

Investigation of Released Cadmium and Lead from Different Colors of Over Glaze Designs to Food Stuff in Different Conditions

H. Hashemi-Moghaddam*

Department of Chemistry, Damghan Branch, Islamic Azad University, P. O. Box 36716-39998, Damghan, Iran

Abstract: In this paper, leaching of lead and cadmium was investigated from porcelain over glaze designs between different colors. Also the effect of microwave heating was considered on leaching of lead and cadmium. Dishes were selected with a decor with the dominant color of gray, red, yellow, blue, and dark blue. Amounts of cadmium and lead which leached from the container by acetic acid and orange juice were measured according to the standard ASTM C738. The results showed that especially in the red and dark blue colors cadmium and lead could be released easily by either acetic acid or orange juice, and these amounts were much higher than the permissible standard amount. Also microwave heating could enhance releasing of lead and cadmium from decorated dinnerware.

Keywords: Lead, Cadmium, Ceramic Décor, Extraction, Microwave

INTRODUCTION

Dinnerware decorated with over glaze designs can release toxic metals into food substances in high enough amounts to constitute health hazards (Sheet, 1997 and Omolaoye *et al.*, 2010). Cadmium and lead are the main components of ceramic colors. In most of the colors, lead oxide and cadmium compounds are used as a flux and pigments in the manufacture of red, orange and yellow colors, respectively. The use of decorated porcelain and glass are usual in Iran and many countries.

Most dinnerware was not intended for use in conventional ovens. The widespread domestic use microwave oven, however, increases the probability of lead and cadmium ingestion from dinnerware.

In the contact with acidic foods such as fruits juices, these containers could release heavy metals and transfer them to foods.

In this study the released cadmium and lead were investigated from different color of over glaze

to food stuff and also effect of microwave heating was considered on release of lead and cadmium.

Results for microwave heating test were compared with results from conventional 24-h acid leaching carried out at room temperature.

MATERIALS AND METHODS

Instrumentation

Lead and cadmium analysis were performed using a Varian AA-240 flame atomic absorption spectrophotometer with a hollow cathode lamp and a deuterium lamp for background correction. The operating parameters for the determination were set as recommended by the company.

The small microwave oven use in these experiments had a rotating turntable and a power output of 622 W.

Selected samples

Overall, 60 decorated porcelain dishes were purchased.

*Corresponding Author: Hashemi-Moghaddam H., Department of Chemistry, Damghan Branch, Islamic Azad University, P. O. Box 36716-39998, Damghan, Iran. Email: h.hashemimoghaddam@damghaniau.ac.ir

Since investigation on release of lead and cadmium from different colors was the main propose of this study, all purchased samples had somewhat the same design, and one color was dominant in each of them. Selected colors were grey, red, orange, blue, and dark blue.

The amounts of lead and cadmium released from the dishes after contacting with 4% acetic acid and natural orange juice, measured and evaluated according to ASTM standards (C738).

All glassware was soaked overnight in 10% (v/v) nitric acid, followed by washing with 10% (v/v) hydrochloric acid, and rinsed with double distilled water and dried before using.

ASTM(C738) Standard test method for lead and cadmium extracted from glazed ceramic surfaces

This test method covered the precise determination of lead and cadmium extracted by acetic acid from glazed ceramic surfaces. Containers having a simple decor were placed in touch with 25 mL of 4% acetic acid solution for about 24 hours at temperature 22 °C to determine for lead and cadmium to be transferred to the acid. The test was performed according to standard ASTM (C738).

Experimental methods

Leaching experiment were carried out on each of samples in following sequence, samples were: (1) filled with 4% acetic acid left to stand for 24 h at room temperature (2) filled with 4% acetic acid and

heated in a microwave oven for 2 min (3) filled with 4% acetic acid left to stand for 2 min at room temperature (4) filled with orange juice left to stand for 24 h at room temperature (5) filled with orange juice and heated in a microwave oven for 2 min (6) filled with orange juice left to stand for 2 min at room temperature, in all cases dish was washed with detergent and rinsed with deionized water before being filled to within 7 mm with leaching solution.

Sample digestion method for the determination of released lead and cadmium to orange juice

For wet decomposition, oxidizing agents are used to decompose the organic samples before metal content determination or to extract metals from inorganic matrices, allowing their determination.

