Asian J. Med. Biol. Res. 2022, 8 (4), 225-229; https://doi.org/10.3329/ajmbr.v8i4.62322

Asian Journal of Medical and Biological Research
ISSN 2411-4472 (Print) 2412-5571 (Online)
https://www.ebupress.com/journal/ajmbr/

Short Communication

Analysis of Cr (VI) accumulation from feed to broiler chicken by using spectroscopy

Md. Showkat Hossen, Shamima Ahmed and Mohammad Shaokat Ali*

Faculty of Food Science and Technology, Chattogram Veterinary and Animal Sciences University, Khulshi, Chattogram – 4225, Bangladesh

*Corresponding author: Mohammad Shaokat Ali, Assistant Professor, Faculty of Food Science and Technology, Chattogram Veterinary and Animal Sciences University, Chattogram – 4225, Bangladesh. E-mail: shaokat@cvasu.ac.bd

Received: 19 October 2022/Accepted: 08 December 2022/Published: 23 December 2022

Copyright © 2022 Md. Showkat Hossen *et al*. This is an open access article distributed under the Creative Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract: Broiler chicken is one of the major dietary protein sources in Bangladesh. This study is aimed to investigate the status of chromium (VI) content in broiler feeds and water, as well as the risk of chromium (VI) in broiler meat, liver, and brain. For this investigation, a total of five broiler-rearing farms were chosen, each with a different type of broiler feed. A total of fifteen broiler chickens along with the water and feed samples were collected from those broiler farms. The concentration of chromium (VI) in feed, water, broiler meat, liver, and brain samples was determined using an Atomic Absorption Spectrophotometer (AAS). Two feed samples (Farm B and Farm D) were found to be chromium (VI) polluted (3.157±0.050 mg/Kg and 3.510±0.095 mg/Kg respectively), while water samples were found to be devoid of contamination. Only meat, liver, and brain samples from several farms were found to have chromium (VI). Brain samples exhibited the highest concentration of chromium (3.550±1.281 mg/Kg) compared to the liver (2.700±1.084 mg/Kg) and muscle meat (0.857±0.076 mg/Kg) samples. The amounts of chromium (VI) in the broiler brain and liver were found to be substantially higher than FAO and WHO acceptable standards. The rate of chromium (VI) concentration in meat samples was below the allowed level. It is proposed that precautions should be taken to detect chromium in chicken feed to assess health hazards and protect humans from food that could have serious negative consequences for their health.

Keywords: chromium (VI); edible organs; broiler chicken

1. Introduction

Poultry chicken is one of the cheap and available major protein sources for the people of Bangladesh (Mottalib *et al.*, 2018; Sarker *et al.*, 2018). According to the FAO/WHO report, Bangladesh consumes 15.23 kg of meat annually per person, of which 35.25% is from poultry meat (Akbar *et al.*, 2013). But now food safety is a growing global concern. In Bangladesh, heavy metal contamination in poultry feed as well as broiler meat is also a growing food safety issue. There are various sources of raw materials for poultry feed production. In many ways, these sources can be associated with anthropogenic heavy metals, particularly Chromium (VI) pollution. It is better to monitor any probable propagation of heavy metals like Cr (VI) into the food chain through the final feeds rather than the various raw materials for feeds (Zhitkovich, 2011; Sarker *et al.*, 2020). Although some of these metals are essential for the normal physiology of the systems, they can become lethal when consumed in food above the threshold value (Jaishankar *et al.*, 2014). Therefore, it is important to quantify the Cr (VI) in the poultry feed and its percentage transported into chicken and eggs (Mazumder *et al.*, 2013).

Chromium is a naturally occurring element found in rocks, soil, plants, animals, and volcanic dust and gases. Chromium is present in the soil as Cr (III) or chromate (Cr VI) ions. Chromium (III) is an essential nutrient in the diet but is required in very small amounts (Zayed and Terry, 2003). It is highly toxic and responsible for health hazards like mutation, cancer, and cell damage (Zhitkovich, 2011). In Bangladesh, several large and many small mills convert solid wastes into protein concentrates without following appropriate standard operating procedures. This protein concentrate is mixed with other ingredients to prepare poultry feeds. Each large mill produces 200–250 tons of protein concentrate per day (Hossain *et al.*, 1998).

