J.Meat Sci., 2014, 9(1) : 41 - 44

Assessment of Heavy Metal Levels in Muscle, Liver and Kidney of Sheep and Goats Slaughtered in Municipality Abattoir of Puducherry, INDIA

R. Premanand R., U.K. Pal, G. Gawdaman, C.D. Das and P.K. Mandal*

Department of Livestock Products Technology

Rajiv Gandhi Institute of Veterinary Education and Research,

Kurumbapet, Puducherry-605009, India

ABSTRACT

A study was conducted to determine the presence and levels of heavy metals viz. chromium, copper, lead and zinc in muscle, liver and kidney of sheep and goats slaughtered in municipality slaughter house of Puducherry. A total of 144 samples, (24 samples of each tissue for each species) were analyzed using Atomic Absorption Spectrophotometer. Mean values of chromium, copper, lead and zinc recorded in muscle, liver, and kidney of sheep were 4.31 ± 0.24, 2.83 ± 0.18, 2.87 ± 0.26; 1.01 ± 0.03, 27.64 ± 3.92, 3.50 ± 0.16; 4.83 ± 0.26, 4.58 ± 0.32, 4.20 ± 0.34; 31.08 ± 3.45, 37.81 ± 1.50 and 25.08 ± 0.53 ppm, respectively. In goat muscle, liver and kidney they accounted for 1.00 ± 0.04, 1.01 ± 0.06, 1.00 ± 0.08; 0.72 ± 0.03, 4.45 ± 0.75, 5.01 ± 0.59; 4.33 ± 0.25, 4.20 ± 0.24, 4.87 ± 0.33; 28.13 ± 1.89, 11.28 ± 0.88 and 18.94 ± 0.26, ppm, respectively. When comparisons were made between goat and sheep tissues, it was found that sheep muscle, liver and kidney contained significantly ($P < 0.05$) higher concentration of chromium, copper and zinc with the exception that copper concentration was significantly ($P<0.05$) higher in goat kidney. The concentration of lead recorded in all the tissues (4.20-4.87 ppm) in both the species was higher than the maximum permissible limit (2.5ppm) prescribed by MFPO in meat product. Levels of other three metals in the tissues of sheep and goat recorded in the present study were below the prescribed maximum permissible limit except the concentration of copper in the liver of sheep (30ppm)

Key words : *Heavy metals, sheep, goat, muscle, liver, kidney.*

Received: 18 January 2014 Accepted: 27 February 2014

INTRODUCTION

The wide spread and indiscriminate use of pesticides, chemicals, metals, drugs, inorganic fertilizers and untreated effluents from industries pollute the environment and end up as residues in food, water and air. Their impact on animals and agriculture produces has resulted in chronic and acute intoxications and their residues further get transferred into meat, dairy and poultry products (Shull and Cheeke, 1983). Although chromium (Cr), copper (Cu) and zinc (Zn) are part of the essential trace elements required in human diets with well defined physiological functions, but may cause serious health problems when get accumulated in the system in higher concentration. Compounds of both hexavalent chromium and trivalent chromium have been reported to induce developmental defects in experimental animals including neural tube defects, malformations and foetal deaths (Lijima and Matsumoto, 1983 and Danielsen et al. 1982). The inhalation of chromium compounds has been shown to be associated with the development of cancer in workers in the chromate industry (Langard, 1982). Similarly, cases of acute copper poisoning resulting in kidney failure in sheep have been reported (Clegg et al. 1986; Gracey and Collins, 1991). Kidney malfunction developed in man when the concentration was above 200 $\mu g/g$ (wet weight basis). Deficiency of zinc and copper might cause clinical manifestation, whereas, increased levels could accumulate in target organs such as liver and kidneys of animals resulting in toxic effects (Cherian and Nordberg, 1983). Lead is a toxic metal and lead poisoning in farm animals is widely reported (Brick, 1975; Gracey and Collins, 1991). Bolger et al. (1996) reported that infants and children are more susceptible to lead toxicity than adults because they consume more food per unit body mass, with the lead getting absorbed more readily.

As meat is one of the major routes through which various chemical residues gain entry into the human system, it is essential to monitor the presence of these residues in meat at regular intervals to ensure that public health is not endangered by residues (Noel et al. 2005). Hence, detection and estimation of heavy metal residues has become mandatory to have a check on these residues for safe and healthy meat production and consumption. Therefore, present study was planned to assess the quantity of metal residues viz. chromium, copper, lead and zinc in muscle, liver and kidney of sheep and goat as meat from these two species are most preferred and widely consumed throughout the country.

