

Determination of Chromium, Lead and Cadmium Levels in Edible Organs of Marketed Chickens in Mashhad, Iran

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Abstract

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Background: Considering high importance of heavy metals residue from view point of food safety, this study was conducted to determine the contents of chromium (Cr), lead (Pb) and cadmium (Cd) in different tissues (liver, heart and muscle) of marketed chickens in Mashhad, Iran.

Methods: Chicken tissues were collected from four popular brands distributed in different markets in Mashhad, followed by preparing through acidic digestion and analyzing using graphite furnace atomic absorption spectrometry. All statistical significant differences were defined at $p < 0.05$ using SPSS v. 16.0.

Results: Mean concentration (\pm standard deviation) of heavy metals in the liver, heart and muscle of chicken samples were 3.87 ± 3.94 , 3.77 ± 2.77 and 2.27 ± 1.07 mg/kg (for Cr), 3.79 ± 3.64 , 2.65 ± 1.88 and 1.65 ± 1.09 mg/kg (for Pb) as well as 0.37 ± 0.09 , 0.32 ± 0.1 and 0.28 ± 0.07 mg/kg (for Cd), respectively, indicating higher heavy metals levels in liver and heart samples compared to those of muscle ones ($p < 0.05$).

Conclusion: The contents of some heavy metals in chicken samples are warning that highlights its public health risk in this region of Iran. Therefore, more effective monitoring procedures and surveillance programs should be applied by the authorities of regional veterinary organization.

Introduction

During recent years, there have been considerable concerns about the prevalence of the environmental pollutions i.e. heavy metals and their adverse effects to public health (Kaplan et al., 2011). Some of potentially toxic heavy metals are harmful even at low concentrations and cause toxic effects, including arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), etc, but some of them such as iron (Fe), manganese (Mn), copper (Cu), zinc (Zn) and selenium (Se) are essential (Uluozlu

et al., 2009). Trace metals as ubiquitous and mobile contaminants can be easily taken up from soil, fertilizers, air, industrial processes, and transportation (Tuzen et al., 2009).

Due to presence of many metals in food as natural components of foodstuffs as well as contamination during processing and environmental contamination, consumption of food is a main source of exposure to trace metals (Fallah et al., 2011; Shah et al., 2010;

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Uluozlu et al., 2009). Cd, Pb, and Cr are some of the most common heavy metals causing environmental and food contamination that stay intact because they cannot be degraded (Akan et al., 2010) and trigger many acute or chronic disorders in humans due to their accumulation in long-term periods in various organs such as liver, kidney, heart and muscles (Iwegbue et al., 2008; Saei-Dehkordi and Fallah, 2011).

The poultry farming has now turned into one of the most important divisions of agriculture in the world and improved rapidly as a dynamic industry in Asia (Mahesar et al., 2010). Nowadays, poultry feed is produced from various raw materials such as fish by-products that can transfer heavy metals to poultry feed in undesirable levels following collecting them from contaminated waters (Shah et al., 2010). The chicken is used as the most consumable food item in Iran and many countries of the world due to low cost, easy availability and valuable nutritional constituents such as protein, vitamins and essential minerals (Fallah et al., 2011; Saei-Dehkordi and Fallah, 2011; Shah et al., 2010).

Considering the fact that poultry products can contain some toxic heavy metals and therefore exposure to the toxic trace metals will be gained through consumption of these products, the accurate determination of them has been focused by researchers in last decades, worldwide (Fallah et al., 2011; Sneddon et al., 2007; Sneddon and Vincent, 2008). However, according to the existing scientific literature, few studies on the comparative heavy metal contents of chicken tissues have been carried out and published in Iran (Saei-Dehkordi and Fallah, 2011). Hence, in present study, the contents of Cr, Pb, and Cd in different tissues of chicken samples presented in Mashhad, North-East of Iran, were determined by graphite furnace atomic absorption spectrometry after acidic digestion.

Materials and methods

Sample collection

In the present cross-sectional survey, 149 fresh samples of different chicken tissues including liver (n=61), heart (n=24) and muscles (n=64) were randomly collected from different distributors of four popular brands (A, B, C and D) in Mashhad, Khorasan Razavi province, Iran (Fig. 1), during June to September 2013.

Chemicals

All solutions were prepared from analytical grade reagents. Double distilled water applied throughout this study was ultrapure quality. Nitric acid and hydrogen peroxide with suprapure quality obtained from Merck (Darmstadt, Germany). Standard solutions of Cr, Cd and

Pb with appropriate dilution (1000 mg/ml) were purchased from Sigma (Chem. Co., St. Louis, USA).

