Acta Scientific MEDICAL SCIENCES (ISSN: 2582-0931)

Volume 8 Issue 3 March 2024

Research Article

Detection of Lead Heavy Metal Contamination in Eggs of Duck and Free-Range Chicken

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Received: October 18, 2023

Published: February 07, 2024

Abstract

Lead heavy metal contamination is increasingly widespread in water, soil, and air, as well as livestock residing in a lead-polluted environment face potential exposure, which could extend to their products. Therefore, this study aimed to determine the presence of lead contamination in eggs of duck and free-range chicken. The samples included 30 eggs of duck and free-range chicken taken from several markets in Denpasar City. Eggs were processed to check for the presence of lead heavy metal and the measurement was carried out using the atomic absorption spectrophotometer (AAS) method at the Analytical Laboratory of Udayana University. The results showed that there were 4 duck eggs containing lead heavy metal with levels of 5.241 ppm, 2.434 ppm, 1.021 ppm, and 0.543 ppm, respectively. However, no contamination was detected in all free-range chicken eggs samples. This indicated that the prevalence of duck eggs exposed to lead was 13.33%, and certain contamination levels exceeded the maximum threshold for food, namely 1.00 ppm. This exposure stemmed from duck reared in lead-polluted areas. Further investigation was needed on the factors related to lead exposure in duck eggs. For egg consumers, based on the results, it was safer to select chicken eggs compared to duck eggs.

Keywords: Lead; Duck; Eggs; Free-Range Chicken

Introduction

Duck and chicken eggs are food ingredients commonly consumed by people in various preparations. The nutritional content of duck eggs is reportedly better compared to native chicken eggs [1]. However, the aquatic nature of duck as waterfowl increases vulnerability to lead heavy metal contamination due to the tendency to reside and forage in water environments. Lead contamination within the blood of village duck in Argentina was reportedly from the water in the environment [2]. The cycle of pollution can ecologically spread to plants, animals, and humans [3]. Cattle kept in landfills are significantly exposed to lead [4]. Intensive rearing of cattle can also result in contamination, as evidenced by dairy cattle raised in Egypt, ingesting lead-tainted grass [5].

Lead heavy metal is very dangerous to animal and human health, with its poisoning generally causing brain degeneration and anemia [6,7,16]. It also leads to the wasting of the liver accompanied by intranuclear inclusion bodies in hepatocytes [6]. Furthermore, lead poisoning in ruminants causes symptoms of gastroenteritis, anemia, and encephalopathy [9]. Hepatotoxicity due to toxicity originating from inorganic substances, culminated in reduced immunity to infectious agents [8].

The accumulative nature of lead heavy metals in body tissues is a concerning factor due to the difficulty associated with its metabolism, resulting in oxidative stress [9]. Although there is a maximum threshold for lead content in food and feed at 1.00 ppm [10], efforts are needed to free food, including eggs, from lead contamination.

Material and Method

A total of 30 eggs samples each from duck and free-range chicken were obtained from several markets in Denpasar City. The collection of eggs was conducted through a cross-sectional design.

The examination of the samples involved separating the yolk and eggs white, each of which was examined for lead heavy metal content. The measurement was conducted using the Atomic Absorption Spectrometry (AAS) method [11] at the Analytical Laboratory of Udayana University. Each 2 g sample was divided into 1 g for both the positive control and measured sample. The positive control (spiked) was prepared by adding 0.25 ml with 1 mg/l of a standard solution and then evaporated on a hot plate at a temperature of 100ºC until it became dry. Furthermore, the measured sample and spiked were placed in a combustion furnace with half of the surface covered. The furnace temperature was gradually increased by 100ºC every 30 minutes up to 450ºC and maintained for 18 hours. The samples were then removed from the combustion furnace and cooled to room temperature. Furthermore, 1 ml of 65% HNO_3 was added and shaken slowly to ensure all ash dissolved in the acid. This was followed by evaporation on a hot plate at a temperature of 100ºC until drying was achieved. The measured sample and spiked were returned to the combustion furnace and the temperature was gradually increased by 100ºC every 30 minutes up to 450ºC, and maintained for 3 hours. After the ash was perfectly formed, 5 ml of 6 M HCl was added, shaken slowly to facilitate the dissolution of all ash in acid, and evaporated on a hot plate at 100ºC. About 10 ml of 0.1 M HNO_3 was also added and cooled to room temperature for 1 hour. The solution was transferred into a 50 ml polypropylene volumetric flask and the matrix modifier solution was added up to the mark using 0.1 M HNO_3. Additionally, the essential heavy metal standard working solutions were prepared for each sample and spiked with a minimum of five concentration points. The standard working solution, sample, and spiked were read on the graphite furnace atomic absorption spectrophotometer at the wavelength corresponding to the metal being tested. Finally, the concentration in µg/g was calculated using the formula (SNI 2354.5:2011).

$$\text{Concentrate} = \frac{(D - E) \times Fp \times V}{W}$$

Description:

D: Concentration of sample (µg/l) from AAS reading

E: Concentration of blank sample (µg/l) from AAS reading

Fp: Dilution factor

V: Final volume of prepared sample solution (ml), converted to liters

W: Weight of sample (g).

