

5. FUSARIUM MYCOTOXINS IN CEREALS

Wheat, maize, barley and oats are staple foods in many countries. Yet they can be colonised in the field by *Fusarium* fungi, which can produce mycotoxins under certain conditions. There is no single 'Fusarium toxin': these substances differ in structure, the foods affected and biological effects. Understanding them explains why cereal testing must be targeted and why an apparently normal harvest is not necessarily contaminant-free.

FUSARIUM: CONTAMINATION OFTEN BEGINS BEFORE HARVEST

Several *Fusarium* species occur in agricultural environments and may infect ears and grains. *Fusarium* head blight in wheat and ear infections in maize are important examples. Rain and humidity at particular growth stages, temperature, varietal susceptibility, crop residues and rotation influence risk, but not equally for every species and toxin.

Fungal mycelium and toxic metabolites are not distributed uniformly. Different portions of a batch may have very different concentrations. Proper storage is essential for preserving the product but does not remove mycotoxins already formed in the field. Agronomic prevention, grain sorting and representative sampling are therefore complementary.

DEOXYNIVALENOL (DON): ONE OF THE MOST MONITORED WHEAT CONTAMINANTS

Deoxynivalenol, or DON, sometimes called 'vomitoxin', belongs to the trichothecenes. It is particularly associated with small-grain cereals, especially wheat, but may also occur in maize and other cereals. Dietary exposure arises through grain and its products, including flour, bread, pasta and other cereal foods, to an extent influenced by raw materials and processing.

Studied effects include nausea and vomiting following sufficiently high acute exposure. For chronic toxicity, assessments particularly consider effects on growth and body weight observed in experimental studies. In 2017 EFSA established a group tolerable daily intake of 1 microgram per kilogram of body weight per day ($\mu\text{g/kg bw/day}$) for DON and certain related forms. This concerns total exposure, not the permitted concentration in any one food.

DON in flour does not automatically imply a risk to consumers: measured concentration, the amount eaten and frequency of exposure must all be considered. Children may have relatively higher exposure per kilogram of body weight.

ZEARALENONE (ZEN): A MYCOTOXIN WITH OESTROGENIC ACTIVITY

Zearalenone is produced by certain *Fusarium* species and can affect maize, wheat and other cereals. Unlike DON, its principal toxicological action involves interaction with hormonal systems: it has oestrogenic activity. Effects and sensitivity differ between animal species. Experimental data are important for risk assessment but must not automatically be extrapolated to humans.

EFSA established a tolerable daily intake of 0.25 µg/kg bw/day and subsequently considered metabolites and modified forms in assessing their relative activity. This does not mean that a single minimal exposure causes endocrine disruption; rather, precautionary assessments consider dietary contributions over time.

FUMONISINS: THE PARTICULAR ROLE OF MAIZE

Fumonisin, especially fumonisin B1 (FB1) and B2 (FB2), are closely associated with maize and maize products. Some fungi producing them can colonise a plant without easily recognisable visible changes. Maize products therefore warrant specific controls regardless of appearance.

Fumonisin interferes with sphingolipid metabolism, important for cell membranes. Experimental studies have shown effects on the liver and kidneys; assessment of possible human effects distinguishes established evidence from epidemiological associations that remain uncertain. EFSA established a group tolerable daily intake of 1 µg/kg bw/day for certain fumonisins.

T-2 AND HT-2 TOXINS: ATTENTION TO OATS AND BARLEY TOO

T-2 and HT-2 are also trichothecenes, but must not be confused with DON: they differ in potency and toxicological profile. They are particularly relevant to certain cereals, including oats and barley, though not exclusively. HT-2 is also a major metabolite of T-2.

These substances can interfere with protein synthesis, and toxicological assessments consider effects on the blood and immune system. In 2017 EFSA indicated a group tolerable daily intake of 0.02 µg/kg bw/day and a group acute reference dose of 0.3 µg/kg bw for T-2, HT-2 and relevant modified forms. The two figures address different issues: repeated long-term exposure and exposure on a single occasion.

FUSARIUM: THERE IS NO SINGLE TOXIN

Analyses must be defined according to the cereal and to the mycotoxins to be investigated.