Analytical procedure

Metal concentrations were determined based on wet weight of the samples (Tuzen et al., 2009; Uluozlu et al., 2009). Each sample was separately stored in polyethylene bag and transferred to laboratory for analyzing. Each glassware was washed with a solution of 10% nitric acid for 48 h followed by rinsing with double distilled water in order to decrease external metal contamination (Saei-Dehkordi et al., 2010). Then, 0.2 g of each sample was digested with equal volume of suprapure nitric acid (65%) and hydrogen peroxide (30%) for 4 h at 160 °C until the tissue was completely dissolved (Deng et al., 2007). After cooling, the digested solution was filtered through Whatman filter paper No. 1. The mixture subsequently were poured into the labeled containers and diluted to 10 ml with double distilled water. Analyzing of heavy metals concentrations (Cd, Cr and Pb) in samples was carried out by graphite furnace atomic absorption spectrometry (Varian model spect, AA 240, USA) using high purity argon as the inert gas. The experimental analytical conditions for Cd, Cr and Pb determination have been listed in Table 1.

Statistical analysis

All data were described as mean \pm standard deviation. Normality of quantitative variables was determined by Kolmogorov-Smirnov test. Kruskal-Wallis and Mann-Whitney tests were used to compare brands of chicken portions together. All statistical significant differences were defined at $p < 0.05$ using SPSS Inc., (Chicago, IL) version 16.0.

Results

Mean concentration (\pm standard deviation) of heavy metals in the liver, heart and muscle of chicken samples were 3.87 ± 3.94 , 3.77 ± 2.77 , and 2.27 ± 1.07 mg/kg (for Cr), 3.79 ± 3.64 , 2.65 ± 1.88 , and 1.65 ± 1.09 mg/kg (for Pb) as well as 0.37 ± 0.09 , 0.32 ± 0.1 , and 0.28 ± 0.07 mg/kg (for Cd), respectively, indicating higher heavy metals levels in liver and heart samples compared to those of muscle ones ($p < 0.05$).

As shown in Fig. 2, Cr contents of all chicken tissues (liver, heart and muscle) were significantly different among all 4 brands ($p < 0.05$). Although, Pb and Cd contents of liver and heart samples were significantly different among all investigated brands ($p < 0.05$), these levels in muscle samples had no significant ($p > 0.05$) difference as it is illustrated in Fig. 3 and Fig. 4.

Table 1: Analytical conditions of investigated heavy metals

Instrumental conditions	Cr	Pb	Cd
Wavelength (nm)	357.9	283.3	228.8
Slit width (nm)	0.2	0.5	0.5
Argon flow pressure (bar)	3	3	3
Modifier	Amunium mono Vanadat		
Heating program:			
Temperature °C (ramp time (s), hold time (s))			
Drying 1	85 (5, 40)	85 (5, 40)	85 (5, 40)
Drying 2	120 (10, 40)	120 (10, 40)	120 (10, 40)
Ashing	1000 (1, 2)	400 (1, 2)	800 (1, 2)
Atomization	2400 (1, 2)	2000 (1, 2)	1900 (1, 2)
Cleaning	2600 (1, 2)	2600 (1, 2)	2600 (1, 2)



Fig. 1: Map showing the sampling area (Mashhad city) located in Khorasan Razavi province, North-East of Iran

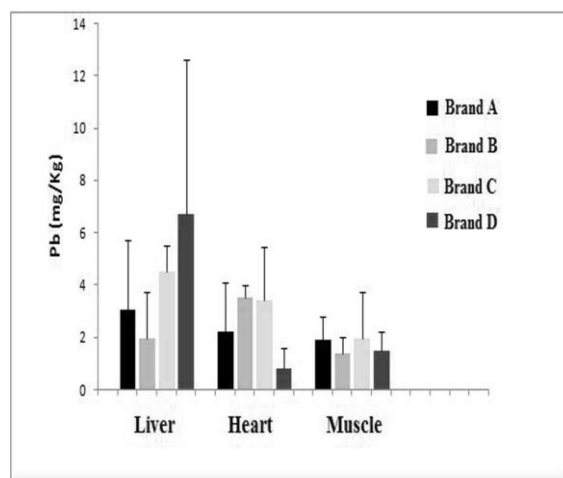


Fig. 3: Distribution of Pb content (mean ± standard deviation) in chicken tissue samples in Mashhad, Iran

