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Evaluation of Heavy Metals in Local Chickens sold at Central Markets in Ado-Ekiti, Akure and Owena Towns

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AOO, OVI and DUM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author OVI managed the analyses of the study. Author DUM managed the literature searches and author AOO supervised the research work and author JOO corrected the work for typographical error. All authors read and approved the final manuscript.

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ABSTRACT

Local chickens sold in the central markets of Ado-Ekiti, Akure and Owena were randomly sampled and slaughtered. Lead (Pb), cadmium (Cd) and zinc (Zn) in their blood and selected organs (intestine, heart, liver and gizzard) were isolated using wet digestion and their concentrations determined using atomic absorption spectrophotometer. Apart from the blood of chickens from Ado-Ekiti and Owena where Pb was not detected, its concentrations in the blood and organs of the chickens obtained from the three towns ranged from 2.00 to 7.33 mg/kg, exceeding the maximum

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tolerance levels (0.1 mg/kg) in internal organs of poultry birdsset by EU, ANZFA and FAO/WHO. With the exception of intestine of chickens from the three towns, Cd was only detected in the heart, blood and gizzard of chickens from Akure as well as liver and gizzard of chickens from Owena, covering a range of 0.11 to 0.67 mg/kg. The upper limit exceeded the maximum limits (0.5 mg/kg) according to FAO/WHO. Zn was detected in all selected parts of chickens from the three towns ranging 5.67 to 183.17 mg/kg. Its concentrations were within the permissible limit(10-50 mg/kg) by EU and FAO/WHO in certain selected parts of some chickens while it exceededthe permissible limit (150 mg/kg) by ANZFA especially in the liver of chicken from Ado-Ekiti. Some organs and blood of local chickens sold in the central markets at Ado-Ekiti, Akure and Owena may pose health risks.

Keywords: Local chicken; central markets; lead; cadmium and zinc.

1. INTRODUCTION

Meat and meat products are nutritional diets necessary for human growth and development. They contain necessary trace elements, particularly zinc and iron [1], andare important source of vitamins B including B12, which is not found naturally in foods of plant origin. They also contain fat, protein and other important minerals such as potassium and selenium. Selenium, for example, is an important antioxidant which has been linked to reduction in risk of heart disease and certain cancers [2].Meat refers to the flesh and organ of animals. The flesh of cattle, pigs and sheep are termed red meat while the flesh of poultry such as chicken, turkey, duck, pigeon and guinea fowl is known as white meat. Due to the fact that meat and meat productsare concentrated sources of high-quality protein, their amino acid composition usually compensates for shortcomings in staple food [3].

Poultry in Nigeria is predominantly made of chicken and sales of these life birds is usually in a specific area of the general market [4]. They have been one of the sources of animal protein to the ever-growing teeming population,making significant contribution to human nutrition and economic development [5]. It produces 454 billion tonnes of meat and 3.8 million eggs yearly from 180 million birds [6]. The increase in poultry production over yearsis due to many advantages of poultry over cattle. These include ability of poultry birds to convert feed into useable protein in meat and eggs, very tender meat with high acceptability to consumers, small take-off capital, relatively low cost of production per unit and high return on investment. Besides,the production cycle is quite short so that capital is not tied up over a long period [7].

Poultrymeat is considered a luxurious food in Nigeria and is usually reserved for special occasions in rural areas. Those who dwell in urban areas consume large amount of poultry due to their relatively higher income levels and greater access to fresh and frozen products in market and fast food outlets [8]. Poultry meat is used in the manufacture of many seasonings; lead into its high demand and influencing its production.Moreover, this has extensively resulted toseveral technological inputs [9].

Metals are natural constituents of the earth's crustand Khan et al. [9] observed this to be the source of some metallic elements present in the ecosystem.Trace metals (well below 50 mg/kg) may occur in food with nutritional or toxicological importance. While some like calcium, potassium and sodium are essential for man,arsenic, cadmium andlead have poisonous effectsat relatively low concentration. Also, zinc, copper and iron which are necessary at very low levels pose health risk at high concentrations.

