1. Overview

The European Commission aims to assure a high level of food safety and food quality within the EU through the “farm-to-fork principle” covering all sectors of the food chain. In order to achieve this goal, strict and steady food control is needed to protect consumers from undeclared contaminants and to guarantee the highest level of food safety/quality. This can be obtained by enforcing maximum allowable concentrations of hazardous substances. Maximum levels for certain contaminants in food are set in the Commission Regulation (EC) No 1881/2006 for the following contaminants: arsenic, cadmium, lead, selenium, thallium, mercury, isotopes, dioxins, polycyclic aromatic hydrocarbons (PAHs), metals and more [1]. Metals such as lead, arsenic, cadmium, antimony, tellurium and other potentially occurring elements. They can be present at various levels in the environment, e.g. in soil, water and atmosphere. Metals can also be found as residues in food due to their presence in the environment, as a result of human activities such as farming, industry or car exhausts, or from contamination during food processing and storage. People can be exposed to metals from the environment or by ingesting contaminated food or water. Their accumulation in the body can lead to harmful effects over time.

In the food market segment, the determination of elements in beverages such as beer, wine and water is a typical ICPMS application for simultaneous evaluation of various nutritional elements present in high concentrations (e.g. Na, potassium – K, calcium – Ca, magnesium – Mg –), in combination with the evaluation of trace elements and toxic elements present in lower concentrations (lead – Pb, cadmium – Cd, arsenic – As, mercury – Hg, thallium – Tl, selenium – Se –). Looking at the food market in European countries, there is a clear focus on beverages such as beer, wine, and water. In these beverages, producers, drinking water plants, distilleries and wine makers make up a significant part of the food market segment.

2. Quantitative Analysis using ICP-MS

For simultaneous quantitative determination of elements in food and food packaging, ICP-MS is the preferred tool for quality control. ICP-MS offers high sensitivity (trace detection), wide dynamic range and high sample throughputs. The Shimadzu inductively coupled plasma mass spectrometer (ICP-MS 2000) represents an easy and fast solution to meet this requirement. In the study, commercially available five beer samples were investigated. Even though beer is regarded as a difficult matrix because of the high number of constituents, sample preparation is not too complicated and needs dilution with water, addition of nitric acid and final adjustment of the ethanol concentration in standard and solution samples. The ICP-MS 2000 is a routine tool in beer analysis and is designed for high stability of the excitation and sensitivity and low interference. The optimized internal structure including the newly-developed optical static cell enables cell analysis at an excellent sensitivity which never seen before interference. Via the injection unit made from where ionized atoms go through are easy to remove and maintain. Shimadzu’s proprietary “Development Assistant and Expert Parameter function” reduces user burden and improve reliability of data. The ICP-MS 2000 can achieve extremely low turning costs based on reduced argon gas flow rate using the mini torch and an “Echo mode” that reduces the argon gas flow rate and RF-power even further during standing. In addition, the use of 99.95% pure argon gas is possible.

3. Materials and Methods

The quality standards for beer analysis are described in the European Brewery Convention (EBC), which includes the determination of elements, oxides (such as nitrite and sulfite), organic compounds (cyanate, glycerine) and other (potable resins). In order to keep at the highest quality level, the investigations have to be performed using different analytical technologies to quantify all potential contaminants [4].

In this study, five commercially available beers were investigated for presence of metals, and thanks to the ICP-MS 2000, analysis could be performed within any time consuming sample preparation. All samples analysis were not degassed in an ultrasonic bath. After this treatment and adjustment of nitric acid concentration, they were aspirated directly to the ICP-MS 2000. All the analyses were performed in a single day with the following matrices: A, B, C, D, E, and F. Beer samples, recovery (%) = 

For each element, the calibration curve includes 5 points in the concentration range from 0.1 to 200 ppb, in a multi-matched solution using 1% nitric acid and 5% ethanol. Beer samples are measured in triplicate and three of them are measured as quality control samples (Beer 1, Beer 2 and Beer 3), spiked with 0.2 ppb, 5 ppb or 50 ppb respectively depending on the element concentration. An internal standard solution in 1% nitric acid (Na, Ca, Mg, Co, Cu, Zn, Cd, Hg, As, Te) was mixed before sample aspiration before aspiration in the nebulizer. As the calibration curve in Figure 3 show, all correlation coefficients r ≥ 0.993 level. Moreover, low values of detection limits (DL), calculated automatically by LabSolutions ICPMS software with the 3o method, indicate the suitability of ICP-MS 2000 for determination of contaminants at ultra low concentration levels. Results are summarized in Table 2 for each beer, and all data are below the minimum allowable limits according to the drinking water regulation.

4. Results and Discussion

Quantitative results in Table 2 demonstrate that ICP-MS 2000 is suitable for simultaneous quantification of various elements present in beer. In order to determine the accuracy of the method, spikes of each element (0.5 ppb, 10 ppb or 50 ppb) are added to three of five beer samples. The results of the spiked samples measured are detailed in Table 3 and calculated using the following formula:

Recovery (%) = \frac{\text{measured value} - \text{initial value}}{\text{initial value}} \times 100

Recovery rates for all elements were between 80% and 120%, indicating the suitability of the method in terms of accuracy, independent of initial element concentration.

5. Summary

Beer is made from natural grain and vegetable base products which are exposed to environmental impacts as well as agricultural treatment. Beer may therefore contain a variety of heavy metals such as arsenic, lead and cadmium at ultra low concentration levels. To track and analyse these elements the Shimadzu ICP-MS 2000 is an easy to use and highly capable routine tool for quality control in order to permanently guarantee the highest quality levels of quality in the most popular alcoholic beverage in Europe: beer.

6. References


