Assessment of Heavy Metal in Imported Red Meat Available in the Markets of Erbil City

Nidhal Y. Yakup[a], Azad B. Sabow[a], Shawnm J. Saleh[a], Ghazee R. Mohammed[a]

[a]*Department of Animal Science, Faculty of Agriculture, Salahaddin University, Erbil, Kurdistan Region, Erbil, Iraq*

azad.sabow@su.edu.krd

Abstract

Meat has comprised a significant part of the human diets worldwide. Nevertheless, pollution is a great health risk to human health, especially the bioaccumulation of heavy metals from anthropogenic. The study examined the concentrations of cobalt (Co), copper (Cu), iron (Fe), zinc (Zn), selenium (Se), nickel (Ni), mercury (Hg), lead (Pb) and arsenic (As) metals from imported meat of cattle, buffalo and lambs consumed in Erbil city by using X-ray fluorescence spectrometer. The estimate of essential metals investigated in meat samples indicates that meat from cattle, buffalo and lamb was found to have significantly higher levels of heavy metals and the concentration of these metals except for copper, iron, selenium and mercury in cattle and lambs exceeded the permissible limits set by international standard. Therefore, people of Erbil governorate that consume imported red meat such as cattle and lamb are likely to be exposed to higher metal levels.

Keywords: Beef meat, buffalo meat, contamination, heavy metals, lamb meat

1. Introduction

Globally meat from cattle, buffalo (beef) and lamb (mutton) constitute a greater percentage of red meat in the diets of human due to its palatability and nutritive value. However, its exposure and pollution is just like other food materials. Heavy metals are amongst the numerous pollutants. In food chain heavy metals pollution poses a serious threat due of their toxic nature, bioaccumulation and bio-magnifications. Additionally, risk associated with the exposure to heavy metals present in meat and meat products is a call for concern for both human health as well as food safety because of their toxic nature. Therefore, regulatory bodies such as the Food and Agricultural Organization (FAO), World Health Organization (WHO), US Environmental Protection Agency (USEPA) have been established as well as from other countries have set tolerable limits for heavy metals in foodstuffs [1]. It could be noted, however, that the chemical forms of metals can be alter, they can neither be degraded nor destroyed. According to Upreti et al. [2] , the gut micro flora have a distinct ability to cope with an increase in the uptake of metals will bring about a significant improvement in defense against metal toxicity which is suggestive to the fact that defense of the epithelium of the gut may be compromised.

During processing, packaging, storage and transportation pollutants produced by air, chemical pollution and unhealthy way of selling meat can contaminate the meat with heavy metals. In some instances, contaminated livestock feeds and raising livestock close to polluted environments were reportedly responsible for heavy metal contamination in meat. Although there has been some works evaluating the quality of frozen meat imported to Erbil, Iraq [3], most information originates from works in meat chickens with little or no attention on the concentration of heavy metals in red meat such as beef and mutton imported from other parts to Erbil city in of Kurdistan Region of Iraq with a population of about 1.75 to 2 million and an area of 15 km^2 remained undocumented. Thus, the objective of the current study is to determine the residual concentration of heavy metals lead, Cadmium, Copper, Zinc and Mercury in imported meat of beef and mutton available in the markets of Erbil city.

2. Materials and methods

2.1. Sample collection

A total of 30 of frozen meat chops were collected across different markets in Erbil city, Kurdistan Region, Iraq during the last quarter of 2017. The samples were classified into 3 groups: (a) beef round boneless rump originating from two different countries (Paraguay, Ukraine), (b) lamb-leg meat from Moldova and (c) buffalo tenderloin meat from India. Each sample collected from different markets weighed between the ranges of 250 - 300 g. The chops were put into clean polythene bags, transported to the laboratory and stored at -20ºC until subsequent analyses. The process was conducted between the months of October 2017 to December, 2017.

2.2. Sample preparation

The samples collected were gently washed with distilled water to remove contaminated particles and chopped into small pieces using a clean ceramic knife. In order to obtain the dry mass of the samples about 50g of meat was homogenized and dried at 90ºC. The dried samples were crushed using a ceramic mortar. About 2g of fine powder was used to analyze the elements. The collected samples were analyzed independently in triplicates per sample.

