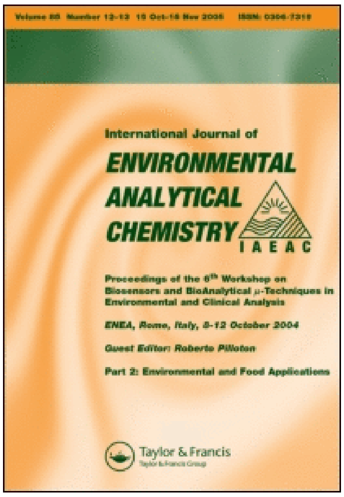

International Journal of Environmental Analytical Chemistry
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713640455

Trace Element Concentration in Egg-Yolk and Egg-White of Farm and Domestic Chicken Eggs

S. Waheed[a]; I. Fatima[a]; A. Mannan[a]; M. S. Chaudhary[a]; I. H. Qureshi[a]
[a] Nuclear Chemistry Division, Pakistan Institute of Nuclear Science and Technology, Rawalpindi, Pakistan

To cite this Article Waheed, S. , Fatima, I. , Mannan, A. , Chaudhary, M. S. and Qureshi, I. H.(1985) 'Trace Element Concentration in Egg-Yolk and Egg-White of Farm and Domestic Chicken Eggs', International Journal of Environmental Analytical Chemistry, 21: 4, 333 — 344

To link to this Article: DOI: 10.1080/03067318508077071

URL: http://dx.doi.org/10.1080/03067318508077071

Intern. J. Environ. Anal. Chem., 1985, Vol. 21, pp. 333–344
0306-7319/85/2104-0333 $18.50/0

Trace Element Concentration in Egg-Yolk and Egg-White of Farm and Domestic Chicken Eggs

S. WAHEED, I. FATIMA, A. MANNAN, M. S. CHAUDHARY and I. H. QURESHI

Nuclear Chemistry Division, Pakistan Institute of Nuclear Science and Technology, P.O. Nilore, Rawalpindi, Pakistan

(*Received November 8, 1984, in final form March 23, 1985*)

Instrumental neutron activation analysis technique was used for the determination of 21 trace elements in egg-yolk and egg-white of 90 farm and domestic chicken eggs. The range, arithmetic mean, geometric mean and median of each element were computed which indicate Gaussian distribution for Se, As, Sb, Cl, Fe, Zn, Na, K, Cs and In in each portion of the egg. The study indicates that the toxic elements are generally concentrated in egg-white whereas essential elements are mostly present in egg-yolk. The dietary intake of each element through farm egg was estimated and compared with daily requirement or tolerance levels.

KEY WORDS: Trace elements, instrumental neutron activation analysis, chicken eggs, distribution in egg-yolk and egg-white.

INTRODUCTION

A balanced diet is necessary for the proper growth and maintenance of the human body. Besides the main components such as carbohydrates, proteins, etc. the body also requires a certain amount of essential inorganic elements. These elements play important roles in various metabolic processes and their deficiency or excess may adversely affect the biochemical functions. Therefore, the diet should also cater for the supply of an adequate amount of essential inorganic elements. The food due to environmental pollution, may also contain certain other elements which have no known deficiency symptoms but their presence even at very low levels are untolerable and are toxic to the biosystem. Thus in order to assess the adequacy and safety of human diet it is important to monitor the food articles and to establish base line levels of essential as well as toxic elements. This can be achieved by either preparing an integrated sample of the various food items of daily consumption and measuring the amount of trace elements in it or determining them in individual food articles. We have adopted the later approach and carried out studies on the measurement of trace elements in certain individual food articles. In the present investigation neutron activation analysis, which is one of the most suitable techniques for the analysis of biological materials has been used for the determination of 21 trace elements in 90 chicken eggs.

