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Metal Residues in Retail Chicken Meat at Shivamogga, Karnataka

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ABSTRACT

Environmental pollution and contravenes in safe and hygienic production have led to contamination of animal origin foods with toxic residues. Occurrence of metal residue contamination in chicken meat poses considerable risk to the human health leading to a spectrum of health related issues. Owing to their public health concerns, market chicken meat samples were analyzed for metal or heavy metal residues. Breast muscle samples collected from retail outlets of Shivamogga city (Karnataka) were digested using nitric acid: per chloric acid and quantitatively analyzed using graphite furnace atomic absorption spectrophotometer (GFAAS). Concentrations of metal residues were expressed as mean ± S.D. range (mg. kg^{-1}) *viz.* Chromium (0.0272±0.0092; 0.0178-0.0515), Copper (0.1004±0.0638; 0.022-0.2199), Iron (2.3247±1.9029; 0.2815-6.9505), Lead (0.0297±0.0107; 0.0083-0.0495), Magnesium (0.1573±0.0337; 0.0949-0.2317), Manganese (0.0740±0.0508; 0.0135-0.1416), Nickel (0.0257±0.0446; 0-0.0822), Tin (0.8296±0.2007; 0.4870-1.3883), Zinc (0.9001±0.3832; 0.2805-1.4988) and Cadmium (not detected). Residue levels found in chicken breast meat samples were within prescribed maximum residue limits (MRLs) of Codex/FAO/WHO and FSSAI for all the ten metal/ heavy metal concentrations. Present study establishes occurrence of metal residues in chicken meat and underscores need for framing national guidelines/ standards for these toxic metals in various kinds of meat and meat products.

Keywords: *Heavy metals, Residue, Food, GFAAS, Analysis, Acid digestion, Food safety*

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INTRODUCTION

Anthropogenic activities and environmental pollution have increased chances of contamination of foods (Schwartz 1994). Of the several environmental contaminants, heavy metal contamination of meat also has been known to potentially impair the consumer health. Traces of toxic metals can enter chicken body through air, contaminated feed/ water or medications/ supplements. Elements having specific gravity of above 5 are referred as heavy metals. Heavy metals are categorized as essential or nutritionally important metals (Cobalt, Chromium, Copper, Iron, Manganese, Molybdenum, Nickel, Vanadium, and Zinc) and non-essential or potentially toxic metals (Arsenic, Cadmium, Mercury, and Lead) (Javed, 2005).

Persistent environmental pollutants can't be inactivated by routine cooking conditions thereby posing threat to the public health across the food supply chains (Levensend and Barnard, 1988). Heavy metals tend to accumulate in the food chain during food processing leading to emergence of their residues in foods. Toxic heavy metals such as lead, mercury and cadmium do not get metabolized in the body and accumulate in tissues (WHO, 2011). Persistent chronic low dose exposure occurring through the environment or food constitutes serious public health threat (EC 178, 2002). Keeping in view the public health risk associated with toxic metal residues in the food chain, present study was undertaken to establish levels of metals residues in chicken meat marketed at retail outlets.

MATERIALS AND METHODS

Chicken meat samples (breast muscle) were collected (n=20) from retail markets of the Shivamogga city (Karnataka State) and transported to the laboratory under chilled conditions. Although chicken edible offal, thigh and leg muscles are sampled for metal residue detection; breast muscle being the most popular samples, it was selected for the pilot study. Heavy

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metals were analyzed following the method of AOAC (2000); metals bound to biological matrix were brought into solution by wet digestion process for quantification using atomic absorption spectrophotometer (AAS). Digested samples were analyzed for metal residues using Atomic Absorption Spectrometer (Thermo Scientific, iCE 3000 Series, C113300080 v1.30). Samples were corrected for dilution factor (1:10) and based on the linear curve of respective standard metals (concentration *versus* detection signal) the concentration of unknown was calculated.

RESULTS AND DISCUSSION

***Chromium (Cr)**:* Concentrations of Cr detected in retail chicken meat were at 0.02720±0.00927 (Min. 0.01781, Max. 0.05157) mg.kg^{-1}. Cr (III) is an essential trace mineral (micronutrient) required in the human diet; it is a cofactor for enzymes associated with metabolism (e.g. insulin); 0.02-0.5 mg of Cr is required daily in the adult human diet (Tarley *et al.,* 2001). Maximum permitted concentration of Cr in meat including poultry is 1 mg.kg^{-1} (WHO/FAO, 2011). All samples analyzed in the present study contained Cr below the prescribed limits for poultry meat.