2.3. Elemental analysis of samples

Lead (Pb), Cadmium (Cd), Copper (Cu), Zinc (Zn) and Mercury (Hg) in meat samples from beef and mutton were determined directly on each sample using X-ray fluorescence spectrometer (Genius 9000 XRF, USA) following the procedures of Chelebi et al. [3] .

2.4. Statistical analysis

The experiment was a complete randomized design (CRD). Data obtained were subjected to one-way analysis of variance (ANOVA) using Statistical Analysis System (SAS), (SAS Institute Inc., Cary, NC, USA). Duncan multiple range test was used to test the differences between the means of meat groups at a significant level of $p<0.05$.

3. Results and discussion

3.1. Essential elements

Red meat is considered to be one of the major sources of iron in human diet. In the present study, significant differences ($p<0.05$) in iron (Fe) was recorded among the meat samples examined. The beef meat from Ukraine and Paraguay appeared to have higher content of Fe 132.250 and 147.981μg/g, while tenderloin meat from buffalo showed the lowest value 95.031 μg/g. It was noticed that the contents of Fe in lamb-leg were significantly low

($p< 0.05$) as compared to those in beef meat (Table 1). Results from the current study showed Iron (Fe) in the entire samples studied fell within the tolerable levels recommended. Similarly, the recommended allowable intake of Fe daily for children between the ages of 0 months to 8 years and males/females 14 - 70 years is 40-45 mg d/1 per person [4]. Copper (Co) in the form of cobalt-containing vitamin B12 is a requisite. Co is commonly dispersed in the organs of animals in comparatively higher concentrations in liver, kidney, bone, spleen, and other glandular tissues [5]. In the current study results showed the all meat samples analyzed had copper contents exceeding the maximum level of 3 μg/gm prescribed by FAO and EC in meat and meat products [6] [7] . The highest level of copper 1.042 μg/gm was observed in beef imported from Ukraine. Beef imported from Paraguay 1.115 μg/gm, lamb-leg 1.088 μg/gm and buffalo tenderloin 0.497 μg/gm had lower copper contents. Zinc (Zn) and Copper (Cu) are cofactors to numerous enzymes [8] Cu and Zn play an important role in the health of humans which may be as a results of its involvement in the transportation of iron absorption and utilization in the body, and therefore, preventing Fe deficiency [1]. In our study, the contents of Cu and Zn in the meat samples evaluated ranged between 0.000 to 52.212 μg/gm and from 0.000 to 604.272 μg/gm, (Table 1) and the highest mean concentration was observed in Ukraine beef while the lowest concentration value was detected in meat from buffalo tenderloin. Even though, Zn and Cu are very vital for good health however, their roles cannot be overemphasized as higher intakes can lead to severe health problems for instance kidney and liver damage especially when levels become extremely higher in the body of humans [9] . According to Johnson [10] 10-30 mg of Cu taken orally from foods deposited in copper vessels may cause headache, intestinal discomfort, and dizziness. In addition, higher amount of Cu can have a severe consequence leading to liver cirrhosis, hepatitis and or hemolytic similar to that seen in acute copper poisoning. According to Salisbury and Chan [11] normal concentration of zinc in meat samples ranged between 23-147.2μg/g, in the present study samples analyzed were dissimilar to those reported by Salisbury and Chan containing high level of zinc. Healthy adults have their daily tolerable levels of Cu and Zn to be between 900 and 1300 μg/ day, and 3300 and 3800 μg/ day [12] . According to Kabata-Pendias and Pendias the acceptable intake of these trace elements is 1.5-4mg/day Cu and around 10 mg/ day Zn [13]. Selenium (Se) levels in the meat samples, depending on the examined animal types, varied between 0.120 and 0.202 μg/g dry weight (Table 1).The highest selenium concentration was found in the meat from Paraguay (beef and lamb) 0.202 and0.198 μg/g respectively, and the least value was observed in buffalo and Ukraine beef meat 0.120 and 0.0121μg/g, respectively. Currently the recommended dietary daily intake of Se for humans is 57 μg (range 30–85 μg) [14] . Selenium is an important nutrient which plays a vital role in guarding tissues from oxidative impairment as a component of glutathione peroxides in humans and animals. Despite the fact that selenium is an important nutrient, inhaling and ingesting higher concentrations predisposes one to have severe health consequences. Selenium seems to influence the capacity of liver proteins to enact some chemical mutagens. Generally, the highest levels of selenium accumulated in many organs of the body are found in the liver and kidney [15].

