HHXRF, TXRF, MICRO-XRF

From raw materials to market

XRF Analysis Solutions for Food Quality and Safety

Innovation with Integrity

XRF Solutions for Food Quality and Safety

Bruker's portfolio of XRF analyzers includes various handheld, portable and benchtop spectrometers. They provide elemental analysis solutions to measure mineral nutrients, screen for dangerous levels of toxic elements, and identify foreign materials found in food. Our XRF spectrometers are used around the world to help ensure the quality and safety of food, from raw materials to the marketplace.

X-ray fluorescence analysis of food products

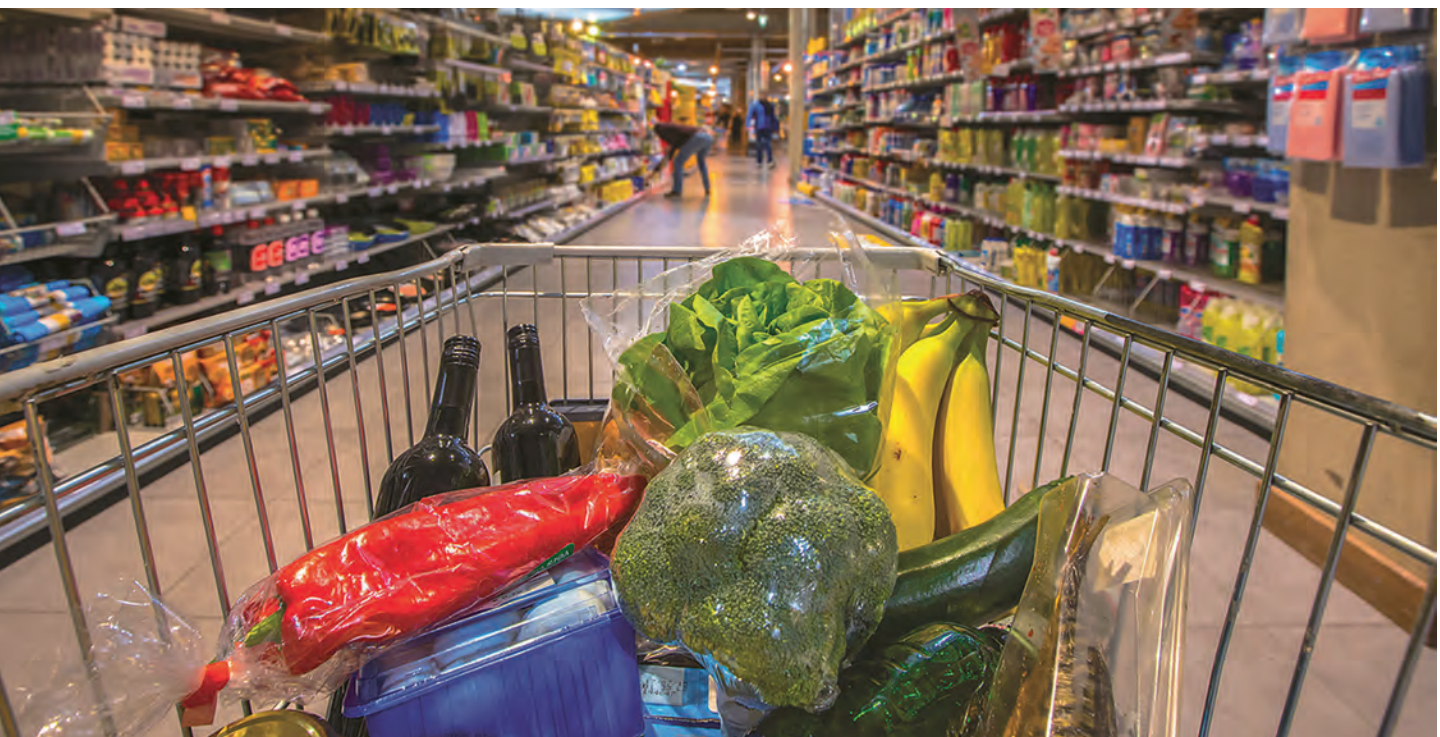
Safe and nutritious food is of primary concern to everyone, from working the farm to gathering at the table, and all the steps in between.

