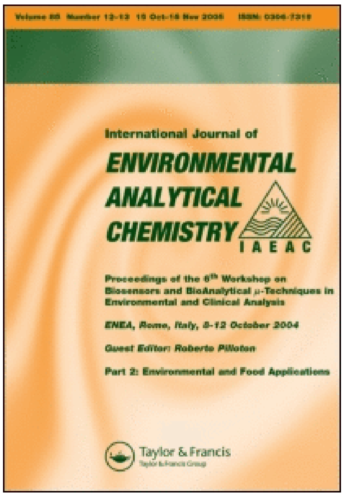

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I. H. Qureshi[a]; J. H. Zaidi[a]; M. Arif[a]; A. Mannan[a]; I. Fatima[a]
[a] Nuclear Chemistry Division, Pakistan Institute of Nuclear Science and Technology, Islamabad, Pakistan

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MINOR AND TRACE ELEMENTS EVALUATION OF PULSES CONSUMED IN RAWALPINDI-ISLAMABAD AREA

I. H. QURESHI, J. H. ZAIDI, M. ARIF, A. MANNAN and I. FATIMA

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

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The concentration of 18 essential and toxic elements has been measured in four different varieties of the pulses consumed in the Rawalpindi-Islamabad area employing neutron activation analysis. The pulses were analysed with and without scales. Among the four varieties of the pulses, lentil (*lens esculenta*) was found to contain higher amounts of essential elements and lower amounts of toxic elements. The comparison of pulses with other food items shows that pulses are also a suitable source of trace elements. The weekly intake of essential and toxic elements through pulses was estimated and compared with the recommended values. The estimated intake of essential elements is adequate and that of toxic elements is well below the tolerance limits.

KEY WORDS: Pulses, neutron activation technique, trace elements, essential elements, toxic elements, dietary intake.

INTRODUCTION

Trace elements have a recognized role in nutrition and clinical medicine. Several studies have been undertaken to assess the state of health relative to environmental influences on constituents of the human body, medical diagnosis of disease and occupational hygiene.[1–3] There has been an increasing interest in the understanding of the role of these elements in biological systems, particularly in human metabolism.[4,5] They reach the human body through foods, water, ambient air and other occupational and accidental exposures. Any significant fluctuation in their normal concentrations in the body causes physiological disorders.[6]

Along with the essential trace elements, food generally contains some toxic elements,[7,8] which if present in relatively high amounts may adversely affect the biochemical system.[9] In view of the importance of trace elements in nutrition, studies have been undertaken in our laboratories to measure the prevailing concentration levels in certain food items.[10,11] In the present investigation a variety of pulses consumed in the area of Islamabad-Rawalpindi have been analyzed.

For multielement analysis, neutron activation, due to its sensitivity, accuracy and specificity,[12] has been extensively used.[10–12] In the present work it has been employed for the determination of 18 toxic, essential and non-essential elements in different varieties of pulses.

EXPERIMENTAL

Sampling and Sample Preparation

Four different varieties of pulses, namely; black bean (*Phaseolus radiatus*), mung bean (*Phaseolus mungo*), lentil (*Lens esculenta*) and chick-pea (*Cicer arietinum*), were purchased from the local market in sufficient quantity. Each of the varieties was divided into two; one half was analysed without removing the scales, while the other was analysed after removing the scales. Each of these samples weighing 5–10 g was washed with 100 ml of distilled deionized water, filtered, air dried and powdered separately using a suitable grinder with PTFE-coated blades to avoid contamination. The powdered samples were thoroughly mixed and homogenized in a vibrating mill with three-dimensional motion. Representative samples for analysis were collected and stored in pre-cleaned polyethylene capped bottles. Homogeneity of the samples was tested by analyzing Mn and K contents; the variation was found to be less than 5% for both the elements for a minimum sample weight of 250 mg. The moisture content of the pre-weighed powdered samples were determined by freeze-drying for 48 h in a Christ Beta A freeze dryer and were found to be in the range of 5–10%.

Irradiation

The representative samples, each weighing about 250 mg, were heat-sealed in pre-cleaned polyethylene vials for short irradiations and in silica vials for long irradiations. The samples along with appropriate amounts of NBS SRM-1567 wheat flour and SRM-1571 orchard leaves were irradiated for 2 min in a pneumatic tube facility and for 24 h in the reactor core of the 5 MW swimming-pool-type Pakistan Research Reactor (PARR-I) at a thermal flux of 2×10^{13} n cm^{-2} sec^{-1}. Thermal neutron flux monitors were inserted between the samples and the standards to monitor the fluctuations in the thermal neutron flux gradient; these were found to be insignificant.