Result

From the 30 duck eggs, 4 of the samples (positive) contain lead heavy metal with levels of 5.241 ppm, 2.434 ppm, 1.021 ppm, and 0.543 ppm, respectively. However, no lead heavy metal was detected in all free-range chicken eggs. These results indicated that the prevalence of duck eggs exposed to contamination was 13.33%. Certain lead levels exceeded the maximum threshold for food, namely 1.00 ppm [10]. The results suggested that duck eggs were more at risk of being exposed compared to free-range chicken eggs. The results of measurement data are presented in Table 1.

No	Duck eggs		Free-range chicken eggs	
	Lead content (ppm)	Description	Lead content (ppm)	Description
1	5.241	Exceeds the BSN standard	0.000	Not detected
2	2.434	Exceeds the BSN standard	0.000	Not detected
3	1.021	Exceeds the BSN standard	0.000	Not detected

4	0.543	Does not exceed the BSN standard	0.000	Not detected
5	0.000	Not detected	0.000	Not detected
6	0.000	Not detected	0.000	Not detected
7	0.000	Not detected	0.000	Not detected
8	0.000	Not detected	0.000	Not detected
8	0.000	Not detected	0.000	Not detected
10	0.000	Not detected	0.000	Not detected
11	0.000	Not detected	0.000	Not detected
12	0.000	Not detected	0.000	Not detected
13	0.000	Not detected	0.000	Not detected
14	0.000	Not detected	0.000	Not detected
15	0.000	Not detected	0.000	Not detected
16	0.000	Not detected	0.000	Not detected
17	0.000	Not detected	0.000	Not detected
18	0.000	Not detected	0.000	Not detected
19	0.000	Not detected	0.000	Not detected
20	0.000	Not detected	0.000	Not detected
21	0.000	Not detected	0.000	Not detected
22	0.000	Not detected	0.000	Not detected
23	0.000	Not detected	0.000	Not detected
24	0.000	Not detected	0.000	Not detected
25	0.000	Not detected	0.000	Not detected
26	0.000	Not detected	0.000	Not detected
27	0.000	Not detected	0.000	Not detected
28	0.000	Not detected	0.000	Not detected
29	0.000	Not detected	0.000	Not detected
30	0.000	Not detected	0.000	Not detected

Table 1: Measurement Results.

Discussion

Lead contamination in duck eggs indicated the presence of lead in the environment where duck is reared. Duck, including waterfowl, is very likely to be exposed through the aquatic environment [2]. Lead circulation in the blood penetrates the barrier system in the placenta, spreading to eggs and fetuses [12]. Therefore, newborn animals can be exposed, initiating a new cycle of contamination in soil, plants, and animals. These results imply that duck eggs can be used as bioindicator of environmental pollution. Bioindicator is a community of interconnected organisms, whose existence or behavior is closely related to certain environmental conditions, resulting in their use as an indicator of environmental quality or for quantitative tests. Each animal exhibits varying sensitivity levels to heavy metal exposure, making it bioindicator of pollution in the environment. Several types of animals have been reported as bioindicator of environmental pollution, including buffalo [13], cattle, sheep, camels [14,15], and forest anoa [17]. The results showed that duck eggs have great potential to be used as bioindicator of lead pollution in the environment. However, no contamination was detected in free-range chicken eggs presumably due to the influence of land habitat. Particles of lead are more easily consumed by duck compared to landfowl, resulting in higher exposure [2].

Based on the results, consuming duck eggs has a greater risk than chicken eggs, evidenced by the prevalence of exposure to lead, which reached 13.33%. The exposure levels exceeded the maximum threshold suitable for consumption. Exposure to duck eggs has also been reported in Thailand [18]. The exposure levels require urgent attention because lead, similar with other heavy metals, can cause disturbances in various tissues in animals and humans [6]. The accumulation in the body for a certain period may lead to lead poisoning, resulting in brain degeneration, anemia [6,7,16], and wasting of the liver accompanied by intranuclear inclusion bodies in hepatocytes [17]. Furthermore, lead poisoning in ruminants causes symptoms of gastroenteritis, anemia, and encephalopathy [6,7]. Hepatotoxicity due to toxicity originating from inorganic substances culminated in reduced immunity to infectious agents [8].

Conclusion

The presence of heavy metal lead contamination in duck eggs shows the dangers of consuming duck eggs rather than free-range chicken eggs. The duck rearing environment can be a source of lead pollution in duck eggs

Acknowledgment

The author is grateful to the Rector of Udayana University for the funding provided through the Head of the Research and Community Service Institution of Udayana University.

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