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Distribution of Some Trace and Macrominerals in Beef, Mutton and Poultry

IRFANA MARIAM[1], SHEHLA IQBAL AND SAEED AHMAD NAGRA
Institute of Chemistry, Quaid-e-Azam Campus, University of the Punjab–Lahore
[1]Corresponding author's e-mail: irfana_mariam@yahoo.com

ABSTRACT

The selected trace minerals present in lean and organ meat of beef, mutton and poultry were determined in the present study. Levels of the selected minerals (Arsenic, cadmium, copper, lead, mercury and zinc) and some macro elements (calcium, sodium and potassium) in the lean and organ meat of beef, mutton and poultry were determined. For this purpose, Varian atomic absorption spectrophotometer model 1275 AA equipped with lamps for different elements and Corning 410 flame photometer were used. The levels of arsenic (40.80 to 52.44 ppm), lead (2.02 to 4.25 ppm) and mercury (31.47 to 78.96 ppm) were found higher than the permissible limits indicating the heavy metal contamination in our environment. Copper and cadmium concentrations were found higher in some samples, whereas zinc (66.26 to 28.52 ppm), calcium (1.72 to 2.27 mg/g), sodium (5.38 to 3.20 mg/g) and potassium (1.44 to 2.43 mg/g) levels were found to be normal. The present study is the indication of environmental pollution with heavy metals and there may be various sources of this environmental pollution.

Key Words: Trace minerals; Macrominerals; Beef; Mutton; Poultry

INTRODUCTION

Toxic metal is defined as that metal, which is neither essential nor has beneficial effect, on the contrary, it displays severe toxicological symptoms at low levels. With increasing industrialization, more and more metals are entering into the environment. These metals stay permanently because they cannot be degraded from the environment. They pass into the food and from food they ultimately make their passage into the tissue (Baykov *et al.*, 1996).

The lead, cadmium, mercury and arsenic are among the main toxic metals. They accumulate in food chains and have a cumulative effect (Cunningham & Saigo, 1997). Heavy metals often have direct physiologically toxic effects and are stored or incorporated in living tissues, sometimes permanently (Bokori e*t al.*, 1996). The contents of arsenic, cadmium, mercury and lead were detected in several tissues of goats. The results showed that the levels of these toxic metals were found to be very high generally above the permissible level (John & Jeanne, 1994). Similarly, the distribution and localization of some heavy metals in the tissues of some calf organs were detected. The most affected organs, which showed higher levels of trace metals, were livers, kidneys and small intestines (Horky *et al.*, 1998).

Mercury can exist in the environment as metal, as monovalent, divalent salts, methyl mercury and dimethyl mercury. The major sources of mercury are geothermal steam used for power production, paper industry, chemical industry, paint industry, pesticides and fungicides. Mercury escapes into the air and soil and from there get accumulated into the plants. The major effects of mercury poisoning are neurological and renal disturbances (Charles & Margaret, 1993) and also on lymphoid components and immune response (Rice, 1996). Lead is a metabolic poison and a neurotoxin that binds to essential enzymes and several other cellular components and inactivates them (Cunningham & Saigo, 1997). Toxic effects of lead are seen on hemopoietic, nervous, gastrointestinal and renal systems (Baykov *et al.*, 1996). Lead is released into the air in the form of metal fumes or suspended particulates from fuel combustion or smelting and disposal of wastes however, most of the lead poisoning is from leaded gasoline.

Food is one of the principle environmental sources of cadmium (Baykov *et al.*, 1996). As the cadmium moves through the food chain it becomes more and more concentrated until it reaches to the carnivores where it has increased in concentration by a factor of approximately 50 to 60 times (Daniel & Edward, 1995). Toxic effects of cadmium are kidney dysfunction, hypertension, hepatic injury and lung damage (John & Jeanne, 1994). Cadmium chloride at teratogenic dose has induced significant alterations in the detoxification enzymes in liver and kidney (Reddy & Yellamma, 1996).

