

BENZO[A]PYRENE AND PAH4: INDICATORS OF CONTAMINATION

Polycyclic aromatic hydrocarbons (PAHs) form a large family of substances. Analysing every member in every food would be complex and is often unnecessary to describe the main contamination situations. Scientific assessment and official controls therefore use particular compounds as indicators. An indicator, however, does not automatically represent the whole mixture or independently measure health risk.

WHY BENZO[A]PYRENE BECAME AN INDICATOR

Benzo[a]pyrene (BaP) is among the most extensively studied PAHs because of its genotoxic and carcinogenic properties and its occurrence in mixtures produced by incomplete combustion. For many years it was selected as a reference substance in food monitoring: determining its concentration was a practical way of identifying contamination that might also include many other PAHs.

This approach had a crucial limitation: the concentration of benzo[a]pyrene does not always reliably track other relevant PAHs. A food may contain little BaP, or have a result below the limit of quantification, yet still contain other PAHs. A negative result for one indicator is therefore not equivalent to the absence of PAHs.

EFSA'S 2008 ASSESSMENT

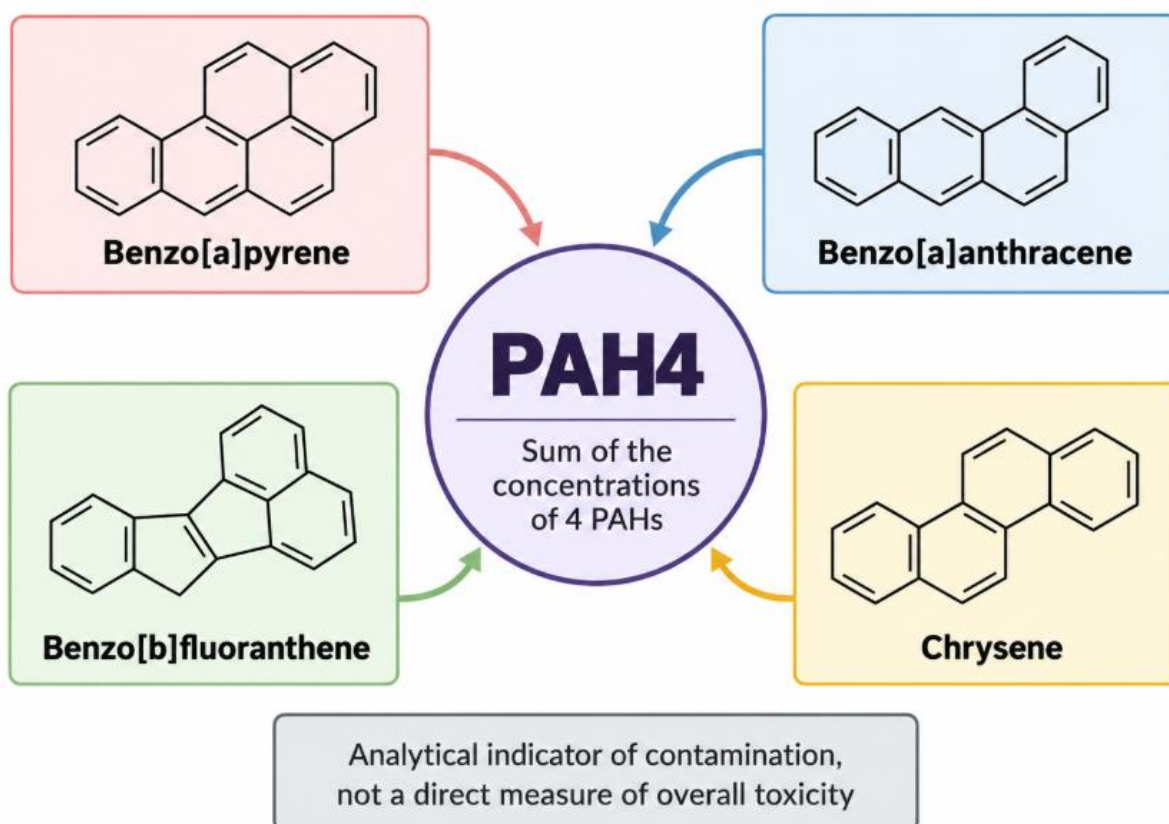
In its 2008 opinion on PAHs in food, EFSA's CONTAM Panel examined available occurrence data and evaluated different groups of compounds as indicators of contamination by genotoxic and carcinogenic PAHs. Benzo[a]pyrene was detected in about half the samples assessed, and chrysene in about 60%. Furthermore, other carcinogenic PAHs were present in about 30% of samples in which benzo[a]pyrene was not detected.