Corresponding author E-mail address: mandalpkm@gmail.com

MATERIALS AND METHODS

Collection samples: Fresh samples of muscle and liver of 100g each and kidneys from eight individual animals of two species (ovine and caprine) were collected from animals slaughtered at Puducherry Municipality slaughter house. Thus 48 samples at a time and a total of 144 samples in three batches were collected for analysis over a period of five months. The collected samples were packed in LDPE bags and labeled properly and were stored at -20^{0}C till further use.

Processing of samples: The samples were digested by wet digestion method for analysis of heavy metals viz. chromium, copper, lead and zinc. A 5g sample was taken in 100ml conical flask to which 10 ml each of analytical grade concentrated nitric acid and 60% perchloric acid were added. The contents were heated at high temperature for a minimum period of 15 minutes and then the temperature was reduced and maintained at 600C until the solution became clear. The clear solution thus obtained was transferred to a 50 ml volumetric flask and volume was made up using triple glass distilled water and mixed well. Samples from this were utilized for metal analysis.

Preparation of standard solution: The stock standard solutions and the working solutions for chromium, copper, lead and zinc were prepared as per the flame methods manual for Atomic Absorption Spectrophotometer (Perkin Elmer 1003 model) using triple glass distilled water.

Detection and quantification of metals: Atomic Absorption Spectrophotometer (AAS) Perkin Elmer 1003 model was used for the estimation of these metals from the digested samples.

The AAS was calibrated using the standard solutions for different metals and after calibrating for each metal, the sample was fed through nebulizer. The concentration of these metals for which it had been calibrated was measured directly by the AAS and the result was displayed in the computer screen interfaced with the AAS from which it was noted. Presence of these metals was estimated using respective hollow cathode lamps to give lamp energy. The fuel oxidant was obtained by acetylene-air mixture which provided the flame for determination of metals. For all elements the fuel/oxidant ratio was used as prescribed in the flame methods manual for atomic absorption. The standard conditions and instructions mentioned in the manual of Perkin Elmer 1003 model were strictly followed.

Statistical analysis: The data obtained were subjected to Analysis of Variance (ANOVA) and critical differences (CD) were calculated to find the differences in heavy metal concentration in different tissues and between the species as per (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

Results pertaining to heavy metal concentration in different tissues of sheep and goat have been presented in Table. 1. The mean levels of chromium in muscle, liver and kidney sample were 4.31 ± 0.24, 2.80 ± 0.18 and 2.87 ± 0.26 ppm, respectively for sheep and 1.00 ± 0.04, 1.01 ± 0.06 and 1.00 ± 0.08 ppm, respectively for goat. Chromium levels in muscle of sheep was significantly ($P<0.05$) higher than in liver and kidney. All the tissues of sheep had significantly ($P<0.05$) higher concentration of chromium than in the tissues of goat. The level of chromium in all the tissues of sheep and goat were much below 30 ppm which was considered as minimum tissue level for chromate poisoning. Robinson et al. (2008) reported that chromium concentration was below detectable level in muscle, liver and kidney of sheep where as for goat tissues the values (1.38 – 1.80 ppm) were little higher than those recorded in the present study. These variations in levels of chromium in sheep and goat tissues might be due to variation in chromium contents of the forages / grasses / plants on which the animals had grazed. Moreover, high concentration of chromium is found in tissues of animals which are grown in the vicinity of metal processing unit, tannery, refinery, asbestos product units which are the major sources of atmospheric chromium emission (Towill et al. 1978).

Copper concentration in liver (27.64 ± 3.92 ppm) of sheep was significantly ($P < 0.05$) higher than that in kidney (3.50 ± 0.16 ppm) and muscle (1.01 ± 0.03 ppm). The differences in copper levels in sheep kidney and muscle were also significant ($P < 0.05$). These values were lower than those reported by Robinson et al. (2008) who recorded copper concentration to the tune of 5.17, 117.36 and 5.85 ppm in muscle, liver and kidney samples of sheep respectively from Chennai region. The maximum permissible limit prescribed by FSSAI (2011) for copper in meat products is 20 ppm. However, the concentration of copper in liver of sheep recorded in the present study was higher than the prescribed limit. Mills and Dalgarno (1972) also reported higher copper concentration in sheep liver (101 μg/g) whereas Sarican et al. (1976) reported a copper concentration of 1.6 μg / g in lamb muscles which were almost similar to the values found in the present study.