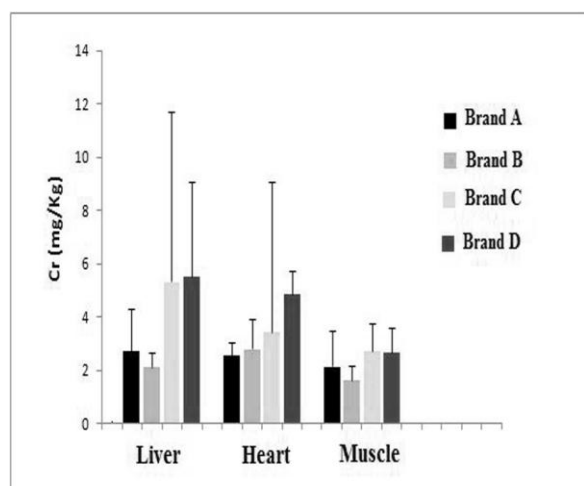


Fig. 2: Distribution of Cr content (mean ± standard deviation) in chicken tissue samples in Mashhad, Iran

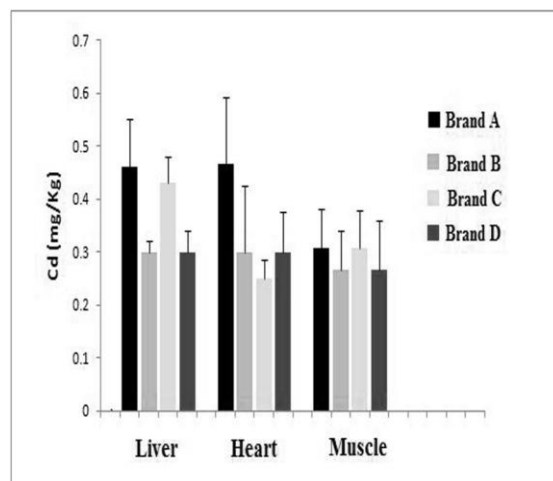


Fig. 4: Distribution of Cd content (mean ± standard deviation) in chicken tissue samples in Mashhad, Iran

Discussion

Heavy metals residues in foods of animal origin such as poultry meat, etc. could be toxic for human at different level endangering public health. Usually, the farm animals may acquire the contamination during ingestion of contaminated feed. Pb is toxic and damages the brain, kidneys and reproductive system (Kaplan et al., 2011; Uluozlu et al., 2009). Skeletal damage, dysfunction of kidney and reproductive deficiencies can be induced by Cd accumulation in human (Fallah et al., 2011; Uluozlu et al., 2009). Although, there is a controversy about trivalent Cr due to its possible adverse effects on health, kidney damage, anemia, liver dysfunction, and weight loss (Cerulli et al., 1998; Wasser et al., 1997) have been reported. In this survey, we determined the levels of three important heavy metals, including Cr, Pb and Cd in chicken samples of North-East of Iran. There are several similar researches carried out in different countries which most of them are in accordance with the present study. Reem et al. (2012) reported that in chicken samples in the local markets of Basrah city, Iraq, Pb contents were in the range of 0.171-3.269 mg/kg. Also, maximum permissible limit of Cd was determined 0.1 mg/kg for muscles and 0.5 mg/kg for internal organs (Reem et al., 2012). Ismail and Abolghait (2013) investigated Pb and Cd residual levels in chicken giblets distributed in Ismailia, Egypt. They reported that the greatest Pb concentrations were found in liver samples (0.8762 ± 0.2089 ppm), whereas gizzard samples contained 0.3186 ± 0.1462 ppm and lowest levels of Pb were detected in heart samples 0.1733 ± 0.06777 ppm. Cd deposited in liver samples reached 0.040714 ± 0.0290 ppm; however gizzard and heart samples contain negligible Cd concentrations (Ismail and Abolghait, 2013). Also, mean concentrations of Pb and Cd in chicken meat product samples of Tenerife Island, Spain were reported as 3.16 and 4.15 mg/kg, respectively (Gonzalez-Weller et al., 2006). Such considerable levels of heavy metals in chicken meat samples in all over the world in the mention studies could be originated from heavy environmental pollution. So, controlling of animal feeds in farms seems too necessary for reduction of the heavy metals residues in foods of animal origin.

In the present survey, higher heavy metals levels were seen in liver and heart samples compared to muscle ones that is similar to most of the previous investigations (Akan et al., 2010; Gonzalez-Weller et al., 2006; Ismail et al., 2013). Also, in an experimental study carried out on chickens, it was shown that kidney Cd levels were higher than those of liver (Heshmati and Salaramoli, 2015). In our survey, we found that heavy metals levels were significantly different among commercial brands.

This finding may be due to differences in origin of poultry farming and therefore their different diet.

Conclusion

The contents of some heavy metals in chicken samples are warning that highlight its public health importance in this region of Iran. Therefore, more effective monitoring procedures and surveillance programs should be applied by the authorities of regional veterinary organization.

Conflicts of interest

The authors declare no conflict of interest.