Knowledge about the elemental composition of food and feed products, as well as of the raw materials used in the production process, is critical for meeting modern quality and safety standards.

XRF is a non destructive elemental analysis method with minimal to no sample preparation which provides real time elemental composition data for food products such as baked goods, beverages, chocolate and confectionary, dairy, edible oils, grains, sugar and honey, animal feed, and pet food.

Several Bruker XRF instruments can be used to measure mineral nutrients and to screen for dangerous levels of heavy metals or other toxic elements, and to identify physical contaminants:

- Portable XRF spectrometers (S1 TITAN, TRACER 5, CTX) quickly monitor mineral nutrients, elemental process indicators and heavy metals in situ and they identify physical contaminants.
- Micro-XRF spectrometers (M4 TORNADO, ELIO) provide elemental density distribution maps of additives like iron or salt in food and identify physical contaminants.
- TXRF spectrometers (S2 PICOFOX, S4 T-STAR®) easily determine ultra-low elemental concentrations in liquids, solids, tissue, and other food product sample types.



Handheld, mobile, and portable benchtop XRF analyzers (HHXRF and PXRF)

S1 TITAN, TRACER 5 and CTX are the most agile XRF analyzers to simultaneously measure elements from sodium (Na) to uranium (U) at concentrations as low as parts-per-million (ppm) to high percentage levels. These analyzers can be used on samples of any form (liquid, solid, powder, film) and the analysis can be performed in any location – in a greenhouse, in the field, or even at sea. Factory ready calibrations for soils, plants and fertilizers are available. EasyCal PC software is also available for customers to develop their own calibrations.

Figure 1
Handheld, mobile, and portable benchtop XRF analyzers (HHXRF and PXRF)
Left top: S1 TITAN
Left bottom: TRACER 5
Right: CTX

Portable and laboratory benchtop micro-XRF analyzers (micro-XRF)

M4 TORNADO and ELIO are micro-XRF spectrometers providing composition and element distribution maps (2D area scans).

The high-performance laboratory spectrometer M4 TORNADO provides a small spot size (down to < 20 µm) and allows multilayer analysis (12 selectable layers). The non-contact portable ELIO has a spatial resolution of 1 mm.

Figure 2
Portable and laboratory benchtop micro-XRF analyzers (micro-XRF)
Left: ELIO
Right top: M4 TORNADO
Right bottom: M1 MISTRAL

Portable and laboratory benchtop total reflection X-ray fluorescence analyzers (TXRF)

S2 PICOFOX and S4 T-STAR® are mobile and laboratory TXRF spectrometers for ultra-trace (sub-ppb) to high percentage elemental analysis. These instruments only require very small sample amounts in the ng or µg range and have low operating costs. Moreover, these "green" analyzers do not require the use of time-consuming sample digestion with hazardous chemicals.

Figure 3
Portable and laboratory benchtop analyzers (TXRF)
Left: S2 PICOFOX
Right: S4 T-STAR®

Food Quality

Mineral Nutrients

High quality and nutritious food is of primary concern to everyone, from the farm to the table. Elemental analysis by X-ray fluorescence provides key information to help assure the presence and amount of essential and beneficial nutrients and additives, such as macro and micro nutrients.

For example, PXRF is used to accurately quantify magnesium (Mg), phosphorus (P), potassium (K), and calcium (Ca) in staple foods such as rice and cereals, as well as in beverages, snacks, and pet foods.

Handheld XRF enables the measurement of these and other elements, from ppm levels to 100%, where materials are received, on the production line, or in the lab.

