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Lead and Cadmium Residues in Commercial Poultry Eggs in West Java Indonesia

Ellin Harlia[1]*, Eulis Tanti Marlina[1], Yuli Astuti Hidayati[1] and Reginawanti Hindersah[2]

[1]Faculty of Animal Husbandry, Universitas Padjadjaran, Sumedang, Jawa Barat, Indonesia
[2]Faculty of Agriculture Universitas Padjadjaran, Sumedang, Jawa Barat, Indonesia
***Corresponding author email: ellin.harlia@unpad.ac.id**

Abstract. Anthropogenic contamination of heavy metals in both soil and water threatens human health through the consumption of livestock products. Important heavy metal toxins, namely lead (Pb) and cadmium (Cd) are present in livestock feed and drinking water and detected in poultry meat and eggs. This study aimed to detect Pb and Cd in poultry eggs (local farms, commercial farms, quail, and ducks) that are consumed by humans almost every day and considered a source of pollution in the environment farm. This research was exploratory research using the survey method and the samples were drawn randomly. The data were analyzed descriptively by calculating the mean of the heavy metal content of Pb and Cd in the samples studied and then compared with the Maximum Residue Limit of Pb and Cd recommended by the Food and Drug Supervisory Agency of the Republic of Indonesia No. 5/2018. The results showed that Pb content in poultry eggs exceeded the Maximum Residue Limit, which was 0.2500 mg/kg except for Pb content in duck eggs and Cd content in poultry eggs in which the samples were below the Maximum Residue Limit.

Keywords: cadmium, lead, egg, residue

Abstrak. Kontaminasi anthropogenik logam berat baik dalam tanah maupun air mengancam manusia dan kesehatan melalui konsumsi produk peternakan. Timah (Pb) dan Kadmium (Cd) adalah logam berat beracun yang berpotensi terdapat di dalam pakan dan air minum peternakan, sehingga dapat terdeteksi di daging dan telur unggas. Penelitian ini mendeteksi logam berat Pb dan Cd pada telur unggas (ayam broiler, ayam kampung, burung puyuh dan bebek) telah dilaksanakan dengan tujuan untuk mengetahui kandungan logam berat Pb dan Cd dalam telur unggas yang dikonsumsi manusia hampir setiap hari dengan mempertimbangkan sumber polusi di lingkungan peternakan. Penelitian ini merupakan penelitian eksploratif menggunakan metode *survey* dan *sampling* secara acak. Data dianalisa secara deskriptif dengan menghitung rataan kandungan logam berat Pb dan Cd dalam sampel yang diteliti kemudian dibandingkan dengan batas residu maksimal Pb dan Cd yang direkomendasikan oleh Badan Pengawas Obat dan Makanan Republik Indonesia No 5 Tahun 2018. Hasil penelitian menunjukkan bahwa kandungan Pb dalam telur unggas melebihi batas maksimum residu yaitu 0.2500 mg/kg, kecuali kandungan Pb pada telur bebek dan Cd pada telur unggas lebih rendah dari batas maksimum residu.

Kata kunci: kadmium, timah, telur, residu

Introduction

Anthropogenic contamination of heavy metals in either soil or body of water brings about environmental problems and threats to the human food chain. Some present studies offer information on the presence of significant toxic heavy metals i.e. lead (Pb) and cadmium (Cd) in poultry feeds and drinking water. Some poultry feeds in Sokoto Nigeria contained Pb and Cd up to 0.55 µg/ml and 0.94 µg/ml, respectively (Suleiman et al., 2015). Pb contamination in poultry feeds was examined in a large study covering 29 nations from 2009 to 2016 (Asia-Pacific, North and Latin America) and to be reported as high as 722 mg/kg (Eskandari and Pakfetrat, 2014), significantly exceeding levels seen in this research. On the contrary, Ifie et al. (2022) demonstrated that Pb concentration in all animal feed samples from Nigeria was above the maximum limit of 5 mg/kg. Lower Pb amounts (0.137-0.369 mg/kg) in poultry feed from northern Germany were also found (Wolf and Cappai, 2021). In Indonesia, the important ingredients of poultry feeds are rice husk and

corn grain. Paddy fields in Indonesia especially in Java are at risk of heavy metal contamination due to many small, medium, and big-scale industries. The lead content in mixed feed for broiler and basal feed for laying hens was 0.089 mg/kg and 0.181 mg/kg respectively, and the highest Pb content of 0.358 mg/kg was detected in mixed feed for turkey.

Agricultural Environmental Research Institute of the Department of Agriculture verified that some paddy fields in Central Java are contaminated with heavy metals up to 4.43 mg/kg Cd; however, Pb content was low (Indratin and Wahyuni, 2018). Contamination risk in paddy soil also derives from vehicle combustion because some paddy fields in Java are located near the road or highway. Irrigation water and phosphate fertilizers are major Pb and Cd contamination sources in paddy. The lead content of irrigation water was up to 0.16 mg/kg, which is above the Maximum Residue Limit, however, the Cd content was low. Naturally, Pb and Cd content in natural P fertilizer are up to 156 mg/kg and 113 mg/kg, respectively (Indratin and Wahyuni, 2018). The Pb impurities were detected in phosphate fertilizers and even in Urea and NPK fertilizer (Benson, 2014, Azzi et al., 2017; Kratz et al., 2017).

