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Original Article

Leaching of cadmium and lead from dried fruits and fruit teas to infusions and decoctions

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Abstract

Leaching of Cd and Pb from selected dried fruits (bilberries and apples) and commercially available fruit teas into infusions and decoctions during preparation of beverages, has been investigated. The content of Cd and Pb in the studied materials and water extracts was analyzed by graphite furnace atomic absorption spectroscopy. Direct slurry sampling of the examined materials to the graphite furnace gave comparable results with dry ashing mineralisation. The content of Cd and Pb in the studied materials was established and the percentage of the total content extracted to infusions and decoctions was found. The highest content of these elements was found in samples of bilberries: Cd—0.813; Pb—1.370 μg/g. The maximum obtained values for leaching of cadmium from apples, bilberries (boiling for 20 min) and fruit teas (infusion for 10 min) were 7.9%, 5.8% and 8.6%, respectively. Lead is more easily leached from the studied materials than cadmium-maximum values: 47.8% for apples; 35.3% for bilberries and 35.2% for fruit teas have been found. The evaluation of the intake of those elements with the consumption of fruits and extracts on the basis of values of provisional tolerable weekly intake (PTWI) and admissible content of the elements in the studied materials is discussed.

Keywords: Cadmium; Lead; Fruit; Dried fruit; Bilberry; Apple; Decoctions; Infusions; GFAAS analysis; Food safety; Metal contamination in food through leeching; PTWI

1. Introduction

Fruits are traditionally an important component of the human diet. They contain a lot of biologically active substances that have beneficial effects on human health as antioxidants, anticancerogens, antimutagens and antibacterial compounds (Awad et al., 2000; Hakkinen et al., 1999; Rauha et al., 2000). An inverse relationship between the consumption of fruits (for example apples, bilberries and their extracts) and risk of coronary heart disease, stroke and cancer has been shown in epidemiological studies (Hakkinen et al., 1999). The bioactive components may be even better absorbed by organisms from extracts than from the plant tissues (Bitsch et al., 2001), that is why fruit infusions are commonly applied in natural medicine. For instance, extracts of bilberries (*Vaccinium myrtillus*) are used in gastroenteritis disease.

On the other hand, fruits may contain and cumulate heavy metals, depending on the place of cultivation and the natural property of the plants (Wagner, 1993) and therefore contribute to the dietic intake of metals by people. Particularly hazardous among them are cadmium and lead.

Cadmium has no beneficial effect on human health. Its known acute toxicity and long half-life (even up to 30 years) in human body make it dangerous under conditions of severe or prolonged exposure. Vegetable food may contribute to about 70% of Cd intake for humans, regarding the level of consumption (Wagner, 1993).

Lead is a cytoplasmatic poison, which reacts with SH groups of enzymes and cellular proteins damaging nervous (hearing nerve), osseous (the main place of accumulation) and blood systems, as well as kidneys and alimentary canal (Ernst, 2002).

Because of the possible health risk, it is very important to control the level of these toxic elements in food, especially

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in products, which are known to have beneficial effects on health. In the analysis of heavy metals in plant materials and food samples atomic absorption spectrometry (GFAAS, FAAS) is reported the most frequently (Szymczak et al., 1993; Jędrzejczak and Szteke, 1989; Błoniarz and Buliński, 1984; Malawska and Wiłkomirski, 2001; Sołtyk and Fijałek, 2000; Robles and Allegr, 1995; Steennkamp et al., 2000). Other techniques such as inductively coupled plasma mass spectrometry (ICP-MS) (Łozak et al., 2002; Sołtyk and Fijałek, 2000; Caroli et al., 1999; Lo Coco et al., 2000; Li et al., 1998), inductively coupled plasma atomic emission spectrometry (ICP-AES) (Mikuła and Puzio, 1999, 2001; Palchetti et al., 2003) and electrochemical methods (DPP (Dubey and Puri, 1995), dPSA (Lo Coco et al., 2000) and electrochemical sensor TMFE (Palchetti et al., 2003)) are also frequently employed. Chromatographic methods are rarely reported (TLC (Jahns et al., 1983), HPLC (Ichinoki and Yamazaki, 1985)). Procedures involving separation and preconcentration for the determination of cadmium using spectrometric techniques are reviewed by Ferreira et al. (2007).