EXPERIMENTAL

Sampling

Inhomogeneity of food stuffs lead to the problem in the selection of a representative sample and the errors associated in sampling are beyond the control of analytical chemists. Sampling errors can best be minimized by random selection. Therefore, for the present investigation five eggs each of domestic chicken as well as of farm chicken from nine different localities of Pakistan were collected in a random manner over a period of four months. Each of these were thoroughly washed with deionized water to remove the external contaminants and then boiled for five minutes to separate out the yolk from the white portion of the egg. The yolk was powdered and then oven dried along with egg-white for 72 hours at an optimum temperature of 40°C as the elevation in drying temperature would lead to release of fat content from both portions of the egg. The water contents were also determined by weighing the samples before and after drying. The average weight of farm egg-yolk and egg-white are 17.8 ± 1.6 g and 32.7 ± 1.6 g respectively whereas the corresponding water contents are 48% and 87%. Similarly the average weight of a farm egg (without shell) is 50.5 ± 1.5 g and its water content is 73%. The average water content of farm eggs do not vary by more than 1–2% from domestic eggs. Egg-white and egg-yolk were finally ground to powder and thoroughly mixed to obtain a homogeneous sample. Homogeneity of each sample was checked by analyzing manganese and potassium contents and the variation was found to be within 5%

Irradiation

About 250 mg, each of egg-yolk and egg-white were taken in triplicate and heat sealed in precleaned polyethylene vials. The samples along with appropriate amount of NBS standard reference material Orchard Leaves (SRM-1571) and IAEA reference material Animal Muscle (H-4) were irradiated for two minutes in pneumatic rabbit facility of PARR-I at a thermal flux of $2 \times 10^{13}\,n\,cm^{-2}\,Sec^{-1}$. For longer irradiations the samples along with the standards were sealed in precleaned silica vials and then packed together in aluminium containers.

The irradiated samples after appropriate cooling were transferred into preweighed polyethylene capsules and reweighed. The gamma-ray spectra of the samples were measured for varying times ranging from 2 minutes to 16 hours employing a 4K series 85 Canberra multichannel analyser and a Ge(Li)detector. The system has a resolution of 2.0 KeV with respect to 1332.5 KeV peak of Co-60 and a peak to compton ratio of 40:1. The detail of the electronics have been described elsewhere.[1]

RESULTS AND DISCUSSION

Concentration of 21 elements in chicken egg-white and egg-yolk were determined on dry weight basis using instrumental neutron activation analysis technique by varying the irradiation and cooling times. Under the optimized conditions as shown in Table I, the elements were divided into three groups. The first group containing Cl, Mn, Na and K was irradiated for two minutes and radioassayed after one hour cooling period, whereas the second group containing Br, As, Sb and U was irradiated for three hours and measured after

TABLE I
Optimum conditions for analysis determined by INAA.

Isotope used	Half-life	γ-ray used KeV	Irradiation time	Cooling time	Counting time
^{38}Cl	37.3 m	2167.5 (1642.4)	2 m	Nil	2 min
^{56}Mn	2.58 h	846.6	2 m	2 h	10 min
^{24}Na	15.0 h	1368.5	2 m	2 h	10 min
^{42}K	12.4 h	1524.7	2 m	2 h	10 min
^{76}As	26.3 h	559.1 (657.1)	3 h	4 d	1 h
^{82}Br	35.4 h	554.3 (776.5)	3 h	4 d	1 h
U(^{239}Np)	2.35 d	277.6 (228.2)	3 h	4 d	1 h
^{122}Sb	2.70 d	564.1	3 h	4 d	1 h
^{203}Hg	46.6 d	279.2	24 h	2 w	16 h
^{75}Se	120.0 d	264.5(135.9), 400,7)	24 h	2 w	16 h
^{181}Hf	42.5 d	482.1	24 h	2 w	16 h
^{59}Fe	44.6 d	1099.3 (1291.6)	24 h	2 w	16 h
^{65}Zn	243.8 d	1115.5	24 h	2 w	16 h
^{51}Cr	27.8 d	320.1	24 h	2 w	16 h
^{60}Co	5.26 y	1173.2 (1332.5)	24 h	2 w	16 h
^{131}Ba	11.5 d	496.3	24 h	2 w	16 h
^{86}Rb	18.6 d	1078.8	24 h	2 w	16 h
^{114m}In	50 d	189.9	24 h	2 w	16 h
^{46}Sc	83.9 d	889.3 (1120.5)	24 h	2 w	16 h
^{169}Yb	31.8 d	307.5 (110,177,197)	24 h	2 w	16 h
^{134}Cs	2.04 y	795.8 (801.9)	24 h	2 w	16 h