Heavy metal sources including industrial wastes, irrigation with effluent waterand othersresult in soilcontamination. Ping et al. [10] reported thatlong term contamination of soil could be a potential source of contamination for plants and animals.Plants grown in such soil and consumed as foodbypoultry birds, fish and human beings, expose organisms to these metals. Accumulation of heavy metals in poultry feeds and water sources is a major source of heavy metal intake to poultry products [9]. Exposure of poultry meat to different heavy metals through poultry feeds and environmental pollution of poultry breeding areas lead to contamination in the food chain. This is of great importance due to its role in nutrition and human health. The main route of human exposure to these metals is ingestion of contaminated food, especially poultry birds and fish.

Heavy metal contamination has become an issue of global concernbecause it poses risk tofood safety, human health and the environment in general. Heavy metals alter DNA structure and a number of parameters of the host's immune system as well as increase the susceptibility to infectious diseases [10]. Moreover, it causes bio accumulation in biological tissues and biomag nification through the food chain.Cuadrado et al. [11] reported that meat and meat products were major sources of total lead intake.Local chickens are often reared on free range basis. Besides the poultry feeds and the water sources they are exposed to, they could feed around waste disposal sites with diverse contaminants. In view of the above, this study was aimed at determining the concentration of some heavy metals in local chickenssold in some central markets in South-western Nigeria.

2. MATERIALS AND METHODS

2.1 Materials

The laboratory materials used include an analytical balance, digestion flasks, Bunsen burner, heating mantle, fume chamber, funnels, digestion tubes, aluminium foil, spatula, gloves, Whatman grade II filter papers, transparent polyethene bag, pre-treated sample bottles and glassware. Distilled water, as well as analar grade reagents by Sigma Aldrich like Nitric acid (HNO_3), Sulphuric acid (H_2SO_4) and Perchloric acid ($HClO_4$) were also used.

2.2 Sampling

Live local chickens were randomly sampled from central market sin Ado-Ekiti, Akure and Owena towns. The chickens were slaughtered by using a sharp stainless knife to cut their throat, thereby severing the jugular vein and carotid artery. Immediately, the blood was collected into an EDTA bottle and stored in the refrigerator until used.

2.3 Sample Preparation and Digestion

2.3.1 Solid sample digestion

Solid chicken heart, gizzard, liver and intestine samples were cut into tiny bits and dried in an oven at 105^{o}C for three days. The dried samples were separatelycrushed using porcelain mortar and pestle.Each wasthen kept in a polythene bagandstored in a desiccator. Wet digestion was used to solubilise the heavy metals in 1.0 g dried sample of gizzard, liver and intestineseparately as well as 0.5 g heart sample using 10 mLof 3:2 65% v/v HNO_3 and 70% v/v $HClO_4$ in a 100 mL beaker.The content of each beaker was gently swirled and allowed to stand overnight. It was then digested on a water bath at 70^{o}C for three hours, swirling at intervals to ensure complete digestion. The digest was allowed to cool, filtered into a 50 mL volumetric flask and made up to the mark. The solution was transferred into a sample bottle for analysis. A blank samplewas preparedwhile each sample type was done in triplicate [12].

2.3.2 Liquid sample digestion

A 0.5 mL solution of HNO_3 and H_2SO_4 in the ratio 20:1 was added to 1.5 mL of each blood sample and 10 mL of water was also added. The mixture was thoroughly mixed by swirlingand heated in a water bath at 60^{o}C until the sample reached half of its initial volume. HNO_3 (1 mL) was then added and heating continued until the sample became clear. It was cooled, filtered into a 50 mL volumetric flask using 110 mm Whatman filter paper and made up to mark. It was then stored in labelled sample bottles and analysed. Blank for each sample wasprepared and each of the samples was made in triplicate.

2.4 Elemental Analysis of Samples

Heavy metals concentration in digestates of each sample were determined using BUCK Scientific 210 VGPAtomic Absorption Spectrophotometer (Serial No. 1619). For each heavy metal, there was a specific “hollow cathode lamp” and the machine set at a particular wavelength for the analysis. The absorbance was measured at 15mA of lamp and the peak height mode of the wavelengths used were 283.3nm, 228.8nm, 213.9 nm for lead, cadmium and zinc respectively.

2.5 Statistical Analysis

Data obtained were presented as mean and standard deviation. SPSS 20.0 was used to compare theheavy metals in each selected sample as well as among all the samples using one-way analysis of variance (ANOVA) at $p=0.05$to assess the significance of variation.