Generally, basic chromium sulfate salt is used in conventional chrome tanning of which about 60% to 70% of the Chromium compound is consumed by hides and skins. Serious illnesses such as kidney disease, damage to the nervous system, diminished intellectual capacity, heart disease, gastrointestinal diseases, bone fractures, cancer, and even death can also happen due to the absorption of heavy metals through food (Adeel *et al.*, 2012). About 90% of tanning industries use Basic Chromium Sulfate (BCS) during tanning (Aravindhan *et al.*, 2004); this Chromium Sulfate binds with the collagen protein to make stabilize it against degradation. On average, the pelt takes up only 60% of the entire chromium, while the remaining 40% chromium is expelled through solid and liquid wastes, especially as spent chrome liquor (Fabiani *et al.*, 1997). Transfer of Chromium (Cr) into poultry may occur through these feeds, which then enter the human food chain. It is very important to know the quantity of chromium present in the feed and the amount of chromium transmitted to the body parts of the chicken which are consumed as human food.

The present study attempted to determine the concentrations and accumulation rate of chromium (VI) in meat and edible organs of broiler chickens reared in selected farms of Chattogram, Bangladesh.

2. Materials and Methods

2.1. Experimental layout

Different broiler farms belonging to the Chattogram city area were selected for the current study. A cross-sectional study was carried out on different feed, meat, liver, brain and water samples from selected broiler farms in the study area to determine the Chromium (VI).

2.2. Sample collection

A total of 15 (n = 15) live broilers (28 to 32 days old), 15 (n = 15) feed samples, and 15 (n = 15) water samples were collected from randomly selected 5 distinct broiler rearing farms (Khulshi, Kotowali, Bakalia, Oxygen, and Muradpur) in Chattogram city. After sacrificing the chickens, different edible parts including muscle meat, liver, and brain were separated. Then meat, liver, and brain samples were collected in sample bags and stored at freezing temperatures for analysis.

2.3. Sample preparation

All collected samples were digested in an acid solution with a microwave digestion system (Analytik Jena, Germany). By following the manufacturer's instructions, sample digestion was accomplished. Briefly, about 750 mg of the representative samples (meat, liver, and brain) were weighed and transferred into the digestive vessel. Then 10 ml of freshly prepared 65% nitric acid (HNO_3) was added and closed the vessel. The digestive vessel was later placed in the microwave oven at 200˚C for 20 min and then cooled to room temperature for about 20 min. The filtrate sample was analyzed through Atomic Absorption Spectrometer (AAS). About 300 mg of the feed sample was weighed and transferred into the digestive vessel. Then 10 ml freshly prepared 65% nitric acid (HNO_3) was added. After shaking the mixture carefully closed the vessel. Thereafter, the digestive vessel was placed in the microwave oven at 230˚C for 10 min and then cooled to room temperature for about 40 min. The filtrate sample was analyzed through Atomic Absorption Spectrometer (AAS). About 100 ml water sample was taken in a conical flask. Then 65% nitric acid (HNO_3) was added drop by drop until the water reached pH=2. Thereafter, the water sample was transferred to a volumetric flask and heated at 80-90˚C until the water became clear. Finally, it was made up to 100ml with distilled water.

2.4. Preparation of standards

The standard solution of Cr (VI) was prepared by dissolving 0.29 g of $K_2Cr_2O_7$ salt (RDH-Germany) into 1000 mL of distilled water to form a 100 ppm (mg/l) solution. Then 2, 4, 6, 8, and 10 ppm of standard Cr (VI) solutions were prepared from 100 ppm solution. The calibration curve was constructed by measuring the absorptions of the standard solutions with atomic absorption spectrophotometer (Perkin Elmer Analyst 100) and the concentrations of Cr (VI) in different samples were evaluated.

