

HOW PAHs FORM AND ENTER FOOD

Polycyclic aromatic hydrocarbons (PAHs) can enter food before harvest, during processing or during domestic preparation. The routes of contamination vary and sometimes affect the same product simultaneously. Understanding their origins is essential for identifying effective preventive measures: the mere presence of PAHs does not, by itself, establish their source.

INCOMPLETE COMBUSTION AND PAH FORMATION

PAHs are formed mainly when carbon-containing materials undergo incomplete combustion or high-temperature thermal decomposition (pyrolysis). Wood, coal, fossil fuels and biomass can produce PAH mixtures of varying quantities and compositions. Formation depends on temperature, oxygen availability, material type and process conditions: there is no single temperature at which all PAHs begin to form.

In ideal combustion, much of the organic carbon is converted into carbon dioxide. In real processes, partial reactions and recombination of molecular fragments can instead produce fused aromatic compounds. The resulting PAHs are emitted as gases or associated with particles and soot, in proportions determined by their physicochemical properties and environmental conditions.



EXTERNAL SOURCES: HUMAN ACTIVITIES AND NATURAL EVENTS

Human-made sources include road traffic, heating systems, certain industrial activities, waste combustion and agricultural burning. Wildfires and natural combustion events can also release PAHs. These sources do not all affect food contamination equally: actual emissions, distance from crops, weather and local environmental characteristics matter.



Industrial activities can be a source of atmospheric PAHs, which may subsequently be transported and deposited in the environment.

PAHs can be transported through the atmosphere, partly attached to particulate matter, and subsequently deposited on soil, water and plant surfaces by dry deposition or precipitation. During transport, some molecules may react with other atmospheric constituents or degrade. The PAH profile measured far from a source therefore need not match the original emissions.

FROM SOIL AND AIR TO CROPS

Deposition on exposed plant parts provides a direct contamination route, particularly where plant surfaces retain dust and particles. A second route involves soils that have accumulated PAHs from atmospheric deposition, past activities or contaminated inputs.

PAHs, especially those with higher molecular weights, often associate with organic matter and soil particles: this can restrict mobility while promoting local persistence.

Root uptake and transfer to edible tissues depend on the particular compound, plant species and circumstances. It is incorrect to assume that PAHs in soil automatically lead to high levels in crops: surface contamination and uptake must be distinguished. Washing, removal of outer parts and processing can alter concentrations without necessarily ensuring complete removal.

WATER, SEDIMENTS AND AQUATIC ORGANISMS

Discharges, atmospheric deposition and runoff can introduce PAHs into aquatic environments. Less soluble molecules tend to associate with suspended particles and sediments, which can become reservoirs of contamination. Different aquatic organisms absorb and metabolise PAHs to different extents: filter feeders such as bivalve molluscs may reflect contamination in their habitat, whereas many fish metabolise some of the PAHs they absorb.

Their occurrence in aquatic organisms does not imply uniform biomagnification throughout the food chain, as seen with some other persistent contaminants. Understanding actual concentrations in seafood requires substance-, species-, tissue- and environment-specific data.

FOOD PROCESSING AS AN INDEPENDENT SOURCE

Food originating in a relatively uncontaminated environment can acquire PAHs during certain processing operations. Smoking, drying in direct contact with combustion fumes, roasting and other heat treatments can form PAHs or transfer them to food. How heat is generated and transmitted is particularly important: merely heating a product does not necessarily produce high concentrations.



Direct-fired drying deserves particular attention because combustion products may contact food as moisture is removed. In vegetable oils, for example, PAHs in raw materials may also originate from the conditions used to dry seeds and other oil-bearing materials. The European Commission has expressly highlighted the importance of investigating and improving these production processes.

During domestic cooking, especially over grills and open flames, fat dripping onto a heat source may burn and produce PAH-containing smoke that deposits on food. Distance from the flame and exposure to smoke therefore matter. Differences between cooking and smoking techniques, and practical ways to reduce contamination, are explored in Chapter 4.

ENVIRONMENTAL CONTAMINATION AND PROCESS CONTAMINATION

It is useful to distinguish two situations. In environmental contamination, PAHs are already present in air, water or soil before processing and may reach the raw ingredients. In process contamination, PAHs form or are transferred to food during industrial or culinary treatment. This is a practical rather than absolute distinction: a raw material may initially contain environmentally derived PAHs and acquire additional contamination during processing.

Identifying sources requires information about the supply chain and processing techniques and, where necessary, multiple samples taken at different stages. A single analytical result from the finished product measures the concentrations of the substances tested; it does not automatically establish the stage at which contamination arose.

WHY IDENTIFYING THE SOURCE IS USEFUL

Locating the stage where PAHs enter the food chain allows targeted measures: reducing emissions and deposition where environmental contamination predominates; changing fuels, equipment or operating conditions where processing is responsible; and taking suitable precautions when preparing food. The effectiveness of each intervention needs to be checked through measurements and controls appropriate to the product and process.

The presence of PAHs does not, on its own, define a health risk. Assessing risk requires identification of the molecules, measured concentrations and dietary exposure. The following chapters examine the foods most affected, the role of cooking and toxicological assessment.

SCIENTIFIC AND REGULATORY REFERENCES

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