3. RESULTS AND DISCUSSION

The mean concentrationsof metals in chicken organs (intestine, heart, liver and gizzard) and blood samples from the three towns (Ado-Ekiti, Akure and Owena) are shown in Table 1.Also, Table 2 shows the concentrations of heavy metals in internal tissues and organs of poultry birds from similar studies and this study while the maximum tolerance limits of some heavy metals in the internal tissues and organs of poultry birds are shown in Table 3.

Table 1. Concentration of heavy metals in chicken blood and organs from Ado-Ekiti, Akure and Owena

	Ado-Ekiti			Akure			Owena		
Chicken Part	**Pb (mg/kg)**	**Cd (mg/kg)**	**Zn (mg/kg)**	**Pb (mg/kg)**	**Cd (mg/kg)**	**Zn (mg/kg)**	**Pb (mg/kg)**	**Cd (mg/kg)**	**Zn (mg/kg)**
Intestine	4.33±1.53^{c}	0.50±0.50^{c}	72.00±13.48^{b}	3.50±1.73^{a}	0.33±0.29^{a}	59.83±1.26^{a}	3.83±2.08^{b}	0.17±0.29^{a}	92.33±5.03^{c}
Heart	7.33±4.73^{c}	N.D^{a}	55.47±8.50^{c}	3.00±1.00^{a}	0.33±0.58^{b}	50.33±5.13^{b}	3.50±0.71^{b}	N.D^{a}	27.00±19.80^{a}
Liver	6.50±6.08^{c}	N.D^{a}	183.17±18.45^{c}	3.17±1.26^{b}	N.D^{a}	73.00±0.50^{a}	2.50±7.26^{a}	0.33±1.04^{b}	135.50±11.53^{b}
Gizzard	6.17±1.61^{b}	N.D^{a}	67.33±5.84^{b}	6.50±1.32^{c}	0.33±0.29^{b}	58.00±1.00^{a}	2.00±5.29^{a}	0.67±0.76^{c}	86.83±13.90^{c}
Blood	N.D^{a}	N.D^{a}	15.67±11.55^{b}	2.67±1.34^{b}	0.11±0.19^{b}	5.67±15.72^{a}	N.D^{a}	N.D^{a}	18.27±18.58^{b}

N.D = Not detected; Values are mean±S.D and n = 3

Same metal with different letters in the same row means significant difference

Table 2. Concentration of heavy metals in the internal tissues and organs of poultry birds from this study and similar ones

Chicken part	**Similar studies**						**Range for this study**		
	Pb (mg/kg)	**Cd (mg/kg)**	**Zn (mg/kg)**	**Pb (mg/kg)**	**Cd (mg/kg)**	**Zn (mg/kg)**	**Pb (mg/kg)**	**Cd (mg/kg)**	**Zn (mg/kg)**
Intestine	-	-	-	-	-	-	3.50-4.33	0.17-0.50	59.83-92.33
Heart	0.11-0.15^{e}	N.D^{e}	28.68-36.84^{e}	-	-	-	3.00-7.33	N.D-0.33	27.00-50.33
Liver	0.10-0.18^{e}	0.007-0.013^{e}	18.25-23.21^{e}	-	-	-	2.50-6.50	N.D-0.33	73.00-183.17
Gizzard	0.10-0.18^{e}	N.D^{e}	31.22-48.50^{e}	0.01-3.22^{g}	0.01-1.02^{g}	9.63-37.03^{g}	2.00-6.50	N.D-0.67	58.00-86.83
Blood	-	-	-	-	-	-	N.D-2.67	N.D-0.11	5.67-18.27

N.D = Not detected; ^{e}[13]; ^{g}[1]

Table 3. Maximum tolerance limits of some heavy metals in the internal tissues and organs of poultry birds

Heavy metal	**EOS (2010)^{k}**	**ANZFA (2001)^{m}**	**EU (2006)^{n}**	**FAO/WHO (2000)^{m}**
Pb (mg/kg)	0.1	1.0	0.1	0.1^{m}
Cd (mg/kg)	0.05	-	0.05	0.06-0.07^{n}
Zn (mg/kg)	150	150	50	10-50^{m}

^{k}[14]^{m}[15] ^{n}[16]

