

Heavy Metals in Broilers Meat and Its Relations to Health Risk to Human

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ABSTRACT

Heavy metals pose significant risks to human health, and their presence in poultry products can serve as an indicator of environmental contamination. This study aims to determine and measure heavy metal concentrations in poultry muscle and liver tissues, assessing potential risks to human consumption.

The levels of heavy metals, including Fe, Cu, Zn, Mn, Se, Co, Cr, Pb, Cd, and

Ni, in chicken meat and meat products, feed, and litter, as well as laying hens' eggs, feed, and litter.

The purpose was to evaluate the safety and quality of these products based on recommended daily allowance (RDA) and tolerable upper levels.

The liver showed the highest accumulation of heavy metals, except for Cr. Alarmingly, the intake of Pb and Cd from poultry products exceeded the RDA for adults, posing potential health risks.

To ensure the safety and quality of poultry products for human consumption, stricter legislation and monitoring systems are necessary. Regulations should focus on the quality control of poultry products, feeds, and litter. Furthermore, detoxification methods should be implemented to reduce heavy metal concentrations in poultry waste.

Key words: heavy metals - broilers meat - health risk - human

I. INTRODUCTION

Plants serve as primary food sources for humans, with a significant portion of nutrition also derived from animals. Among animal products, poultry meat—particularly chicken—has gained widespread acceptance due to its high protein content, digestibility, palatability, low fat and cholesterol levels, and lack of religious or cultural restrictions (Javadi and Safarmashaei, 2011; Ogu et al., 2017).

However, in developing countries, a significant health challenge is the potential contamination of poultry meat with toxic metals

during feeding, transportation, processing, or retailing (Ogu et al., 2017).

Studies have highlighted the global prevalence of heavy metal contamination in chicken tissues and organs (Benouadah et al., 2015; Haleelu et al., 2015; Makanjuola, 2016; Mottalib et al., 2018). Environmental pollution from industrial waste, excessive use of agrochemicals, and fossil fuel combustion are common sources of heavy metals (Tchounwou et al., 2012). These metals can infiltrate both plant and animal-based food chains, leading to contamination of raw and processed foods.

Heavy metals, defined as elements with an atomic density of $\geq 4,000 \text{ kg/m}^3$ (ElHamaky et al., 2023), pose serious risks to human health. Animals absorb these metals through food, water, sediment, and air (Mehtar et al., 2023). Particularly hazardous metals include arsenic (As), lead (Pb), cadmium (Cd), and mercury (Hg), which can accumulate in poultry tissues such as the liver, kidneys, and reproductive organs (Hoque et al., 2023). Chronic exposure to low doses of these metals can damage tissue structures, leading to potential health risks for humans consuming contaminated poultry products.

On the other hand, essential metals like zinc (Zn), iron (Fe), copper (Cu), and selenium (Se) play crucial roles in metabolic regulation (Valkova et al., 2023). However, when levels of harmful metals exceed safe limits, they can overshadow the nutritional benefits of poultry. Contamination often originates from poultry feed, which may contain fungi, parasites, or trace levels of toxic metals introduced as additives (Singh et al., 2023).

Heavy metals like Cd, Pb, As, Cr, Hg, and Ni can bioaccumulate in poultry tissues, posing risks to consumers (Lysenko et al., 2021). Prolonged exposure leads to deposition in vital organs such as the brain, liver, and kidneys, increasing the likelihood of adverse effects. Industrial fertilizers, waste disposal, and improper feed storage and handling exacerbate this issue.

Poultry farming is critical to global food production, with chicken meat accounting for 40% of global meat output in 2019 and egg production reaching 83 megatons (Emami et al., 2023). Given this scale, even trace contamination has far-reaching consequences for public health.

To minimize risks, governments and industry stakeholders must enforce stringent regulations on poultry farming practices, feed quality, and waste management. Measures to monitor and control heavy metal contamination in poultry products are essential to protect public health. Continued research is also needed to address the bioaccumulation of toxic metals and explore mitigation strategies. By addressing these concerns, the poultry industry can ensure safer, more sustainable food production while preserving human and environmental health (Jaishankar et al., 2014).