The expense of animal feed and nutrition is a significant operating cost for most commercial livestock producers. To maintain an optimum balance between feed costs and productivity, ingredients are analyzed for macro-, micro- and trace mineral nutrients with X-ray fluorescence since these values are essential to formulating the rations and required supplements.

Similarly, X-ray fluorescence analysis is used to distinguish nutrient sources in pre-mixes and forages which can vary in mineral concentrations, especially of Ca, K, Mg, copper (Cu), zinc (Zn), cobalt (Co), and molybdenum (Mo).

TXRF enables the measurement of trace levels, even in the parts per billion (ppb) levels of these elements. Bruker's TXRF spectrometers achieve ICP-like detection limits without gases, hazardous chemicals, or labs with hoods and exhausts for sample preparation or analysis.

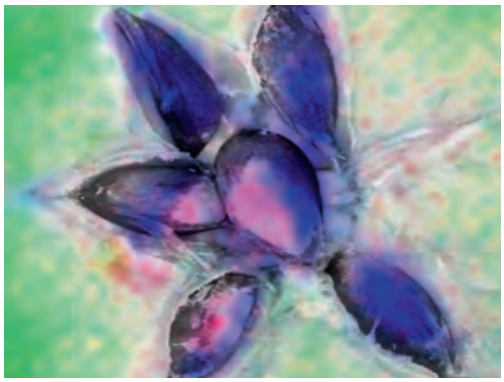


Figure 4
Analysis of an apple core with the ELIO micro-XRF spectrometer: elemental distribution map with calcium (blue), potassium (green) and sulfur (red).

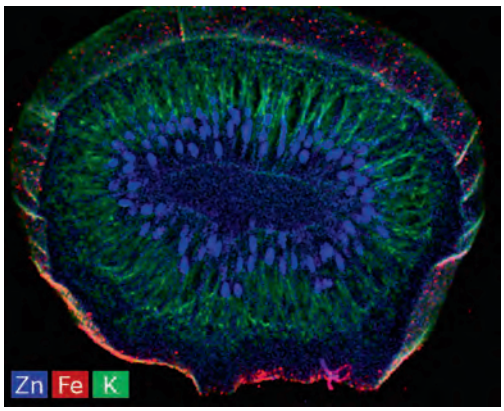


Figure 5
Analysis of a kiwi slice with the M4 TORNADO micro-XRF spectrometer: color-coded map of zinc (blue), iron (red) and potassium (green).

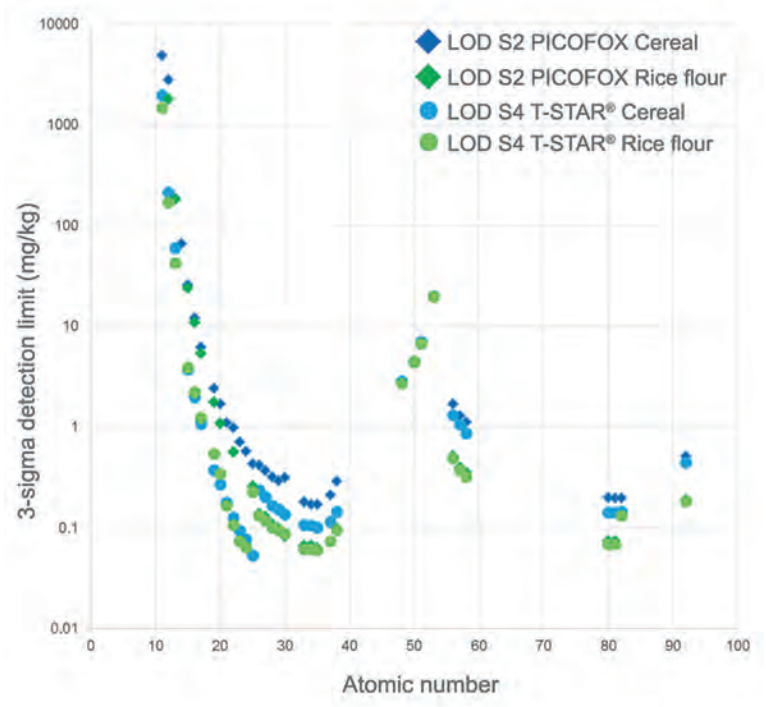


Figure 6
TXRF analyzers can achieve ICP like detection limits without gases, hazardous chemicals, or labs with hoods and exhausts for sample preparation or analysis.

