

WHICH FOODS MAY CONTAIN BTEX AND OTHER UNWANTED VOCs?

The occurrence of volatile organic compounds (VOCs) in food is highly varied. Some form part of the normal aroma profile of fruit, coffee, cheese and fermented foods; others may originate from the environment, contaminated raw materials or production and storage. BTEX – benzene, toluene, ethylbenzene and xylenes – fall into this second area of concern when their presence is undesirable. There is, however, no universal ranking of foods ‘most contaminated’ by BTEX: available studies concern different matrices, periods and analytical conditions.

WATER INTENDED FOR HUMAN CONSUMPTION

Water is the matrix for which a specific, readily interpretable European regulatory reference exists for benzene. Directive (EU) 2020/2184 sets a parametric value of 1.0 µg/L for water intended for human consumption. This value concerns compliance for that matrix; it is not automatically applicable to juices, milk or other foods. Benzene in water is primarily associated with environmental contamination, not with the normal composition of water.

Where water is used as an ingredient or to wash raw materials, water quality can contribute to the quality of the finished product. Nevertheless, food prepared with compliant water does not necessarily contain measurable benzene: dilution, volatilisation and other changes may occur during processing. Conversely, compliant water does not rule out contamination introduced at subsequent stages.

SOFT DRINKS, FRUIT DRINKS AND JUICES

Beverages provide some of the best-documented instances of benzene occurring at very low concentrations. Investigations by the US Food and Drug Administration (FDA) have shown that benzene may form during storage in some formulations containing benzoates and ascorbic acid (vitamin C). Light and temperature can promote formation, but the simultaneous presence of the ingredients does not automatically mean measurable benzene will develop.

In the FDA investigation of almost 200 samples between 2005 and May 2007, ten products exceeded 5 µg/L, the US drinking-water benchmark; the affected products were reformulated or discontinued. These figures describe a historical US investigation, not the current situation of beverages sold in Europe. Nor should a drinking-water comparison value be presented as a general European limit for all beverages.

The mechanism is examined in Chapter 4. The important principle here is that a contaminant in a beverage need not have entered directly from the environment: it may arise from precursors already present in the formulation.

ANIMAL PRODUCTS, EGGS AND FATTY FOODS

Earlier analytical studies investigated benzene in foods including eggs, butter and meat. A study published in the Journal of AOAC International in 1993 examined more than fifty products using gas chromatography: in foods without added benzoates, including eggs, concentrations did not exceed 2 ng/g under the study conditions. This is also relevant when critically assessing earlier reports of much higher concentrations in eggs.

The affinity of some VOCs for lipids makes their distribution into the fatty fraction of food plausible. On its own, however, this does not establish that butter, meat or eggs are normally the principal dietary sources of BTEX. Reliable analysis, information on provenance and representative consumption data are needed. Volatility can also substantially affect the amount actually measured in a sample.



CEREALS, VEGETABLES AND AGRICULTURAL PRODUCE

Crops may come into contact with VOCs in air, irrigation water or soil. The extent of transfer depends on the compound, environmental conditions and plant part concerned. For BTEX, however, the possibility of transfer is not proof of systematic accumulation in food crops.

Without targeted investigations, it would be incorrect to single out rice, wholegrain cereals, leafy vegetables or fruit as necessarily more contaminated by BTEX.

Assessments should consider the production site, local exposures and sampling methods. Knowledge of pesticide or metal contamination cannot automatically be transferred to volatile solvents, whose chemical properties and environmental behaviour differ.

PROCESSED FOODS, COOKING AND SMOKING

Processing changes the profile of volatile substances: heating, roasting, fermentation and smoking generate or alter numerous molecules, many of which are normal aroma constituents. Undesirable compounds may also form under particular conditions. Yet detecting a VOC in cooked food is not equivalent to identifying industrial contamination, and not every analytical peak represents a toxicological problem.

Compounds resulting from incomplete combustion, such as certain polycyclic aromatic hydrocarbons (PAHs), require separate treatment. Although they may share sources with benzene, they are not synonymous with BTEX and have different physicochemical properties and regulatory frameworks. The PAH section is therefore kept separate.

PACKAGING, STORAGE AND PROCESSING ENVIRONMENTS

Materials, adhesives, inks, detergents and solvents used in industrial settings can be possible sources of unwanted VOCs. Actual transfer to food depends on the substance, material, nature of contact, temperature and time. It is therefore scientifically unjustified to attribute BTEX contamination indiscriminately to all packaged foods.

The air in processing facilities and sampling containers also deserve attention. Measurement at very low concentrations can be distorted either by accidentally introduced contamination or by loss of the compound before analysis. Analytical findings must therefore be assessed alongside laboratory quality controls.

WHAT CAN CONSUMERS CONCLUDE?

Among the matrices discussed, beverages containing specific combinations of ingredients provide a particularly well-documented example of possible benzene formation; drinking water has a precise European parametric value. Evidence for many other foods is more fragmented, and limited studies cannot establish general rankings. The possibility of contamination is not the same as an actually measured concentration, which in turn is not equivalent to an estimate of health risk.

The more useful question is not 'Which food contains the most BTEX overall?' but 'Which substance was tested, by what method, in which matrix, under what conditions

and at what concentration?' These details alone allow reliable comparisons and form the basis for assessing dietary exposure.

SCIENTIFIC AND REGULATORY REFERENCES

1. European Parliament and Council (2020). Directive (EU) 2020/2184 on the quality of water intended for human consumption, Annex I, Part B. [Source](#)
2. U.S. Food and Drug Administration. Questions and Answers on the Occurrence of Benzene in Soft Drinks and Other Beverages. [Source](#)
3. U.S. Food and Drug Administration. Determination of Benzene in Soft Drinks and Other Beverages. [Source](#)
4. McNeal T. P., Nyman P. J., Diachenko G. W., Hollifield H. C. (1993). Survey of benzene in foods by using headspace concentration techniques and capillary gas chromatography. Journal of AOAC International, 76(6), 1213–1219. [Source](#)
5. World Health Organization (2022). Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda. [Source](#)