Significant ($P<0.05$) differences in copper concentration were found among goat muscle, liver and kidney with the highest concentration in kidney followed by liver and muscle. Ayyadurai and Krishnasamy (1986) reported a copper content of 0.52 mg/100g in kidney and 1.05 mg/100g in liver of goats which were lower than those recorded in the present study. On the contrary Robinson et al. (2008) reported higher copper concentration in muscle, liver and kidney (14.5±1.50ppm) samples of market slaughtered goats.

In comparison to goats, sheep accumulated higher concentration of copper in muscle and liver. But goat kidney had higher level of copper. These species differences might be due to their differences in grazing pattern, age, exposure to different copper levels through feeds and fodder. The reason for variation among tissues within a species might be due to the variation in their composition and biological activity. Alonso et al. (2000) stated that toxic metal content in muscle was generally low, whereas, liver and kidney often accumulated higher metal concentrations.

The mean values of lead contents in muscle, liver and kidney of sheep and goat varied between 4.20 ± 0.24 to 4.87 ± 0.33 (Table. 1). No significant difference in the levels of lead among tissues of sheep and goat were observed. The concentrations of lead in these tissues in both the species were above the permissible limit of 2.5 ppm prescribed by FSSAI (2011). The levels recorded in the present study were above the levels reported by Edwards et al. (1975) who reported a lead content of 0.46 ppm in muscle and 0.45 ppm in kidney of animals from Oklahoma. Robinson et al. (2008) reported that lead contents were below detectable level in organs and muscle of sheep and goat reared and slaughtered at Madras Veterinary College, Chennai, India whereas in market slaughtered goats level of lead were 27.39 ± 0.62, 29.84 ± 1.16, 27.06 ± 0.54 ppm in kidney, liver and muscle, respectively. Higher concentration of lead in muscle and organs of sheep or goat were attributed to air pollution due to vehicular emission, eating of wall papers by sheep and goats and water pollution.

The concentration of zinc in muscle, liver and kidney samples of sheep (25.08 ± 0.53 – 31.08 ± 3.45 ppm) and goat (11.28 ± 0.08 – 28.13 ± 1.89 ppm) were well below the permissible limits (50 ppm) prescribed by FSSAI (2011). Similar results were reported by Sarican et al. (1976) who reported a zinc concentration on 28.80 μg/g in sheep muscle. Robinson et al. (2008) reported lower concentration of zinc in kidney, liver and muscle of sheep (5.10 – 14.05 ppm) and 14.40 – 25.18 ppm zinc in the same organs and tissues of goat. These were contrary to the results obtained in the present study where higher concentration of zinc was recorded in muscle, liver and kidney of sheep compared to muscle, liver and kidney of goats.

CONCLUSION

Overall, it was observed that sheep muscle, liver and kidney contained higher concentrations of chromium, copper, lead and zinc with the exceptions of copper and lead which were in higher levels in goat kidneys. All these differences might be due to their different grazing habits, supply of different feeds and forages, differences in levels of exposure to environmental contamination.

ACKNOWLEDGEMENT

The authors thank the Dean, Rajiv Gandhi Institute of Veterinary Education and Research, Kurumbapet, Puducherry-605009, India and Dr. Robinson J.J. Abraham, Professor & Head, Dept. of Meat Sciences and Technology, Madras Veterinary College for his help.

Table 1: Levels of heavy metal concentration (Mean± S.E) in muscle, liver and kidney of sheep and goat