four days cooling period. For the rest of the elements, the samples were irradiated for 24 hours and radioassayed after two weeks. No interference was observed in the analyses of Se, Hf, Fe, Co, Cr, Rb, Cs, Ba, Sc, Yb and In. The photopeaks of Zn-65 and Sc-46 at 1115.5 KeV and 1120 KeV respectively were not clearly resolved due to relatively higher amounts of zinc. This problem was solved by graphical resolution of the doublet. Similarly the photopeaks of Hg-203 and Se-75 which have a difference of only 0.3 KeV cannot be resolved. Therefore, the contribution of 279.5 KeV peak of Se-75 to 279.2 KeV peak of Hg-203 was calculated and the necessary correction was applied in determining the amount of mercury from this peak.

TABLE II
Analysis of IAEA and NBS reference materials

	Orchard leaves (SRM-1571)		Animal muscle (H-4)	
Elements	Our values	NBS values	Our values	IAEA values
Hg	0.165±0.025	0.155±0.015	12±1[b]	14[b]
Se	0.078±0.01	0.08±0.01	0.29±0.15	0.28
As	11±2	10±2	9±1[b]	(7)[b]
Sb	2.7±0.2	2.9±0.3	8±2[b]	—
Br	11.5±1.5	(10)	3.9±0.3	4.1
Cl	720±25	(690)	1710±125	1890
U	0.027±0.010	0.029±0.005	—	—
Hf	28±2	23[b]	—	—
Fe	297±6	300±20	48±2	49
Zn	24±2	25±3	90±4	86
Mn	91±2	91±4	0.71±0.05	0.52
Co	0.21±0.03	(0.2)	10±1[b]	(8)[b]
Cr	2.4±0.1	2.6±0.3	77±5[a]	(80)[b]
Na	80±3	82±6	0.204±0.005[a]	0.206[a]
K	1.46±0.02[a]	1.47±0.03[a]	1.56±0.03[a]	1.58[a]
Rb	14±2	12±1	18±1	19
Cs	0.05±0.01	(0.04)	0.14±0.02	0.12
Ba	43±3	(44)	—	—
In	2.0±0.2	(1.5)[b]	—	—
Sc	75±7[b]	90±60[b]	—	—
Yb	34±3[b]	(30)[b]	—	—

[a]Values in percentage.
[b]Values in ppb.
Values in parentheses are uncertified.

Employing the above mentioned experimental conditions, the NBS Orchard Leaves (SRM-1571) and the IAEA Animal Muscle (H-4) were analysed to check the accuracy of the procedure. The results are tabulated in Table II which are in fairly good agreement with the NBS and IAEA values.

The range, arithmetic mean, geometric mean and median of 21 elements analysed in 90 eggs of farm and domestic chickens were computed and presented in Table III. The arithmetic mean of yetterbium, hafnium and manganese were not computed due to large scatter in the data. The range arithmetic mean, geometric mean and

TABLE III

Trace element concentration in egg-white and yolk of farm and domestic chickens on dry weight basis

