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Determination of Bromine and Iodine in Normal Tissues from Beijing Healthy Adults

XIAOLIN HOU,*[1] CHIFANG CHAI,[1] QINFANG QIAN,[1] CHUNSHENG LI,[1] AND QING CHEN[2]

[1]*Institute of High Energy Physics and Laboratory of Nuclear Analysis Techniques, Academia Sinica, PO Box 2732, Beijing, 100080, P. R. China; and* [2]*School of Public Health, Beijing Medical University, Beijing, P. R. China*

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ABSTRACT

The contents of bromine and iodine in samples of heart, liver, spleen, lung, muscle, and hair from healthy adults living in Beijing, China, were determined using epithermal neutron activation analysis. The results indicate that the contents of bromine in lung and iodine in liver are higher than those in other tissues, except human hair. The bromine contents in Beijing human tissues are significantly lower than those in other countries. The contents of iodine are slightly lower than those in other countries, but the difference is not significant. Three biological standard reference materials were simultaneously determined with the samples, and our results agree well with the certified values.

Index Entries: Iodine; bromine; human tissue; epithermal neutron activation analysis; standard reference material.

INTRODUCTION

Iodine is one of trace elements essential to humans. Its excess and deficiency are harmful to human health. Iodine deficient disorder (IDD) is a worldwide endemic disorder *(1,2)*, which seriously threatens human health. The determination of reference value of iodine in human tissues is very useful for the study of IDD and the evaluation of human iodine nutrition status.

*Author to whom all correspondence and reprint requests should be addressed.

Bromine is one of trace elements widely existing in biological and environmental materials. It is known as an inessential element to humans. Bromine intake at higher level is toxic, since it is excreted quite slowly from the body tissue, which causes brominism with the symptoms of mental disturbance, impaired memory and thought process, drowsiness, and so on *(3)*. In addition, the excessive intake of bromine can also inhibit the absorption and bioavailability of iodine. Recent research results show that bromine is also related to dilated cardiomyopathy and uremia heart failure *(4,5)*. The maximum permissible intake limit of bromine set by the World Health Organization (WHO) is 1.0 mg/person/d *(6)*.

Both iodine and bromine are volatile, and their contents in human nonthyroid tissues are very low. Thus, it is difficult to accurately determine them in normal human tissues. Data on the concentrations of iodine and bromine in human tissues are very scarce in literature, and the reference values of iodine and bromine in tissues of healthy adults living in the Beijing district are not available. Neutron activation analysis (NAA) is a sensitive and accurate technique for the determination of iodine and bromine, but the strong radioactivities of ^{24}Na, ^{38}Cl, and ^{42}K isotopes of the minor elements Na, Cl, and K in biological samples after irradiation with reactor integral neutrons spectra critically interfere with their determinations. In order to improve the detection limits of I and Br, epithermal neutron activation analysis (ENAA) was used to determine the contents of iodine and bromine in six normal tissues from healthy adults living in Beijing, China.

MATERIALS AND METHODS

Collection of Samples

Normal human tissues were collected from healthy male adults living in Beijing, China, who died in accidents at 20–40 yr of age. Heart from the wall of the left ventricle, liver from the right edge, lung from the inferior lobe, muscle from the chest, and the full spleen were collected 24–48 h after death and immediately put into a refrigerator and preserved at –20°C. Before analysis, the samples were cut into pieces with stainless steel scissors, lyophilized, and ground to fine powder. The ratios of dry to wet mass of samples were between 0.18 and 0.27.

The human hair samples were collected from healthy middle school teachers living in Beijing, and cut at the occiput part. Then they were washed with 5% neutral detergent and deionized water, dried at 60°C, and cut into pieces of 0.1–0.2 cm.

Preparation of Samples and Standards

About 150–200 mg of lyophilized tissue samples, two dried biological standard reference materials (SRMs) (NIST-1577a [bovine liver] and

NIST-1566 [oyster tissue]), 100–150 mg of human hair samples, and (Chinese human hair SRM (GBW-09101) were taken. The comparative chemical standard containing 1.12 μg iodine or 2.05 μg bromine was prepared with analytical pure KBr and KIO_3 *(7)*. All samples and standards were sealed in a 10×10 mm^2 polyethylene film, respectively.

Neutron Activation Analysis

The ENAA with the boron nitride (BN) as thermal neutron shield material was used to determine iodine and bromine *(7)*. The prepared samples and standards were put into a BN shield capsule with a wall thickness of 1.8 mm. The BN capsule was then put into a polyethylene rabbit capsule and heat-sealed. The irradiation was carried out in an inner irradiation site of Miniature Neutron Source Reactor with the epithermal neutron flux of 2.6×10^{10} $n/cm^2 \cdot s$. After 15 min irradiation, the samples and standards were decayed for 5–15 min and counted for 600 s. The 433 and 616 keV γ-rays of iodine and bromine, respectively, were determined with a PC computer γ-multichannel analysis system. The software CIAE/SPAN developed by the China Institute of Atomic Energy was used to analyze the γ spectra. The contents of iodine and bromine in samples were calculated by using the comparative method.