The irradiated samples and standards were transferred to pre-weighed polyethylene vials and re-weighed to determine their net weight. These were counted after appropriate cooling (see Table 1) using a 4 K Canberra Series 85 (model 8503) multichannel analyzer coupled to an ORTEC coaxial intrinsic Ge detector, with an FWHM of 2.0 keV for the 1332.5 keV peak of ^{60}Co and a peak/compton ratio of 40:1. The data from MCA were transferred to the central computer facility through a serial port and were processed employing various computer programmes developed by our group.

RESULTS AND DISCUSSION

The optimum conditions along with nuclear data, for the determination of essential, toxic and non-essential elements in four varieties of pulses, are listed in Table 1. In the light of these studies, the elements Cl, Mn, Na, and K were determined employing

Table 1 Optimum experimental conditions and nuclear data[13] employed for the analyses

Irradiation Time	*Cooling Time*	*Isotope*	*Half-life*	*γ-peak used (keV)*
2 m	30 m	^{38}Cl	37.20 m	1642.4, 2167.5
	2 h	^{56}Mn	2.58 h	846.6
		^{42}K	12.40 h	1524.7
		^{24}Na	15.00 h	1368.5
24 h	2 d	^{82}Br	35.40 h	776.5
		^{76}As	26.30 h	559.1
		^{122}Sb	2.70 d	564.1
	2 w	^{51}Cr	27.80 d	320.1
		^{59}Fe	44.60 d	1099.3, 1291.6
		^{60}Co	5.26 y	1173.2, 1332.5
		^{65}Zn	243.80 d	1115.5
		^{46}Sc	83.90 d	889.3, 1120.5
		^{134}Cs	2.04 y	795.8
		^{86}Rb	18.60 d	1078.8
		^{181}Hf	42.50 d	482.0
		^{152}Eu	13.20 y	1408.0
		^{203}Hg	46.60 d	279.2
		^{75}Se	120.00 d	264.5, 135.9

short irradiations, whereas long irradiations along with appropriate cooling times were employed for the determination of Br, As, Sb, Se, Hg, Fe, Zn, Cr, Co, Rb, Sc and Cs. The peaks of all these elements except Zn and Hg were well resolved and free from any serious interference. The full energy peak area of 1115 keV from ^{65}Zn was determined after subtracting the contribution of the 1120 keV peak area of ^{46}Sc.

Table 2 Analysis of NBS reference materials in μg/g ± standard deviation[a]

Element	*Wheat flour SRM-1567*		*Orchard leaves SRM-1571*	
	Our values	*NBS values*	*Our values*	*NBS values*
Fe	18.2 ± 1.0	18.3 ± 1.0	298 ± 8	300 ± 20
Mn	8.9 ± 0.5	8.5 ± 0.5	92.8 ± 4	91 ± 4
Zn	9.4 ± 0.4	10.6 ± 1.0	27.0 ± 2	25 ± 3
Co[b]	17 ± 1	—	230 ± 30	(200)
Cr	—	—	2.8 ± 0.2	2.6 ± 0.3
Na	8.7 ± 0.3	8.0 ± 1.5	81.6 ± 3	82 ± 6
K	1370 ± 150	1360 ± 40	14600 ± 700	14700 ± 300
Hg[b]	1 ± 0.6	1 ± 0.8	160 ± 10	155 ± 15
Se	1.2 ± 0.3	1.1 ± 0.2	0.078 ± 0.01	0.08 ± 0.01
As	0.005 ± 0.002	(0.006)	12.7 ± 2.0	10 ± 2
Br	10.4 ± 1.2	(9)	12.1 ± 1.3	(10)
Rb	0.9 ± 0.08	(1)	11.2 ± 0.9	12 ± 1

[a] Values in parentheses are uncertified.
[b] In ng/g ± standard deviation.

Similarly, the full energy peak area of 279.2 keV from ^{203}Hg was determined by subtracting the contribution from the 279.5 keV peak area of ^{75}Se. The reliability of our method was checked by analyzing NBS SRM-1557 wheat flour and SRM-1571 orchard leaves employing the above mentioned experimental conditions. Our values are in fairly good agreement with the NBS values as shown in Table 2.

The results summarized in Table 3 show that the Fe contents in all the four varieties are higher and that of Co are lower than the other (essential) trace elements, Cr, Zn and Mn. The concentration of Cr is lower by a factor of 2–7 in chick-pea as compared to the other pulses. Table 3 also reveals that the concentrations of As and Sb are 3–5 times higher in black bean, while Hg and Se contents are 2–4 times higher in mung bean and chick-pea, respectively, than in the other pulses. Lentil contains comparatively high amounts of Fe, Cr, Zn, Mn and Co and lower amounts of Hg, Se and As. The comparison of our values with the literature values[14] given in Table 4 shows fairly good agreement for Fe, Mn, and K concentrations. However, the Zn content in our pulses is less by a factor of 2.

