

6. LEAD IN FOOD

ORIGIN, CONTAMINATION, EXPOSURE AND HEALTH RISKS



WHAT IS LEAD AND WHY CAN IT BE PRESENT IN FOOD?

Lead (Pb) is a chemical element naturally present in the Earth's crust. It has no essential biological function in the human body and, under certain exposure conditions, can cause toxic effects. Its presence in the environment results from both geological processes and human activities, including mineral extraction and processing, metallurgy, some industrial operations, and the historical use of lead in petrol, paints and pipes.

It would be incorrect to interpret every detection of lead in food as evidence of a recent pollution event. In some settings, natural sources contribute to its presence; elsewhere, contamination from human activities predominates, even when it occurred many years earlier. Because lead is an element rather than a biodegradable organic molecule, it

does not disappear through biodegradation. However, its chemical form, mobility and environmental availability may change.

HOW LEAD ENTERS THE FOOD CHAIN

Lead can reach crops through soil particles adhering to surfaces, deposition of airborne dust, or uptake by roots. The amount actually transferred to edible plant parts depends on many factors, including plant species, soil characteristics, pH, organic matter and the chemical form of the metal. Its presence in soil therefore does not automatically imply an equivalent concentration in agricultural produce.

In foods of animal origin, possible pathways include feed, water and ingestion of environmental particles. Game animals shot with lead-containing ammunition are a particular case: even very small metallic fragments can remain in the meat and produce high, unevenly distributed concentrations.



Lead-containing hunting ammunition can leave metallic fragments in the meat of wild game.

Contact with unsuitable materials, ceramic glazes or equipment containing lead is another potential source, distinct from agricultural contamination.

Drinking water can also contribute to exposure, particularly where old pipes, solder joints or fittings release lead. In this case, concentrations depend on the characteristics

of the plumbing system and the water itself, not solely on the quality of the water at its source.

WHICH FOODS MAY CONTRIBUTE MOST TO EXPOSURE?

There is no universally valid ranking of the “most contaminated” foods. A distinction must be made between foods that occasionally contain high concentrations and those that, although they contain modest amounts, are eaten frequently and therefore contribute to overall exposure.

The EFSA report published in 2025, based on data collected in Europe between 2013 and 2023, identifies particularly high concentrations in some samples of game meat. For adults, it identifies certain meat-based foods and bread and similar products among contributors to dietary exposure. For young children, cereal-based foods intended for infants and young children may also be relevant, together with other food categories depending on dietary surveys. These findings describe specific populations, scenarios and eating habits: they do not mean that all meat, all bread or all infant foods are particularly contaminated.

Spices, dried herbs, supplements and other concentrated ingredients warrant specific attention when they come from poorly controlled supply chains. However, contaminant concentrations must always be interpreted alongside the amount actually consumed and frequency of use.

PRESENCE, EXPOSURE AND RISK: THREE DIFFERENT CONCEPTS

Presence means that an analysis has detected lead in a sample, potentially quantifying its concentration in mg/kg or µg/kg. Dietary exposure, by contrast, depends on the amount ingested, frequency of consumption and body weight. Health risk concerns the likelihood and severity of adverse effects associated with exposure, also taking age and individual vulnerability into account.

For example, two foods with the same lead concentration may contribute very differently to exposure if one is eaten every day and the other only occasionally. Similarly, the same amount ingested represents a higher exposure relative to body weight for a young child than for an adult.

Lead deserves particular caution because, for several critical effects, no exposure threshold has been identified below which the absence of effects can be guaranteed. This does not mean that a single detection at a very low concentration necessarily

causes measurable harm. Rather, it points to the need to reduce avoidable exposure over time.

HEALTH EFFECTS AND MORE VULNERABLE GROUPS

The developing nervous system is one of the main targets of lead toxicity. Scientific assessments highlight possible effects on children's cognitive and neurobehavioural development. In adults, prolonged exposure is associated, among other outcomes, with effects on blood pressure, the cardiovascular system and kidney function. During pregnancy, the mobilisation of lead previously stored in the mother's bones is also relevant.