Process Indicators

Additionally, XRF's ability to monitor critical process indicators is important. For example, PXRF monitoring of P in the production of edible oils is indicative of phosphatide content which determines oil quality and helps monitor the refining process, especially important during the degumming process.

Another example is monitoring Fe levels during the production of cocoa powder to ensure product safety, consistent taste, optimum nutrient content, and to help prevent accidental Fe contamination from processing equipment.

Additives

Equally important is PXRF's ability to measure additives and fortificants, such as sodium (Na) and iron (Fe), used in food products. For example, cereals and snack food are frequently fortified or enriched to enhance nutritional value as well as flavor.

Micro-XRF enables the creation of distribution maps of elements such as P, sulfur (S), iron (Fe), chlorine (Cl), sodium (Na), aluminum (Al), silicon (Si), and others on food products. This helps determine additive processing effectiveness.

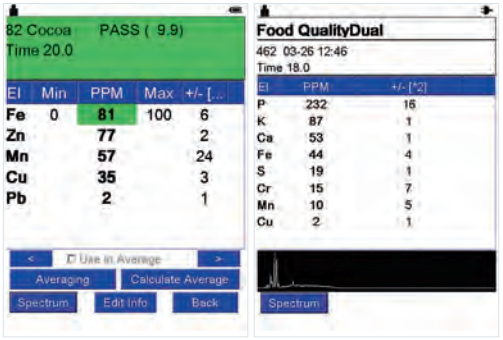
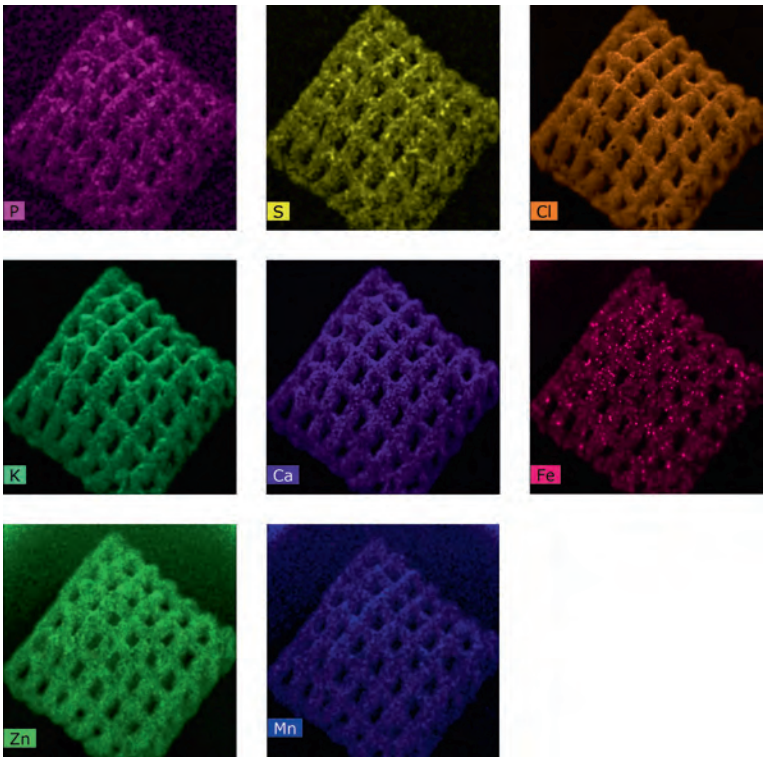


Figure 7
Portable XRF can be programmed at the factory for specific calibrations such as Fe in food products and analyze all elements in the sample simultaneously displaying the element of interest.