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References

- Akan J.C., Abdulrahman F.I., Sodipo O.A., Chiroma Y.A. (2010). Distribution of heavy metals in the liver, kidney and meat of beef, mutton, caprine and chicken from Kasuwan Shanu market in Maiduguri Metropolis, Borno State, Nigeria. *Research Journal of Applied Sciences, Engineering and Technology*. 2: 743-748.
- Cerulli J., Grabe D.W., Gauthier I., Malone M., McGoldrick M.D. (1998). Chromium picolinate toxicity. *Annals of Pharmacotherapy*. 32: 428-431.
- Deng H., Zhang Z., Chang C., Wang Y. (2007). Trace metal concentration in great tit (*Parus major*) and greenfinch (*Carduelis sinica*) at the western mountains of Beijing, China. *Environmental Pollution*. 148: 620-626.
- Fallah A.A., Saei-Dehkordi S.S., Nematollahi A., Jafari T. (2011). Comparative study of heavy metal and trace element accumulation in edible tissues of farmed and wild rainbow trout (*Oncorhynchus mykiss*) using ICP-OES technique. *Microchemical Journal*. 98: 275-279.
- Gonzalez-Weller D., Karlsson L., Caballero A., Hernandez F., Gutierrez A., Gonzalez-Iglesias T., Marino M., Hardisson A. (2006). Lead and cadmium in meat and meat products consumed by the population in Tenerife Island, Spain. *Food Additives and Contaminants*. 23: 757-763.
- Heshmati A., Salaramoli J. (2015). Distribution pattern of cadmium in liver and kidney of broiler chicken: an experimental study. *Journal of Food Quality and Hazards Control*. 2: 15-19.
- Ismail S.A., Abolghai S.K. (2013). Estimation of lead and cadmium residual levels in chicken giblets at retail markets in Ismailia city, Egypt. *International Journal of Veterinary Science and Medicine*. 1: 109-112.
- Iwegbue C.M.A., Nwajei G.E., Iyoha E.H. (2008). Heavy metal residues of chicken meat and gizzard and turkey meat consumed in southern Nigeria. *Bulgarian Journal of Veterinary Medicine*. 11: 275-280.
- Kaplan O., Yildirim N.C., Yildirim N., Cimen M. (2011). Toxic elements in animal products and environmental health. *Asian Journal of Animal and Veterinary Advances*. 6: 228-232.
- Mahesar S.A., Sherazi S.T.H., Niaz A., Bhangar M.I., Rauf A. (2010). Simultaneous assessment of zinc, cadmium, lead and

- copper in poultry feeds by differential pulse anodic stripping voltammetry. *Food and Chemical Toxicology*. 48: 2357-2360.
- Reem H., Manal E., Hanady M. (2012). Assessment of heavy metals (Cd, Pb and Zn) contents in livers of chicken available in the local markets of Basrah city, Iraq. *Basra Journal of Veterinary Research*. 11: 43-51.
- Saei-Dehkordi S.S., Fallah A.A. (2011). Determination of copper, lead, cadmium and zinc content in commercially valuable fish species from the Persian Gulf using derivative potentiometric stripping analysis. *Microchemical Journal*. 98: 156-162.
- Saei-Dehkordi S.S., Fallah A.A., Nematollahi A. (2010). Arsenic and mercury in commercially valuable fish species from the Persian Gulf: influence of season and habitat. *Food and Chemical Toxicology*. 48: 2945-2950.
- Shah A.Q., Kazi T.G., Baig J.A., Afridi H.I., Kandhro G.A., Khan S., Kolachi N.F., Wadhwa S.K. (2010). Determination of total mercury in chicken feed, its translocation to different tissues of chicken and their manure using cold vapour atomic absorption spectrometer. *Food and Chemical Toxicology*. 48: 1550-1554.
- Sneddon J., Rode P.W., Hamilton M.A., Pingeli S., Hagen J.P. (2007). Determination of metals in seafood and fish in Southwest Louisiana. *Applied Spectroscopy Reviews*. 42: 23-42.
- Sneddon J., Vincent M.D. (2008). ICP-OES and ICP-MS for the determination of metals: application to oysters. *Analytical Letters*. 41: 1291-1303.
- Tuzen M., Soylak M., Citak D., Ferreira H.S., Korn M.G., Bezerra M.A. (2009). A preconcentration system for determination of copper and nickel in water and food samples employing flame atomic absorption spectrometry. *Journal of Hazardous Materials*. 162: 1041-1045.
- Uluozlu O.D., Tuzen M., Mendil D., Soylak M. (2009). Assessment of trace element contents of chicken products from Turkey. *Journal of Hazardous Materials*. 163: 982-987.
- Wasser W.G., Feldman N.S., D'Agati V.D. (1997). Chronic renal failure after ingestion of over-the-counter chromium picolinate. *Annals of Internal Medicine*. 126: 410.