Heavy metal contamination in poultry production systems might bring about significant changes in biochemical reactions and neural systems in poultry (Chowdhury et al., 2011) and hence egg production. Heavy metal toxicity in poultry causes liver damage, growth inhibition, and less egg production; decreased egg weight, egg shell, egg white, and egg yolk were also reported elsewhere (Kim et al., 2019). In poultry metabolism, Pb dan Cd inhibits enzyme activity since the metal replaces essential inorganic co-factor; thereby interrupting the egg formation system (Gattea Koshan Al-Rikabi et al., 2021).

Special attention is required to heavy metal-contaminated eggs since it is bioaccumulating and not essential for human. In Indonesia, including West Java, egg consumption as the protein source in daily diet is increased. Table egg is becoming more important as a source of protein, vitamins and minerals (Chowdhury et al., 2011) due to their relatively lower price compared with meat and fish. Measuring the Pb and Cd levels in commercial poultry eggs in West Java where most Indonesian population inhabits was the goal of this study.

Materials and Methods

The research has been conducted in the Laboratory of Faculty of Husbandry, Universitas Padjadjaran. The research method was descriptive quantitative research concerning Pb content in local chicken, commercial farms, duck, and quail.

Sample Collection

A total of 199 eggs were obtained from some commercialized farms in West Java. The sampled eggs included 33 chicken eggs and 36 duck eggs from Tanjungsari District, Sumedang Regency; 90 quail eggs from a farm in Paseh District, Bandung Regency, and 40 chicken eggs from a local farm in Malangbong District, Garut Regency.

Sample Preparation

Sample preparation starts with weighing the sample, separating each sample, and labeling the egg sample. Eggs were broken, and the yolks and whites were separated. The separated egg yolk was then put into an Erlenmeyer as much as 5 g, then 10 ml of HNO_3 and 5 ml of H_2SO_4 were added. The flask was covered with a watch glass, heated on a hotplate in an acid chamber for 10 hours at 115^oC, and the watch lid was opened to evaporate and dry the sample. Then the samples were put in a kiln at 400^oC for 2 hours to let dry. As much as 5 ml of 6% HNO_3 was added. The samples were filtered with Whatman paper no. 42 to obtain a clear filtrate which was then stored in a volumetric flask; added with 10 ml of distilled water, and transferred to a test tube for

analysis of Pb and Cd residues by using Atomic Absorption Spectrophotometry (AAS) following mixed-acid digestion (Tsalev and Zprianov, 1983).

Heavy Metal Residue Determination

All eggs were subject to Pb and Cd content analysis using AAS at a wavelength of 283.3 nm for heavy metal Pb, and 228.8 nm for heavy metal Cd.

Statistical Analysis

The research was conducted using survey methods and sampling techniques in the form of simple random sampling. Data were analyzed descriptively, measured the average amount of Pb and Cd heavy metals of the studied samples and standard deviation, then compared with the Maximum Residue Limit 2018 for Pb and Cd heavy metals.

Results and Discussion

Lead and Cadmium residue content in some poultry eggs are presented in Table 1 and Table 2, respectively. The residue content of heavy metal Pb in 50% of quail egg samples, 41.6% of commercial farm egg samples, 5.6% of duck egg samples and 78% of local hen samples exceeded the Maximum Residual Limit 2018 (0.2500 mg/kg). The Cd residue content in 22.2% of quail egg samples and 20% of local hen samples exceeded the Maximum Residual Limit in 2018, but eggs from commercial farm eggs and duck eggs were below the Maximum Residual Limit in 2018 (0.1000 mg/kg). The highest and lowest Pb concentration was in the egg yolk and the albumin, respectively. Pb concentration was higher in the liver and ovaries than in the oviduct. Where ovulation occurs, the protein of the egg yolk is synthesized and accumulated in the egg, whereas the protein of the albumin is synthesized in the oviduct and deposited during ovulation (Yuan et al. 2013). Cd residue content in commercial farm eggs, duck eggs did not exceed the Food and Drug Supervisory Agency 2018 Maximum Residue Limits, which is in line with Abduljaleel and Othman-Shuhaimi (2011) from Kajang City Malaysia and (Kabir et al. 2019) from Chittagong Bangladesh reporting lower Cd concentration in the chicken egg than the recommended limit. In line with the research of Tanhan et al. (2020) in Thailand who reported that duck eggs contained Cd heavy metal residues below the standard.