3.2. Non-essential elements

Breathing air, drinking water, smoking of cigarettes and eating food (meat) may likely predispose humans to nickel (Ni). In the current study the concentration of Nickel obtained ranged between 0.000 and 7.386 μg/g of beef, lamb and buffalo meats as shown in Table 2. These values appeared lower than those recorded by Chowdhury et al. [16]. The authors reported that the concentration Ni in beef and buffalo meat ranges between 2.64 to 41.4vμg/g dry weight. In little amounts or concentrations nickel is important, however; when the uptake is too high it risks human lives. The highest agreeable levels of intake of nickel in children (1 - 3 years old) and adults (19 - 70 years old) is 7 and 40 mg d^{-1}, [14]. Mercury (Hg) may induce neurological changes and some diseases [17]. The mercury contents in samples ranges between 0.015 and 0.020 μg/g. Beef meat from the Ukraine contained the highest concentration of Hg, while lamb-leg meat, buffalo tenderloin meat and beef from Paraguay had the lowest value. Mercury showed no significant variation between all samples studied (Table 2). Hg concentrations obtained from the current study were lower than the allowed mercury limit of 1.0 μg/g [18]. Assessing the amount of lead (Pb) present in meat is essential [19]. Food or meat contaminated during production and or processing in places that are contaminated is chief among the reasons for enhanced Pb intake through foodstuffs. Results of the current finding showed high Pb concentration in meat samples from Paraguay beef, Ukraine beef and lambs with mean 0.723 μg/g, however this metal were not detected in meat from Indian buffalo (Table 2). Additionally, no significant difference($p>0.05$) was recorded between in terms lead content in samples obtained from different meat collected. However, the values obtained had exceeded the maximum concentration of lead (Pb) levels allowed by FAO [7] for meat and meat products i.e. 0.5 μg/g. The recommended dietary exposure of lead is 18 μg kg^{-1} for adults, 46 μg kg^{-1} for toddlers and 30 μg kg^{-1} for young people [20]. Consuming large amounts of lead, which exceeds the threshold becomes toxic and may likely cause an acute or chronic poisoning symptoms [21]. High concentration of Pb may be attributed to its widespread distribution in the environment due to pollution, air borne traces, polluted water and fumes and effluents emitted from moving vehicles in traffic [1]. Lead has been identified to cause reduced cognitive development and intellectual performance in children and a rise in blood pressure and cardiovascular diseases in adults [1]. Arsenic (As) is a toxicant found in the environment has been detected in all meat samples evaluated and ranges between 1.437 to 2.059 μg/g with mean 1.638 μg/g. The results of arsenic were considered high when compared with those reported by USDA [22] . The levels of (As) in meat animals, with the exception of some seafood, are generally well below 1 μg/g in terms of dry weight. One of the real components by which it applies its poisonous impact is through a hindrance of cell breath through the restraint of different mitochondrial catalysts, and the uncoupling of oxidative phosphorylation [23]. Inorganic arsenic is normally present at abnormal states in the groundwater in various nations. Drinking-water, crops flooded with defiled water and sustenance arranged with polluted water from these meat creatures may be wellsprings of arsenic presentation [24] .

4. Conclusions

Meat consumption is the major pathway for human exposure to heavy metals and so threatens the health of the general populace. The concentration of heavy metals in beef meat (Ukraine and Paraguay), lamb and buffalo meat in Erbil city were determined and assessed by comparing the results within the permissible limits. The results showed variation in the values of the heavy metals measured between meat samples. Most estimated metals in beef and lamb meat indicated a potential risk to health as their values were higher than the permissible limits set by international standards. The concentrations of iron, copper, selenium and mercury in meat samples were all within the tolerable limits.

