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Iodine content of commonly consumed foods and water from the goitre-endemic northeast region of India

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Iodine content of commonly consumed foods and water from goitre-endemic northeast India is reported. The iodine content of water ranged between 3.0 and 31.5 μg litre^{-1} with 82% of the samples containing 5–10 μg litre^{-1}. Pooled mean water iodine content from northeast India (7.38 ± 2.7 μg litre^{-1}) was very low compared with non-endemic areas like Hyderabad (36.5 ± 4.8 μg litre^{-1}. Similarly, foods from northeast India had low iodine with all the samples analysed exhibiting iodine contents below 30 μg per 100 g sample. Commonly consumed foods like cereals, legumes, spices, roots and tubers were 30–76% lower than values encountered from non-endemic areas like Hyderabad. The low iodine in foods and water from goitre-endemic northeast India reflects the environmental iodine deficiency in the region. © 1998 Elsevier Science Ltd. All rights reserved

INTRODUCTION

The role of iodine deficiency as the principal environmental determinant in the development of endemic goitre and related diseases is firmly established. These pathological conditions have been permitted to be grouped under the common name of Iodine Deficiency Disorders (IDD) (Hetzel *et al.*, 1990). In India, IDD is one of the most widely prevalent nutritional disorders and it is estimated that about 120 million of the population in the country are exposed to IDD (ICMR multicentric study, 1989; Pandav & Kochupillai, 1982). Food and water are considered the major sources of iodine to meet the daily metabolic requirement. The iodine content of the diet is considered critical to compensate for the metabolic losses (Vought *et al.*, 1964; Koutras *et al.*, 1970). Goitre surveys so far are limited to clinical symptoms, urinary iodine output and, to some extent, plasma thyroid hormone levels. Thus, less priority is given to quantitative factors, such as absorption and the balance of iodine resulting from important sources like water and food.

Data on the iodine contents of foods and water from the goitre-endemic northeast region of India are scanty (Tulpule, 1969; Sharma *et al.*, 1994). Despite the widespread occurrence of IDD, very few studies provide comprehensive information on the iodine content of Indian diets in the endemic region. Therefore, in the present study an attempt is made to screen water and commonly consumed foods from the goitre-endemic northeast region of India for iodine content.

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MATERIALS AND METHODS

Sample collection and processing

Food and water samples were collected from the North Eastern states of Nagaland, Manipur, Mizoram, Meghalaya, Arunachal Pradesh, Assam and Sikkim. Some food and water samples were also supplied by the Health Directorates of the respective state governments of Manipur, Assam, Mizoram and Sikkim. Randomly collected samples from households and markets were dispatched by air to Hyderabad for analysis. Food samples included commonly consumed staples such as cereals (143), legumes (248), spices (26), roots and tubers (18) that would normally constitute a major part of the diet. Care was taken to collect foods that are normally grown and consumed in the area. The dots on the map show the broad areas of sample collection (Fig. 1).

Prior to analysis, food samples were dried in an oven at 60°C for 12 h, powdered to pass through a 40 mesh sieve and stored in air-tight polyethylene bottles. Water samples were collected from the municipal supplies or springs and rivers that are used as drinking water sources only. Upon arrival at the laboratory water samples were refrigerated at 4°C until analysis.

Iodine estimation

Estimation of iodine was carried out by the kinetic method based on the catalytic reduction of Ceric Ce (IV) to Ceric Ce (III) after ashing of food samples (Mahesh *et al.*, 1992). Depending on the food samples to be analysed, 0.5–1.0 g were taken in duplicate for ashing and subsequent estimation of iodine. Water samples were brought to room temperature and 0.5 ml were taken directly for estimation. Duplicate analyses were carried out for each sample. As a laboratory check material, casein (ICN Nutritional Biochemistry) was used with every batch of food samples taken for analysis.