Lead is not a natural constituent of living systems. Its presence in the blood has serious health implication like acute encephalopathy, especially for children [17]. It was however detected in all the organs and blood samples analysed except in the blood samples of chickens from Ado-Ekiti and Owena. This suggests anthropogenic influence. The trendsgenerally observed for lead areAdo-Ekiti>Owena>Akure for intestine and heart, Ado-Ekiti>Akure>Owena for liver and Akure>Ado-Ekiti>Owena for gizzard Table 1. Low lead level in the trend for some organs from Owena was probably because it was not as populated and industrialized as Ado-Ekiti and Akure. Kalogeropoulos et al. [17] reported that a positive correlation exists between urbanisation and heavy metal pollution. Gizzard of chicken samples from Owena also had the lowest lead mean concentration (2.00 mg/kg) while the highest occurred in heart of chicken from Ado-Ekiti (7.33 mg/kg). Lead for this study ranged as 3.50-4.33 mg/kg for intestine, 3.00-7.33 mg/kg for heart, 2.50-6.50 mg/kg for liver, 2.00-6.50 mg/kg for gizzard. The trend was heart> liver>gizzard>intestine>blood (Table 2), its concentration in liver being higher than in gizzard as also observed by Elsharawy [14].

Also, there was significant difference ($p < 0.05$) in the concetration of lead in the blood and organs of chicken samples from the three towns. This could be as a result of variation in the chicken rearing practise used; whether it is free range which could expose the chicken to scavenging waste sites of diverese composition, exposure to contaminated sources including feed, water, container [18,19] and sanitation [20], among others. Lead concentration in the blood of chicken from Akure and all the organs of chickens from the three towns exceeded the maximum tolerance limit of 0.1 mg/kg by Egyptian Organization for Standardization and Quality Control (EOS) [21], European Union (EU) [22], Food and Agriculture organization and World Health Organization and 1.0 mg/kg by Australia New Zealand Food Authority [23] as seen in Table 3.

Cadmium was the most undetected metal in blood and organs of chickens sampled from the three towns (Table 1). It was not detected in liver of chicken from Akure as well as heart and blood of chicken samples from Owena while in chickens from Ado-Ekiti, it was detected only in the intestine. There is paucity of data for cadmium in intestine, heart and blood of poultry. In this study, the respective concentrations obtained for intestine, heart and blood were 0.17-0.50 mg/kg, 0.33 mg/kg and 0.11 mg/kg (Table 1).Cadmium was highest in gizzard of chicken from Owena (0.67 mg/kg) and lowest in blood of chicken from Akure (0.11 mg/kg), the blood samples where it was only detected. Nasef and Hamouda [23]and Khalafalla et al. [24] reported bioaccumulation of cadmium in the gizzard. Cadmium affects the health of children [25] andinterferes withcalcium,phosphorus and bone metabolism [16].

Where detected, the trend for cadmiumin chicken was Owena>Ado-Ekiti>Akure.No significant differ ence was observed in cadmium concentration for chicken intestine from Akure and Owenawhereas a significant difference existed in gizzard of chicken from Akure and Owena ($p < 0.05$). Similar studies vary in their reports on cadmium (Table 2). Inone of such, cadmium was not detected in the heart while itwas 0.33 mg/kg for this study.The range of cadmium concentration in liver for two studies was from 0.007 to 0.23 mg/kg while 0.3 mg/kg was observed for this study. Similarly, cadmium in gizzard ranged from 0.01 to 1.02 mg/kg in a study whereasin this study, the range was 0.33 to 0.67 mg/kg.Besides, concentration of cadmium in parts where it was detected was higher that the tolerance limit (0.05 mg/kg) set by EOS and EU [21,22] as well as 0.06-0.07 mg/kg set by WHO/FAO [26].

Zinc is a trace element essential for protein synthesis [26]. Poultry meat has been observed to be a source of zinc and that the metalfunctions as a cofactor in metalloenzymes and in regulation of gene expression [27]. A level of it (35-45 mg/kg) is needed in poultry birds [28], for consumption by man as a deficiency of it causes retardation in growth and impaired immune responce, amomg others [27]. From Table 1, zinc concentration in the organs and bloodof chickens from the three towns trend asliver>intestine> gizzard>heart>blood and the general trend observed in this study (Zn>Pb>Cd) agrees with that reported by Ogu et al. [19]. Besides, highest level of zinc found in the liver of chickens from the three towns agrees with the report of Akan [15].Zinc was also observed in the blood of chickens from Ado-Ekiti and Owena, unlike lead and cadmium. Moreover, zinc was significantly different ($p < 0.05$) in the same sample type from the three towns.