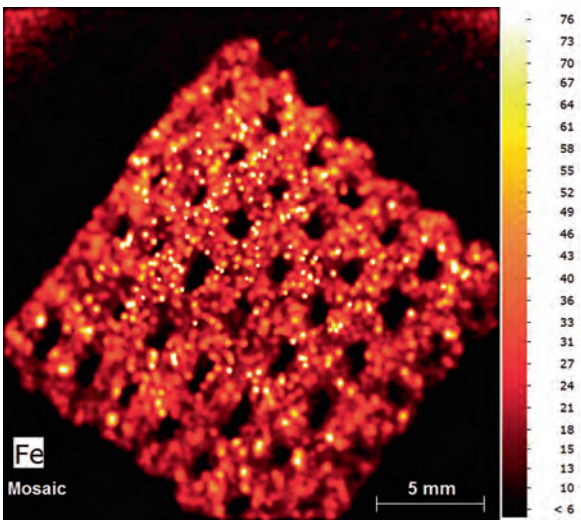


Figure 8
Micro-XRF spectral mapping can help QC inspection of salt distribution on snacks and other food products. a) Mosaic image of the potato chip with measurement area, b) element distribution maps for Na and Cl, c) element distribution map of Na with defined objects, d) spectra corresponding to the objects in c).

Food Safety

Toxic Metals

Safe food is of primary concern to everyone. The recent prevalence of contaminants and adulterated, counterfeit or fraudulent food has led to an increase in public awareness and government regulations. Although newsworthy cases highlight contaminants at high levels, even low concentration levels can be dangerous such as arsenic (As) in baby food and lead (Pb) in fruit juice.

No manufacturer wants heavy metals or other dangerous elements in their food products. However, such elements can enter production through intentional or incidental adulterants, such as Pb and chromium (Cr) in colorants or As and bromine (Br) from pesticides. PXRF, micro-XRF and TXRF technology is used to screen raw materials, goods in-process, and finished products prior to final release.

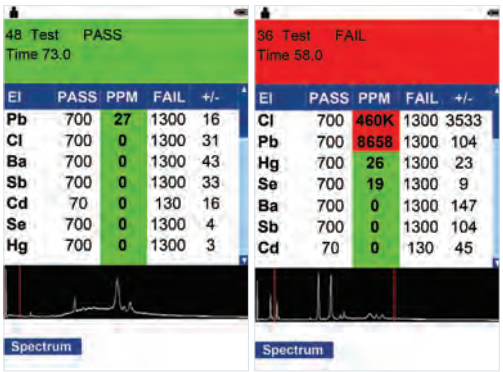


Figure 9
Portable XRF analyzers allow the input of threshold concentration values of heavy metals or other elements to enable quickly identifiable QA/QC results.

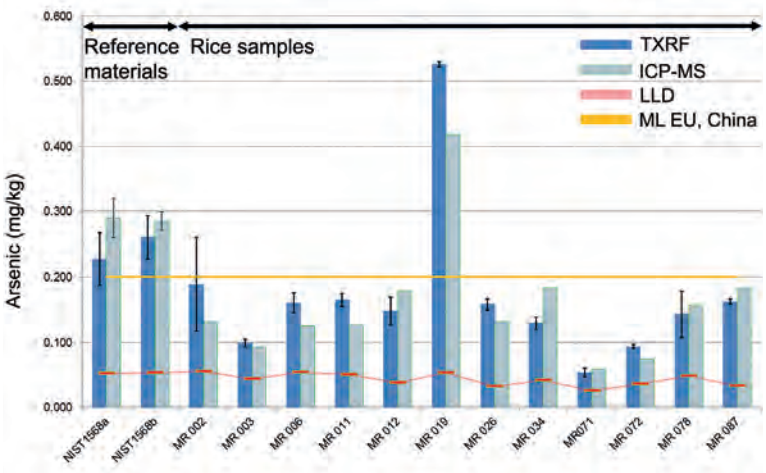


Figure 10
Recovery of As in rice, comparison of TXRF results (blue bars) with ICP-MS values (grey bars). Red line: achieved TXRF detection limits, yellow line: maximum levels (ML) of As in rice for selected regions.

