

Determination of Cr (VI) in tea

Keywords: chromium (VI), determination, tea, materials, oxidation, compounds, potential, particular, humans, animals, metabolism, industry

Mini review

Chromium is extensively used in the industrial processes and its compounds are discharged into the air, water and terrestrial environments. While Cr(III) is considered as an essential element for the proper functioning of living organisms, Cr(VI) with high oxidation potential shows mutagenic and carcinogenic effects. For this reason, the selective determination of Cr(VI) in different plant materials which are consumed by humans and animals is of particular importance. This article summarized the reported works for tea leaves and their infusions focused on determination of Cr(VI) content.

The most stable oxidation states of chromium, e.g. Cr(III) and Cr(VI), exhibit significantly different biological and toxicological properties. Cr(III) is considered as an essential element for the proper functioning of living organisms, particularly in glucose metabolism, while Cr(VI) shows mutagenic effects. It is regarded as carcinogenic owing to its oxidizing potential and easy permeation of biological membranes. Unfortunately, Cr(VI) compounds have a large application in industry, and soils and sediments can become contaminated with this species. Because of the dangerous effects of hexavalent chromium and its high mobility in the environment, several directives have been adopted by the European Commission to limit the release of Cr(VI) into the environment. The maximum concentration of total chromium and Cr(VI) in drinking water was set as 50 µg/L and 20 µg/L, respectively, according to European Council Directive 98/83/EC. For this reason, the selective determination of Cr(VI) in different food samples is of particular importance. Thor et al.¹ evaluated the availability and reliability of analytical data on the total chromium composition of foods reported in the literature.¹

The proposed in literature analytical procedures for speciation of chromium can be divided onto two groups. In the first of them hyphenated techniques such as high performance liquid chromatography or capillary electrophoresis have been utilized.^{2,3} In the second group, selective liquid-liquid extraction procedures, co-precipitation, separation of one or two chromium species onto a solid phase extraction column or complexation reactions have been proposed.⁴⁻⁶ Such approaches enable also preconcentration of given species. The content of the second species is then calculated by the difference after determination of total chromium preceded reduction of Cr(VI) or oxidation of Cr(III).

The analytical procedure for chromium speciation in food samples depends on the nature of the sample matrix. Additionally, exposure to light, the type of storage container and high storage temperature may affect the stability of chromium species.^{4,5} The lower the pH of solution, the more likely it is for the species of chromium to be Cr(III) or be converted to Cr(III). Thus, the main difficulty is to preserve the initial distribution of both redox chromium species in a sample as well as to obtain the high extraction efficiency.⁷ From solid food samples chromium species have to be extracted. Na₂CO₃ solution at elevated temperature was used for extraction of Cr(VI) from several species of plants collected in South Africa and Russia,⁸ tea leaves^{9,10} and tomato

Volume 4 Issue 4 - 2017

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Received: February 14, 2017 | Published: May 09, 2017

and corn leaves.⁹ This alkaline digestion procedure was recommended for Cr(VI) extraction from soils, sediments and similar materials as US EPA 3060A method. The accuracy of selective extraction of Cr(VI) was verified by the analysis of CRM 545 with good agreement between the certified and determined value.⁸ However, that reference material (Cr (VI) in welding dust) has completely different matrix. The validation of the proposed procedures were done by spiking tea or tomato leaves with Cr(VI) standard solutions just before the treatment with Na₂CO₃.^{9,10} As good recovery was obtained, the conclusions were made that Cr(VI) were not altered during extraction process. Atomic absorption spectrometry with electrothermal atomization was applied for quantification of Cr(VI) content in the leaching solutions. However, this method measures total chromium content, although it was stated that the determined values were for Cr(VI). Applying that procedures it was found that the concentration of Cr(VI) in typical cup of tea (2.0g of tea leaves extracted with 200mL of hot water) was higher in black tea (up to 17.5 µg/L) than in green tea (0.70 µg/L).¹⁰ Taking into account these results, consumption of common drink could represent long-term chronic exposure to Cr(VI) with health hazard.

It is well known that tea leaves and the infusions prepared from them contain several flavonoid compounds with strong antioxidant activity¹¹ and the presence of reducing organic matrix in such samples inhibits and prevents the existence of Cr(VI) species. It was confirmed using more sensitive and specific analytical method such as HPLC with ICP MS detection.¹² Moreover, by the use of enriched stable isotopes of chromium it was possible to check interconversion of chromium species during the whole analytical procedure. The addition of ⁵⁰Cr(VI) to the tea extract caused its reduction, but added ⁵³Cr(III) was not oxidized. Thus, it was proved that Cr(VI) cannot exist in tea infusion in the presence of such organic matrix containing antioxidants. Similar results were obtained for wine, fruit juices and tea infusions followed by determination of Cr(VI) using also HPLC ICPMS.^{13,14} The data confirmed that Cr(VI) does not exist in foodstuffs of plant origin and the use of methodology based on species-specific isotope dilution mass spectrometry is essential to obtain reliable data for Cr(VI).

Acknowledgements

None.

Conflict of interest

The author declares no conflict of interest.

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