thermo scientific

Metals in Food and Beverage

Identification and quantitation workflows

ThermoFisher SCIENTIFIC

Introduction to metal analysis in food

Trace elemental screening and speciation analysis of food is receiving global attention. Some elements are an essential part of a healthy diet, but others, such as lead, mercury, arsenic and cadmium, offer no nutritional benefits to humans and are toxic.

Over the past few decades the measurement of toxic, essential and nutritional elements in food has become a major topic of public interest.

Elements typically analyzed in food samples	
Essential, nutritional	Na, K, Mg, Ca, Cu, Fe, Zn
Essential, low level	Cr, Se, Mn, Co
Toxic, low level	As, Sb, Hg, Cd, Pb

As food is the primary conduit for elements to enter humans, regulators are becoming stricter and require manufacturers to monitor levels of hazardous elements in foodstuffs. The safe production and monitoring of food and related products, such as herbal medicines and dietary supplements is ever more prevalent with the increase in homeopathic and organic traditional remedies and diets. In addition, food manufacturers and suppliers are legally required to label food with ingredients and nutritional information.

This is driving industry-wide demand for fast, sensitive, reliable and cost-effective testing methods for high-throughput trace elemental analysis of food.

Once toxic elements are in the food chain, they can pose significant health risks. For this reason, it is essential to have simple and robust, analysis methods using techniques such as atomic absorption spectroscopy (AAS), inductively coupled plasma – optical emission spectroscopy (ICP-OES) and inductively coupled plasma – mass spectrometry (ICP-MS) for determination of major and minor concentrations of elements and their species in food.

Emerging areas of concern are speciation analysis of arsenic and selenium as well as nanoparticle analysis.

That is why we have created breakthrough technologies and an unrivalled range of solutions for all food and beverage customers to identify elements at ppm to sub-ppt levels with our broad portfolio of instrumentation. We help make it possible for scientists to work faster—and with the confidence and flexibility to adapt to changing demands.

Sample preparation

Although elemental analysis can be conducted directly on solid samples through coupling of ICP-OES or ICP-MS with laser ablation instruments, the majority of food materials are analyzed in liquid form as digested, dissolved or diluted samples.

Accurate Analysis of Low Levels of Mercury in Fish by Vapor Generation AA

Thermo Scientific™ Block Heater

Solid food samples cannot directly be introduced into a plasma, instead they are brought into solution. The main procedure used to dissolve food samples is acid digestion involving the dissolution of the food sample in nitric acid (HNO_3) and heating the acid using either a heating device such as the Thermo Scientific Block Heater or technologies such as microwave digestion.

Thermo Scientific™ VP100 Continuous Flow Vapor Generator

The analysis of toxic elements in food such as arsenic, mercury, antimony and selenium is driven by regulations. These require parts per trillion detection limits ensuring that contamination by toxic substances is kept to a minimum. The analytical performance of these elements can be enhanced by the use of a dedicated hydride generation sample introduction system such as the Thermo Scientific VP100.

Metal analysis in food - AAS

Atomic absorption spectrometry is still a popular choice for uncomplicated trace element analysis in food and beverages.

Flame Atomic Absorption Spectrometry (FAAS) is widely accepted in many industries which continue to utilize the unique and specific benefits of the technique for measuring elements in the ppb to ppm range. Graphite Furnace Atomic Absorption Spectrometry (GFAAS) is an established technique for measuring elements at parts per trillion (ppt) to parts per billion (ppb) concentrations with low sample volumes.

iCE™ 3300 FAAS System

A fast and easy solution, the Thermo Scientific™ iCE™ 3300 flame atomic absorption system detects essential and trace minerals in food samples. Developed to allow rapid, robust and reliable analysis, even for samples with high levels of dissolved solids or acidic content, it offers unrivalled flame sensitivity which is achieved by high efficiency nebulization via a fully inert impact bead and spray chamber.

iCE™ 3500 GFAAS System

The ideal solution if your food laboratory routinely requires ultra-sensitive detection limits from furnace analysis. The dual atomizer flame and graphite furnace AAS with both deuterium and Zeeman background correction ensure accurate detection of toxic elements as well as high concentration elements such as sodium and also water for labeling of beverage samples.

Determination of Trace Elements in Rice Products by Flame and Graphite Furnace Atomic Absorption Spectrometry

The Analysis of Cadmium in Chocolate by Graphite Furnace Atomic Absorption Spectrometry

Iron and Magnesium Determination in Meat using Flame Atomic Absorption Spectroscopy

Cadmium Determination in Crab Meat using Graphite Furnace Atomic Absorption Spectroscopy

The Analysis of Trace Elements in Honey by Flame and Graphite Furnace Atomic Absorption Spectrometry

Metal analysis in food - ICP-OES

The Thermo Scientific™ iCAP™ 7000 Plus Series ICP-OES is a powerful, easy to use instrument for users who are new to food analysis using the ICP-OES technique, offering simplicity with no compromise on performance.