Animals vary in their arsenic accumulation depending upon the type of food they consume (John & Jeanne, 1994). Acute arsenic exposure can give symptoms with rapid onset of headache, nausea and severe gastrointestinal irritation (Allan *et al.*, 1995). Similarly, increased levels of copper cause liver, kidney and brain damage, which may follow hemolytic crisis (Judith, 1994). Zinc concentrations were found to be highest in meat, liver, fish and eggs (Janet & Carl, 1994). Potassium affects the transmembrane potential and also plays its role as the major determination of intracellular ionic strength (Man, 1994). In the city like Lahore, with increasing industrialization, more and more industrial waste get accumulated in various regions and make their passage through soil into animal body, especially, in their liver, kidney and lean meat. The present study was planned to determine the prevalence of selected trace elements in lean and organ meat of beef, mutton and poultry which are the items of every day consumption in human food.

MATERIALS AND METHODS

Collection of materials. The fresh samples of lean meat, livers and kidneys of beef, mutton and poultry were collected from various markets of Lahore. These samples were used for mineral analysis.

Decomposition of samples for mineral analysis. The collected samples were decomposed by wet digestion method for the analysis of various minerals (Bock, 1979). A known quantity, approximately 10 g of each sample was introduced into the long neck digestion flask. 20 mL of Anal R grade sulphuric acid was added into it. The digestion flask was heated for about 30 min. After the flocculation was settled, the flask was heated on high flame. After 2 h digestion, hydrogen peroxide was added drop wise until a clear solution was obtained. The contents of the flask were reduced by heating and then exactly diluted to 20 mL with distilled water. These dilutions were used for mineral analysis.

Mineral analysis. Mineral analysis was carried out by two techniques:

Atomic absorption spectroscopy. Trace metals were analyzed by using Varian atomic absorption spectrophotometer model 1275 AA equipped with lamps for different elements. The elements analyzed by atomic absorption along with their working conditions are shown in Table I.

Corning 410-flame photometer. For the estimation of calcium, potassium and sodium, Corning 410 flame photometer was used.

Preparation of Standard Solutions and Standard Curves

Arsenic. A 1000 ppm stock solution of arsenic was prepared by dissolving 1.32 g of As_2O_3 in one litre of distilled water. Ten working standards were prepared from stock solutions, which ranged from 5 to 50 ppm. The standard curve for arsenic was plotted and the amount of arsenic present in the study samples was calculated from the standard curve.

Cadmium. One gram of cadmium metal was dissolved in one ml HCl and then diluted with distilled water upto one litre for the preparation of 1000 ppm stock solution of cadmium. Five working standards were prepared from stock solution, which ranged from 0.2 to 1 ppm. A standard curve was obtained and the amount of cadmium present in digested samples was calculated from standard curve.

Copper. One gram of copper metal was dissolved in 1.5 ml of HCl and was diluted to one litre with distilled water. Ten working standards, ranged from 0.1 to 1.0 ppm were prepared for standard curve, which was used to calculate the copper concentrations in digested samples.

Lead. 1000 ppm stock solution of Lead was prepared by dissolving 1.83 g of lead acetate in one litre of distilled water. Ten working standards ranged from 1 to 10 ppm were prepared from this solution. A standard curve was plotted and the amount of lead present in the samples was worked out from the curve.

Mercury. 1.20 g of HgO was dissolved in one ml of glacial acetic acid. It was diluted to one litre with distilled water to get 1000 ppm Hg solution. Ten working standards ranged from 1 to 10 ppm were prepared for the preparation of standard curve and amount of mercury present in digested samples was calculated.

Zinc. One gram of zinc metal was dissolved in one ml of HCl and volume was made upto one litre with distilled water to make 1000 ppm stock solution of zinc. Five working standards ranged from 0.5 to 2.5 ppm were prepared. The standard curve drawn was used to find out the amount of zinc in digested samples.

Calcium. To obtain 1000 ppm stock solution of calcium, 2.589 g of calcium phosphate were dissolved in one ml of HCl and then diluted to one litre with distilled water. Ten working standards were prepared from this solution, which ranged from 20 to 200 ppm. The emission of these standards was used to draw the standard curve for determination of calcium.

Potassium. 1.91 g of KCl was dissolved in one litre of distilled water to get 1000 ppm stock solution of potassium. Ten working standards ranged from 0.5 to 5.0 ppm were prepared from this solution. The amount of potassium present in each sample was calculated after plotting a graph between the concentration and emission of standards.