II. AIM OF THE STUDY:

This study aimed to study the incidences and types of heavy metals in broilers meat and its relations to health risk to human

III. REVIEW OF LITERATURE 1- HEAVY METAL CONTAMINATION IN POULTRY:

The diet of broilers is often supplemented with trace elements such as Fe, Cu, Zn, Mn, I, and As to support growth, immunity, and metabolic functions (Attia et al., 2016). However, excessive intake of these minerals can lead to their excretion in manure, contributing to environmental pollution (Eton et al., 2008). Additionally, toxic heavy metals like cadmium (Cd), lead (Pb), mercury (Hg), and arsenic (As) are not essential for biological functions and can pose significant risks to both animal and human health when present in excessive amounts (McCroy et al., 2005).

a. Cadmium (Cd) in Poultry

Cadmium is a critical environmental contaminant continuously released from industrial and natural sources, such as smelting operations, fossil fuel combustion, phosphate fertilizers, and sewage sludge (Shi et al., 2023). Poultry are exposed to Cd primarily through contaminated food and drinking water, leading to its accumulation in tissues after binding to metallothionein in the bloodstream.

Cd exposure in poultry causes significant health issues, including deformities, anemia, osteoporosis, chronic rhinitis, and non-hypertrophic emphysema.

It can also impair egg production, reduce feed intake, and increase stress susceptibility due to histopathological damage (Zhao et al., 2022; Aljohani et al., 2023). The accumulation of Cd in organs such as the liver and kidneys poses risks to human health through the food chain. Cd-induced oxidative stress, mediated by the production of lipid peroxidases and free radicals, is particularly harmful to the kidneys and liver, causing tissue damage (Emami et al., 2023).

b. Lead (Pb) in Poultry

Lead is one of the most prevalent environmental toxins, particularly in industrialized regions, and can enter the environment through emissions from gasoline combustion, lead-based paints, recycled materials, and contaminated water

(O'Connor et al., 2020). While poultry absorb only small amounts of Pb, chronic low-level exposure can result in its accumulation in tissues due to the slow elimination rate.

Pb exposure affects multiple organ systems, including the nervous system, liver, kidneys, and reproductive system, by generating free radicals and inducing oxidative stress. This toxic metal disrupts antioxidant defenses, increasing vulnerability to oxidative damage (Mateo et al., 2014; Smirnova et al., 2023). Accumulated Pb in poultry tissues can be transferred to humans through consumption, leading to severe health consequences.

c. Mercury (Hg) in Poultry

Mercury is a potent neurotoxin with severe health implications for both animals and humans. Although methylmercury is the most toxic form, mercury (II) is more abundant in the environment and adversely affects poultry health (Kojima et al., 2023). Major sources of mercury include the chemical, paint, and pesticide industries, as well as geothermal steam.

Mercury exposure in poultry results in anemia, growth retardation, and immune dysfunction due to oxidative stress and nitric oxide suppression. Young chickens are particularly susceptible to its toxic effects. Mercury accumulates in the liver and kidneys of poultry, and its bioaccumulation in these organs poses significant risks to human health when consumed (Tian et al., 2022).

d. Arsenic (As) in Poultry

Arsenic, a naturally occurring environmental contaminant, poses serious health risks to poultry, especially in areas with arsenic-

contaminated water and feed. Common sources include polluted feed, drinking water, plants, and air emissions (Younas et al., 2023).

Acute arsenic poisoning in poultry causes symptoms such as diarrhea, hypothermia, salivation, and circulatory collapse. Chronic exposure can lead to oxidative stress, liver damage, and increased susceptibility to carcinomas in the skin, liver, and lungs (Abu et al., 2022). Reactive oxygen species (ROS) generated by arsenic-induced oxidative stress are key contributors to its toxic effects (Medda et al., 2020).