Accumulation of heavy metal residue in poultry eggs was attributed to several sources such as contaminated feed and drinking water due to environmental pollution. Heavy metal Pb and Cd potentially enter the body through poultry feed and contaminated drinking water (Hashish et al., 2012; Hejna et al., 2018; Hossain et al., 2014; Rajaganapathy et al., 2011; Rashid et al., 2018). Nutrients circulating throughout the body can enter the vascular system, and heavy metals deposited in the liver, bone, soft tissue and eggs are mostly distributed to all body tissues (Korish and Attia, 2020). The kidney and liver are where Pb and Cd accumulate, given the liver is the site of the synthesis process of vitellogenesis and albumen through the oviduct. Heavy metals will bind protein yolk and albumen through amino acids, which in the long term leads to the increase of accumulated and absorbed Pb and Cd.

Table1. Average Residual Pb content in Poultry Eggs

No	Type EggsPoultry	The content ofPb (mg/kg)
1	Commercial Farm eggs	0.3716± 0.2882
2	Local farm eggs	0.5484±0.5294
3	Duck	0.0457± 0.0084
4	Quail	0.2693±0.1991
	Maximum Residual Limit (2018)	0.2500

Table2. Average Residual Cd content in Poultry Eggs

No	Type Eggs Poultry	The content ofCd (mg/kg)
1	Commercial Farm eggs	0.0133± 0.0094
2	Local farm eggs	0.0849± 0.0451
3	Duck	0.0109± 0.0067
4	Quail	0.0647± 0.0617
	Maximum Residual Limit 2018	0.1000

Cadmium is not effectively transferred into milk or eggs (Rahimzadeh et al., 2017). It was in line with Alkhalaf et al. (2010), Siddiqui et al. (2011), Sarkar et al. (2017) who reported higher Pb levels than Cd in poultry feed.

Cadmium residue in eggs is derived from polluted food and drinking water. The feed given to intensively reared poultry consists of bran, soybean meal, corn, and concentrates. The commercial quail feeds, chicken feed and drinking water in West Java where the egg samples were collected contained significant Pb and Cd levels (Table 3).

Grains and their by-products are usually the main sources of heavy metals Cd (Siddiqui et al., 2011). Research collaboration between the Faculty of Agriculture and Agricultural Environmental Research Institute reported that Cd content in un-hulled rice grown in uncontaminated soil was 0.02 mg/kg, but the level increased to 2.41 when cultivated in paddy soil with 18.95 mg/kg Cd (Aji and Hindersah, 2012).

The use of fertilizers and pesticides in rice, soybeans and corn can be the source of contamination through Cd-contained feed (Alkhalaf et al., 2010; Corguinha et al., 2015). Cadmium can damage the kidneys and accumulate in bone (Kim et al., 2019; Bortey-Sam et al., 2015; Wang et al., 2021). According to several research findings, there is a significant correlation between the content of heavy metals in feed with that in eggs. Eggs containing a disproportionately high amount of Cd are harmful to human health. Higher cadmium concentration in the diet will accumulate particularly in the kidney and liver, and induce significant biological and neurological abnormalities in humans even at ultra-trace levels (Rahimzadeh et al., 2017). This study found different levels of heavy metals in poultry feed with higher concentrations of lead than cadmium, as similarly reported by Ahmed et al., (2017), Yan et al. (2020), and Alkhalaf et al. (2010) revealing that some plants were able to absorb more lead from the soil and some plants naturally absorbed lead more than others.

The poisoned egg poses a risk to public health because lead consumed by the chicken through the tainted feed is deposited in bones, soft tissue, and eggs. Repeatedly consuming contaminated eggs from a family-owned brood can expose the body to a harmful dietary source since lead can be sequestered from hen to egg (Bautista et al., 2014). Apparently, high levels of cadmium in the diet can lead to a higher accumulation of eggs produced. Pb levels in chicken and quail, and Cd in all kinds of eggs were quite alarming. Although the consumption is not as much as chicken, both chicken and quail eggs are still popular.

Table3.The content of heavy metals in poultry feed and drinking water

No	Poultry Type	Feed (mg/kg)		Drinking water (mg/kg)	
		Pb	Cd	Pb	Cd
1	Quail	1,227	0,1645	0,054	0,004
2	Local farm eggs	1,1445	5,7225	0,2985	1,4925
National Research Council (2005)		0.5000			

Local people in West Java traditionally consumed eggs from local hens and quail since they raised them for daily consumption and economic reason. However, present consumers of these types of eggs are dominated by urban citizens assuming that healthy food is from local food.

Conclusions

The Pb level of 0.25 mg/kg in the poultry eggs does not exceed the 2018 Maximum Residue Limit, while the Cd level was within the limit, which is less than 0.10 mg/kg of the Maximum Residue Limit. This study provided prominent data on heavy metal contamination of poultry eggs in Sumedang and Bandung regions of West Java. This finding is important for the risk assessment of the egg consumer. Although the Pb and Cd content in eggs were below the Maximum Residue Limit, the presence of heavy metal residue was necessary to anticipate the long-term accumulation of both toxic heavy metals that might threaten the consumers' health.

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