Elements		Egg-yolk (poultry)	Egg-white (poultry)	Egg-yolk (domestic)	Egg-white (domestic)
Hg (ppb)	R	2–13	9–70	7–14	31–52
	A.M	6±4	31±4	10±2	39±6
	G.M	4	22	10	39
	M	2	13	10	37
Se (ppm)	R	0.55–0.93	0.85–1.7	0.6–1.5	1–2.3
	A.M	0.74±0.11	1.3±1.14	0.94±0.2	1.8±0.3
	G.M	0.73	1.26	0.9	1.7
	M	0.76	1.3	0.87	1.7
As (ppm)	R	0.07–0.15	0.66–1.2	0.5–1	0.79–1.5
	A.M	0.12±0.03	0.9±0.16	0.84±0.18	1.04±0.26
	G.M	0.11	0.92	0.80	1.01
	M	0.12	0.91	0.86	1.00
Sb (ppb)	R	11–20	39–60	1–7	4–37
	A.M	17±3	48±7	4±2	14±11
	G.M	17	47	3	10
	M	19	46	2	10.8
Br (ppm)	R	5.6–14	26–51	2–16	10–67
	A.M	9.8±2.6	38±7.6	5±4	38±20
	G.M	9.4	37	4	32
	M	9.8	35.8	3	36.7
Cl (ppm)	R	146–176	460–826	103–155	498–759
	A.M	162±10	650±123	132±18	610±83
	G.M	161	637	130	604
	M	163	649	138	602
U (ppm)	R	0.13–0.37	0.76–2.9	0.2–6.0	0.2–6.5
	A.M	0.25±0.07	1.8±0.9	2±2	2±2.1
	G.M	0.24	1.5	1.05	1.07
	M	0.24	1.5	1.53	1.5
Hf (ppb)	R	0.9–5.2	4.2–20	1.4–95	13–368
	A.M	—	—	—	—
	G.M	1.5	10	7.5	31.9
	M	1.3	12.1	5.7	15.9
Fe (ppm)	R	44–101	1–5	85–156	1.9–6.7
	A.M	79±21	4±1	109±21	4.4±1.3
	G.M	76	3	107	4.0
	M	81	4	100.5	4.8
Zn (ppm)	R	29–85	1–3	62–121	1–5
	A.M	57±21	2±0.7	82±20	3±1.2
	G.M	53	1.6	80	2.8
	M	55	2	78.7	3
Mn (ppm)	R	1.2–2.5	—	1–14	—
	A.M	—	—	—	—
	G.M	1.9	—	2	—
	M	1.8	—	1.5	—

TABLE III (continued)

Elements		Egg-yolk (poultry)	Egg-white (poultry)	Egg-yolk (domestic)	Egg-white (domestic)
Co (ppb)	R	16–52	3–25	2–27	7–14
	A.M	27±15	10±9.3	18±6.7	10±2
	G.M	24	12	16	9.6
	M	18	7	17	9
Cr (ppm)	R	0.33–0.52	0.2–4	0.2–1.35	0.13–0.6
	A.M	0.40–0.06	0.3±0.06	0.5±0.4	0.3±0.16
	G.M	0.39	0.27	0.4	0.2
	M	0.38	0.29	0.33	0.2
Na (%)	R	0.08–0.14	1–1.5	0.1–0.2	0.9–1.7
	A.M	0.118±0.021	1.2±0.1	0.14±0.02	1.2±0.19
	G.M	0.116	1.16	0.14	1.16
	M	0.115	1.2	0.14	1.2
K (%)	R	0.13–0.30	0.75–1.5	0.1–0.27	0.66–1.9
	A.M	0.216±0.054	1.03±0.2	0.2±0.04	1.06±0.3
	G.M	0.209	1.0	0.17	1.01
	M	0.21	1.02	0.19	1.01
Rb (ppm)	R	0.7–2.0	6.6–12	0.6–2.3	1.5–14
	A.M	1.2±0.4	10±2.2	1.2±0.6	6.3±4.2
	G.M	1.1	9	1.0	5
	M	1.2	10.7	1.04	2.2
Cs (ppb)	R	2.0–16	5–12	1.1–3	2–13
	A.M	8±5	7.7±2.6	2±0.7	8±4
	G.M	6	7	1.9	7
	M	6.0	7	2.3	6.5
Ba (ppm)	R	2–90	2–50	3–14	1.2–17
	A.M	45±35	27±17	7±4	7.4±5.6
	G.M	21	16	6	5.2
	M	61	34	5.4	4.6
In (ppb)	R	0.3–1.5	0.3–1.7	0.2–1.6	0.16–1.4
	A.M	0.56±0.4	0.6±0.4	0.75±0.4	0.7±0.4
	G.M	0.5	0.5	0.6	0.56
	M	0.5	0.5	0.7	0.55
Sc (ppb)	R	0.2–1.4	0.6–1	0.2–1.5	0.3±1.7
	A.M	0.8±0.4	1±0.2	0.8±0.5	0.9±0.5
	G.M	0.7	0.9	0.6	0.7
	M	1	1	0.94	0.99
Yb (ppb)	R	2.0–30	4–17	1–27	0.9–27
	A.M	—	—	—	—
	G.M	9	7	6	4.3
	M	8	6	13	2.8