ICP-OES is a fast multi-element technique with the capability to analyze 70+ elements in one analytical run and provides better sensitivity and a higher linear dynamic range than AAS. Due to its robust design it can handle complex food sample matrices without degrading detection limits for trace contaminants.

iCAP 7000 Plus Series ICP-OES

This instrument is available in two configurations: dual view and dedicated radial view. The iCAP 7000 ICP-OES Duo is typically used for food applications where low concentrations of essential and toxic elements are analyzed in axial view, while simultaneously determining nutritional and matrix components in the radial view.

For ultimate matrix robustness, as is needed in the analysis of food grade table salt for example, the iCAP 7000 ICP-OES Radial is the perfect choice since it has a vertical ceramic D-Torch that provides enhanced torch lifetime and reduces the frequency of user maintenance for routine laboratories.

Analysis of Elemental Contaminants in Beverages using the Thermo Scientific iCAP 7200 ICP-OES

Robust Single Method Determination of Major and Trace Elements in Foodstuffs Using the iCAP 7400 ICP-OES Duo

Analysis of Trace Elements in Whisky Using the Thermo Scientific iCAP 7000 Plus Series ICP-OES

Analysis of Trace Elements and Major Components in Wine with the iCAP 7400 ICP-OES

Analysis of Toxic Elements in Drinking and Bottled Waters Using the iCAP 7200 ICP-OES

Analysis of Trace Elements in Traditional Chinese Medicine (TCM)

Elemental Analysis of Canola Oil Using the iCAP 7400 ICP-OES

Ultra-Fast Agricultural Soil Analysis Using the iCAP 7600 ICP-OES Radial

Metal analysis in food - ICP-MS

The Thermo Scientific™ iCAP™ RQ ICP-MS and the Thermo Scientific iCAP TQ ICP-MS systems offer tailored solutions for all laboratories working on food analysis.

One of the main challenges of a modern food and beverage testing ICP-MS laboratory is not only to determine total concentration of a given element in a sample, but also to distinguish between different chemical forms, for example inorganic and organic forms of arsenic, or to size and quantify nanoparticles in a given sample matrix.

iCAP RQ ICP-MS

Choose this robust, high-productivity system to simultaneously measure toxic and essential trace elements for food and beverage QA/QC, while a suite of integrated software features enable regulatory compliance. Couple with a metal-free IC system to easily and accurately speciate critical elements such as arsenic and chromium.

iCAP TQ ICP-MS

For challenging food matrices or low-level analysis of heavily interfered elements such as arsenic or selenium, the iCAP TQ ICP-MS is equipped with triple quadrupole technology that enables advanced interference removal using an additional quadrupole mass filter and the option to use reactive gases such as oxygen and hydrogen.

Total Elemental Analysis of Food Samples Using the iCAP TQ ICP-MS with Autodilution

Speciation

Speciation is the process of separating and quantifying different chemical species of an element, which can exhibit very different physiochemical properties, including varying toxicities.

Speciation analysis has become important for the food and beverage industry, where simply measuring the total amount of an element is insufficient. The determination of an element´s concentration usually gives enough information to evaluate potential risks associated with the consumption of a given food. Identifying the different species and concentrations of those species provides a more informed understanding of the health related impact from foodstuffs.

Analytes that require speciation analysis:

- Arsenic – Fish and seafood, as well as rice and rice products
- Chromium – Dairy products, cereal products, chocolate, vegetables, fruits, meat, fish, eggs, and beverages
- Iodide – Milk and milk products
- Mercury – Fish and shellfish
- Selenium – Nutraceuticals and vitamin supplements

If a powerful separation technique such as ion chromatography (IC) is hyphenated to ICP-MS, it is possible to separate and detect individual species independent from each other; the result is more specific information regarding the content of a sample.

Speciation Applications Summary Ion Chromatography - Trace Elemental Species Separation and Detection

Speciation analysis of Cr (III) and Cr (VI) in drinking waters using anion exchange chromatography coupled to the Thermo Scientific iCAP Q ICP-MS

IC-ICP-MS speciation analysis of As in apple juice using the Thermo Scientific iCAP Q ICP-MS

Speciation of Bromine Compounds in Ozonated Drinking Water using Ion Chromatography and Inductively Coupled Plasma Mass Spectrometry

IC-ICP-MS Speciation Analyzer

Speciation analysis is straightforward using the iCAP RQ ICP-MS or iCAP TQ ICP-MS systems and a Thermo Scientific™ Dionex™ Aquion™, Thermo Scientific™ Dionex™ Integrion™ HPIC™ or Thermo Scientific™ Dionex™ ICS-6000 HPIC™ system. Configure the system for your budget, throughput, performance and detection requirements for your food and beverage application.