Effects depend on total exposure, which may include food, water, dust, the home environment and occupational activities. An analytical result for a single food therefore cannot, on its own, diagnose lead poisoning or quantify an individual's risk.

WHAT THE MOST RECENT EUROPEAN DATA SHOW

In its 2025 report, EFSA initially considered 288,239 analytical results for lead in food and drinking water and used food consumption surveys from 23 European countries. In the scenario that also included extreme values observed in some game meats, the highest reported mean exposure estimate for children aged one to three years was 1.80 µg/kg body weight per day; for infants, the highest 95th-percentile estimate reached 3.36 µg/kg body weight per day. These are exposure estimates, not concentrations measured in an individual food or safety thresholds.

Compared with the 2012 EFSA assessment, some exposure estimates are lower. However, this comparison is also influenced by improved methods, differences in datasets and changes in eating habits. Analysis of historical data suggests declining lead levels in numerous food categories and possible increases in certain others; EFSA nevertheless identifies statistical uncertainties that preclude simplistic interpretations of these trends.

EU MAXIMUM LEVELS AND WHAT COMPLIANCE MEANS

In the European Union, Regulation (EU) 2023/915, as subsequently amended, establishes maximum levels of lead for numerous food categories. The limits are not necessarily the same for all products: they depend on the food matrix and, in some

cases, intended use, as with foods for infants and young children. Compliance must be assessed against the specific applicable regulatory entry and its accompanying notes.

Exceeding a maximum level makes a food non-compliant for marketing purposes under the conditions set out in the legislation. A result below the limit, by contrast, establishes compliance for that parameter and food category, but does not mean “no lead” and is not equivalent to a complete assessment of an individual’s exposure. Legal limits are tools for risk management and contamination reduction along the food supply chain; they must not be mistaken for sharp boundaries between biologically harmless and harmful quantities.

OFFICIAL CONTROLS, ANALYSIS AND UNCERTAINTIES

Official controls and food business operators’ own checks are essential for verifying compliance, detecting problems and improving supply-chain safety. Sensitive analytical techniques are used to measure lead, including inductively coupled plasma mass spectrometry (ICP-MS), within validated methods and appropriate sampling procedures.



Each result must be interpreted in light of the limit of quantification (LOQ), measurement uncertainty, sample representativeness and possible variation within the batch. The latter can be especially important when contamination arises from localised particles or

fragments. A result “below the LOQ” does not demonstrate the absolute absence of lead; it means only that its concentration cannot be quantified by the particular method under the conditions used.

EFSA also emphasises that exposure assessments depend on the geographical and temporal coverage of sampling, food consumption data, treatment of results below analytical limits, and available information on food preparation. Acknowledging these limitations does not call the usefulness of controls into question: it allows their scope to be understood correctly and helps improve the quality of available information.

HOW TO REDUCE EXPOSURE WITHOUT CAUSING ALARM

The most effective prevention starts with controlling contamination sources: the quality of agricultural soils and water, emission controls, appropriate food-contact materials and supplier verification. For consumers, a varied diet, attention to product origin and caution about routinely using supplements or preparations from uncertain sources are reasonable precautions. Washing vegetables can remove some surface soil and dust particles, but it cannot remove lead that has been taken up into plant tissues.

People who regularly eat game, especially when serving it to children or pregnant women, should consider the specific risk linked to lead ammunition. Cooking does not destroy the chemical element and does not guarantee its removal. For domestic water, problems related to old plumbing require targeted checks and action to address the sources of lead release.

KNOWING THE CONCENTRATION TO MAKE INFORMED CHOICES

Contaminant testing does not automatically turn a food into a “safe” or “dangerous” product: it adds verifiable information. Knowing the result, the sensitivity of the method and the criteria applied makes it possible to distinguish compliance with legal requirements from more restrictive voluntary standards. The latter represents a choice about quality and transparency, but does not in itself demonstrate a clinical benefit.

The purpose of accurate scientific communication is not to assign undifferentiated risks to entire food categories, but to explain where substances come from, how they behave along the supply chain and what analytical measurements really mean.

SCIENTIFIC AND REGULATORY REFERENCES

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