***Copper (Cu)**:* The Cu is an essential trace element. In the present study, broiler chicken meat had Cu concentration of 0.10046±0.06382 (Min.0.02243, Max. 0.21994) mg.kg^{-1}. Higher concentrations of Cu in human diet would lead to Cu toxicity. The WHO (1996) has fixed maximum dietary intake of Cu at 1-10 mg.kg^{-1} for humans. Concentration of Cu increases in chicken body with age and its tissue concentrations depend upon Cu intake through the feed in poultry (Kar *et al.,* 2018). Further, Cu acquired through poultry feed or other sources in birds gets excreted in manure and crops grown on such contaminated manure also acquire Cu, it eventually leads to food chain contamination (Poulsen, 1998). The Cu is an essential nutrient for poultry; it is also constituent of several enzymes. It is incorporated into poultry feed to enhance growth. However, higher intakes of Cu in poultry were associated with hepatic and renal damages (Agency for Toxic Substances and Disease Registry 2004). The concentrations of Cu observed in broiler chicken meat in this study were below the WHO specified maximum permissible limit of 0.4 mg.kg^{-1} (WHO/FAO 2011).

***Iron (Fe)**:* The concentration of Fe detected in chicken meat was 2.32476±1.90298 (Min. 0.28158, Max. 6.95054) mg.kg^{-1}. Iron naturally occurs in animals and plants; it is also an essential trace mineral required for the growth of human body; it is part of several physiological pathways; component of heme-proteins and Fe is part of redox systems in the body (Kanakaraju *et al.,* 2008). Iron tends to accumulate in the body; excess Fe would lead to health problems. Upper daily tolerable level of Fe is 40 mg in children and 45 mg in adults (Institute of Medicine 2003).

***Lead (Pb)**:* Concentrations of Pb detected in chicken meat samples was at 0.02979±0.01076 (Min. 0.00838, Max. 0.04953) mg.kg^{-1}. Poultry gets exposure to Pb through feed, water and the environment. Lead (Pb) also accumulates in plants leading to its successive magnification across the food chain (Halliwell *et al.,* 2000). The maximum recommended level of Pb in meat is 0.1 mg.kg^{-1} as specified by the Codex. Lead and other heavy metals have direct physiological and toxic effects; Pb gets accumulated in living tissues and acts as a metabolic poison (Baykov *et al.,* 1996). Pb binds and inactivates enzymes and other cellular components; Pb bio accumulates in food chain and also undergoes bio magnification process and acts as a cumulative poison (Cunningham and Saigo, 1997). Lead predominantly affects hemopoietin, nervous, gastrointestinal and renal systems (Baykov *et al.,* 1996). Polluted water, feed and the environment act as source of contamination to the poultry. The Pb enters poultry production systems through such contaminations occurring due to industrial pollutions or through feed and water. Higher levels of Pb in the diet are associated with health problems in human consumers such as impairment of nervous and cardiovascular functions especially in the growing children (CEC, 2001). Lead is known to affect cognitive performance in the children and is associated with cardiovascular diseases in adults (CEC 2001). Chicken meat samples analyzed in the present study had Pb concentrations below the maximum recommended level of 0.1 mg.kg^{-1} (ANZFA, 2001).

***Magnesium (Mg)**:* Concentration of Mg in the chicken meat detected was 0.15733±0.03379 (range 0.09491-0.23174) mg.kg^{-1}. Magnesium is a major essential nutrient mineral and its daily requirement for humans exceeds 100 mg. About half of Mg is stored in the body systems and remaining is seen in muscles, soft tissues and body fluids.

***Manganese (Mn)**:* The Mn concentration recorded in retail chicken meat samples was 0.07403±0.05080 (Min.0.01350, Max. 0.14160) mg/kg. The Mn is an essential trace element required in small quantities in diet for growth and maintenance of human body. Deficiency of Mn leads to problems of the nervous system (Dermirezen and Uruc, 2006). Nevertheless, excessive concentrations of Mn in the diet lead to toxicities. The upper tolerable daily intake of Mn is 2-11 mg (Anonymous, 2003).