[a]R = Range of values.
A.M = Arithmetic mean.
G.M = Geometric mean.
M = Median.

median are similar for selenium, arsenic, antimony, chlorine, iron, zinc, sodium, potassium, cesium and indium in both the portions of farm and domestic chicken eggs indicating gaussian distribution. Mercury, cobalt and rubedium also have gaussian distribution in both the portions of domestic egg whereas these elements have irregular distribution pattern in farm egg-yolk and egg-white. Regular distribution patterns of bromine, chromium and scandium are only observed in farm egg-yolk and egg-white. Uranium and manganese exhibit regular distributions only in farm egg-yolk while the rest of the elements have irregular distribution pattern in both the type of eggs.

The geometric mean of concentration of each element in both the portions of farm and domestic chicken eggs are depicted by bar graphs in Figure 1. The bars 1 and 2 represent farm egg-yolk and egg-white whereas bars 3 and 4 represent domestic egg-yolk and egg-white. It can be seen from Figure 1 that egg-white have higher concentrations of mercury, selenium, arsenic, bromine, chlorine, hafnium, sodium, potassium and rubedium than egg-yolk in both the type of chicken eggs. The comparison of data between both types of egg-yolk as well as egg-white in Table III show that, except for antimony, the concentration of most of the elements do not vary significantly. However, mercury, selenium iron and zinc are slightly higher in domestic egg-yolk and egg-white which may be due to different food habits of farm and domestic chickens. It is difficult to find a possible explanation for higher amount of toxic elements in egg-white, however, the higher value of antimony in both the portions of farm eggs could be due to feed contamination.

The ratio of elemental concentration of egg-white to egg-yolk was also computed which indicate that except for mercury, arsenic, bromine, uranium, hafnium, manganese, chromium and cesium, the rest of the elements have similar values in farm and domestic eggs.

The screening of data in Table III show that the essential elements such as iron, zinc, manganese, cobalt and chromium are concentrated in egg-yolk. The comparison of farm egg-yolk and domestic egg-yolk show that their concentration do not vary appreciably. The rest of the elements are distributed uniformly in both portions of farm and domestic eggs.

In order to estimate the daily intake of toxic and essential elements through eggs, the elemental concentration in farm whole-

