Evaluation of heavy metal migration from different types of plastic food packaging materials into aqueous simulants using ICP-MS

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1. Introduction

Food packaging materials that contact food directly may cause food contaminations due to toxic substances and elements leaching out into the food. plastics are widely used in food packaging in modern food industry. Heavy metal contamination caused by plastic packaging materials is one of the significant concerns in food safety [1]. Thus, accurately determining heavy metal migration from food packaging material is essential to evaluate the potential health hazards to human beings. Inductively coupled plasma mass spectrometry (ICP-MS) is a powerful tool to investigate the elemental migration from food packaging materials to food simulants and thus help to ensure food safety. In this work, the release of heavy metals into food simulants were evaluated by immersing the testing plastic packaging materials in two test solutions with (acetic acid and water). The elemental concentrations of the leaching solutions were determined by ICP-MS. The effect of contact time on heavy metal migration was investigated using food simulants.

2. Experimental

2.1 Sample and standards preparation

Three different types of plastic packaging polycarbon (PS), polyethylene (PE), and polypropylene (PP) were chosen for this study. The packaged food products were meat, drinks, and fruits. 0.5 g of each packaging material were weighed and immersed in 40 mL of aqueous solutions for heavy metal leaching at room temperature. The aqueous solutions used as leaching solvents were DI water (simulant A), 3% acetic acid (simulant B) [2] and 3% acetic acid 50% DI water (simulant C). The soaking times were 1 h and 72 h. The concentrations of the leached metals were detected by ICP-MS. Two replicates were performed for each sample.

2.2 Recovery and repeatability

The ICP-MS method was evaluated by spiking a known concentration (50 ppb) of heavy metals into plastic container and PP film with two plastic packages samples (PS container and PP film). The sample leaching solution were achieved for all elements except for Li, Na, K, Ca, Mg, Mg and Cu. The recovery rates were calculated with RSD% obtained less than 3% for most of the elements as shown in Table 3. Good recovery rates indicated the method accuracy and absence of interferences. The repeatability for three replicates were checked with RSD% obtained less than 3% for most of the elements as shown in Table 3.

3. Results and Discussion

3.1 Calibration linearity

Under the experimental conditions described in the above section, good linearity of calibration curves was achieved. The correlation coefficients are shown in Table 2 with r > 0.9999 for all targeted elements. LODs and LOQs were calculated based on 3 and 10 times the standard deviations of 10 continuous measurement of the calibration blank. Sub ppb or ppt level of LODs and LOQs were achieved for all analytes except for Zn and Cu. All the determinate elements were measured for Ba, Co, Pt, Li, Sn and Zn as described in EU 101/2011 [1]. The ND of the method indicated the excellent sensitivity to determine heavy metal migration in food simulants.

3.2 Migration of heavy metal from plastic packaging materials

Heavy metal migration from three plastic packaging materials into food simulant B after soaking for 72 hours were determined and compared in Table 3. The leaching results were in ppb level but varied largely for different plastic packaging materials. For example, for the PS film, the Cd leaching was 20.3 µg/kg but much lower with contact time of 1 h with concentration of 14.25 and 13.95 µg/kg, respectively. While for PS and PP container, the most leached element was Cd followed by Cu and non-targeted elements were not detected for any plastic materials. Regarding to the toxic elements, arsenic and lead were detected with concentration ranges of 0.36 – 0.46 µg/kg and 0.19 – 3.27 µg/kg. Cadmium leaching was not found from PS and PP container, but 0.26 µg/kg was detected from PE film. The measured concentrations in Table 4 are much lower than the restriction levels for Ba, Co, Cu, Fe, Li, Sn and Zn as described in EU 101/2011 [1]. The ND of the method indicated the excellent sensitivity to determine heavy metal migration in food simulants.

4. Conclusions

The method was applied to determine the heavy metal migration from plastic packaging materials. The detected leaching amounts of 14 metal elements were lower than the restriction levels defined by EU Food and Feed Directive No. 2002/32/EC. The leaching decrease with contact time of 1 h. More metals migration was observed with increased contact time. Good sensitivity, low RSD% and low method detection limits were achieved using the developed method.

References