The analysis of pulses was carried out with and without scales as both types are consumed by the inhabitants of this area. Perusal of Table 3 shows that elemental concentrations are generally similar in pulses with and without scales except for Cr in black bean, Sb in chick-pea and As and Cr in mung bean. The Cr content in black bean without scales is 2-fold lower than in the pulse with scales, indicating high Cr contents in scales. The concentrations of Sb in chick-pea and As and Cr in mung bean are 30–35% lower in pulses without scales compared to pulses with scales.

Comparison of pulses data with the literature values[15] of some local food articles in Table 5 indicates that the Fe, Zn, and Co contents of pulses are comparable to those of wheat flour and chicken. The average concentrations of Fe and Zn in pulses are 60 mg/kg and 40 mg/kg, respectively, which are similar to wheat flour and close to chicken values. The Cr and Co contents are slightly lower than those of chicken and wheat flour, whereas the Mn concentration is 16 times higher than in chicken, but slightly lower than in wheat flour. Comparison of toxic elements shows that Hg is higher by a factor of 2 in pulses than in chicken and wheat flour. The concentrations of As and Sb are significantly lower in pulses than in chicken. This comparison indicates that pulses are also a suitable trace element nutritional source.

The weekly dietary intake values for essential and toxic elements through the pulses were estimated assuming that a person ingests 75 g of each of the varieties per week. The estimated values are reported in Table 6 along with the recommended weekly requirement/tolerance limits. The estimated intake of Fe is lowest in black bean, whereas the intake of Cr is lowest through chick-pea. The intake of Zn is the same through lentil and chick-pea, but less through black bean and mung bean. The estimated intake of Mn, Fe, Zn, Cr and Co corresponds to 31, 17, 19, 4 and 0.2% respectively of the recommended weekly requirement. The intake of Co through all four varieties is lowest amongst the essential elements. In fact this has been the case with all the food items studied so far in our laboratory[15–17] which necessitates the reassessment of recommended value of this element. The estimated intake of toxic elements is well below the tolerance limits.[18]

Table 3 Trace element concentration in pulses on dry weight basis (in ng/g ± standard deviation)

Element	*Black bean*		*Mung bean*		*Lentil*		*Chick-pea*	
	with scales	*without scales*	*with scales*	*without scales*	*with scales*	*without scales*	*with scales*	*without scales*
Hg	22 ± 1	19 ± 2	60 ± 3	58 ± 2	26 ± 2	23 ± 1	15 ± 1	12 ± 1
Se	69 ± 2	56 ± 3	17 ± 2	14 ± 1	25 ± 2	21 ± 1	95 ± 4	80 ± 2
As	410 ± 20	360 ± 20	120 ± 10	85 ± 5	30 ± 1	25 ± 1	80 ± 4	70 ± 3
Sb	84 ± 3	78 ± 2	13 ± 1	12 ± 1	15 ± 1	13 ± 1	29 ± 3	19 ± 2
Br[a]	2.1 ± 0.1	1.9 ± 0.1	2.9 ± 0.3	2.3 ± 0.2	15.5 ± 0.6	13.7 ± 0.8	4.2 ± 0.3	3.7 ± 0.4
Cl[a]	81.6 ± 4.8	79.3 ± 1.1	121 ± 4.0	116 ± 6.0	319 ± 18	312 ± 21	185 ± 7.0	178 ± 6.0
Fe[a]	44.0 ± 2.0	42.4 ± 1.9	66.4 ± 3.2	65.0 ± 2.5	67.4 ± 1.5	66.0 ± 3.0	65.2 ± 1.5	62.4 ± 1.7
Cr	110 ± 10	45 ± 2	140 ± 10	95 ± 4	145 ± 10	130 ± 10	20 ± 2	18 ± 2
Zn[a]	33.6 ± 1.5	29.8 ± 1.4	26.8 ± 1.5	23.3 ± 1.6	46.0 ± 2.5	45.1 ± 3.0	47.2 ± 2.1	46.4 ± 1.8
Mn[a]	22.1 ± 1.1	17.9 ± 1.1	13.3 ± 0.4	12.2 ± 1.1	19.6 ± 1.3	18.3 ± 1.0	26.2 ± 1.6	24.6 ± 1.5
Co	27 ± 2	22 ± 1	30 ± 2	25 ± 2	30 ± 2	28 ± 1	33 ± 3	32 ± 1
Na[a]	212 ± 12	183 ± 10	7.2 ± 0.7	6.9 ± 0.5	29.0 ± 1.9	27.5 ± 3.0	12.6 ± 1.2	11.8 ± 1.0
K[a]	13000 ± 800	12400 ± 900	14000 ± 990	13600 ± 400	9620 ± 500	8100 ± 400	9580 ± 680	9400 ± 700
Cs	34 ± 2	29 ± 1	25 ± 2	24 ± 2	26 ± 2	23 ± 1	16 ± 1	15 ± 1
Sc	24 ± 2	20 ± 2	24 ± 2	23 ± 2	13 ± 1	12 ± 1	15 ± 2	14 ± 1
Rb[a]	2.3 ± 0.1	2.1 ± 0.2	5.9 ± 0.3	5.1 ± 0.1	17.0 ± 1.5	15.8 ± 1.2	8.6 ± 0.5	8.2 ± 0.4
Hf	10 ± 1	9 ± 1	15 ± 2	9 ± 1	10 ± 1	8 ± 2	11 ± 2	9 ± 1
Eu	23 ± 2	19 ± 1	7 ± 1	6 ± 1	9 ± 1	7 ± 1	24 ± 2	22 ± 1