The Panel consequently considered BaP alone insufficiently representative and identified two more suitable groups, called PAH4 and PAH8. PAH8 comprises eight substances, but EFSA considered its additional information as an indicator limited compared with PAH4. This does not mean that four compounds fully describe every substance present or the toxicity of every possible mixture.

WHICH FOUR PAHS MAKE UP PAH4?

PAH4 is the sum of the concentrations of four specified compounds: benzo[a]pyrene, benz[a]anthracene, benzo[b]fluoranthene and chrysene. All belong to the PAH family, but they are not interchangeable: each has its own chemical properties and toxicological profile. PAH4 is therefore a conventional analytical sum, not the name of a single substance.

For example, a sample might contain 0.3 µg/kg benzo[a]pyrene, 0.8 µg/kg benz[a]anthracene, 0.5 µg/kg benzo[b]fluoranthene and 1.2 µg/kg chrysene. Its PAH4 sum is 2.8 µg/kg. This is purely an illustrative example, not an experimental result. The sum expresses the combined quantity of the four compounds without weighting each according to toxicological potency.



WHY BOTH BENZO[A]PYRENE AND PAH4 ARE MEASURED

For the relevant food categories, Regulation (EU) 2023/915 specifies separate maximum levels for benzo[a]pyrene and the PAH4 sum. The parameters complement each other: the former limits one substance of particular toxicological relevance, while the latter provides a broader description of contamination by priority PAHs.

It would be wrong to declare food compliant using only the sum when a separate BaP limit also applies to its category, or to consider BaP alone while ignoring PAH4. Numerical maximum levels differ across food matrices and are examined in the chapter on legislation and controls.

WHAT DOES A SUM MEAN WHEN SOME VALUES CANNOT BE QUANTIFIED?

A result below the limit of quantification (LOQ) does not prove that a substance is absent: it means that under the conditions of the method it cannot be quantified sufficiently reliably. For maximum levels based on the PAH4 sum, Regulation (EU) 2023/915 adopts a 'lower-bound' approach: results below the LOQ are treated as zero when calculating the sum. This is a prescribed convention for regulatory comparison, not proof of zero concentration.

Interpreting a laboratory report therefore requires knowing the individual results, their LOQs, the summation approach and any measurement uncertainty. The practical significance of these factors is examined in Chapter 9.

AN INDICATOR IS NOT THE SAME AS OVERALL RISK

Two foods with the same PAH4 concentration may contain different mixtures of PAHs not included in the indicator. Risk also depends on amounts and frequency consumed and on the substances' toxicological properties. PAH4 is therefore useful for surveillance and enforcing limits but cannot replace a full assessment of exposure and hazards.

The strength of the European system lies in using scientifically justified, measurable and comparable indicators. Its limitation is that reducing a complex mixture to a few compounds inevitably omits some information. Recognising both points helps interpret controls appropriately without dismissing their value or assigning them precision they do not possess.

SCIENTIFIC AND REGULATORY REFERENCES

[EFSA CONTAM Panel \(2008\). Polycyclic Aromatic Hydrocarbons in Food. EFSA Journal, 6\(8\), 724. <https://doi.org/10.2903/j.efsa.2008.724>](https://doi.org/10.2903/j.efsa.2008.724)

[EFSA \(2008\). Opinion on indicators of PAH occurrence and toxicity in food \(summary in Italian\).](#)

[European Commission. Regulation \(EU\) 2023/915 on maximum levels for certain contaminants in food, Annex I, Section 5.1 \(as amended\).](#)

[Food Standards Agency \(2018\). Polycyclic Aromatic Hydrocarbons in cereals, vegetables and traditionally smoked foods.](#)