spectrum is simple, making it easy to associate each measured peak with an analyte. Secondary (qualifier) isotopes can be used to confirm the identity of unexpected elements, based on the isotope abundance template fit, as shown in Figure 2. Quick Scan spectra are automatically processed by IntelliQuant, giving semiquantitative results for all measurable elements without needing element-specific standards.

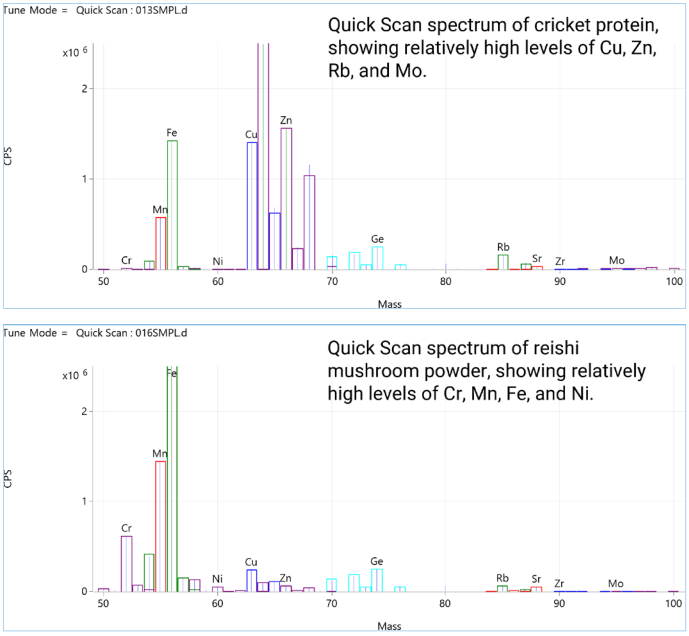

Figure 2. Mass 50 to 100 from the Quick Scan spectra for cricket protein (top) and reishi mushroom (bottom). Same intensity scale used for both. Quick Scan identifies unexpected elements, and the identity is confirmed by the isotope template match. IntelliQuant gives semiquantitative concentrations without requiring element-specific standards.

References

1. Nelson, J. McCurdy, E., ICP-MS Analysis of Heavy Metals and Other Trace Elements in Alternative Proteins Per US FDA EAM 4.7, Agilent publication, 5994-5303EN
2. Nelson, J. *et al*, Determination of Heavy Metals and Trace Elements in Alternative Meats Per EAM 4.7 Method for ICP-MS. Agilent publication, 5994-5181EN

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