Table 1: Concentration of essential metals in various imported red meat samples available in the markets of Erbil city

Meat of animal	Country	Heavy metals (µg/g dry weight)				
		Iron	*Cobalt*	*Copper*	*Zinc*	Selenium
Beef	Paraguay	132.250 ± 1.75^{b}	1.042 ± 0.02b	23.813 ± 1.67^{b}	445.406 ± 17.08^{b}	0.202 ± 0.01^{a}
	Ukraine	147.981 ± 6.39^{a}	1.115 ± 0.02a	52.212 ± 5.74^{a}	604.272 ± 40.26^{a}	0.121 ± 0.00^{b}
Lamb	Moldova	121.000 ± 5.65^{c}	1.088 ± 0.01ab	15.224 ± 1.54^{b}	363.323 ± 55.37^{b}	0.198 ± 0.04^{a}
Buffalo	India	95.031 ± 0.00^{d}	0.497 ± 0.00c	0.000 ± 0.00^{c}	0.000 ± 0.00^{c}	0.120 ± 0.00^{b}

$^{a-d}$ Means in the same row with different letters are significantly different at $p<0.05$.
Values are means ± standard error.

Table 2: Concentration of toxic metals in various imported red meat samples available in the markets of Erbil city

Meat of animal	Country	Heavy metals (µg/g dry weight)			
		Nickel	Mercury	Lead	Arsenic
Beef	Paraguay	7.258 ± 0.35^{a}	0.016 ± 0.00	0.702 ± 0.02^{a}	1.483 ± 0.05^{b}
	Ukraine	7.386 ± 0.92^{a}	0.020 ± 0.00	0.733 ± 0.08^{a}	1.437 ± 0.08^{b}
Lamb	Moldova	3.931 ± 0.80^{b}	0.015 ± 0.00	0.734 ± 0.12^{a}	1.575 ± 0.68^{b}
Buffalo	India	0.000 ± 0.00^{b}	0.015 ± 0.00	0.000 ± 0.00^{b}	2.059 ± 0.00^{a}

^{a,b} Means in the same row with different letters are significantly different at $p<0.05$.
Values are means ± standard error.

References

[1] D. A. Zahrana, B. Hendy, Heavy metals and trace elements composition in certain meat and meat products sold in Egyptian markets., Int. J. Sci.: Basic Appl. Res. ROAD 20 (1) (2015) 82–293.

[2] R. K. Upreti, S. R., U. Chaturvedi, Gut microflora and toxic metals: chromium as a model, Indian J. Med. Res 119 (2) (2004) 49–59.

[3] N.A., Chelebi; J.N.A., Bazzaz; N.Y., Yakub ; A.A. Bazzaz and G.R. Hammad. Heavy metal residues in frozen chicken meat consumed within erbil province, MRJMMS 3 (11) (2015) 517–