Metal	Animal	Muscle	Liver	Kidney
Chromium	Sheep	4.31 ± 0.24^{bB}	2.83 ± 0.18^{aB}	2.87 ± 0.26^{aB}
	Goat	1.00 ± 0.04^{A}	1.01 ± 0.06^{A}	1.00 ± 0.08^{A}
Copper	Sheep	1.01 ± 0.03^{aB}	27.64 ± 3.92^{cB}	3.50 ± 0.16^{bA}
	Goat	0.72 ± 0.03^{aA}	4.45 ± 0.75^{bA}	5.01 ± 0.59^{cB}
Lead	Sheep	4.83 ± 0.76	4.58 ± 0.32	4.41 ± 0.34
	Goat	4.33 ± 0.25	4.20 ± 0.24	4.87 ± 0.33
Zinc	Sheep	31.08 ± 3.45^{b}	37.81 ± 1.50^{cB}	25.03 ± 0.53^{aB}
	Goat	28.13 ± 1.89^{C}	11.28 ± 0.88^{aA}	18.94 ± 0.26^{bA}

n= 24 for each tissue of each species for each metal
a,b,c Means bearing different superscripts in a row differed significantly ($P<0.05$)
A, B Means bearing different superscripts in a column within a parameter differed significantly ($P>0.05$)

REFERENCES

Alonso ML, Bendito JL, Miranda M, Castillo C, Henandez J and Shore RF (2000) Toxic and trace elements in liver, kidney and meat from cattle slaughtered in Galicia (NW Spain). Food Addttv. Contmnt 17: 447-457.

Ayyadurai K and Krishnasamy V (1986) A study on the concentration of copper, zinc and mercury in goat's kidney and liver samples. J Food Sci. Technol 23: 332-334.

Bolger PM, Yess NJ, Gunderson EL, Troxell TC and Carrington CD (1996) Identification and reduction of sources of dietary lead in the U.S. Food Addttv. Contmnt 13: 53-60.

Buck WB (1970) Lead and organic pesticide poisoning in cattle. J. Am. Vet. Med. Assoc 156: 1468-1472.

Cherian MG and Nordberg M (1983) Cellular adaptation in metal toxicology and metallothionien. Toxicol 28: 15.

Cleg MS., Casey SM and Keer C.L.(1986) Water borne copper toxicity in sheep. Agri. Practice 7:19-22.

Danilsson GRG., Hassoun ED and Kencker L (1982)

Embrytoxicity of chromium: distribution in pregnant mice and effects on embryonic cells in vitro. Arch. Toxicol 51: 233-245.

Edwards WC., Clay BR. and Buck WB (1976) Determination of lead levels in beef randomly selected from supermarkets. Vet. Toxicol 18: 70-72.

Gracey JF and Collins DS (1991) Meat Hygiene. 9th Edition, English Literature Book Society, Bailliere Tindall Publishers, London. pp.218-219 and p.452.

Langard S (1982) Absorption, transport and excretion of chromium in man and animals. In: Biological and Environmental Aspects of Chromium. Langard, S.(ed.). Elsevier Biomedical Press, Amsterdam,pp.149-169.

Lijima S and Matsumoto N (1983).Transfer of chromic chloride to embryonic mice and changes in the embryonic mouse neuroepithelium. Toxicol 26: 257-65.

FSSAI (2011) Food Safety and Standard Authority of India (regulation), The Ministry of Health and Family Welfare, Govt. of India.

Mills CF and Dalgarno AC (1972) Copper and zinc status of ewes and lambs receiving increased dietary concentration of cadmium. Nature 239: 171.

Noel L, Dufailly V, Lemahieu N, Vastel C and Guerin T (2005) Simultaneous analysis of cadmium, lead, mercury and arsenic content in foodstuffs of animal origin by inductively coupled plasma/mass spectrometry after closed vessel microwave digestion: Method validation. J. Assoc. of Official Analytical Chemists Intl 88: 1811-1821.

Robinson JJ Abraham., Narendra Babu R. and Ezhilvelan S (2008) Toxic metals in sheep and goat muscles and organs. Invited paper. In: compendium: UGC sponsored two days National level seminar on " Animal Food Processing" held on 7-8 August, 2008, V.V. Vanniaperumal College for Women, Virudhunagar, (T.N).pp. 93-99.

Sarican C, Wagner KH and Wagner-Herwag F (1976) Gehalt an protein und mineralstoffen im h van verschidenen kreuzungen. Die fleischwirtschuft 56: 1791.

Shull LR and Cheeke PR (1983) Effects of synthetic and natural toxicants on livestock. J. Ani. Sci., Suppl 2: 330-354.

Snedecor GW and Cochran WG (1989) Statistical Methods. 8thedition, Iowa State University press, USA.

Towill LE, Shriner CR, Druy JS, Hammons AS and Hollman JW (1978) Reviews of the environmental effects on pollution. III. Chromium. United States Environmental Protection Agency, May 1978, pp.208.