Sodium. 2.54 g of NaCl were dissolved in one litre distilled water to get 1000 ppm stock solution. Ten working stock solution were prepared from this stock solution. A standard curve was plotted. The amount of sodium in this study sample was measured from the graph.

Table I. Working conditions of atomic absorption spectrophotometer for analysis of minerals

Element	Lamp current	Fuel	Support	Flame stoichiometry	Wavelength	Spectral band pass
Arsenic	EDL	Acetylene	Nitrous oxide	Oxidizing	193.7 nm	1 nm
Cadmium	3.5 mA	Acetylene	Air	Oxidizing	228.8 nm	0.5 nm
Copper	3.5 mA	Acetylene	Air	Oxidizing	324.8 nm	0.5 nm
Lead	EDL	Acetylene	Air	Oxidizing	217.0 nm	1.0 nm
Mercury	EDL	Acetylene	Air	Oxidizing	253.7 nm	0.5 nm
Zinc	5 mA or EDL	Acetylene	Air	Oxidizing	213.9 nm	1.0 nm

RESULTS AND DISCUSSION

Arsenic. The arsenic concentration in the study of lean and organ meat of different animals has been summarized in Table II, III and IV. Highest arsenic concentration (52.44 ppm) was found in the liver of beef and lowest (40.80 ppm) in the kidney of mutton. All the remaining study samples showed minor variation amongst each other (42.78 to 46.77 ppm) .The permissible limit of arsenic in the livers of chickens has been reported as 2.0 ppm (ANZFA) and it was found that the concentration of arsenic in chick livers was higher (46.77 ppm) than the permissible limit.

Table II. Concentration of toxic elements arsenic, cadmium, lead and mercury in the livers of beef, mutton and poultry (ppm)

Elements	Beef	Mutton	Poultry
Arsenic	52 .4 4 ± 5.22	42.78 ±3.80	46.77 ± 5.33
Cadmium	0.42 ± 0.10	0.41 ± 0.07	0.49 ± 0.16
Lead	2.18 ± 0.38	4.25 ± 0.80	3.15 ± 1.08
Mercury	31.47 ± 12.24	77.77 ± 28.22	78.96 ± 30.96

Table III. Concentration of toxic elements arsenic, cadmium, lead and mercury in the kidney of beef and mutton (ppm)

Elements	Beef	Mutton
Arsenic	46.99 ± 6.76	40.80 ± 5.88
Cadmium	0.909 ± 0.19	0.45 ± 0.09
Lead	2.02 ± 0.44	3.85 ± 0.63
Mercury	50.65 ± 13.42	63.45 ± 27.83

Table IV. Concentration of toxic elements arsenic, cadmium, lead and mercury in the lean meat of beef, mutton and poultry (ppm)

Elements	Beef	Mutton	Poultry
Arsenic	46.46 ± 3.41	42.40 ± 4.95	44.09 ± 3.62
Cadmium	0.33 ± 0.05	0.37 ± 0.06	0.31 ± 0.073
Lead	2.19 ± 0.28	4.25 ± 0.54	3.1 ± 0.58
Mercury	62.39 ± 23.76	76.28 ± 28.55	76.10 ± 27.44

Table V. Concentration of trace elements copper and zinc in the liver of beef, mutton and poultry (ppm).

Elements	Beef	Mutton	Poultry
Copper	93.24 ± 15.89	318.82 ± 80.63	6.91 ± 1.53
Zinc	58.49 ± 7.01	56.26 ± 6.72	54.53 ± 8.46

Table VI. Concentration of trace elements copper and zinc in the kidney of beef and mutton (ppm)

Elements	Beef	Mutton
Copper	5.42 ± 2 .01	6.40 ± 1.25
Zinc	46.18 ± 10.69	51.38 ± 12.10

Higher concentration of arsenic in livers and kidneys of cattles and goats has also been reported by Krupa and Swida (1997). The arsenic content in the muscles and internal organ proved to be much higher and also constitute to toxic hygienic danger (Jozef *et al.*, 1997).

