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A survey of arsenic in foodstuffs on sale in the United Kingdom and imported from Bangladesh

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Abstract

Arsenic is a highly toxic element and its presence in food composites is a matter of concern to the well being of both humans and animals. Arsenic-contaminated groundwater is often used in Bangladesh and West Bengal (India) to irrigate crops used for food and animal consumption, which could potentially lead to arsenic entering the human food chain.

In this study, we used graphite furnace atomic absorption spectroscopy to determine the total arsenic concentrations in a range of foodstuffs, including vegetables, rice and fish, imported into the United Kingdom from Bangladesh. The mean and range of the total arsenic concentration in all the vegetables imported from Bangladesh were 54.5 and 5–540 μg/kg, respectively. The highest arsenic values found were for the skin of Arum tuber, 540 μg/kg, followed by Arum Stem, 168 μg/kg, and Amaranthus, 160 μg/kg. Among the other samples, freshwater fish contained total arsenic levels between 97 and 1318 μg/kg. The arsenic content of the vegetables from the UK was approximately 2- to 3-fold lower than those observed for the vegetables imported from Bangladesh.

The levels of arsenic found in vegetables imported from Bangladesh in this study, in some cases, are similar to those previously recorded for vegetables grown in arsenic-affected areas of West Bengal, India, although lower than the levels reported in studies from Bangladesh. While the total arsenic content detected in our study in vegetables, imported from Bangladesh, is far less than the recommended maximum permitted level of arsenic, it does provide an additional source of arsenic in the diet. This raises the possibility that the level of arsenic intake by certain sectors of the UK population may be significantly higher then the general population and requires further investigations.

Keywords: Graphite furnace atomic absorption spectroscopy; Arsenic; Food; Bangladesh; Diet

1. Introduction

The accumulation of trace elements in environmental samples (soil, sediment, water, biota, etc.) can cause a potential risk to human health due to the

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transfer of these elements in aquatic media, their uptake by plants and subsequent introduction into the food chain. It is therefore necessary to monitor human exposure to toxic trace elements present in the food chain, and a number of studies have reported the total arsenic content of foodstuffs from different countries (Dabeka et al., 1993; Tsuda et al., 1995; Sapunar-Postruznik et al., 1996; Roychowdhury et al., 2002, 2003; Meharg and Mazibur, 2003; Alam et al., 2003; Das et al., 2004).

Arsenic is ubiquitous in the environment, being naturally present in soil, air, water and food, and concentrations may be increased by anthropogenic contamination (Villa-Lojo et al., 2002). It is present in the environment in a number of different inorganic and organic chemical forms due to its participation in complex biological and chemical processes. Some of the most important arsenic species from a toxicological perspective include the two oxidation states As (III), As (V), monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), arsenobetaine and arsenocholine.

Humans are exposed to many different inorganic and organic arsenic species present in food, water and other environmental media. Routes of arsenic intake include respiratory for dust and fumes and oral for water, beverages, soil and food. The most common mode of arsenic toxicity in humans is the inactivation of an enzyme system by binding through various biological ligands (Nagvi et al., 1994). Humans who are occupationally exposed, such as in the industrial application of wood treatments, are routinely monitored for arsenic exposure by bodies such as the Health and Safety Executive (UK). Chronic exposure to inorganic arsenic may give rise to several health effects on the gastrointestinal tract, respiratory tract, skin, liver, cardiovascular system, hematopoietic system, nervous system, etc. Some of these human health effects are currently being observed in populations in south and southeastern Asia, particularly in countries such as Bangladesh, India and Taiwan. Arsenic is recognized as a toxic element and has been classified as a human carcinogen to skin and lungs (WHO, 1980). It has been reported that the toxicity of arsenic decreases with increasing methylation (Londesborough et al., 1999), although, recently, it has been reported that trivalent forms of MMA and DMA can be more carcinogenic than inorganic As (Vega et al., 2001).

Bangladesh, a country in South Asia with a population of about 150 million, is one of a number of countries that has arsenic contamination in its groundwater, which results from the underlying mineralogy and geology of the area. Arsenic contamination has been reported in groundwater in 41 out of the 64 districts in Bangladesh (Samanta et al., 1999). About 61% of the water analysed from tube wells has arsenic content above 0.05 mg/l and about 13% have arsenic content above 0.01 mg/l (Ali and Tarafdar, 2003). The average concentration of arsenic in contaminated water is about 0.26 mg/l with a maximum level of 0.83 mg/l. This is significantly higher than the World Health Organization (WHO) maximum permissible limit in drinking water which is 0.05 mg/l and the recommended value is 0.01 mg/l (WHO, 2001). The Environment Protection Agency (EPA) has recently adjusted the upper limit for arsenic in drinking water to 0.01 mg/l (EPA, 2001). Groundwater is the main source of potable water in Bangladesh and the agricultural system is mostly groundwater-dependent. Food chain aspects of arsenic contamination in Bangladesh have recently received attention (Duxbury et al., 2003; Meharg and Mazibur, 2003). Arsenic contamination in the Bangladeshi staple food, rice, showed presence of high levels of arsenic 1700 μg/kg (Meharg and Mazibur, 2003). Relatively high concentration of arsenic has also been recently detected in vegetables grown in the arsenic-affected region of Bangladesh (Alam et al., 2003; Das et al., 2004). The Bangladeshi population in the United Kingdom is quite significant and they consume large quantities of food imported from Bangladesh. Our objective in this study was to analyse certain imported foodstuffs for their total arsenic content using graphite furnace atomic absorption spectroscopy (GFAAS) to determine whether this section of the UK population is being exposed to high concentrations of arsenic in their diet.

Similar studies have been conducted to estimate the level of arsenic in foods in a number of other countries. For example, in Croatia (Sapunar-Postruznik et al., 1996), low levels of arsenic were recorded in fruits (0.2 μg/kg) and vegetables (0.4 μg/kg). Foods were collected from different cities in Canada between 1985 and 1988 and the mean and range of arsenic concentrations in all samples reported were 73.2 and <0.1–4830 μg/kg, respectively (Dabeka et al., 1993). In Japan, over a 2-year period, a total diet study (market