Determination of Level of Lead (Pb) and Cadmium (Cd) Migration on Bowl and Clear Plastic Cup Using Atomic Absorption Spectrophotometer

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Abstract. Food safety is a condition and efforts needed to prevent food from biological and chemical pollutants and other things that might irritate, harm, endanger human health. So the food is safe to consume. Besides, it should not against religion, faith, and culture. Chemical pollutants may come from migration of the food container or packaging, for example from a bowl or clear plastic cup. Migration happens as a result of the high temperature of food, duration of storage, and the production process. The higher the temperature the higher the possibility of migration. The existence of lead (Pb) and cadmium (Cd) in food may be because of environmental pollution, absorption of metal from equipment. Research has been conducted on the determination of the level of lead (Pb) and cadmium (Cd) from the migration of some bowls and plastic glasses that are available online by using spectrophotometer atomic absorption. The research is using acetic acid 4% simulant. The sample is identified by using Near Infra-Red. The result of two kinds of plastic bowls and one kind of clear plastic cup are Polypropylene (PP). The sample is filled with acetic acid 4% simulant, stored in a dark place for twenty-four hours, then it is measured with Atomic Absorption Spectrophotometer (AAS). In all samples consist of two kinds of bowls and one clear plastic cup. The lead and cadmium are not detected with a limit of detection (LoD) Pb is 1.33 µg/ml dan (LoD) Cd is 0.22 µg/ml, while the limit of quantitative (LoQ) Pb is 4.43 µg/ml and (LoQ) Cd is 0.74 µg/ml. LoD dan LoQ for lead is too high because are using AAS Flame, while ideally using AAS Graphite Furnace.

1. Introduction

Currently, online trading is widely practiced, including bowls, plastic cups and is in great demand by the public because of its low prices and attractive shapes and colors. In the last two decades, plastics packaging has captured the global packaging market share, replacing cans and glass packaging. Some of the names of plastics commonly used are HDPE (High-Density Polyethylene), LDPE (Low-Density Polyethylene), PP (Polypropylene), PVC (Polyvinyl chloride), PS (Polystyrene), and PC (Polycarbonate). PE (Polyethylene) and PP have many similarities and are often referred to as polyolefins [1]. Food packaging is a material used to contain and/or wrap food, whether it is in direct contact with the food or not [2].

Lead (Pb) is widely used as packaging material, drains, household items, and decorations. In the form of lead oxide, it is used as a pigment/dye in the cosmetic and glaze industries as well as in the ceramic industry, some of which are used in household appliances [3]. Research on Pb, Cd, Hg, and Cu...
content in *rejung* fish (S. sihama) was carried out by Nica Cahyani et al from August 2015 to January 2016, the results were very volatile. Most of the average heavy metal content of Pb, Hg, Cd, and Cu in each month has exceeded the threshold of the quality standard limit that has been set, but some are still below the quality standard threshold [4]. Meanwhile, the research results of Lian Dwi Fibrianti and R. Azizah showed that workers in the used battery home industry who had lead (Pb) levels in the blood ≥ 10 µg / dL had hypertension [5].

Suryo Irawan and Guntarti Supeni in 2013 researched on the levels of migrated metal in packs made of melamine, multilayer, and household appliances made of polymer with results that were still safe, which was below the threshold set by the POM [6].

BPOM head Regulation No. HK 03.1.23.07.11.6664 in 2011 determined that the total heavy metal content of lead (Pb), cadmium (Cd), chromium VI (Cr VI), and mercury (Hg) for all types of plastics is 1 ppm (parts per million). Under certain conditions, contact between plastic and food can cause migration (movement) of chemicals from the food container. Migration occurs due to the influence of the heat temperature of the food, storage time, and the processing process. The higher the temperature, the higher the possibility of migration [7]. According to Ir. Wawas Swathata frijiah from the Polymer Technology Center of the BPPT Ministry, in general plastics are safe as food packaging, as long as they are made according to applicable regulations. As food utensils, plastic made from virgin or not recycled plastic must be chosen. Also, it does not contain additives that exceed the specified threshold, has high chemical resistance, and is made with a good process [7].