As for the two metals earlier discussed, Table 2 gives the range of values for this study for intestine (59.83-92.33 mg/kg) and for blood (5.67-18.27 mg/kg), hitherto uncommon. The results of similar studies fall within the ranges obtained for this study.The mean concentration of Zincin liver of chicken from Ado-Ekiti (183.17±18.45 mg/kg) is above the tolerance limit of 50 mg/kg by FAO/WHO [22] and EU [21] as well as 150 mg/kg by EOS [19] and ANZFA [29] (Table 3). Above this tolerance limit, zinc becomes deleterious and results in copper deficiency, increased possiblility of prostrate cancer and respiratory disorder [30,13].

4. CONCLUSION

The results of this study revealthat concen trations of lead, cadmium and zinc in organs and blood of local chicken sold at the central markets of Ado-Ekiti, Akure and Owenavaried in concentration and trend. Zinc was the only metal detected in all the five sample types from all the three towns; its levels in each sample type from the three towns were significantly different ($p < 0.05$) and it was generally the metal with the highest concentration, the trend being zinc>lead>cadmium.The trend observed for zinc in organs and blood was liver> intestine> gizzard>heart>blood, the liver and the gizzard showing a higherconcentration ofthe three metals. The concentrations of all the metals exceed the tolerance limit set by some standard organisations (FAO/WHO, EU, ANZFA and ESO) and the chicken samples could therefore pose health risk to consumers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Iwegbue CMA, Nwajei GE, Iyoha EH. Heavy metals residues of chicken meat and gizzard and turkey meat consumed in Southern Nigeria. Bulgarian Journal of Veterinary Medicine. 2008;11(4):275-280.
2. Thirulogachandar AME, Rajeswar M, Ramya S. Assessment of heavy metals in Gallus and their impacts on human. International Journal of Scientific and Research publications. 2014;4(6):1-8.
3. Pagani P, Yerima Abimiku JE, Emeka-Okolie W. Food and agriculture organiztion of the united nations, Nigeria consultative mission on assessment of the nigerian poultry market chain to improve biosecurity; 2008. Available:http://www.fao.org/3/a-ak778e.pdf on 22nd May, 2020.
4. Tumwebaze RP. Decision enhancement for poultry farmers in East Africa. Gronin gen: University of Groningen, SOM research school, Netherlands; 2016.
5. Africa Sustainable Livestock (ASL) 2050. Livestock production systems spotlight Nigeria. FAO, Rome, Italy; 2018. Available:http://www.fao.org/3/CA2149EN/ca2149en.pdf
6. Heinke H, Alexandra C, T. The poultry market in Nigeria: Market structures and potential for investment in the market. Inter national Food and Agribusiness Manage ment Review, special issue A. 2015;18 (198):197-222.
7. Katherine K. Poultry market in West Africa: Nigeria. Evans School Policy Analysis and Research (EPAR), EPAR Brief No.87; 2010.
8. Abdullah IM, Babagana K, Yakubu AG. Heavy metals in selected tissues of adult chicken layers (*gallusSpp*). ARPN Journal of Science and Technology. 2013;3(5) :518-522.
9. Khan MZ, Shahnaz P, Karim G, Iqbal SK, Nadeem B, Rooh K, Tancveer J. Concen trations of heavy metals in liver, meat and blood of poultry chicken *Gallus domesticus* in three selected cities of Pakistan. Carnadian Journal of Pure and Applied Scieces. 2015;9(9):3313-3324.
10. Ping Z, Zou B, Huanping L, Zhan L. Heavy metal concentrations in five tissues of chickens from a mining area. Pol J Environ Stud. 2014;23(6):2375-2379.
11. Cuadrado C, Kumpulainen J, Moreiras O. Lead, cadmium and mercury contents in average Spanish market baskets diets from Galicia, Valencia, Andalucía and Madrid. Food Additives and Contaminants. 1995;12:107-118.
12. Soad AI, Said KA. Estimation of lead and cadmium residual levels in chicken giblets at retail markets in Ismaila city, Egypt. International Journal of Veterinary Sciences and Medicine. 2013;1(2):109-112.
13. Prockop LD, Rowland LP. Occupational and environmental neurotoxicology in: Merritt's Neurology, Editted by L.P. Row land, Chapter. 2005;167.
14. Al Bratty M, Alhazmi HA, Ogdi SJ, Otaif JA, Al-Rajab AJ, Alam MF, Javed SA. Determination of heavy metals in various tissues of locally reared (Baladi) chicken in

