

BENZENE IN FOOD: ORIGINS AND FORMATION

Benzene is a volatile organic compound with the formula C_6H_6 , used mainly as an intermediate in chemical manufacturing. It also occurs in combustion emissions, notably tobacco smoke and numerous industrial and urban sources. Its classification as carcinogenic to humans makes it important to understand possible routes into food. Yet identifying a hazardous substance does not establish that every trace in food presents the same risk: concentration, consumption frequency and total exposure matter.

TWO DISTINCT PATHWAYS: CONTAMINATION AND FORMATION

Benzene may reach food as an environmental contaminant or, under particular circumstances, form from components already present in the product. These are distinct phenomena requiring different preventive measures. In the first case, water quality, proximity to emission sources and plant management may matter; in the second, formulation, processing and storage conditions become critical. It is incorrect to regard all beverages or all processed foods as equally exposed.

ENTRY FROM THE ENVIRONMENT

Emissions from petroleum-related activities, traffic, combustion and industrial operations contribute to airborne benzene. Fuel leaks and other pollution events can also contaminate soil and groundwater. Contaminated water used as an ingredient, for washing products and equipment or in some manufacturing processes can therefore provide a transfer pathway. The amount actually transferred into food, however, depends on the matrix and process and cannot be inferred merely from environmental occurrence.

Because benzene is volatile, some may escape during operations involving contact with air or heating. This property does not, in itself, guarantee the absence of residues in the finished product. Any treatment must be assessed for its actual effectiveness and within the broader manufacturing context.

FORMATION IN SOME BEVERAGES: BENZOATES AND ASCORBIC ACID

One of the best-documented cases involves certain beverages containing both benzoates and ascorbic acid (vitamin C), or erythorbic acid. Benzoates, including sodium benzoate, may be added as preservatives; ascorbic acid may be added or naturally present in ingredients. Under particular conditions, chemical reactions can convert a small proportion of benzoate into benzene. Having both components present creates a possibility of formation, not certainty that measurable benzene will occur.

The chemistry involves oxidative reactions capable of generating radical species, including hydroxyl radicals. These can promote decarboxylation of benzoate to benzene. Certain metal ions, including iron and copper, may act as catalysts in particular circumstances. The overall composition of the beverage can markedly affect reaction rates: an ingredients list alone therefore cannot predict the final concentration.



THE ROLE OF TEMPERATURE, LIGHT AND STORAGE

Experiments and investigations by the US Food and Drug Administration (FDA) have shown that heat and light can promote benzene formation in certain formulations containing benzoates and ascorbic acid. Storage duration and conditions are therefore important. This does not mean that every exposure to sunlight creates significant quantities, nor is the phenomenon confined to carbonated drinks. Evaluation requires tests on the particular formulation under realistic distribution and consumption conditions.

Sugars and other recipe components can also affect the reactions. Some studies have identified conditions in which certain ingredients inhibit formation; that does not justify concluding that a sugary drink is automatically safer than a sugar-free one. Industrial prevention rests on experimentally testing the product and reformulating it where necessary.

WHAT TESTING OF BEVERAGES HAS SHOWN

Between 2005 and May 2007, the FDA tested around 200 samples of soft drinks and other beverages. A small proportion showed levels above approximately 5 micrograms per litre (5 parts per billion in aqueous drinks). The manufacturers concerned subsequently reformulated or discontinued products; in reformulated samples checked by the FDA, concentrations were below 1.5 parts per billion. This investigation demonstrates that the phenomenon exists and can be reduced, but it does not describe beverages currently marketed in Europe.

The reference value of 5 micrograms per litre used in that FDA communication corresponds to the US drinking-water standard; it must not be interpreted as a general European limit for all beverages. European requirements for individual food categories are examined in the legislation chapter.

NOT ALL MEASUREMENTS ARE EQUALLY RELIABLE

Benzene is often present at very low levels, making sensitive analytical methods, blank controls and rigorous sample handling essential. Volatility can cause losses during collection and preparation; conversely, some analytical conditions may introduce contamination or artefacts. The FDA itself reassessed historical Total Diet Study data and identified problems limiting their reliability. This illustrates why data quality must be verified before drawing conclusions about the prevalence of contamination in foods.

WHAT PRODUCERS CAN DO

Prevention targets sources: using suitable water, checking raw materials when appropriate, preventing environmental contamination and controlling processes. For drinks susceptible to benzene formation, choices of preservatives and antioxidants, possible reformulation and stability testing under expected storage conditions are important. Testing immediately after manufacture does not necessarily describe the product at the end of its shelf life.

HOW TO INTERPRET BENZENE DETECTION

When benzene is reported in food or beverages, the first questions are whether the result is confirmed, what the method's limit of quantification is, what units were used and which batch was sampled. Consumption levels and other exposure routes must then be considered. Benzene's carcinogenic classification calls for care and prevention, but it does not allow an occurrence result to be converted automatically into an individual estimate of health risk. Health effects and exposure assessment are discussed in Chapter 7.

IN SUMMARY

Benzene may enter food through external contamination or form through specific chemical reactions during the product's lifetime. The well-documented case of some drinks containing benzoates and ascorbic acid illustrates the relevance of formulation, heat, light and storage duration. The issue can be controlled technically, but cannot be generalised: what matters is properly measuring the actual product and interpreting results in the light of exposure conditions.

SCIENTIFIC AND REGULATORY REFERENCES

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6. Directive (EU) 2020/2184 on the quality of water intended for human consumption (a regulatory scope distinct from other beverages). [Source](#)