Research conducted by Titin Agustina in 2014 shows that many foods are contaminated with heavy metals such as lead (Pb), mercury (Hg), Arsenic (As), and Cadmium (Cd) so that their safety is not guaranteed. The source of this contamination comes from environmental pollution such as motor vehicle fumes, the use of metals as a pest repellent (pesticides) [8].

Plastics consist of various polymers or monomers. Under certain conditions, contact between plastic and food can cause migration (transfer) of chemicals from the container to the food. Plastics are made by polymerization, namely arranging and forming a continuous plastic base material called monomers. Research conducted by [9] states that there is a migration of Cd and Pb metals from plastic containers to fresh, contacted milk. Cd metal migration that occurred ranged from 0.0000 - 0.0184 ppm for 4 hours of contact time and ranged between 0.0000 - 0.0480 ppm for 8 hours of contact time. Meanwhile, the Pb metal migration that occurred ranged from 0.0000 - 0.048 ppm for 4 hours of contact time and ranged from 0.0000 - 0.0677 ppm for 8 hours of contact time [9].

This study used samples of plastic bowls and clear plastic cups purchased online at low prices. The samples were identified to determine the type of plastic using the Near Infra-Red tool. To determine the levels of lead (Pb) and Cadmium (Cd) using a 4% acetic acid simulant which describes watery food such as soup, whether it is acidic or not [10]. Many people use plastic bowls for soup so that it is necessary to test the migration of Pb and Cd heavy metals from the bowl. Plastic cups are also often used for hot coffee or tea holders. Migration is the process of moving a substance from food packaging into food [2]. Food simulants are media used to imitate characteristics of certain food [2].

The results of this study can be used to determine the type of plastic from bowls and clear plastic cups and to determine whether or not lead (Pb) and cadmium (Cd) contamination comes from the migration of plastic bowls and clear plastic cups.

2. Method

**The instrument and material:** Atomic Absorption Spectrophotometer – AAS (Figure 1); Near Infra-Red– Phazir (Figure 2); Analytical balance. Standard of certified raw lead (Pb) and cadmium (Cd): 4% acetic acid solution, and aquademineral. The green plastic bowl; the white plastic bowl and the clear plastic cup (Figure 3).

A. **IDENTIFICATION**

Identification of the samples used by Near Infra-Red.

B. **LEVELS OF GREEN AND WHITE PLASTIC BOWLS AND PLASTIC CUP**

Preparation of sample:
The sample bowl was filled with acetic acid 4% to 0.6 cm below the top surface. Then the container is closed using a metal-free watch glass or aluminum foil and placed in a dark place at room temperature. Incubation was carried out at room temperature for 24 hours - Solution A. Figure 4[11]

**Preparation of standard solution (S)**
Standard solution of Pb and Cd each with a concentration of 1000 µg/ml

**Preparation of Intermediate Standard Solution (IS)**
Pipettes of 50.0 mL of main standard solution (S) of Pb and 5.0 mL of standard solution (S) of Cd are each put into a 100 mL volumetric flask, diluted with 4% acetic acid to the mark. Obtained a standard solution with a concentration of 500 µg / mL for the Pb standard and 50 µg / mL for the Cd standard.