Heavy metal contamination in poultry, including Cd, Pb, Hg, and As, has significant implications for both animal health and human food safety. These toxic metals bioaccumulate in poultry tissues, entering the human food chain and posing risks of oxidative stress, organ damage, and chronic health conditions. To mitigate these risks, stringent regulations on feed quality, environmental pollution, and waste management are crucial. Additionally, further research on the mechanisms of heavy metal toxicity and effective detoxification methods can contribute to safer poultry farming and healthier food production (Suleman et al., 2022).

e-Other metals:

Mineral contamination in animal feeds is considered inevitable due to environmental pollution, the presence of heavy metals in supplements and concentrates, and the use of machinery and equipment during production (Aljohani et al., 2023). Essential organs like the liver and kidneys are critical for detoxifying and excreting toxic elements. Consequently, these organs are often the most affected by the accumulation of excess heavy metals in feed or food, leading to significant damage in both humans and animals (Pappas et al., 2006).

2-Health Risks Associated with Heavy Metals in Poultry

Consumption of poultry contaminated with heavy metals can lead to severe health issues such as weight loss, organ damage, cancer, and even death. Raising awareness of the sources of heavy metal contamination and their adverse effects is crucial for maintaining food safety. The implementation of rigorous monitoring and regulatory measures in feed quality and production processes is necessary to minimize contamination and safeguard public health (Shaheen et al., 2016).

Heavy metals can enter poultry through the environment or the food chain. The diet of

broilers often includes microelements like Fe, Cu, Zn, Mn, I, and As to support their growth and health (Ekhtator et al., 2017). These minerals play a vital role in metabolic activity, bodily function balance, and immunity (Abdel-Rahman et al., 2018). However, excess trace minerals are excreted in manure, contributing to environmental pollution (Tchounwou et al., 2012).

Recently, researchers worldwide have intensified investigations into the health risks associated with heavy metal exposure through food sources (Elalfy et al., 2018; Issa et al., 2018; Hu et al., 2018; Kigigha et al., 2018; Kim et al., 2018; Thompson and Darwish, 2019). Heavy metals are particularly concerning because they are nondegradable, tend to accumulate in tissues, and can cause severe organ damage (Ogu et al., 2017). Their persistence in biological systems poses a long-term health risk along the food chain (Jaishankar et al., 2014).

Continuous consumption of poultry products contaminated with heavy metals can lead to both short-term and long-term health effects. Thus, frequent monitoring of heavy metal levels in chicken meat is essential to identify potential consumer risks and track trends in environmental contamination. Despite the relatively high cost of chicken meat and restrictions on frozen chicken imports in Nigeria, many consumers continue to purchase poultry from groceries and roadside markets without consideration for its chemical and biological safety (Ekhtator et al., 2017; ElWehedy et al., 2018; Ogu and Akinnibosun, 2019).

Effects of Heavy Metals on Biological Systems

The harmful impacts of heavy metals include significant disruptions to cellular metabolism and oxidative damage to biological macromolecules, including nuclear proteins and DNA (Saleh et al., 2018). While small amounts of these metals are essential for physiological and biochemical functions, exceeding permissible levels leads to cellular dysfunction and toxicity (Hu et al., 2018).

The sources of heavy metal contamination vary depending on the specific element and are influenced by soil composition, environmental factors, animal species, feed quality, and geographic location (Saleh et al., 2018; Oyewale et al., 2019).

Heavy metal contamination in poultry products represents a critical public health and environmental concern. Regular monitoring, coupled with stringent quality controls in feed production and environmental management, is

essential to reduce contamination risks. Consumers must be made aware of the potential dangers of consuming contaminated poultry products, highlighting the need for informed purchasing decisions and robust regulatory frameworks (Makanjuola, 2016; Ogu et al., 2017)..

IV. CONCLUSION

This study concludes that prolonged exposure to heavy metals leads to the bioaccumulation of As, Pb, Cd, and Hg in various chicken organs, including the kidneys, liver, reproductive organs, and lungs. This poses significant health risks to humans who consume chicken or other poultry products. Heavy metals adversely affect multiple poultry organs, starting with the liver and extending to the kidneys, brain, and reproductive system. Their excessive presence induces oxidative stress in poultry, contributing to organ damage. To safeguard human health and minimize environmental contamination from poultry manure, it is essential to eliminate heavy metals from animal feed or strictly regulate their use as supplements.

Future research should explore the interactions between minerals in poultry production and the link between poultry diets and litter composition to develop strategies for minimizing contamination and improving overall food safety.

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