Mixtures of nitric acid and hydrochloric acid were used for decomposition of orange juice at 70 °C for six hours.

Then 10 mL distilled water was added and the solution was passed through the filter. The solution quantitatively was transferred into a 50 mL flask and diluted to the mark with water. Finally, the absorbance was measured by AAS (Oliveira, 2003).

RESULTS AND DISCUSSIONS

The obtained results for concentrations of lead and cadmium in final leaching solutions of acetic acid and orange juice are tabulated in tables 1 and 2.

Table 1. Lead and cadmium extracted from glazed ceramic surfaces in contact with 4% acetic acid ; acetic acid 24-h room temperature test (*Acetic 24-h*); acetic acid 2 min room temperature test (*Acetic 2 min*) acetic acid 2 min microwave test(acetic micro).

Color	Lead Concentration mg kg ⁻¹			Cadmium Concentration mg kg ⁻¹		
	Acetic 24-h	Acetic micro	Acetic 2 min	Acetic 24-h	Acetic micro	Acetic 2 min
Grey	0.1	0.03	<0.01	<0.001	<0.001	<0.001
Blue	0.13	0.04	<0.01	<0.001	<0.001	<0.001
Dark Blue	2.1	0.2	0.03	0.007	<0.001	<0.001
Red	1.8	0.14	0.05	1.5	0.14	0.05
Orange	1.34	0.11	0.03	0.09	0.005	<0.001

Table 2. Lead and cadmium extracted from glazed ceramic surfaces in contact with orange juice; orange juice 24-h room temperature test (juice **24-h**); orange juice 2 min room temperature test (juice **2 min**) orange juice 2 min microwave test (juice micro).

Color	Lead Concentration mg kg ⁻¹			Cadmium Concentration mg kg ⁻¹		
	juice 24-h	juice micro	juice 2 min	juice 24-h	juice micro	juice 2 min
Grey	0.03	<0.01	<0.01	<0.001	<0.001	<0.001
Blue	0.017	<0.01	<0.01	<0.001	<0.001	<0.001
Dark Blue	0.18	0.09	0.05	0.003	<0.001	<0.001
Red	0.21	0.07	0.02	0.12	0.02	<0.001
Orange	0.018	<0.01	<0.01	0.017	0.005	<0.001

Based on ASTM (C738), maximum permissible limits for released lead and cadmium are tabulated

in table 3. Concentrations are higher than the permissible levels in most cases.

Table 3. Permissible limits for released lead and cadmium from dinner dishware.

Kind of dish	Maximum permissible limits of Lead mg kg ⁻¹	Maximum permissible limits of Cadmium mg kg ⁻¹
Plate	0.8	0.07

The following conclusions could be obtained from these results:

Release of lead and cadmium depends on the colors of decor. In the red colors, released cadmium and lead is higher than in the other colors. And in the dark blue colors, released lead is much higher than in the other colors. With regard to using cadmium in red pigment and low resistivity of dark blue color in the presence of acid, these observations are acceptable. Thus, generally, foods and especially acidic foods should not contact with decor of porcelain and glass for a long time, and it is more important in the case of red and dark blue colors.

Also obtained results show that microwave heating could enhance releasing of lead and cadmium from decorated dinnerware.

The international expert committee on food additives on 2000 established a permissible chronic intake level of lead and cadmium for adults of 0.025 and 0.006 mg/kg body weight of lead per week respectively (ECFA, 2000)

In table 2 and 3 are shown of total amounts of lead and cadmium extracted from the dishes during the acetic and orange juice microwave experiments. The value indicates that eating a single meal microwave in some dishes could result in the

ingestion of amount of lead approaching or exceeding the permissible weekly limits for adults.

REFERENCES

- Oliveira, E. D., 2003. Sample preparation for atomic spectroscopy: evolution and future trends J. Braz. Chem. Soc., 14, 174-182.
- Omolaoye, J. A., A. Uzairu, and C.E. Gimba, 2010. Heavy metal assessment of some ceramic products imported into Nigeria from China Archives of Applied Science Research, 2 (5),120-125.
- Sheets, R. W., 1997. Extraction of lead, cadmium and zinc from overglaze decorations on ceramic dinnerware by acidic and basic food substances, Science of The Total Environment, 197, 167-175.
- ECFA, 44th Report of joint FAO-WHO, expert committee on food additives, WHO, Geneva, 2000

