Pak. j. sci. ind. res., vol. 32, no. 3, March 1989

INVESTIGATION ON MULTI-ORGAN HEAVY TRACE METAL CONTENT OF MEAT OF SELECTED DAIRY, POULTRY, FOWL AND FISH SPECIES

M. Jaffar and Shahid Pervaiz

Department of Chemistry, Quaid-e-Azam University, Islamabad

(Received June 28, 1988; revised February 19, 1989)

The muscle, liver and kidney meat of various dairy, poultry, fowl and fish species was analyzed for Mn, Cr, Zn, Cu, As, Hg, Pb, Fe, Ni and Cd content by atomic absorption method. The concentrations of essential trace metals (Fe, Cu, Zn and Mn) were found to follow the order liver kidney muscle while the concentration of non-essential metals followed the order kidney liver muscle. Zinc and iron were found to be the most abundant metals, their respective maximum levels being 74.15 µg/g in liver of Rohu fish and 75.1 µg/g in liver of pigeon. Lead, cadmium and nickel were found at lower concentration levels ranging between 0.03-1.90, 0.01-1.51 and 0.10-4.12 µg/g in different organs of the species. Old animals were found to accumulate higher metal levels in their muscle, liver and kidney.

Keywords: Multi-organ analysis, Trace metals in meat, Heavy metal enrichment studies on meat.

INTRODUCTION

During the last two decades awareness has arisen with regard to certain toxic trace metals present in the meat of various animals. This is specifically true of Pb, Cd, Cr and Hg content in beef [1], and some other toxic metals in muscle, liver and kidney of wild and farm animals [2-5]. Studies related to the transfer of the heavy metals from feed into milk [6] and into tissues of meat producing animals [7] have been undertaken from the health hazard point of view. Such studies indicated species-specificity of trace metal distribution in various body organs of different animals.

Heavy trace metal content of meat is not only important for establishing the nutritional quality of meat of various types but also for studying the distribution pattern these metals adopt in body organs of the relevant animals. In line with this objective, base-line data for the levels of ten essential/non-essential toxic trace metals were evolved in the present study. The meat of muscle, liver and kidney of different local dairy, poultry, fowl and fish species was investigated as a function of the age of the species and the relevant environment. The essential metals included in the investigation were Fe, Zn, Cu and Mn, while the non-essential metals were Cr, As, Hg, Pb, Ni and Cd. All metals, except arsenic and mercury, were quantified by the flame atomic absorption method using nitric acid/perchloric acid wet digestion procedure. Arsenic and mercury were estimated by the cold-vapour method. The results obtained were reviewed from the view point of trace metal content in muscle, liver and kidney of the selected species and their relative accumulation as a function of age/environment.

EXPERIMENTAL

The cow, calf, goat and fish meat samples were procured from local markets. The pigeons were obtained from bird vendors. The samples were briefly washed with deionized water and drained gently under folds of filter paper. The specimens (~100 g) were packed in small but strong polythene bag and deepfrozen at -10°. At the time of analysis 10.0 g portions of the defrosted muscle, liver and kidney samples were digested in $HNO_3/HClO_4$ mixture as per procedure described elsewhere [8]. The digest was subjected to heavy trace metal analysis by the flame atomic absorption method. A Shimadzu atomic absorption spectrophotometer, model AA-670, equipped with an automatic background correction microprocessor unit was used throughout this work. Arsenic and mercury were estimated by the flameless method described elsewhere [9, 10]. All reagents used for the preparation of standards and sample solutions were of ultrahigh purity, spectroscopic grade. Deionized water was used throughout reagent blanks were run the same way as the samples. Triplicate samples of each organ were run in parallel.

RESULTS AND DISCUSSION

Table 1 summarizes data on trace metal content of liver, muscle and kidney meat of various dairy animals, fowl and fish. The listed results are averaged for triplicate parallel measurements conducted for each metal in each organ; the overall variability of each result being within ± 1-2%.

The data indicated a small variation in the levels of a given metal in respective organs of a given species. On this basis, the muscle of grazing animals was found to contain the minimum and maximum trace metal level in liver distinctly different from those for fowl or fish. However, the species differed considerably in terms of their trace metal content of an organ. For example, the Mn content in the liver of all the animals, birds and fish varied from 0.93 to 7.20 µg/g. Pigeon was found to contain maximum liver content (7.20 µg/g) of Mn as compared with all other species. The next Mn content was determined at 4.71 µg/g in the liver of amrine fish, sample F1. The Fe content in the muscle of dairy animals ranged

Table 1. Trace metal content* of meat in lever (L), muscle (M) and kidney of various dairy, poultry, fowl and fish species.