[a] In μg/g ± standard deviation.

Table 4 Intercomparison of trace elements in pulses (in $\mu g/g \pm$ standard deviation)

Element	*Black bean*		*Mung bean*		*Lentil*	
	Pakistan	*Bangladesh*[a]	*Pakistan*	*Bangladesh*[a]	*Pakistan*	*Bangladesh*[a]
Mn	17.9 ± 1.1	15.4 ± 1.1	12.3 ± 0.4	20.3 ± 1.3	19.3 ± 1.3	16.4 ± 1.1
Fe	44.0 ± 2.0	68.4 ± 4.7	66.4 ± 3.2	40.4 ± 2.8	67.4 ± 1.5	69.6 ± 4.8
Zn	29.8 ± 1.5	64.1 ± 5.9	22.3 ± 1.5	54.6 ± 5.0	46.0 ± 2.5	83.5 ± 4.1
K	13000 ± 800	16185 ± 280	13600 ± 400	11650 ± 203	9620 ± 500	7021 ± 125
Br	1.9 ± 0.1	ND	2.9 ± 0.3	ND	15.5 ± 0.6	ND
Rb	2.3 ± 0.1	29.7 ± 2.0	5.9 ± 0.3	52.4 ± 3.0	17.0 ± 1.5	41.8 ± 2.3

ND: not detected
[a] Values taken from Ref. 14.

Table 5 Comparison of trace element in pulses with some local food articles[a] (average concentration in $\mu g/g$)

Element	*Pulses*	*Wheat flour*	*Rice*	*Chicken*	*Mutton*	*Beef*
Fe	60	62	24	48	121	107
Cr	0.1	0.22	0.09	0.45	1.8	0.14
Zn	40	40	27	54	67	246
Mn	19	28	11	1.2	2.2	1.1
Co[b]	26	39	26	58	66	39
As[b]	160	—	—	2000	12	4
Hg[b]	33	20	2	15	61	5
Se	0.05	0.5	0.47	1.5	2.7	0.18
Sb[b]	35	5	185	460	12	25

[a] Literature values taken from Ref. 15.
[b] Concentration in ng/g.

Table 6 Dietary intake values of trace elements through pulses (in mg/week per person)[a]

Element	*Black bean*	*Mung bean*	*Lentil*	*Chick-pea*	*Total intake*	*Weekly requirement, tolerance*[18]
Fe	3.1	4.6	4.7	4.4	16.8	70–140
Cr[b]	7.7	8.3	8.9	1.2	26.1	70–1400
Zn	2.1	1.7	3.2	3.2	10.2	56–105
Mn	1.4	0.85	1.3	1.8	5.4	3.5–35
Co	0.002	0.002	0.002	0.003	0.009	1–12
Na	14.1	0.5	2.0	0.85	17.5	805–21000
K	916.5	957.4	660.2	650.2	3184	2100–35000
As[b]	30.0	10.0	2.0	5.0	47.0	2800
Hg[b]	1.6	4.2	1.8	1.0	8.6	280
Se[b]	4.9	1.2	1.7	6.4	14.2	1400
Sb[b]	5.9	0.9	1.0	2.0	9.8	—
Cl	5.6	8.4	21.9	12.6	48.5	1400–3500
Br	0.14	0.2	1.1	0.3	1.7	7
Cs[b]	2.4	1.7	1.8	1.1	7.0	—
Sc[b]	1.7	1.7	0.9	1.0	5.3	—

[a] All values expressed on dry weight basis. Weekly ingestion of each of the pulses taken as 75 g.
[b] Intake expressed in μg/week per person.

CONCLUSIONS

The present investigation provides the baseline values of certain essential and toxic elements in pulses of the Rawalpindi-Islamabad area. The data indicate that the different varieties of pulses analyzed contain fairly adequate amounts of essential trace elements which are comparable with many other food items. The dietary intake of toxic trace elements is within the safe limits recommended by joint WHO/FAO expert committees.[19] Therefore, it appears that the trace element nutritional status of pulses is quite satisfactory. Further studies on other cereals are desirable.

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