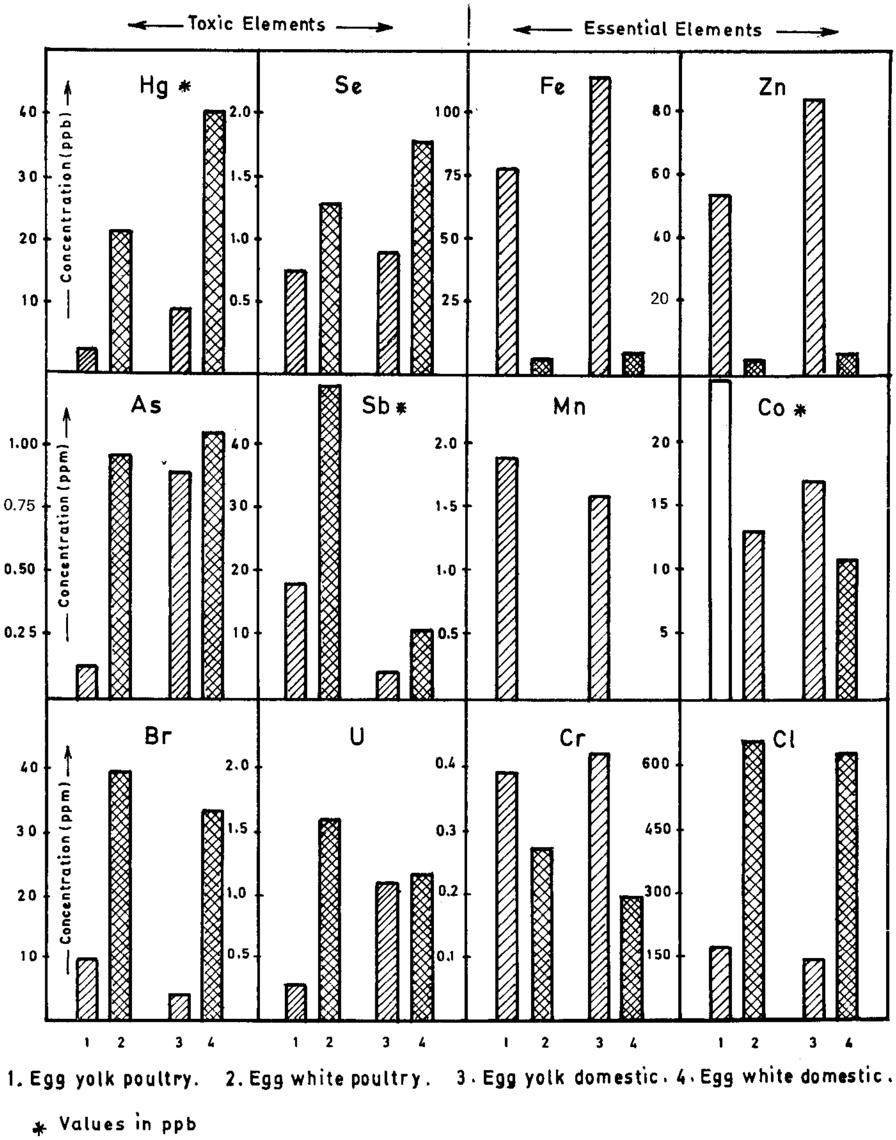

FIGURE 1 Distribution pattern of toxic and essential elements in egg yolk and egg white of poultry and domestic chickens.

TABLE IV
Comparison of daily intake of trace elements through egg with daily requirements

Elements	Daily (2, 3) requirement	Daily intake[b] through eggs
Hg	40 μg[a]	0.261 μg
Se	130–150 μg	24 μg
As	400 μg[a]	10 μg
Sb	—	0.71 μg
Br	1 mg	487 μg
Cl	275–5100 mg	8.37 mg
Fe	8–18 mg	1.39 mg
Zn	8–15 mg	964 μg
Mn	0.5–5 mg	34 μg
Co	0.14–1.77 mg	0.49 μg
Cr	0.01–0.2 mg	9.32 μg
Na	115–3300 mg	120.6 mg
K	350–5625 mg	123.5 mg

[a]Daily tolerance.
[b]Dry weight basis.

egg was calculated by adding its geometric mean value in both the portion of egg on dry weight basis. The dietary intake was estimated on the basis of two eggs per person per day and tabulated with the daily requirement or tolerance values[2–3] in Table IV. The estimated daily intake of mercury, selenium and arsenic are 0.26 μg, 24 μg and 10 μg respectively which are quite low as compared to the recommended daily tolerance level of 10–40 μg, 130–150 μg and 400 μg for human.[4–11]. For other toxic elements such as antimony and bromine the estimated daily intake values for a person are 0.71 μg and 487 μg respectively. Bromine intake value contributes to about 49% of the daily requirement.[12]