Many studies have shown a concentration of heavy metals in fruits (Szymczak et al., 1993; Jędrzejczak and Szteke, 1989; Błoniarz and Buliński, 1984), but leaching of these toxic elements is only reported from selected herbs (Łozak et al., 2002; Kalny et al., 2007) and black teas (Ferndez et al., 2002). In medical treatment, extracts of fruits and fruit teas are frequently recommended (Bitsch et al., 2001), but preparation of them can result in toxic metals leaching into the extracts.

Slurry sampling has become an attractive approach for determination of trace elements in various materials by electrothermal atomic absorption spectroscopy due to simplicity and rapid sample preparation. Advantages and drawbacks of slurry sampling (Arslan and Tyson, 2007; Pereira et al., 2006; Cal-Prieto et al., 2002; Barałkiewicz, 2002; Viñas et al., 2000) as well as application of chemical modifiers in electrothermal atomic absorption spectroscopy are widely discussed (Acar, 2005; Volynski, 2004; Ortner et al., 2002; Acar et al., 2000; Lima et al., 1998).

The main goal of this study was assessment of cadmium and lead migration from dried fruits into infusions and decoctions. The aim of this research was to estimate the quantity of Cd and Pb intake in the drinking of fruit extracts prepared from dried apples, bilberries and fruit teas (composed of dried fruit, mainly berries) commercially available in Poland. Extracts were prepared by decocting or infusing with water, following the prescription given by the producer and placed on the package. Studied materials and extracts were analyzed for cadmium and lead content by GF AAS. Direct slurry application technique was applied for analysis of dried fruit and fruit tea samples.

2. Materials and methods

Six samples of apples (code assigned to samples A1–A6), five samples of bilberries (code B1–B5) and five samples of fruit teas (code T1–T5) were subjected to analysis. The samples of apples were collected from allotments in the Silesia region in Poland, dried bilberries and fruit teas (such as tea bags) coming from five different producers were commercial products purchased in the shop. The samples were dried at a temperature of 105 °C to constant mass, then they were ground in a ball mill and sieved. Fractions under 0.102 μm were collected for further experiments.

Aqueous extracts were made of studied materials, following the prescription given by the producer and placed on the package, or by preparing these kinds of beverages from dried fruits in the usual way.

2.1. Reagents and apparatus

- Standard solutions of Cd (1 mg/ml) and Pb (1 mg/ml)—Merck; working standard solutions at ng/ml level were prepared from the stock solutions daily by serial dilution.
- Cetyltrimethylammonium chloride (25% water solution)—Aldrich.
- Concentrated 65% w/v nitric acid—Merck.

All reagents used were of analytical grade:

- Atomic absorption spectrometer (Carl Zeiss Jena) AAS30 equipped with deuterium background correction and the graphite furnace EA30 with the autosampler MPE; hollow cathode lamps Photron PTY. Ltd., Australia, operating at 5 mA, were used as light sources. Pyrolytic graphite coated graphite tubes were used and signals were measured as peak areas.
- Variable speed rotor mill "Pulversiette" type 05.102 (FRITSH—Germany).

2.2. Sample preparation

2.2.1. Slurry technique

One gram weighed portions of powder materials were transferred into 50 ml volumetric flasks. Then 2.5 ml of concentrated nitric acid and 4 ml of 2.5% cetyltrimethylammonium chloride were added and made up to 50 ml with redistilled water. Slurries were shaken for 5 min and the volume of 20 μl was directly transferred into the graphite furnace. A blank test was prepared simultaneously.

2.3. Preparation of extracts

2.3.1. Decoctions of dried apples and bilberries

In total, 2.5 g weighed portions of dried fruits were placed in quartz beakers, 100 ml of boiling redistilled water were added and then the samples were boiled under cover on a heating plate for 5, 10 or 20 min. The decoctions were filtered, evaporated to the volume of about 10 or 20 ml, transferred into 10 or 25 ml volumetric flask and made up to the mark with redistilled water.