2.5. Detection and estimation

The atomic absorption instrument was set up and flame condition and absorbance were optimized for the analyte according to manufacturer's recommendation. Then blanks (deionized water), standards, sample blanks and samples were aspirated into the flame in AAS (iCE 3300, Thermo Scientific, UK). The calibration curves were obtained for concentration vs. absorbance. Data were statistically analyzed using the fitting of a straight line by a least square method. A blank reading was also taken, and necessary corrections were made during the calculation of the concentration of various elements. All laboratory works were performed at Chattogram Veterinary and Animal Sciences University (CVASU) and Bangladesh Council of Scientific and Industrial Research (BCSIR), Chattogram, Bangladesh.

2.6. Statistical analysis

GraphPad Prism 9.0 was used for statistical analysis and graphical representation of the collected data. Descriptive analysis (ANOVA and paired t test) was performed by using the mean and standard deviation for different variables. The level of significance was set ≤ 0.05.

3. Results and Discussion

The highest mean concentration of chromium (VI) level in the feed sample of farm D was found at 3.510 ± 0.095 mg/Kg (Figure 1). The lowest mean concentration of chromium (VI) in the feed sample was found at 0.00 in farm A, farm C, and farm E respectively (Figure 1). The result was closely related to the study conducted by Jothi *et al.* (2016). In the case of water samples, no chromium (VI) was found in any farms at the permissible level of WHO and FAO.

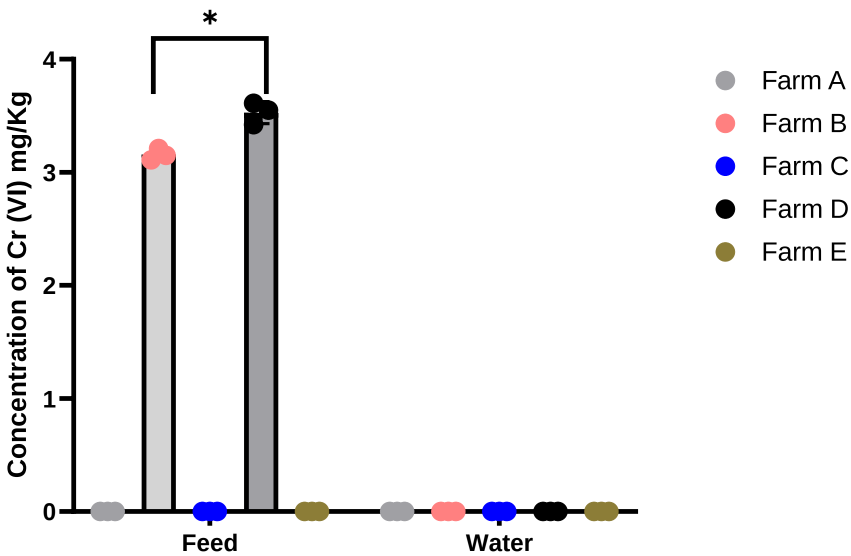

Figure 1. Concentration (mg/Kg) of Cr (VI) in the feed and water of different broiler rearing farms. In the feed of farm B and farm D Cr (VI) was found and the concentration was significantly different ($p<0.05$). *Significant difference between feed samples of Farm B and Farm D.

In the case of broiler chickens' different edible organs (muscle meat, liver, and brain) from farm A, farm C and farm E had no concentration of chromium (VI). But in case of farm D; highest chromium (VI) concentration was found in muscle meat (0.857 ± 0.076 mg/Kg), liver (2.700 ± 1.084 mg/Kg) and brain (3.550 ± 1.281 mg/Kg) (Figure 2). The reason for this high concentration of Cr (VI) might be due to the utilization of Cr (VI) contaminated feeds in farm D. This finding was very much closed to the experiment reported earlier (Uluozlu *et al.*, 2009; Islam *et al.*, 2019). However, this finding is lower than the previously reported chromium concentration which was 4.5 mg/Kg on the 29 days old chicken (Rajib *et al.*, 2016).