Trace Elemental Contaminants

TXRF was established as a standard method for the measurement of trace elements of heavy metals in biological and environmental samples on the production line or in the lab, e.g., arsenic (As), cadmium (Cd), mercury (Hg), and lead (Pb) on the production line or in the lab.

TXRF analysis is extremely beneficial in monitoring elements which are nutritiously important at low levels, but very dangerous at slightly higher levels, such as selenium (Se) in feed, mother's milk, solid and liquid supplements, and wheat products.

The analysis of As in rice is becoming an important task in developing countries and in remote areas, using TXRF complicated sample preparation procedures, calibrations and data evaluation can be avoided.

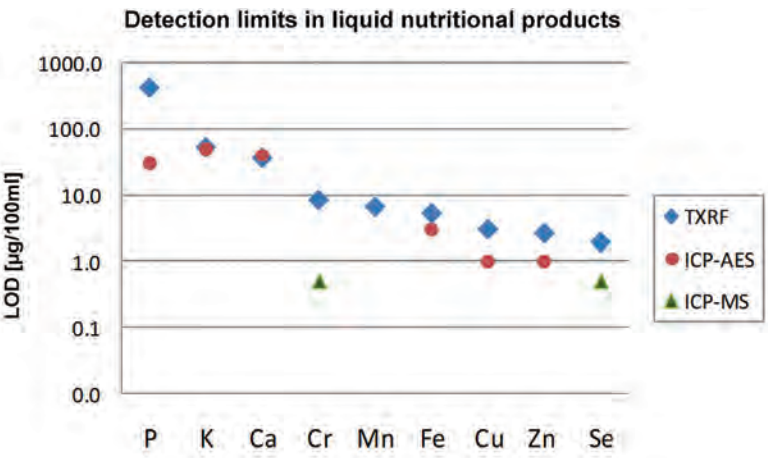


Figure 11
TXRF analyzers are especially helpful for situations where the elemental concentration of what is safe comeraed to what is dangerous is a narrow margin.

Foreign Body Identification

A very important aspect in the production of food is the avoidance of physical contamination. Foreign bodies found in food products need to be identified to be able to determine their source for taking corrective action in a timelier manner.

Foreign objects can enter food products from the wear and tear of production line equipment. Sources of physical contaminants are typically augers, conveyors, grinders or cutters, mixers, roller mills, and sorting and packaging equipment. The most common foreign bodies found are slivers of metal, chips of stone or ceramic, small shards of glass and even bits of plastic or rubber depending on the process.

Of course, food manufacturers have measures in place to prevent contaminants from getting into the finished goods. Typical prevention of physical contaminants incorporate inspection during production. This is usually achieved with an X-ray or metal detector. When a foreign body is detected, the product containing it is removed.

Enhanced prevention procedures include identifying the found contaminant to determine its source. Consequently, PXRF and micro-XRF instruments are used to identify foreign physical contaminants (Foreign Body Identification) found as quickly as possible to decrease the time it takes to locate the contaminant source. This ability can be a substantial cost savings as it helps to determine if the contaminant is from faulty equipment, starting material, or even a false claim.

Figure 12
Yoghurt containing physical contamination.

