Arsenic – EU Maximum Levels Published for Rice Products

Arsenic – along with nitrogen, phosphorus, antimony, and bismuth – counts among the elements from the 5th main group of the periodic table. Bearing the atomic number 33, arsenic is a period 4 element and is hence to be found in the transition area from metals to non-metals, as is evidenced by the extensive and complicated chemistry of its compounds.

Food Chemistry Institute of the Association of the German Confectionery Industry

Institute Director:
Prof. Dr.
Reinhard Matissek

Adamsstraße 52 - 54
51063 Köln

phone
+49 221 62 30 61
fax
+49 221 61 04 77
web
www.lci-koeln.de

Hence arsenic, as a semi-metal, not only acts anionically like a non-metal but also cationically like a metal. In its compounds, arsenic occurs in the oxidisation stages +5, +3, and 3, its +3 compounds being the most stable.

Occurrence and extraction

Arsenic is a predominantly naturally occurring, ubiquitous element that is found in the Earth's crust with a concentration level of 1.0–2.0 mg/kg, making it one of the more rare elements. Arsenic occasionally occurs in native (elementary) form. However, it is most frequently found as inorganic arsenic in the compound form of its sulphides in the Earth's crust. It also occurs in the form of its oxides and in arsenic alloys, as metal arsenide ($[AsO_3]^{3-}$) and metal arsenate ($[AsO_4]^{3-}$), as well as in biological material, in organic arsenic compounds such as arsenocholine, arsenobetaine, or arsenosugar.

Arsenic is mainly extracted by heating up arsenopyrite (FeAsS) or loellingite ($FeAs_2$) under the exclusion of air at 700°C in horizontally laid clay pipes, whereby arsenic is first sublimated and then collected and condensed in cooled vessels. The occurrence of arsenic(III)oxide as a by-product of extracting, processing, and purifying especially copper, lead, cobalt, and gold is nowadays arguably the most predominant method for extracting arsenic.

Arsenic levels in foodstuffs

In people not exposed to arsenic in their professional lives, this element is chiefly taken up via foods which have been contaminated through exposure to geogenic and anthropogenic sources. The erosion of rocks and volcanic emissions leads to arsenic being transferred from the Earth's crust into soils, water, and the air. Arsenic concentration levels measured in ground water range from not detectable to 800 µg/l. Arsenic levels in drinking water can reach up to 9 mg/l in some regions of the world, such as West Bengal and Bangladesh. Various studies have shown that the arsenic content of rice increases where rice growers irrigate their crops with arsenical water. What is more, headlines are repeatedly generated by reports on the arsenic levels determined in rice from China. In Germany, arsenic uptake through food consumption arises predominantly from fish and fish products containing organic arsenic in the form of arsenobetaine, where values of up to 50 mg/kg (North Sea plaice, octopus) can occur. Brown and red algae, in which over 100 mg/kg of arsenosugar has been determined, also continue to have relevance. Overall there is little data on arsenic levels detected in cocoa and cocoa products.

Analytical method for determining arsenic

At trace level concentrations, the analytical method for determining arsenic is nowadays conducted both qualitatively and quantitatively based on a thermal or acidic digestion of samples using modern instrument-based measuring methods such as AAS (atomic absorption spectroscopy) as well as via a multi-element analysis using ICP-OES (inductively coupled plasma optical emission spectrometry).

Toxicology

Exposure to arsenic compounds is doubtless one of today's biggest environmental challenges. Whereas arsenic was once mainly known for being a murderous poison, nowadays the main focus has shifted to its chronic toxic effects, especially in regions where high levels of arsenic are observed in drinking water. This includes the first signs of skin changes and circulatory disorders ("blackfoot disease"), and also cancerous diseases of the skin, lungs, bladder, and kidney. Increased tumour frequencies are already being observed at comparatively low arsenic levels in drinking water (as of ca. 50 mg/l); the mechanisms of action have been identified as the induction of oxidative stress, the impairment of DNA repair processes, and the change of DNA methylation patterns with subsequent dysregulations of the genetic expression. These mechanisms are particularly observed in connection with the trivalent (+3) inorganic arsenic compounds, the arsenates ($[AsO_4]^{3-}$) and their methylated metabolites. Organic compounds, such as arsenobetaine and arsenosugar, are considered hardly or mildly toxic since they are excreted unchanged via the kidney.

Maximum limits for arsenic

The World Health Organization (WHO), the USA's Environmental Protection Agency (EPA), and the German Drinking Water Ordinance (Trinkwasserverordnung) have all set a drinking water limit of 10 µg arsenic/l. Since 1 January 2006, this limit has also been applicable to natural mineral and table waters; water used for preparing infant formulae may not exceed a limit of 5 µg arsenic/l (German Mineral and Table Water Ordinance [MTVO]).

At the end of 2009, the Panel on Contaminants in the Food Chain (CONTAM) of the European Food Safety Authority (EFSA) published an expert report on arsenic levels in foodstuffs. In this report the Panel came to the conclusion that the provisional tolerable weekly intake (PTWI) of 15 µg/kg body weight set by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) could not be upheld: data had shown that inorganic arsenic not only causes skin cancer but also cancer of the lungs and bladder and that a series of side-effects had been reported at exposure values below those reviewed by the JECFA. For this reason, the CONTENT Panel has placed a lower confidence limit on the benchmark dose of 0.3–8 µg/kg body weight/day.

The EFSA report also established that consumers in Europe who eat a lot of rice, e.g. small children under three years of age, may be exposed to a high level of inorganic arsenic as a result of such a diet. For this reason, at the end of June 2015, the European Commission set maximum levels for inorganic arsenic in rice and various rice products in its Regulation (EU) 2015/1006 amending Regulation (EC) No 1881/2006 as regards maximum levels of inorganic arsenic in foodstuffs. A maximum level of inorganic arsenic of 0.3 mg/kg now applies to rice wafers and rice crackers, whereas parboiled and husked rice may not exceed a maximum level of 0.2 mg/kg of inorganic arsenic. The determined maximum levels have been applicable since 1 January 2016. SV