In order to check the adequacy of some trace metals in human biosystem through eggs, daily intakes were also estimated for these essential elements. The estimated daily intake of iron and zinc are 1.39 mg and 964 μg respectively which would contribute to only 17.4% and 12.1% of their daily requirements.[13–14] Manganese concentration in white part of egg is too low to be determined non-destructively. The range of its values in poultry and domestic egg-yolk are 1.2–2.5 and 1–14 ppm. The daily intake are estimated to be

34 μg indicating egg to be a poor source of this element. Cobalt and chromium are estimated to be 0.5 μg and 9.32 μg in two eggs and these are quite low as compared to the daily requirement range of 0.14–1.77 mg and 0.01–0.2 mg.[3,15–17]

CONCLUSION

In the present investigation, farm and domestic chicken eggs were analysed using instrumental neutron activation analysis to establish the base line levels of trace elements. Such data will be helpful to monitor the degree of contamination from external sources in the future. The measurement of elemental distributions in farm and domestic egg-white and egg-yolk indicates that generally toxic elements such as mercury, selenium, arsenic, antimony and bromine are relatively higher in egg-white whereas essential elements like iron, zinc, manganese, chromium and cobalt are higher in egg-yolk. The elemental concentration in farm whole-egg was also calculated to estimate their daily intake which indicate that the level of intake of toxic elements are low as compared to their tolerance limit.

Acknowledgement

The authors would like to acknowledge the technical assistance of Messrs Shaukat Ali, M. Saeed and A. K. Rana. We are also grateful to the Reactor Operation Group and Computer Division for arranging the irradiation of samples and computation of the data.

This study was co-sponsored by IAEA through a research agreement no. 2370/CF, entitled "Health-Related Environmental Research Using Nuclear Techniques".

References

1. S. Ahmad, M. S. Chaudhary, A. Mannan and I. H. Qureshi, *J. Radioanal. Chem.* **78,** 375 (1983).
2. S. J. Khurshid and I. H. Qureshi, *PINSTECH/NCD-105*, 55 (1983).
3. H. R. Roberts, *Food Safety* (John Wiley and Sons, New York, 1981), Chap. 3, pp. 77.
4. C. A. R. Dennis and F. Fehr, *Sci. Total Environ.* **3,** 267 (1975).
5. L. J. Goldwater, *R. Inst. Pub. Health Hyg. J.* **27,** 279 (1964).
6. C. Kellershohn, D. Comar and C. Lopoec, *J. Lab. Clin. Med.* **66,** 168 (1965).
7. H. A. Shoreder, P. V. Frost and J. J. Balassa, *J. Chronic Dis.* **23,** 227 (1970).
8. J. N. Thompson, P. Erdody and D. C. Smiths, *J. Natr.* **105,** 274 (1975).

9. M. F. Robinson, J. M. McKenzie, C. D. Thompson and B. Van Rij, *J. Nutrl.* **30,** 195 (1973).
10. J. F. J. Cade, *Med. J. Aust.* **I,** 684 (1975).
11. B. M. Anderson, *U.S. Geo. Surv. Open File Rep.* (1972).
12. World Health Organization, *Techn. Rep. Series,* No. 502 (1972).
13. Recommended Dietary Allowances, 8th Ed.; *Nat. Acad. of Sci.,* Washington, D.C.; U.S.A. (1974).
14. A. E. Harper, *Nutr. Rev.* **31,** 393 (1973).
15. G. K. Murthy, U. Rhuee and J. T. Pecler, *Enviro Scie. Tech.* **5,** 436 (1971).
16. H. Shroeder, A. P. Nason and I. H. Tipton, *J. Clinis* **20,** 869 (1967).
17. I. H. Tipton, P. L. Stewart and P. G. Martin, *Health Phy.* **12,** 1683 (1966).