WHEAT

DON
Zearalenone

MAIZE

Fumonisin
DON / Zearalenone

BARLEY AND OATS

T-2 and HT-2
Other possible mycotoxins

These associations are not exclusive and do not replace the analysis.

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MODIFIED MYCOTOXINS AND CO-OCCURRENCE: WHAT CONTROLS MUST CONSIDER

A plant can convert some of a mycotoxin into a derivative, such as DON-3-glucoside. Certain processing steps or biological transformations can also change the analytical profile. So-called 'modified' forms are not all equivalent: some can release the parent compound during digestion; for others, toxicological data remain incomplete.

Several mycotoxins may also occur simultaneously in the same cereal. Co-occurrence alone does not prove a synergistic toxic effect: estimating cumulative risk requires specific information on modes of action, potency and exposure. EFSA therefore distinguishes substances with established group assessment criteria from those for which knowledge is insufficient.

WHAT HAPPENS DURING MILLING AND COOKING?

Cleaning, screening and optical sorting can reduce some contamination by removing damaged grains or more heavily affected fractions, although effectiveness varies. Milling redistributes mycotoxins among flour, bran and other by-products. It is incorrect to claim that all wholegrain products are necessarily more contaminated: the outcome depends on the cereal, batch and process.

Fusarium mycotoxins behave differently during fermentation, extrusion, cooking and other processes. Certain concentrations may decrease, but domestic cooking cannot be

relied on to make a raw material exceeding applicable limits safe. Prevention must begin before processing.

EUROPEAN LIMITS: PROTECTION SPECIFIC TO TOXIN AND FOOD

Regulation (EU) 2023/915, as currently applicable and amended, sets maximum levels for specific mycotoxins and food categories. For the toxins discussed here, relevant limits cover DON, zearalenone, the sum of fumonisins B1 and B2, and the sum of T-2 and HT-2 toxins. These values are not interchangeable and may depend on the cereal's intended use: unprocessed raw material, flour, ready-to-eat food and products for children can have different requirements.

In 2024 the EU amended DON maximum levels through Regulation (EU) 2024/1022 and introduced specific limits for T-2 and HT-2 through Regulation (EU) 2024/1038. For example, the consolidated version of Regulation 2023/915 consulted for this chapter provided a DON maximum of 1,000 µg/kg for the general category of unprocessed cereals and 1,500 µg/kg for unprocessed durum wheat and maize, subject to exceptions and conditions. These figures must not automatically be applied to flour, bread or infant foods.

A legal maximum determines regulatory compliance and supports health protection in the light of available assessments; it is not a threshold below which the absolute absence of every effect has been demonstrated. Similarly, 'not quantifiable' can only be interpreted by knowing the method's limit of quantification.

WHAT THIS MEANS FOR PEOPLE CHOOSING CEREALS AND CEREAL PRODUCTS

A cereal grown in an area relatively free of industrial pollution can nevertheless develop *Fusarium* mycotoxins, because their origin is biological and depends partly on agronomic and weather conditions. This illustrates why an area's environmental quality is not synonymous with food safety. Documented product quality depends on good agricultural practices, correct storage and analytical checks appropriate to the matrix.

Consumers cannot identify DON, zearalenone or fumonisins from a food's colour or taste. Effective protection mainly comes from food business operators' responsibilities, supply-chain controls and public oversight. Subsequent chapters explore how these substances are prevented, sampled and measured.

SCIENTIFIC AND REGULATORY REFERENCES

[EFSA CONTAM Panel \(2017\). Risks related to deoxynivalenol and its acetylated and modified forms. EFSA Journal, 15\(9\), 4718.](#)

[EFSA CONTAM Panel \(2016\). Group health-based guidance value for zearalenone and its modified forms. EFSA Journal, 14\(4\), 4425.](#)

[EFSA CONTAM Panel \(2018\). Group health-based guidance value for fumonisins and their modified forms. EFSA Journal, 16\(2\), 5172.](#)

[European Commission. Regulation \(EU\) 2023/915, current consolidated version \(see Annex I, mycotoxins\).](#)

[European Commission. Regulation \(EU\) 2024/1022 amending maximum DON levels.](#)

[European Commission. Regulation \(EU\) 2024/1038 on maximum levels of T-2 and HT-2 toxins.](#)