Jazan region of Saudi Arabia: Assessment of potential health risks. 2018;50(4):1509-1517.
15. Elsharawy NTM. Some heavy metals residues in chicken meat and their edible offal in New Valley. In 2nd Conference of Food Safety, Suez Canal University, Facu lty of Veterinary Medicine. 2015;1:53-60.
16. Akan JC, Abdulrahman FI, Sodipo AI, Chiroma YA. Distribution of heavy metals in the liver, kidney and meat of Beef, Mutton, Caprice and Chicken from Kasuwan Shanu Market in Maiduguri Metropolis, Borno State, Nigeria. Research Journal of Applied Sciences, Engineering and Technology. 2010;2(8):743-748.
17. Khan Z, Sultan A, Khan R, Khan S, Imranullah and Kamran Farid. Concen trations of heavy metals and minerals in poultry eggs and meat produced in Khyber Pakhtunkhwa, Pakistan. Meat Sciences and Veterinary Public Health. 2016;1(1):4-10.
18. Kalogeropoulos N, Karavoltsos S, Sakellari A, Avramidou S, Dassenakis M, Scoullos M. Heavy metals in raw, fried and grilled Mediterranean finfish and shellfish. Food and Chemical Toxicology. 2012;50:3702-3708.
19. González-Weller D, Karlsson L, Caballero A, Hernández F, Gutiérrez A, González-Iglesias T et al. Lead and Cadmium in meat and meat products consumed by a Spanish population (Tenerife Island, Spain). Food Additives and Contaminants. 2006;23(08):757-763.
20. Ogu GI, Madar IH, Okolo JC, Eze EM, Srinivasan S, Tayubi IA. Exposure assessment of chicken meat to heavy metals and bacterial contamination in Warri Metropolis, Nigeria. International Journal of Scientific Innovations. 2018; 3(02):047-054.
21. EOS: Egyptian organization forstandardi zation and quality control. Maximum level for certain contaminants infood stuffs. ES No. 7136/2010; 2010.
22. EU- European Union, Commission Regu lation as regards heavy metals, Directive, 2001/22/EC, No: 466; 2001.
23. FAO/WHO - Joint FAO/WHO Expert Committee on Food Additives (1998: Geneva, Switzerland), World Health Orga nization & Food and Agriculture Organi zation of the United Nations. Evaluation of certain food additives: Fifty-first report of the Joint FAO/WHO expert committee on food additives. World Health Organization; 2000.
Available:https://apps.who.int/iris/handle/10665/42245
24. Nasef E, Hamouda A. Residues of lead, cadmium, mercury and tin in some canned fish products sold in markets of Damietta governorate, Journal Egypt Vet Med Assoc. 2008;68(4): 267-280.
25. Khalafalla A, Fatma H, Schwagele F, Mariam A. Heavy metal residue in beef carcasses in Beni-Suef abattoir, Egypt. Veterinaria, Italiana. 2011;47(3):351-361.
26. Jārup L, Ȧkesson A. Current status of cadmium as an environmental health problem, Toxicology and Applied Pharma cology. 2009;238(3):201-208.
27. Miller DD. Minerals: In Fennema's Food Chemistry, Edited by Srinivasan Damo daran, Kirk L. Parkin and Owen R. Fennama, CRC Press, Taylor & Francis Group. 2008;523-558.
28. Ahmad RS, Imran A, Hussain MB. Nutritional composition of meat: In meat science and nutrition. 2018;61-77.
Available:http://dx.doi.org/10.5772/intechopen.77045
29. Underwood EJ. Trace elements in human and animal nutrition, 4th Ed. Academic Press, New York; 1977.
30. ANZFA (Australia New Zealand Food Authority), 2001. Wellington NZ 6036 May; 2001.
31. Plum LM, Rink L, Haase H. The essential toxin: Impact of zinc on human health. Int J Environ Res Public Health 2010;7:1342–136.

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