RESULTS AND DISCUSSION

Our experimental results of iodine and bromine in six kinds of normal human tissues are listed in Table 1. It can be seen that the concentrations of iodine and bromine in different tissues are remarkably different. With the exception of hair, the highest iodine concentration was found in liver. In the human body, iodine mainly exists as organic iodine, in which only T_3 and T_4 have metabolic activity. Besides the thyroid, the T_3 is converted from T_4 mainly in liver by I-type iodo-thyronine deiodinase *(9)*. Our research results show that the content of iodine in liver was higher than those in other tissues. Thus, the metabolism of iodine in liver is likely to be faster than those in other tissues.

It has been reported that the excretion of bromine is quite slow and can be accumulated in the human body *(3)*. The bromine concentration in the lung is higher than those in other tissues. Thus, the lung may be a main tissue accumulating bromine. A possible interpretation is that Br in air is easily absorbed by lung, because of its high volatility, and it constitutes another important channel of Br to enter human body besides diet.

In Table 2, the contents of iodine and bromine in human tissues of other countries and of Shanghai, China, are listed. Comparing them with our values, it can be found that the concentrations of bromine in Beijing human tissues are significantly lower than those in other countries (and also lower than those in Shanghai, but the difference is not significant).

Table 1
Analytical Results of Br and I in Normal Tissues of Beijing Healthy Adults

Tissue		Bromine, μg/g		Iodine, ng/g	
		Range	$\bar{X} \pm SD$	Range	$\bar{X} \pm SD$
Heart (n=11)	Dry	3.70–6.47	4.78 ± 0.79	160–424	232 ± 74
	Wet	0.74–1.30	0.96 ± 0.16	32.1–85.5	46.6 ± 14.9
Liver (n=11)	Dry	1.90–4.70	3.23 ± 0.96	342–766	627 ± 125
	Wet	0.52–1.28	0.88 ± 0.26	93.0–211	170 ± 34
Spleen (n=10)	Dry	4.50–12.8	7.41 ± 2.39	85.0–214	124 ± 41
	Wet	0.95–2.69	1.56 ± 0.50	17.9–44.9	26.0 ± 8.6
Lung (n=11)	Dry	10.3–18.4	14.0 ± 2.58	116–279	175 ± 56
	Wet	1.96–3.50	2.66 ± 0.49	22.0–53.0	33.3 ± 10.6
Muscle (n=9)	Dry	1.26–2.80	2.19 ± 0.49	42.0–205	105 ± 64
	Wet	0.28–0.63	0.49 ± 0.11	9.4–45.9	23.5 ± 14.3
Hair (n=10)		0.50–3.91	1.56 ± 1.01	243–1980	927 ± 528

We have studied the daily dietary intakes of trace elements *(10)*, finding the average intake of bromine by Chinese people to be 2.28 mg/d/person; the intake of bromine in south China (including Shanghai) was 3.57 mg/d/person, which was lower than those in Japan (24.9–32.5 mg/d/person) and Pakistan (4.74 mg/d/person) *(3)*. It shows the concentrations of bromine in human tissues to be related to the dietary intake of bromine. The intake of trace elements relates mainly to the dietetic habits and the concentrations of elements in diets. The contents of bromine in aquatic products, meat, and egg are higher than those in other diets, such as grain, vegetable, and so on *(10)*. In China, the main diets are grain and vegetable, while the dietetic consumption of meat, egg, and milk are higher in Western countries. In Japan, the consumption of aquatic products is quite high, and the concentrations of bromine in diets are higher than those in other countries *(3)*. It can explain why the contents of bromine in Beijing human tissues are lower than those in other countries.

The concentrations of bromine in Shanghai human tissues are slightly higher than those in Beijing. This is not only attributed to the higher intake of bromine in Shanghai; another possible reason is that Shanghai is located at the seaside, and the concentration of bromine in the air is higher than in Beijing.

Three biological SRMs (human hair [GBW-09101], bovine liver [NIST-1577a], and oyster tissues [NIST-1566]) were simultaneously determined with samples as analytical quality assurance SRMs. Our results are listed in Table 3, together with the certified values. The agreements between them are satisfactory.

Table 2
Comparison of Iodine and Bromine Contents in Human Tissues in Different Countries and Regions (fresh weight)

	Bromine, μg/g			Iodine, ng/g		
Tissue	Beijing	Shanghai	Other countries	Beijing	Shanghai	Other countries
Heart	0.96	1.18 ± 0.30 *(13)*	2.15 *(8)*	46.6		
Liver	0.88		2.06 *(8)*, 4 *(8)*	170		200 *(1)*
Spleen	1.56	3.92 ± 0.84 *(13)*		26.0		
Lung	2.66		7.5 *(8)*	33.3		70 *(1)*
Muscle	2.19	2.93 ± 0.28 *(13)*		23.5		10 *(1)*, 104 *(8)*
Hair	1.56		6.6 ± 0.0 *(8)*, 5.38 ± 0.43 *(14)* 4.4–10.6 *(12)*	927	360 ± 0.70 *(13)*	430 ± 0.50 *(8)*

Table 3
Analytical Results of 4 SRMs for Br and I

SRM	Br μg/g		I ng/g	
	This work $\bar{X} \pm SD$	Certified values	This work $\bar{X} \pm SD$	Certified values
NIST-1577a	9.58 ± 0.26	9	261 ± 10	
NIST-1566	54.0 ± 1.5	55	2880 ± 40	2800
GBW-09101	0.695 ± 0.015	0.602	874 ± 17	875

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