

COOKING, SMOKING AND PAH FORMATION

How we prepare food can affect its polycyclic aromatic hydrocarbon (PAH) content as much as contamination occurring before processing. Grilling, roasting, smoking or drying does not automatically produce PAH-rich foods: specific process conditions, especially combustion and contact with its fumes, determine the extent to which these compounds form and are deposited.

WHEN HEAT PROMOTES PAH FORMATION

PAHs form primarily during the thermal decomposition of organic matter and incomplete combustion of carbon-containing materials. Flames, glowing charcoal, burning wood and fat dripping onto a very hot source may generate PAH-containing smoke. These compounds can then settle on exposed food surfaces.

High temperature matters, but is not sufficient to explain the phenomenon. Oxygen availability, fuel type, distance from the heat source, treatment duration, ventilation and the volume and composition of smoke also matter. There is therefore no single temperature above which all foods necessarily develop the same PAH concentrations.

BARBECUING: THE ROLE OF DRIPPING FAT AND SMOKE

When food is cooked over embers, dripping fat and juices may reach the coals and flames. Their combustion or decomposition generates rising smoke that contacts the food surface: this is a well-recognised PAH contamination mechanism. Its intensity depends greatly on the actual cooking technique, rather than simply whether food is described as 'grilled'.

To reduce PAH formation, it helps to prevent fat from dripping directly onto the heat source, use indirect cooking zones, control flare-ups and avoid prolonged exposure to dense smoke. With charcoal, the initial intensely smoky lighting stage should finish before food is placed on the grill. Removing heavily charred areas can reduce consumption of degraded material, but cannot guarantee removal of all PAHs already deposited.

BROWNEED AND BURNT SURFACES ARE NOT THE SAME

A golden or browned surface does not, by itself, establish PAH concentration. Reactions producing colour, flavour and crust — such as the Maillard reaction — differ from PAH

formation, although they can occur simultaneously during intensive heat treatment. Blackened areas and carbonised residues indicate severe cooking conditions, but colour still cannot provide a reliable measurement of contamination.

PAHs should not be confused with heterocyclic amines, another family of substances that can form when meat and fish are cooked at high temperatures. These families have different formation mechanisms and chemical characteristics and should be assessed separately.



From browning to charring: surface appearance reflects different cooking conditions but does not allow PAH concentrations to be determined.

SMOKING: FLAVOUR AND CONTAMINATION MAY SHARE AN ORIGIN

Smoking exposes food to a complex mixture of substances generated by heating wood or other materials permitted for the process. Some contribute to flavour and preservation; others, including certain PAHs, are undesirable. Smoke composition depends on the material, how smoke is generated and how it is carried to the food.

Direct smoking, in which the product comes into contact with fumes from the source, requires careful control of the smoke generator, temperature, draught, distance and

possible dripping of fat onto the combustion source. Separately generating and treating smoke, together with better-controlled processes, can reduce PAH levels without implying that every 'indirect' system is necessarily free of contamination.

Traditional techniques also vary considerably: it is incorrect to assign the same PAH concentration to every smoked food. Production methods and analyses of the finished product remain decisive.

DRYING, ROASTING AND OTHER INDUSTRIAL TREATMENTS

Contamination may increase when cereals, seeds, cocoa, spices or other ingredients are dried with combustion gases that contact the product directly. PAHs may then originate from the energy source and smoke rather than necessarily from the heated food itself. Indirect heat exchangers, suitable fuels, proper maintenance and combustion control can reduce this contribution.

Roasting and heating can involve very different conditions: it would be scientifically unjustified to regard all roasted foods as contaminated or to assume that treatment without direct flame always guarantees zero concentrations. Initial raw-material quality and earlier supply-chain stages also influence the final result.

PREVENTION: CONTROL THE PROCESS, NOT JUST THE FINISHED PRODUCT

The Codex Alimentarius has a code of practice specifically aimed at reducing PAH contamination during smoking and direct drying of food. The approach is to identify and change contaminant-generating conditions without compromising microbiological safety or essential food characteristics.

Practical measures include choosing appropriate fuels and materials, separating the heat source from the product where technically possible, controlling temperatures and smoke flow, reducing flare-ups and fat drips, and undertaking analytical monitoring of processes with a contamination risk. Individual measures do not achieve identical results in every facility: their effectiveness must be confirmed in the food actually produced.

WHAT CONSUMERS CAN CONCLUDE

Grilled, smoked or dried food is not necessarily dangerous: PAH occurrence and concentration depend on verifiable conditions, not merely the name of the preparation. Equally, compliance with ordinary hygiene rules or a producer's artisanal reputation does not itself demonstrate that PAHs are absent.

For domestic barbecues, indirect cooking is preferable where possible, alongside limiting contact with flames and combustion fumes, preventing fat from dripping onto embers and avoiding charring. For commercial foods, good processing practices and the required controls are the appropriate tools. The relationship between measured levels, legal limits and health risk is examined in the chapters on legislation and toxicology.

SCIENTIFIC AND REGULATORY REFERENCES

[EFSA CONTAM Panel \(2008\). Polycyclic Aromatic Hydrocarbons in Food. EFSA Journal 724, 1–114.](#)

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

[Codex Alimentarius. CXC 68-2009: Code of Practice for the Reduction of Contamination of Food with Polycyclic Aromatic Hydrocarbons \(PAH\) from Smoking and Direct Drying Processes \(FAO collection\).](#)

[European Commission. Regulation \(EU\) 2023/915, as amended, Annex I, Section 5.1.](#)

[WHO/IARC \(2015\). Cancer: Carcinogenicity of the consumption of red meat and processed meat – questions and answers.](#)