According to Mozumder *et al.* (2013), the transfer of Cr (VI) from poultry feed based on tannery solids to chicken liver was correlated. They discovered that the highest level of Cr (VI) in liver was 0.177±0.025 mg/Kg, which is lower than the outcome of the current investigation. Regarding Cr (VI) accumulation in broiler chicken, the highest amount of Cr (VI) was found in the brain and the minimum amount was found in muscle meat. About 40% of commercial feed samples have Cr (VI) concentration higher than the maximum permitted concentrations recommended by European Commission, (2003), and all the water samples were free from Cr. Besides, the accumulation of Cr (VI) in different parts followed the order: Brain>Liver>Meat. More samples need to be investigated in order to produce more conclusive evidence, and different modern methods like Ion chromatography and ICP-MS should be used in order to precisely compare the results.

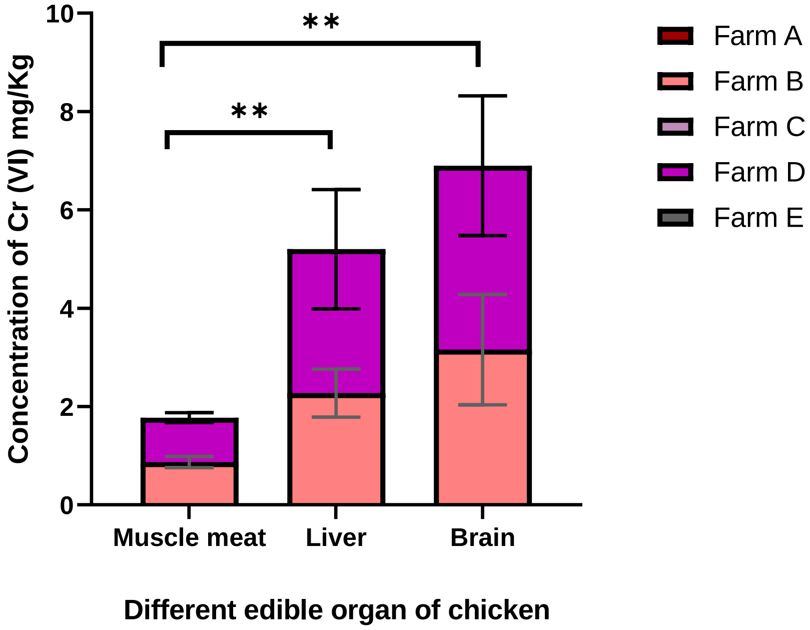

Figure 2. Cr (VI) concentration (mg/Kg) in the different organs of chicken. Since the chicken of farm B and farm D were exposed to Cr (VI) contaminated feed, so the accumulation of Cr (VI) was found in the different organs of that chickens. The accumulation of Cr (VI) in muscle meat, liver, and brain of the chicken was highly significant (p<0.05). **Significant difference of Cr (VI) concentrations between the samples (muscle meat, liver and brain) of Farm B and Farm D.

4. Conclusions

Broiler meat is one of the major sources of protein in developing countries like Bangladesh. Animal protein is essential for the synthesis of body tissues and their growth. The result of this study indicated that broilers raised with commercial feed have significant concentrations of chromium over the permissible FAO/WHO levels. The high concentration of chromium in broiler feed resulted in their bioaccumulation in the muscle tissues of the broiler. There is a significant correlation between feed, meat, liver, and brain of the broiler. The findings revealed that a higher concentration of chromium was accumulated in the brain of the selected broiler other than in the liver and meat. To maintain the safety of the food chain and to minimize heavy metals contamination, it is mandatory for the feed producers to always observe and maintain standards for heavy metals in chicken feeds. The concerned authority like BSTI, Ministry of Livestock, and GOB/ National Food Safety Authority should take the necessary initiative to monitor the feed companies to ensure standard quality of poultry feed which will eventually ensure safe food and sound human health.

Acknowledgements

The authors would like to express the heartiest thanks to Ministry of Science and Technology, Bangladesh for the research fund. Authors are very much thankful to the Quality and Analytical Laboratory, Chattogram Veterinary and Animal Sciences University and Bangladesh Council of Scientific and Industrial Research Lab, Chattogram for their technical lab support.

Data availability

Experimental tabulated data are preserved by the authors. The data would be provided if needed.

Conflict of interest

None to declare.