***Nickel (Ni)**:* The Ni was detected at concentration of 0.05457±0.01946 (range undetected to 0.08221) $mg.kg^{-1}$ in chicken meat samples. In the present study, Ni was not detected in 35% samples. The Ni is essential for humans; Ni plays pivotal role cofactor and catalyst in several enzyme systems. However, higher Ni concentrations cause health conditions such as serious respiratory distress, eczema and at higher concentrations Ni is known to exert teratogenic and genotoxic effects (Ihedioha *et al.,* 2014). Exposure of humans to toxic doses of Ni was associated with respiratory problems. Further, Ni is known to disrupt enzyme activity, induce developmental and neurological deficits in children, cardiovascular diseases and also increase the risk of lung cancer (Macomber and Hausinger 2011). This element has been categorized as a carcinogen by the ATSDR (2004) and its maximum tolerance daily intake limit was set at 7 mg for children and 40 mg for the adults. The specified standard for Ni in meat by WHO/FAO (2011) is 0.5 $mg.kg^{-1}$. Chicken samples sold at retail of the study area were compliant with the global standard for Ni in meat food.

***Tin (Sn)**:* The Sn was detected at 0.82966±0.20079 (Min. 0.48707, Max. 1.38835) $mg.kg^{-1}$ concentration in retail chicken meat samples. Deficiency symptoms of the Sn have not been reported in humans. However, consumption of excessive concentrations (5-7 $mg.kg^{-1}$ body weight) had resulted in toxicity symptoms. Kidney and liver accumulation of Sn has also been reported. Absorption of Sn from the gut is very less (about 5% only) and excretion from the body through kidney is very rapid. Hence, symptoms of tin toxicity are rare. Nevertheless, lung and bone deposition of Sn is possible (Winship, 1988). Chicken meat analyzed in the present study was found compliant with specified norms. Permissible limit for tin in tinned food is 0.25 $mg.kg^{-1}$ (WHO); 50 $mg.kg^{-1}$ specified by codex for luncheon, cooked, cured or chopped meats (CODEX STAN 193-1995).

***Zinc (Zn)**:* Concentration of Zn observed in samples of retail chicken meat in the chicken meat was 0.90014±0.38321 (Min.0.28054, Max. 1.49887) $mg.kg^{-1}$. Zinc is one of the essential trace minerals required in the human diet. The Zn is required only in traces in the human diet; however, excessive Zn consumption would lead to health problems in consumers such as irritations in the intestines (ATSDR, 2004). Like Cu, higher Zn concentrations in poultry manure could lead to contamination of soil; crops grown on such soil can accumulate Zn (Poulsen, 1998). The permissible limit set by Australia-New Zealand Food Authority (ANZFA) is 150 $mg.kg^{-1}$.

***Cadmium (Cd)**:* Cd was not detected in any of the chicken samples analysed in the present study. The Cd is toxic heavy metal and food is the major source of its entry into the human body (Baykov *et al.*, 1996). Once ingested, Cd is known to stay in human body for longer durations (10-40 years) with its relative preference to organs such as kidneys (Rubio *et al.*, 2006). Cadmium is toxic to almost every system of human body; it accumulates in liver and kidneys and is associated with organ dysfunction, damages to the skeletal muscles and prostates (Uluozlu *et al.*, 2008). Further, Cd interacts with other minerals (Zn, Fe, Cu and Se) and due to its structural similarities competes for binding sites (McLaughlin *et al.*, 1999); affect bones due to influences on the metabolism Ca and P (Jarup *et al.*, 1998). The maximum permissible level of Cd in meat is 0.5 $mg.kg^{-1}$ (CCFAC, 2001; FAO/WHO, 2002). However, codex revised the level of Cd in meat to 0.2 $mg.kg^{-1}$ (CODEX STAN 193-1995, Amendment: 2010). According to the WHO, the permissible level of Cd in meat is 0.3 $mg.kg^{-1}$ (WHO/FAO 2011).

CONCLUSION

Major sources of metal exposure of the poultry supply chain are the pollution or contamination of the feed, water or environment that lead to entry of residues in the food chain. Public risk arises due to the indirect exposure of the consumers by the way of food in the diet. Analysis undertaken in this study revealed that the chicken meat found in retail stalls contained heavy metals at very low level which is below the permissible level. It is further suggested that the market meat supplies must be monitored regularly for the heavy metal residual concentrations in order to provide the wholesome meat to the consumers.

CONFLICT OF INTEREST STATEMENT: Authors declare no conflict of interest in preparing this manuscript.

ETHICS STATEMENT: Chicken samples were purchased from retail markets and experiments did not involve live birds handling or slaughter.

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