The speciation analyzer includes a metal-free IC system with high resolution ion exchange columns and simple online connectivity, together with high sensitivity ICP-MS and the integrated Thermo Scientific™ ChromControl software plug-in for the Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ (ISDS) platform software based on Thermo Scientific™ Chromeleon™ 7.2 Chromatography Data System (CDS) software so that only one software is needed to fully control the hyphenated system.

iCAP™ TQ ICP-MS

Dionex™ Aquion™ Ion Chromatography (IC) System

Dionex™ Integrion™ HPIC™ System

Dionex™ ICS-6000 HPIC™ System

System configurations

Speciation element	Dionex™ Aquion™ Ion Chromatography (IC) System	Dionex™ Integrion™ HPIC™ System	Dionex™ ICS-6000 HPIC™ System
Arsenic	◐	◔*	●*, **
Bromate	◐	●*	◔
Chromium	◔	●	◔
Mercury	◔	●	◔
Selenium	◐	◔*	●*, **

◐ Limited to inoganic species ◔ Suitable ● Recommended

*Organic species **Enhanced optimization

Nanoparticles

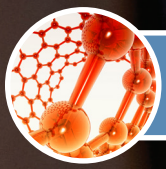
Packaging containing nanoparticles can extend the shelf life of foodstuffs, reduce the need for preservatives, and provide non-stick, easy-clean surfaces. Among them are a number of metal-containing nanoparticles made of silver, zinc oxide, titanium dioxide or magnesium. Studies have shown that nanoparticles can migrate from packaging into food.

Acidity and heating techniques can influence migration of nanoparticles into food.

An additional challenge that laboratories working in the area of food analysis are facing in recent years is the presence of nanoparticles added intentionally as food additives, for example E-171 and titanium dioxide, or present as an artefact from production or natural processes.

Characterization of Nanoparticles using ICP-MS: Advantages and Challenges for Nanoparticles in Food

Typical Performance for iCAP RQ ICP-MS for Ultratrace Elemental Analysis



Nanoparticle Characterization Via Single Particle Inductively Coupled Plasma – Mass Spectrometry (spICP-MS) Using a Dedicated Plug-in for Qtegra ISDS Software

Single particle ICP-MS (spICP-MS)

This technique allows analysts to determine the presence of nanoparticles in different food sample matrices, using our state-of-the-art analytical technologies and software.

The Qtegra Intelligent Scientific Data Solution (ISDS) Software uses the Thermo Scientific™ npQuant plug-in for spICP-MS data acquisition and evaluation. Alternatively, nanoparticles of different sizes may also be separated using Asymmetric Flow Field-Flow-Fractionation, selected models of which can be fully integrated into the ICP-MS workflow using the ChromControl plug-in.

Software

ICP-MS and ICP-OES

Minimize training, automate food and beverage analytical workflows, simplify your experience, and improve efficiency with the innovative Thermo Scientific Qtegra Intelligent Scientific Data Solution (ISDS) Software. Designed for workflow, scalability, compliance and data management, Qtegra ISDS Software provides essential tools for consistent, accurate analysis.

Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ (ISDS) Software

Designed around the four pillars of workflow, scalability, compliance and data management, the comprehensive QC protocols that Qtegra ISDS software include essential tools for consistent, accurate food and beverage analysis, with assured compliance in this highly regulated environment.

With intelligent auto-dilution, food analysis can be completely automated, from the dilution of standards over a range of samples to QA/QC procedures. Complemented by compliance there are ready features for audit control, data security, data integrity, electronic signatures and user management.

Software Enhancements

- Speciation analysis – ChromControl software provides seamless hyphenation of both ion chromatography (IC) as well as high performance liquid chromatography (HPLC) instruments, enabling full control of either device from within Qtegra.
- Nanoparticle analysis – direct sizing and counting of nanoparticles is within easy reach using the npQuant plug-in.
- Element Finder – is a tool for the iCAP 7000 ICP-OES that finds interference free wavelengths based upon selection of analyte and matrix elements. It decreases method development time drastically and makes it much simpler so that inexperienced users can set up a method in only a few minutes.
- Reaction Finder – this intuitive software for the iCAP TQ ICP-MS enables effective interference removal on key analytes via intelligent measurement mode selection. It removes the complexity from TQ technology by automatically selecting the optimum isotope, reaction gas and product ion for the target analyte via a single click selection by the user.

iCE SOLAAR Software

Our reliable and productive software assists those conducting food and beverage analysis in meeting regulatory compliance when using the iCE 3000 Series AAS.

This software uses smart wizards to walk you through various operations to quickly achieve complete instrument and method set up, ready for efficient results generation.

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