Sample code	Sample description (age/weight)	Organ	Metal concentration (μg/g, wet weight) Mn	Cr	Zn	Cu	As	Hg	Pb	Fe	Ni	Cd
B1	Cow(4 Y)	L	2.10	1.08	23.31	2.34	0.93	0.71	0.67	39.15	0.43	0.02
		M	0.65	0.47	16.29	0.33	0.31	0.56	0.44	10.52	0.26	0.01
		K	0.83	2.03	22.15	0.98	0.81	1.08	1.29	16.21	0.68	0.02
B2	Calf (1.5 Y)	L	1.89	0.43	31.37	3.13	0.61	0.21	0.87	28.37	0.31	0.08
		M	0.59	0.35	26.02	0.33	0.46	0.16	0.37	11.42	0.29	0.03
		K	0.71	0.61	29.10	2.78	0.70	0.18	0.90	22.26	0.41	0.21
M1	Goat (2 Y)	L	4.10	0.41	43.12	4.81	1.68	0.21	0.21	34.13	0.81	0.09
		M	0.66	0.29	28.76	0.43	0.44	0.17	0.08	8.07	0.58	0.04
		K	2.89	0.39	31.30	2.93	1.98	0.31	0.30	19.11	1.37	0.06
M2	Goat (1 Y)	L	2.12	0.38	37.90	2.70	0.93	0.81	0.13	18.11	0.91	0.07
		M	0.38	0.30	19.10	0.50	0.31	0.08	0.03	6.13	0.41	0.03
		K	1.98	0.51	23.43	2.30	1.03	0.73	0.18	12.19	0.93	0.19
F1	Salmon sole (6 kg)	L	4.71	1.21	19.12	3.08	4.81	1.67	1.81	43.14	1.83	0.81
		M	0.32	0.17	5.89	0.61	0.81	0.41	0.09	9.23	0.19	0.05
		K	1.80	0.83	17.21	1.13	5.32	2.18	1.90	21.12	3.14	1.51
F2	Rohu *(Labeo rohita)*(3 kg)	L	4.38	4.12	74.15	28.23	8.10	4.69	0.81	54.21	1.41	1.31
		M	0.27	0.81	9.32	3.15	2.12	0.17	0.08	32.13	0.10	0.08
		K	2.97	5.19	39.78	12.13	9.15	4.73	0.91	39.19	1.51	1.32
G1	Pigeon (1 Y)	L	7.20	0.81	48.13	4.39	0.37	0.09	0.38	75.10	4.12	0.42
		M	1.88	0.25	12.85	1.53	0.19	0.08	0.08	35.25	2.22	0.06
		K	4.10	0.93	31.10	2.31	1.26	0.12	0.41	47.20	3.78	0.39
P1	Chicken (1 Y)	L	1.11	1.51	32.32	3.18	1.21	0.18	0.30	40.12	0.75	0.27
		M	0.27	0.51	14.00	2.48	0.31	0.03	0.15	20.74	0.25	0.03
		K	0.89	1.91	21.45	2.50	1.41	0.21	0.41	31.13	0.81	0.31
P2	Chicken (0.25 Y)	L	0.93	1.61	19.23	2.83	0.60	0.12	0.31	39.73	0.36	0.71
		M	0.13	0.21	9.18	1.32	0.11	0.02	0.10	11.34	0.12	0.02
		K	0.63	1.71	13.12	1.08	0.81	0.18	0.21	26.22	0.41	0.91

* Averaged for triplicate runs in each case

between 6.13-11.42 μg/g for goat and calf. The corresponding variation of Fe in the muscle of fish ranged between 9.23-32.13 ug/g; fowl were also found to contain an almost comparable range of Fe content, 11.34-35.25 μg/g in their muscle. The study thus showed that both pigeon and chicken muscle were rich sources of the essential metal, Fe, as compared with goat, calf and fish. However, in the case of Zn dairy animals had relatively higher muscle content of the metal as compared with fish, pigeon and chicken. In the case of Cu, the dairy animals had low metal accumulation in muscle while a comparably higher level was found in other species. The data thus suggested a clear-cut species specificity in terms of distribution of a given metal in various organs of different species.

In the case of essential heavy trace metals, a unique relationship existed between the trace metal content of liver, muscle and kidney. The data indicated that the order of the trace metal concentration distribution in these organs followed the pattern: liver >kidney> muscle. The reason for this higher accumulation by liver could certainly be based on specific metabolism process and enzyme-catalyzed reactions involving Cu, Zn and Mn taking place in the liver. In the case of non-essential metals the following distribution emerged: kidney>liver> muscle. However, a few observed exceptions to this pattern were Cd in sample M1 and G1, Ni sample G1, Pb in sample P2, Hg in sample B2 and M2, as in sample B1 and Cr in F1. Within limits of experimental uncertainty, these could be considered as boarderline cases.