The arsenic concentration in the livers, kidneys and lean meats of study samples is strikingly high and indicative of arsenic pollution in the environment, which may be due to copper smelting, coal combustion, burning of firewood and cowdung (Charles & Margaret, 1993).

Cadmium. The cadmium concentration as observed in the lean and organ meat of different animals has been summarized in Table II, III and IV. Highest cadmium concentration was observed in the kidney of beef (0.9 ppm) and lowest (0.31 ppm) in the lean meat of poultry. Other study samples showed minor variation amongst each other (0.37 to 0.49 ppm). The permissible limit for cadmium in kidney has been reported as 1 ppm (FAO/WHO, 2000). The highest value in beef kidney observed in the present study is close to permissible limit. However, the concentration of cadmium in the lean meat (0.31 ppm) was higher than the 0.5 ppm, the permissible limit (FAO/WHO, 2000). Similarly the liver cadmium concentration (0.41 ppm in mutton, 0.42 ppm in beef and 0.49 ppm in poultry) was found to be low than permissible limit (0.5 ppm) set by (FAO/WHO, 2000). Aranha *et al.* (1994), and Roga *et al*,. (1996), detected the cadmium levels in the livers and kidneys of cattle of Poland and found the cadmium concentration above the action level. Similarly, Doganoc (1996) found higher levels of cadmium and zinc in the livers and kidneys of the hens and chickens, which exceeded from the official tolerance levels. The higher concentration of cadmium in the kidney tissue is due to the detoxification function of the organ where this metal get accumulated as also reported by Aranha (1994) and Stoyke *et al.* (1995).

Lead. The lead concentration was observed in the lean and organ meat of different animals and it was found that the liver and lean meat of mutton showed the highest concentration of 4.25 ppm and lowest concentration of 2.02 ppm in the kidney of beef (Table II, III & IV). The results showed that the lead concentration in the liver and kidney of all species was higher than the permissible limit of 1 ppm (ANZFA). Similarly, in the lean meat of beef, mutton and poultry the lead concentration was observed to be higher than the permissible limit. A higher concentration of lead than the permissible limit in the liver and kidney of animals has been reported by Aranha (1994) and Danev *et al.* (1996) and showed that 86% samples of liver and 100% samples of kidney were contaminated above the limits set by the country regulations. Similarly, Maldonado *et al.* (1996) studied the lead with reference to its intestinal absorption, mobilization and redistribution during lactation in rats and showed significantly higher levels of lead in the livers and kidneys.

Table VII. Concentration of trace elements copper and zinc in the lean meat of beef, mutton and poultry (ppm)

Elements	Beef	Mutton	Poultry
Copper	81.51 ± 15.02	5.01 ± 2.46	12.86 ± 4.80
Zinc	66.26 ± 7.63	65.82 ± 6.29	28.52 ± 3.39

Table VIII. Concentration of electrolytes calcium, potassium and sodium in the liver of beef, mutton and poultry (mg/g)

Elements	Beef	Mutton	Poultry
Calcium	2.27 ± 0.32	1.63 ± 0.14	1.75 ± 0.26
Potassium	2.09 ± 0.86	2.38 ± 0.56	2.60 ± 0.74
Sodium	5.17 ± 0.63	3.41 ± 0.62	4.36 ± 0.73

Table IX. Concentration of electrolytes calcium, potassium and sodium in the kidney of beef and mutton (mg/g)

Elements	Beef	Mutton
Calcium	2.14 ± 0.41	1.76 ± 0.24
Potassium	1.44 ± 0.92	1.90 ± 0.68
Sodium	5.38 ± 1.06	3.95 ± 0.76

Table X. Concentration of electrolytes calcium, potassium and sodium in the lean meat of beef, mutton and poultry (mg/g)

Elements	Beef	Mutton	Poultry
Calcium	1.75 ± 0.15	1.72 ± 0.16	1.72 ± 0.18
Potassium	2.43 ± 0.92	2.83 ± 0.91	2.59 ± 0.55
Sodium	4.82 ± 0.69	3.57 ± 0.24	3.20 ± 0.87

The results have revealed that the lead concentration in meats is alarming and are indicative of the higher levels of lead pollution in the environment. The major source of lead pollution is automobile exhaust gases, which arise from antiknocking agents added in gasoline. Other sources are untreated waste effluents of industry, which find their way to irrigation channels and hence pollute the fodder through soil.