Author's contributions

Md. Showkat Hossen: Conduction of laboratory experiments, sample collection and preparation, and interpretation of collected data; Shamima Ahmed: Conceptualization and writing of manuscript; Mohammad Shaokat Ali: Experimental design, supervision, and review and editing of manuscript. All authors have read and approved the manuscript.

References

Adeel SS, A Wajid, S Hussain, F Malik, Z Sami, IIU Haq, A Hameed and RA Channa, 2012. Recovery of chromium from the tannery wastewater by use of Bacillus subtilis in Gujranwala, Pakistan. IOSR J. Pharm. Biol. Sci., 2: 36-45.

Akbar MA, MR Amin, MA Ali, MSA Bhuiyan, AKMA Kabir and SR Siddiki, 2013. Animal Husbandry- A Business Education for Today and Tomorrow 3rd Annual Conference and Seminar 2013, Bangladesh Society for Animal Production Education and Research (BSAPER).

Aravindhan R, B Madhan, JR Rao, BU Nair and T Ramasami, 2004. Bioaccumulation of chromium from tannery wastewater: an approach for chrome recovery and reuse. Environ. Sci. Technol., 38: 300-306.

Commission EE, 2003. Opinion of the scientific committee on animal nutrition on undesirable substances in feed. Brussels, European Commission of Health and Consumer Protection Directorate.

Fabiani C, F Ruscio, M Spadoni and M Pizzichini, 1997. Chromium (III) salts recovery process from tannery wastewaters. Desalination, 108: 183-191.

Hossain SM, SL Barreto and CG Silva, 1998. Growth performance and carcass composition of broilers fed supplemental chromium from chromium yeast. Anim. Feed Sci. Technol., 71: 217-228.

Islam M, S Kabir, Y Sarker, M Sikder, S Islam, A Akhter and M Hossain, 2016. Risk assessment of chromium levels in broiler feeds and meats from selected farms of Bangladesh. Bangladesh J. Vet. Med., 14: 131-134.

Jaishankar M, T Tseten, N Anbalagan, BB Mathew and KN Beeregowda, 2014. Toxicity, mechanism and health effects of some heavy metals. Interdiscip. Toxicol., 7: 60-72.

Jothi JS, N Yeasmin, IJ Anka and S Hashem, 2016. Chromium and lead contamination in commercial poultry feeds of Bangladesh. Int. J. Agril. Res. Innov. Technol., 6: 57-60.

Mazumder L, S Hasan and M Rahman, 2013. Hexavalent chromium in tannery solid waste based poultry feed in Bangladesh and its transfer to food chain. IOSR J. Environ. Sci. Toxicol. Food Technol., 3: 44-51.

Mottalib M, G Zilani, TI Suman, T Ahmed and S Islam, 2018. Assessment of trace metals in consumer chickens in Bangladesh. J. Health Pollut., 8: 1-10.

Rajib A, AS Islam, MR Ahmed, M Tariqur, M Rahman, A Rahman and ABM Ismail, 2016. Detection of chromium (Cr) using X-ray Fluorescence Technique and Investigation of Cr Propagation from poultry Feeds to Egg and chicken Flesh. Am. J. Eng. Res.,5: 243-247.

Sarker YA, MM Hasan, TK Paul, SZ Rashid, MN Alam and MH Sikder, 2018. Screening of antibiotic residues in chicken meat in Bangladesh by thin layer chromatography. J. Adv. Vet. Anim. Res., 5: 140-145.

Sarker YA, SZ Rashid, S Sachi, J Ferdous, BL Das Chowdhury, SS Tarannum and MH Sikder, 2020. Exposure pathways and ecological risk assessment of common veterinary antibiotics in the environment through poultry litter in Bangladesh. J. Environ. Sci. Health B, 55: 1061-1068.

Uluozlu OD, M Tuzen, D Mendil and M Soylak, 2009. Assessment of trace element contents of chicken products from Turkey. J.Hazard. Mater., 163: 982-987.

Zayed AM and N Terry, 2003. Chromium in the environment: factors affecting biological remediation. Plant Soil, 249: 139-156.

Zhitkovich A, 2011. Chromium in drinking water: sources, metabolism, and cancer risks. Chem. Res. Toxicol., 24: 1617-1629.