

OCHRATOXIN A, PATULIN AND OTHER MYCOTOXINS

Aflatoxins are not the only mycotoxins of concern in food. Other substances produced by microscopic fungi can contaminate cereals, fruit and processed foods. Ochratoxin A and patulin deserve particular attention because of the food matrices in which they occur and their different toxicological profiles. Lesser-known compounds, including citrinin and some *Alternaria* toxins, are also subjects of evolving scientific and regulatory knowledge.

OCHRATOXIN A: ORIGIN AND AFFECTED FOODS

Ochratoxin A (OTA) is produced by certain *Aspergillus* and *Penicillium* species. Contamination may occur under different conditions depending on the fungal species, environment and product. OTA has been detected in cereals and cereal products, raisins and other dried fruits, coffee, cocoa, spices, wine and other foods. A category being potentially susceptible does not mean that every product in it contains OTA.

Formation may depend on humidity, temperature, raw-material condition and harvesting, drying and storage practices. OTA is relatively stable under many processing conditions: certain treatments can reduce concentrations, but roasting, cooking or fermentation cannot be assumed to eliminate it completely. Prevention throughout the supply chain therefore remains essential.

OCHRATOXIN A: WHAT IS KNOWN ABOUT HEALTH EFFECTS?

In experimental studies, the kidney is an important target organ of OTA toxicity. Kidney tumours have also been observed in laboratory animals. EFSA's 2020 assessment identified evidence of genotoxicity while stressing that the mechanisms of genetic damage and potential carcinogenicity are not fully understood.

For this reason EFSA moved away from the previous tolerable weekly intake approach and used the margin of exposure (MOE), comparing levels associated with effects in studies with estimated population exposure. The assessment identified health concerns for several consumer groups. This is an exposure-based risk assessment, not proof that any individual compliant food causes harm.

PATULIN: APPLES AND JUICES

Patulin is a mycotoxin produced by several moulds, including *Penicillium*, *Aspergillus* and *Byssoschlamys* species. It is particularly associated with damaged or rotten apples and products made from inadequately sorted fruit, such as juices, purées and other apple products. It may also occur in other matrices.

PATULIN: THE CRITICAL POINT IS THE RAW MATERIAL

Example of the supply chain for apples intended for juices and purées



Removing visible rot does not demonstrate the absence of the toxin.

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Part of the problem is that spoiled fruit can enter processing and, once formed, the toxin may pass into the liquid or processed product. Removing only visibly damaged areas does not analytically guarantee the absence of patulin: effectiveness also depends on the extent of damage and internal contamination. Fruit sorting, storage conditions and final-product testing are therefore important for producers.

Experimental findings mainly describe toxic effects on various organs and the gastrointestinal tract, as well as immune effects. Some studies have investigated genotoxicity, but carcinogenicity in humans has not been demonstrated. Patulin should not be assigned the same risk profile as aflatoxins: these are different substances requiring separate assessments.

Selection of fruit to reduce patulin

Fruit suitable for processing



- Healthy and intact
- No signs of mould
- Lower risk of patulin in the final product

Fruit to discard



- Damaged or altered
- With visible mould
- Higher risk of patulin contamination

WHY FOODS FOR CHILDREN REQUIRE PARTICULAR ATTENTION

For infants and young children, exposure per kilogram of body weight may be higher, particularly when a food category is consumed frequently. European legislation therefore provides specific, more stringent maximum levels of patulin for specified apple juices, apple products and infant foods than for certain products intended for the general population. This does not mean that drinking apple juice occasionally is inherently dangerous: controls address toxin levels and overall exposure.

CITRININ: A DISTINCT MYCOTOXIN

Citrinin can be produced by fungi belonging to several genera, including *Penicillium* and *Monascus*. Toxicological interest focuses especially on possible kidney effects observed experimentally. One specific regulatory case concerns food supplements based on red yeast rice fermented with *Monascus purpureus*, for which EU contaminants legislation sets a maximum citrinin level.

Citrinin must be distinguished from monacolins that may also occur in these products: they are different compounds, with different safety concerns and regulatory provisions. Obtaining a supplement through traditional fermentation does not remove the need for analytical controls.

ALTERNARIA TOXINS: EVIDENCE STILL DEVELOPING

Certain *Alternaria* species produce metabolites that may occur in cereals, oilseeds, fruit, vegetables and processed products. Among the most studied are alternariol (AOH), alternariol monomethyl ether (AME), tenuazonic acid (TeA) and tentoxin (TEN). Reports include tomato-based products and some cereal matrices.

EFSA has examined the available dietary exposure data and identified significant uncertainties, partly owing to limited sample coverage and a high proportion of results below quantification limits. Their occurrence therefore warrants scientific attention, but each detection cannot be treated as proof of a demonstrated health risk. It would also be wrong to regard all *Alternaria* metabolites as toxicologically equivalent.

EUROPEAN LIMITS: NO SINGLE VALUE FOR ALL FOODS

Regulation (EU) 2023/915, together with applicable amendments, sets maximum levels for several mycotoxins in specified foods. Ochratoxin A has differentiated limits for numerous matrices. For patulin, illustrative limits include 50 µg/kg for many fruit juices, 25 µg/kg for certain solid apple products intended for consumers and 10 µg/kg for specified foods for infants and young children. For citrinin, the Regulation specifies 100 µg/kg for food supplements based on rice fermented with *Monascus purpureus*.

These figures illustrate the system rather than providing an exhaustive table applicable to every formulation: assessment of compliance requires precise identification of the

product category and the current version of the legal Annex. A statutory maximum is neither a desirable contamination target nor a universal threshold of zero risk.

MULTIPLE CONTAMINANTS AND TARGETED TESTING

A raw material may contain more than one contaminant, but absence of one does not establish absence of the others. An analysis targeting OTA does not automatically describe the situation for patulin or Alternaria toxins. The choice of analytes should be based on the matrix, provenance, production process and available evidence about relevant hazards.

Sampling also matters: contamination may not be uniformly distributed, and an unrepresentative sample can give a misleading picture. Analytical findings must be interpreted alongside prevention and traceability, without confusing 'not quantified by this method' with 'absolutely absent'. Sampling procedures and analytical criteria are explored further in the chapter on controls.

KEY POINTS TO REMEMBER

Ochratoxin A, patulin, citrinin and Alternaria toxins show why it is misleading to describe mycotoxins as a single, undifferentiated threat. Their fungal producers, affected foods, toxicological mechanisms, knowledge gaps and EU provisions differ. Sound assessment always starts with the combination of the particular substance, measured concentration, food consumed and level of exposure.

SCIENTIFIC AND REGULATORY REFERENCES

- [EFSA CONTAM Panel \(2020\). Risk assessment of ochratoxin A in food. EFSA Journal 18\(5\):6113.](#)
- [EFSA \(2020\). Ochratoxin A in food: public health risks assessed.](#)
- [WHO \(2023\). Mycotoxins – fact sheet.](#)
- [EFSA \(2016\). Dietary exposure assessment to Alternaria toxins in the European population. EFSA Journal 14\(12\):4654.](#)
- [European Commission. Regulation \(EU\) 2023/915, Annex I, sections 1.2, 1.3 and 1.7; consult the current consolidated text.](#)
- [European Commission. Contaminants in food – legislation and regulatory updates.](#)