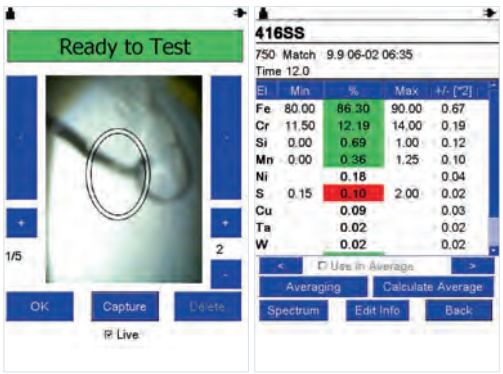
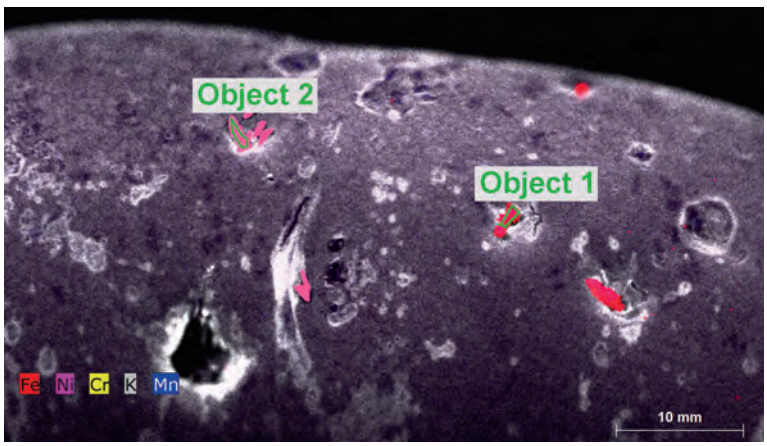


Figure 13
For the foreign body identification, handheld XRF analyzers need only four simple steps to identify a metal object from preparing the found object to test and view results. The found object is a dangerous metal sliver.



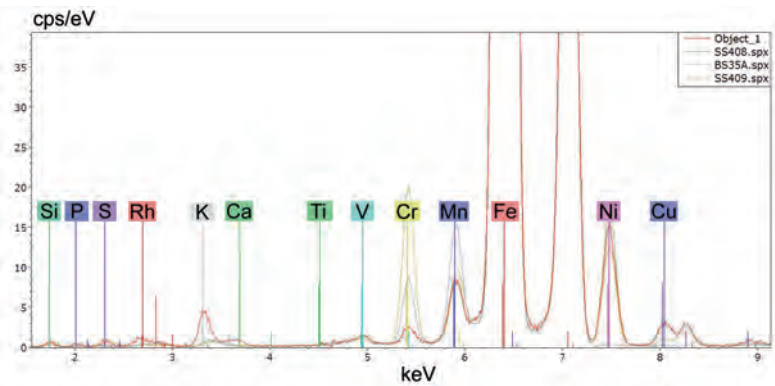


Figure 14
Surface contamination analysis on a raw potato. Micro-XRF elemental distribution map of a potato with different metal contaminants and spectrum of Object 1 with possible alloy database matches. The M4 TORNADO is a critical tool for indentifying very small objects (<20 µm) and is also particularly helpful to identify glass materials.

Further Information

Handheld/mobile/portable X-ray fluorescence (HHXRF and PXRF) spectrometers have the capability to non-destructively qualify or quantify nearly any element from fluorine to uranium, depending on specific instrument configurations.

- S1 TITAN
- TRACER 5
- CTX

www.bruker.com/hhxrf

Micro-X-ray fluorescence (micro-XRF) spectrometers are the instruments of choice for the elemental analysis of non-homogeneous or irregularly shaped samples as well as small objects or even inclusions.

- M4 TORNADO
- ELIO

www.bruker.com/micro-xrf

Total reflection X-ray fluorescence (TXRF) spectrometers are well-established for the ultra-trace element analysis on a variety of samples and very small sample amounts in the µg, ng or pg range. The transportable instruments can be used in field and laboratory.

- S2 PICOFOX
- S4 T-STAR®

www.bruker.com/txrf

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