Mercury. The mercury concentration as determined in lean and organ meat of beef, mutton and poultry has been summarized in the Tables II, III and IV. Highest mercury concentration was found in the liver of poultry (78.96 ppm) and lowest (31.47 ppm) in the liver of beef. All the study samples showed mercury concentration much higher (31.4 to 78.96 ppm) than the permissible limit of 0.03 ppm (ANZFA).

Coni *et al.* (1996) determined the levels of cadmium, copper, lead and mercury in the specific organs of cow, sheep and goat and found that liver and kidney of cows had higher levels of cadmium, copper, lead and mercury than the liver and kidney of sheep and goat. Zarski *et al.* (1997) investigated the mercury levels in muscles, liver and kidney of cattle and reported that mercury levels exceeded from the accepted hygienic standards. Similarly, Samek *et al.* (1997) found the highest mercury levels in the skin and in livers of chicks.

A greater concentration of mercury in poultry as compared with beef and mutton may be due to a greater intake of mercury-contaminated feed by the poultry as compared with other animals. The main sources of mercury contamination may be industrial wastes, pesticides and fungicides. The mercury escapes into the air and soil and get accumulated in fodder plants and hence, in animal tissues.

Copper. Copper concentration in the lean and organ meat of different animals has been shown in Tables V, VI and VII. Highest copper concentration was found in the liver of mutton (318.82 ppm) and lowest (5.01ppm) in the lean meat of mutton. The copper concentration in the livers of mutton was higher than the permissible limit of 200 ppm (ANZFA). In the remaining study samples the concentration was below than the permissible limit.

Mukhacheva and Bezel (1995) found higher levels of copper and zinc in the livers and kidneys of mutton and beef. Jozef *et al.* (1997) reported the accumulation and distribution of zinc, copper, arsenic, lead and cadmium in the livers, kidneys, spleen, musculature, uterus and in the ovaries of seven experimental and five control sheep. The results indicated that liver, kidney and uterus were the organs with the highest copper accumulation.

Copper is essential component of various enzymes and it plays a key role in bone formation, skeletal mineralization and in maintaining the integrity of the connective tissues. It is essential element but its concentration in the livers of mutton suggests that it may not be used frequently and get accumulated in large concentrations.

Zinc. The zinc concentration in the lean and organ meat of beef, mutton and poultry has been summarized in Tables V, VI and VII. Highest zinc concentration (66.26 ppm) was found in the lean meat of beef and lowest concentration (28.52 ppm) in the lean meat of poultry. All the values in the study samples were below the permissible limit (150 ppm) set by (ANZFA). Jozef *et al.* (1997) reported the zinc and copper intoxication by industrial emission in the livers, kidneys, spleen, musculature and in the ovaries and uterus of some experimental sheep. Results showed that the highest concentration of zinc in the experimental animals, died of zinc intoxication, was in the liver and kidneys.

The low concentration of zinc may be attributed to zinc deficient soils, consequently the fodder/cereals available to poultry and cattle are deficient of zinc. Perhaps, this is one of the reasons for low tissue content of zinc.

Electrolytes. Calcium, potassium and sodium concentrations determined in the livers, kidneys and lean meat of different animals has been summarized in Tables VIII, IX and X.

Highest calcium concentration was observed in the liver of beef (2.27 mg/g) and lowest (1.63 mg/g) in the liver of mutton. It is essential constituent of the body and is the most important intracellular cation. It acts as a second messenger in various signal transduction cascades.

Highest potassium concentration (2.43 mg/g) was observed in the lean meat of mutton and lowest (1.44 mg/g) was found in the kidney of beef. It is an essential element and is involved in maintaining the membrane integrity.

Highest concentration of sodium (5.38 mg/g) was observed in the kidney of beef and lowest concentration of (3.20 mg/g) in the lean meat of poultry. It is also an important cation in the body and is involved in maintaining transmembrane potential. There are no permissible limits of calcium, potassium and sodium.

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