**Preparation of working standard (WS)**
A serial standard solution is made with the concentration and dilution method as shown in the following table 1. (Solution B):

### Table 1. Working standard

| No. | Vol. from IS (ml) | The final vol. with 4% acetic acid (ml) | Concentration of Pb (µg/ml) | Concentration of Cd (µg/ml) |
|-----|------------------|----------------------------------------|-----------------------------|-----------------------------|
| 1   | 0                | 100.0                                  | 0                           | 0                           |
| 2   | 1.0              | 100.0                                  | 5                           | 0.5                         |
| 3   | 2.0              | 100.0                                  | 10                          | 1.0                         |
| 4   | 3.0              | 100.0                                  | 15                          | 1.5                         |
| 5   | 4.0              | 100.0                                  | 20                          | 2.0                         |
| 6   | 8.0              | 100.0                                  | 40                          | 4.0                         |

**Preparation of Blank solution**
Prepared in the same way as the sample-less test solution. - Solution C – Figure 5

**Method of Determination**
The absorption of solutions A, B, and C were measured using an atomic absorption spectrophotometer at the maximum wavelength of Pb $\lambda$: 283.3 nm and Cd $\lambda$: 228.8 nm and the levels were calculated using the following formula:

$$\text{The levels of Pb or Cd (µg/mL) = Csp x F}$$

Csp = concentration obtained from calculations using a calibration curve (µg/mL)
F = dilution (mL)

![Figure 1. Atomic Absorption Spectrophotometer – AAS](image)
Figure 2. Near Infra-Red – Phazir

Figure 3. The samples are green bowl plastic; white bowl plastic and a clear plastic cup

Figure 4. Preparation of samples

Figure 5. Preparation of blank
3. Results and Discussion
Identification: Method Near Infrared

RESULTS:

a) The Green plastic bowl, polypropylene (PP) type
b) The White plastic bowl, polypropylene (PP) type
c) The Clear plastic cups, polypropylene (PP) type (Table 2)

Table 2. The Result of Identification

| No. | No. of Sample | Figure | Plastic identification |
|-----|--------------|--------|------------------------|
| 1   | 1            | ![Green Bowl](image) | PP                     |
| 2   | 2            | ![White Bowl](image) | PP                     |
| 3   | 3            | ![Clear Cup](image)  | PP                     |

Results: PP

Result: PP

Result: PP
Determination Of Lead (Pb) And Cadmium (Cd)

a. Calibration Curve

1. Lead (Pb)
   \[ A = 0.0042092 \]
   \[ B = 0.0061205 \]
   \[ r = 0.9996 \]

   \[ Y = 0.0061205X + 0.0042092 \] (Figure 6)

2. Cadmium (Cd)
   \[ A = 0.010597 \]
   \[ B = 0.14548 \]
   \[ r = 0.9989 \]

   \[ Y = 0.14548X + 0.010597 \] (Figure 7)
Figure 7. Calibration Curve of Cd

The level Pb and Cd of the green plastic bowl and white plastic bowl and a clear plastic cup

a. The lead (Pb): not detected with limit of detection (LoD) is 1.33 µg/ml and limit of quantitation (LoQ) is 4.43 µg/ml

b. The cadmium (Cd): not detected with limit of detection (LoD) is 0.22 µg/ml and limit of quantitation (LoQ) is 0.74 µg/ml.

Discussion:
The results are not detected possibly because:
1. The type of plastic is polypropylene (PP), which is a type of plastic that is good for use as packaging
2. Undetectable because the Pb LOQ is too high is 4.43 µg/ml, AAs - Graphite Furnace should be used

Suggestion:
a. Need to do Pb testing using AAS - Graphite Furnace
b. It is necessary to test Pb and Cd using hot water simulant.
c. Limit of detection (LoD) Pb is 1.33 µg/ml and (LoD) Cd is 0.22 µg/ml, while the limit of quantitative (LoQ) Pb is 4.43 µg/ml and (LoQ) Cd =0.74 µg/ml. LoD and LoQ for Pb too high because of using AAS Flame, while ideally using AAS Graphite Furnace.

4. Conclusions
The type of sample consisted of green, white plastic bowls, and clear plastic cups namely polypropylene (PP). There was no migration of Pb and Cd metals from the three samples which were analyzed using AAS Flame with the LoD or Pb was 1.33 µg / ml and LoQ was 4.43 µg / ml, while the LoD of Cd was 0.22 µg / ml and LoQ is 0.74 µg / ml.
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