The muscle to liver or kidney enrichment ratio was found to be comparable both in case of essential and non-essential metals. In the case of cow, the liver to muscle enrichment ratio ranged from 1.4 to 7.0 for Zn and Cu, respectively. Thus the liver of cow accomulated more Cu than any other metal, the same was true about calf that had this ratio equal to 9.5. A similar pattern was also observed in the case of goat. In the case of fish, the marine fish (*Salmon sole*) had a relatively higher enrichment of copper in its liver compared with fresh water fish (Rohu).

Multi-organ trace metal content of marine and fresh water fish showed a minimum level of Mn (0.27 μg/g) in the muscle of Rohu, while the maximum Mn content (4.71 μg/g) was found in the liver of *Salmon*. This range was found to be lower than the corresponding range (1.5-9.01 μg/g) for the same organs reported by Berveridge et.al. [11]. The Fe content in the muscle of chicken, ranging betwen 11.34-20.74 μg/g, agreed well with the range 11.0-18.9 μg/g [12]. Our Zn content in liver ranged for al the species from 19.12-74.15 μg/g again in good agreement with Doyal et.al. [13]. The chicken muscle copper content ranged from 1.32-2.48 μg/g, also in agreement with data reported by Stevenson [12], giving an average of 1.25 μg/g. The Mn, Cr, Ni and Hg concentrations estimated in various organs were also comparable to Wenlock *et.al.* data [14].

In conclusion, the muscle of all the species was found to be safe for human consumption (Table 2). The liver and kidney were found to be rather unsuitable from this purpose.

Table 2. US recommended daily dietary allowances (RDA) supplied by 100g serving of meat [15]

Trace metal	Metal intake (mg)
Arsenic	0.03
Cadmium	0.014
Iron	0.05- 2.0
Lead	0.3
Copper	2.0 - 3.0
Zinc	2.6
Mercury	0.008
Nickel	0.01
Chromium	0.05- 0.20
Maganese	2.5 - 5.0

The fresh water fish was found to have higher concentration of metals as compared with marine fish. Pigeon and chicken retained far smaller amounts of metals in their liver and kidney. Older animals were found to contain higher trace metal concentration as compared with their young ones. However, additional temporal studies are required before any quantitiative modelling is established for the observed trace metal distribution in various organs.

Acknowledgement: We are grateful to Pakistan Science Fundation for the financial assistance in part to an ongoing research project.

REFERENCES

1. K. Josef, L. Fritz, S. Erwin and G. Josef, Wien Tieraeztl Moriatsshr, 73, 266 (1986).
2. H. Hermann, Fleischwirtschaft, 66, 1246 (1986).
3. K. Toshikazu, N. Michiko, T. Fumiko, I. Shigeru, W. Sadao, W. Shigenobu and L. Kazutoshi, Kanagwa-Ken Eisei Kenkyuscho Kenkyn Hokoku, 15, 62 (1985).
4. K.H. Hasan, Y. Raheela and N. Mohammad, Biologia, 32, 111 (1986).
5. R. Nada, C. Milorad and P. Mary, Tehnol Mesa, 27, 11 (1986).
6. K. Verman, N.G. Van der Veen, E.J. Van der Molen and W.G. De Ruig, Neth. J. Agri. Sci., 34, 129 (1986).
7. N.G. Van der Veen and K. Verman, Neth. J. Agri. Sci., 34, 145 (1986).
8. M. Jaffar, M. Ashraf and A. Rasool, Pak. j. sci. ind. res., 31, 189 (1988).
9. S. Maria, M. Gonzalez, W. Lara and A. Ober, Bull. Environ. Contam. Toxicol., 37, 393 (1986).
10. W.R. Hatch and W.L. Ott, Anal. Chem., 40, 2085 (1978).
11. M.C.M. Berveridge, E. Stafford and R. Covttes, Aquaculture and Fisheries Management, 1, 41 (1985).
12. M.H. Stevenson, N. Jackson, Bri. J. Natr., 43, 205 (1980).
13. J.J. Doyle and J.D. Spaulding, Anim. Sci., 47 (2), 398 (1978).
14. R.W. Wenlock, D.H. Buss and E.J. Dixon, Bri. J. Nutr., 41, 253 (1979).
15. F.M. Tenny, E.J. Gauglitz, A.S. Hall and C.R. Houle, J. Agri. F. Chem., 32, 852 (1984).