

8. OTHER METALS IN FOOD: NICKEL, CHROMIUM, ALUMINIUM AND OTHER ELEMENTS

ORIGINS, CHEMICAL FORMS, DIETARY EXPOSURE AND RISK ASSESSMENT

Metallic elements and metalloids occur in the environment at widely varying concentrations. Some are essential nutrients; others have no recognised biological function in humans. Their presence in a food does not, by itself, demonstrate abnormal contamination or make it possible to predict harm to health. Interpreting a result requires, at a minimum, knowledge of the element's chemical form, concentration, amount and frequency of consumption, bioavailability and characteristics of the exposed individual.

This chapter focuses on nickel, chromium and aluminium, with a brief discussion of other elements that may warrant targeted testing. Arsenic, cadmium, lead and mercury are covered separately in other chapters of the library.

1. HOW METALS ENTER FOOD

Some metals originate naturally from rocks, soils and water. Their availability to plants depends on mineralogy, pH, redox potential, organic matter and uptake processes. Other potential sources include industrial emissions, atmospheric deposition, irrigation, certain materials used in agriculture and transfer during processing, packaging or domestic preparation. A natural origin does not necessarily mean that a substance is harmless, just as an anthropogenic origin does not automatically establish that exposure is hazardous.

Along the food supply chain, contamination of raw materials must be distinguished from migration from food-contact materials. Cookware, utensils, surfaces and packaging may contribute under specific conditions; the extent of release depends on the material, the food's acidity, temperature, contact time and surface condition. It is not appropriate to attribute every measured concentration indiscriminately to metal containers.

2. NICKEL: OCCURRENCE IN FOOD AND SENSITISED INDIVIDUALS

Nickel (Ni) occurs naturally in many soils and can be taken up by plants. Relatively high concentrations may be found, depending on origin and product, in cocoa and chocolate, pulses, nuts, seeds and certain cereals. Concentrations also vary within the same food category. An absolute ranking of the "most contaminated foods" without comparable data may therefore be misleading.

In its 2020 assessment, EFSA established a tolerable daily intake (TDI) for chronic oral exposure of 13 micrograms per kilogram of body weight per day. The TDI is a

toxicological reference point for assessing repeated exposure, not a maximum permitted nickel concentration in individual foods. The same assessment recognised a separate concern: in individuals already sensitised to nickel, acute oral exposure can trigger flare-ups of eczema. For this effect, EFSA used a margin-of-exposure approach rather than a universal acute reference dose.



Cutaneous sensitisation to nickel does not automatically imply food intolerance. Any dietary restrictions should be assessed with a healthcare professional, particularly because many sources of nickel are also nutritionally valuable foods. There is no scientific justification for recommending a low-nickel diet indiscriminately to the entire population.

3. NICKEL: NEW EUROPEAN PROVISIONS

Commission Regulation (EU) 2024/1987 amended Regulation (EU) 2023/915 by introducing maximum levels for nickel in specified food categories, including nuts, certain vegetables, pulses, oilseeds, cocoa and cocoa products, foods for infants and young children, and cereals. The provisions generally apply from 1 July 2025; for certain cereal categories, the date of application is 1 July 2026. The levels differ across

categories. To establish compliance, the relevant entry in the Annex and any notes concerning the edible portion or product in question must be consulted.

Compliance with a maximum level means that the applicable legal requirement is met; it does not mean that nickel is absent or that a sensitised individual cannot experience a reaction. Conversely, quantifying nickel in a food does not amount to non-compliance: the result must be compared with the relevant legal category, where one exists, while taking analytical uncertainty into account.

4. CHROMIUM: WHY CHEMICAL FORM IS CRUCIAL

Referring simply to “chromium” can obscure essential toxicological differences. Trivalent chromium, Cr(III), and hexavalent chromium, Cr(VI), have profoundly different properties and hazard profiles. Cr(VI) is particularly relevant when assessing environmental and industrial contamination; the risk associated with Cr(VI) must not automatically be attributed to total chromium measured in food.

In its 2014 opinion, EFSA assumed that chromium in food was present as Cr(III) and found estimated dietary exposures to be far below the tolerable daily intake of 0.3 mg/kg body weight per day identified in that assessment. For Cr(VI), EFSA separately considered exposure primarily through water. The authors highlighted the need for better data on chromium speciation in food and water.

Analysis of total chromium can be useful for screening, but it cannot, on its own, identify the proportions present as Cr(III) and Cr(VI). Where there is a substantiated suspicion of specific contamination, validated speciation methods are needed, together with safeguards against chemical transformations of the sample during collection and preparation.

5. ALUMINIUM: NATURAL SOURCES, ADDITIVES AND MATERIALS

Aluminium (Al) is one of the most abundant elements in the Earth’s crust. It may enter the diet through its natural occurrence in raw materials, certain additives authorised for specific uses and under specified conditions, and migration from food-contact materials. However, concentration and the fraction actually absorbed are not the same: some ingested aluminium has relatively low bioavailability, which varies according to its chemical form and the food matrix.