520.
[4] Dietary reference intakes: applications in dietary planning. subcommittee on interpretation and uses of dietary reference intakes and the standing committee on the scientific evaluation of dietary reference intakes, in: Institute of Medicine of the National Academies, the National Academies Press, Institute of Medicine, Washington, DC, 2003, p. 248.
[5] J.C. Akan, F. Abdulrahman, O. Sodipo, Y. Chiroma, 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. Appl. Sci. Eng. Technol 2 (8) (2010) 743–748.
[6] E.C. 178, Regulation (ec) no 767/2009 of the european parliament and of the council of 13 July 2009 on the placing on the market and use of feed, amending european parliament and council regulation (ec) no 1831/2003 and repealing council directive 79/373/eec, Official Journal of the European Union 229 (2002) 1–28.
[7] F.A.O., Report of the codex committee on food additives and contaminants, food and agricultural organization (2002). URL http://www.fao.org/fileadmin/templates/agns/pdf/jecfa/2002910_Explanatory_note_Heavy _ Metals.pdf
[8] S. Mohammed, R. K., Fezea, Determination of some trace element levels in Iraqi male patients with colorectal cancer, Ibn Al-Haitham J. for Pure & Appl. Sci 29 (2) (2016) 254–261.
[9] A.T.S.D.R., Agency for toxic substances and disease registry, division of toxicology, clifton road (2004).
URL http://www.atsdr.cdc.gov/toxprofiles/
[10] M. A. Johnson, Encyclopaedia of food science, food technology and nutrition, in: M. acrae R, R. K. Robinson, M.J.Sadler (Eds.), Encyclopaedia of Food Science, Food Technology and Nutrition, Academic Press, London, 1993.
[11] C. D. C. Salisbury, W. Chan, Multielement concentrations in liver and kidney tissues from five species of canadian slaughtered animals, J. Assoc. Off. Anal. Chem 74 (1991) 587–591.
[12] C. J. Boreiko, Essentiality and toxicity in copper health risk assessment: overview of health risk assess- ments for zinc, J. Toxicol. Environ. Health. (Part A) 73 (2010) 166–74.
[13] A. Kabata-Pendias, H. Pendias, Biogeochemia pierwiastków śladowych, Wydawnictwo Naukowe PWN, Warszawa, 1999.
[14] M. P. Rayman, Food-chain selenium and human health: emphasis on intake, Br. J. Nutr 100 (2008) 254–268.
[15] P. Aljaff, B. O. Rasheed, D. M. Salh, Assessment of heavy metals in livers of cattle and chicken by spectroscopic method, IOSR J. Appl. Phys 6 (1) (2014) 23–26.
[16] M. Z. A. Chowdhury, S. Z.A., H. S.MA., K. A.I., A. M.A., A. S., Z. M.M, Determination of essential and toxic metals in meats, meat products and eggs by spectrophotometric method, J. Bangladesh Chem. Soc 24 (2) (2011) 165–172.
[17] B. Badis, R. Z. E. B, Levels of selected heavy metals in fresh meat from cattle, sheep, chicken and camel produced in algeria, Annual Research & Review in Biology 4 (8) (2014) 1260–1267.
[18] E.U., Commission regulation as regards heavy metals. amending regulation nº (2005).
[19] WHO, Evaluation of certain food additives and contaminants (1993).
[20] FSIS, Food safety and inspection service 2000 total diet study of 12 elements – aluminium, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, tin and zinc. food survey information sheets.48/04 (2004).
URL http://www.food.gov.uk/science/surveillance/.
[21] L. Jarup, Hazards of heavy metal contamination, Br. Med 68 (2003) 167–182.
[22] U.S.D.A., Foreign agricultural services gain, Vol. 1, 2006, p. 60.
[23] H. Hamasalim, H. Mohammed, Determination of heavy metals in exposed corned beef and

chicken luncheon that sold in sulaymaniah markets, Afr. J. Food Sci 7 (7) (2013) 178–182.
[24] P. Mandal, An insight of environmental contamination of arsenic on animal health, Emerging Contaminants 3 (1) (2017) 17–22.

الخلاصة

تحتوي اللحوم على أجزاء ذات اهمية معنوية لغذاء الانسان في عموم العالم. يعتبر التلوث عامل خطر على صحة الانسان وبالأخص خطر التراكم الحيوي للمعادن الثقيلة. ي هذه الدراسة تم قياس تراكيز معادن الكوبالت والنحاس والحديد والزنك والسيلينيوم والنيكل والزئبق والرصاص والزرنيخ في عينات لحوم الابقار والجاموس والاغنام المستوردة والمتوفرة في أسواق مدينة أربيل والمستهلكة من قبل الناس. أظهرت فحوصات تقدير المعادن المهمة والضرورية في عينات اللحوم احتواء لحوم الأبقار والجاموس والاغنام على نسب عالية معنوية من المعادن الثقيلة باستثناء النحاس والحديد والسيلينيوم والزئبق في لحوم الابقار والاغنام فقد تجاوزت الحدود المسموح بها حسب المعايير الدولية. لذا فان الناس في منطقة اربيل تستهلك لحوم الابقار والاغنام الحمراء المستوردة كأنها تعرضت الى مستويات عالية من التلوث بالعناصر الثقيلة.

الكلمات المفتاحية: لحوم الابقار, لحوم الاغنام, لحوم الجاموس, التلوث, العناصر الثقيلة