In its 2008 assessment, EFSA established a tolerable weekly intake (TWI) of 1 mg/kg body weight per week. The weekly timeframe also reflects considerations relating to the element’s persistence in the body. EFSA noted that some estimates of exposure, particularly among children, could exceed this value. This points to the need to monitor

overall exposure, not to a conclusion that any single consumption occasion necessarily causes harm.



Aluminium containers and foil may release greater amounts under certain conditions, such as prolonged contact with highly acidic or salty foods at high temperatures, particularly when the product is not designed for that use. Manufacturers' instructions should be followed. Exposure assessments must also avoid inappropriately adding together total-aluminium measurements and hypothetical contributions from every possible source.

6. OTHER ELEMENTS: TIN, COPPER AND MANGANESE

Tin may be relevant in foods stored in tin-plated metal containers, particularly where the condition of the coating and storage conditions favour migration. Inorganic tin must be distinguished from organotin compounds, which have different origins and toxicological properties. Regulation (EU) 2023/915 establishes maximum levels for inorganic tin in specific categories of canned foods; these limits should not be applied indiscriminately to all foods.

Copper and manganese, by contrast, are essential elements: the body requires them in appropriate amounts, whereas excessive intake may be undesirable. For both, interpretation calls for nutritional and toxicological context rather than the assumption that detection alone constitutes contamination. Their relevance depends on the circumstances and may justify targeted testing of water, raw materials or specific products.

7. WHAT LABORATORIES MEASURE

Techniques such as ICP-MS and ICP-OES can measure numerous elements, often at very low concentrations. A result expressed in mg/kg or µg/kg indicates the amount of the element measured in the matrix, but not necessarily its chemical form, bioavailability or the consumer's actual exposure. Speciation analysis requires different protocols and appropriate quality controls.

It is essential to report the limit of quantification (LOQ), the matrix analysed, sample preparation and measurement uncertainty. For results below the LOQ, "not quantified" does not mean "absolutely absent". Sampling matters too: a single lot or sample cannot, without further evidence, represent all products of the same origin, brand or category.

8. OFFICIAL CONTROLS: VALUE AND LIMITATIONS

Public controls, food businesses' own-check systems and European legislation are essential prevention tools. Maximum levels are established for specific foods and contaminants on the basis of toxicological assessments, occurrence data, feasibility and risk-management considerations. Not every element has a harmonised limit for every food, and a legal requirement may concern total content rather than a particular chemical species.

A compliant product is not, by definition, free of metals; an exceedance or unexpected result, meanwhile, requires proper regulatory and analytical verification. Assessment of an individual's health risk also depends on habitual consumption, body weight, other sources of exposure and specific vulnerabilities. Regulatory maximum levels and toxicological reference values answer different questions and must not be confused.

9. HOW TO INTERPRET A FOOD TEST RESULT

To interpret a laboratory report correctly, the following questions should be asked: which element, and where relevant which chemical form, was measured? How representative is the sample? Which units are used and what is the LOQ? Is there a maximum level applicable to the precise food category? What would exposure be, given the portion size

and frequency of consumption? Is this a general risk or a particular situation, such as nickel sensitisation?

Transparency of analytical data—also an important principle for consumer-information models based on lot testing—helps people make informed choices. It must nevertheless be accompanied by cautious interpretation: not all detectable substances have the same significance, and mere measurability is not a diagnosis of danger.

10. CONCLUSIONS

Nickel, chromium and aluminium illustrate three different issues. For nickel, both chronic exposure and the response of previously sensitised individuals are central; for chromium, oxidation state is a decisive factor; for aluminium, overall exposure must be assessed, including contributions from materials and authorised uses. It is therefore not scientifically appropriate to discuss “metals in food” as though they all had uniform toxicity.

The most robust strategy combines official controls, representative analyses, knowledge of chemical forms, a varied diet and accurate communication. Information about residues should improve prevention, not turn every positive test result into a cause for alarm.

SCIENTIFIC AND REGULATORY REFERENCES

1. EFSA CONTAM Panel (2020). Update of the risk assessment of nickel in food and drinking water. EFSA Journal 18(11):6268. <https://doi.org/10.2903/j.efsa.2020.6268>
2. European Commission (2024). Commission Regulation (EU) 2024/1987: maximum levels of nickel in certain foodstuffs. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32024R1987>
3. European Commission (2023). Commission Regulation (EU) 2023/915: maximum levels for certain contaminants in food (consolidated text). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32023R0915>
4. EFSA CONTAM Panel (2014). Scientific Opinion on the risks to public health related to the presence of chromium in food and drinking water. EFSA Journal 12(3):3595. <https://doi.org/10.2903/j.efsa.2014.3595>
5. EFSA AFC Panel (2008). Safety of aluminium from dietary intake. EFSA Journal 754, 1–34. <https://doi.org/10.2903/j.efsa.2008.754>
6. EFSA (2008). EFSA Advises on the Safety of Aluminium in Food. <https://www.efsa.europa.eu/en/news/efsa-advises-safety-aluminium-food>