RESULTS AND DISCUSSION

Iodine content in water

The mean iodine content in water samples from the goitre-endemic states of northeast India ranged from

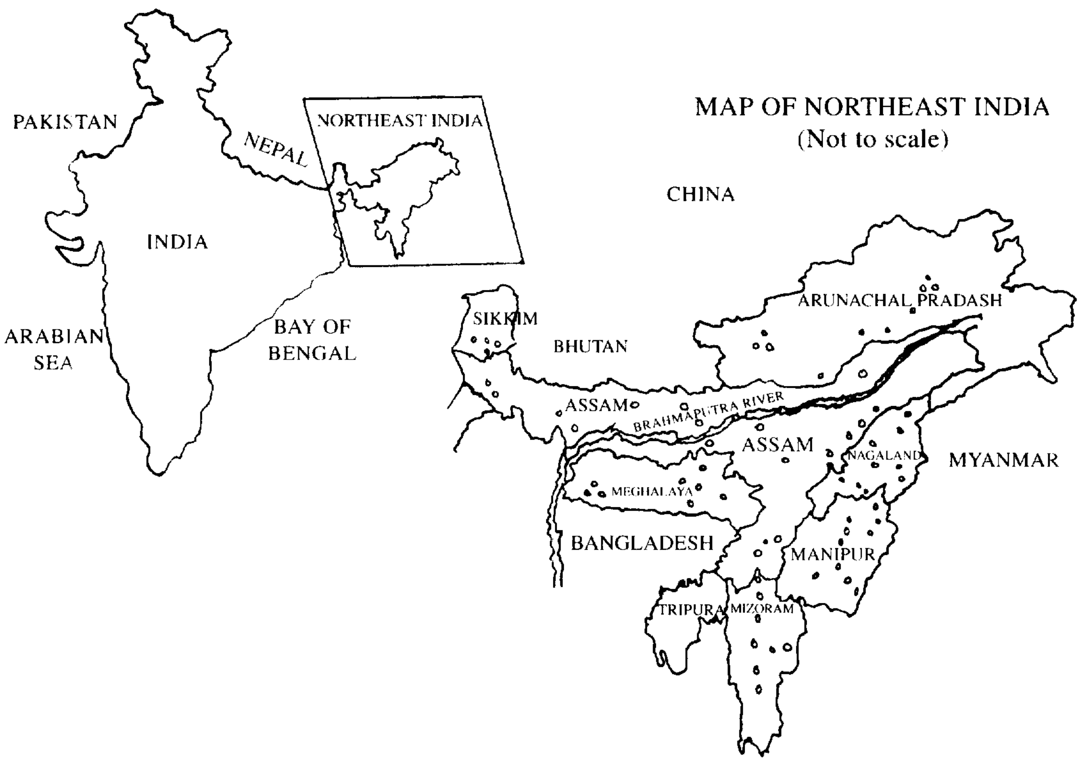

Fig. 1. Map of India (not to scale). The dots indicate broad sites of sample collection.

Table 1. Iodine content in water samples from northeast India (μg litre^{-1})

State	No. of samples	Range μg litre^{-1}	Mean μg litre^{-1} ± SD	Frequency distribution (%)				
				< 5.0	5.1–7.5	7.6–10.0	10.1–15.0	> 15.0
Arunachal Pradesh	24	3.5–14.5	6.98 ± 2.1	16.7	62.5	16.7	4.1	—
Assam	44	4.3–31.5	8.89 ± 4.9	11.4	56.8	15.9	4.5	11.4
Manipur	51	3.8–22.0	7.80 ± 2.8	7.8	51	29.4	7.9	3.9
Meghalaya	35	4.3–14.7	7.68 ± 1.84	8.6	51.4	37.1	2.1	—
Mizoram	48	4.0–13.9	6.92 ± 1.7	14.6	60.4	22.9	2.1	—
Nagaland	54	3.2–11.9	6.57 ± 1.5	10.3	65.5	20.7	3.5	—
Sikkim	31	3.0–12.6	6.65 ± 1.8	16.2	64.5	19.3	—	—
Pooled data	287	3.0–31.5	7.38 ± 2.7	12.2	58.9	23.0	3.5	2.4
Hyderabad[a]	50	5.0–63.7	36.5 ± 4.8	—	—	—	—	—

[a]Data of Mahesh (1993).

$6.65 \pm 1.8\,\mu g$ litre^{-1} in Sikkim to $8.89 \pm 4.98\,\mu g$ litre^{-1} in Assam (Table 1). In this study, water iodine content from northeast India varied from 3.0 to $31.5\,\mu g$ litre^{-1}. However, values below $3\,\mu g$ litre^{-1} in Gelecky PHC, Assam, have been reported (RMRC Dibrugarh; Annual Report 1991–1992). In Arunachal Pradesh, water iodine content ranged from 3.5 to $14.5\,\mu g$ litre^{-1}, whereas Tulpule (1969) reported a higher iodine content of 13–26$\,\mu g$ litre^{-1} in water samples from erstwhile NEFA, now Arunachal Pradesh. This could be due to seasonal fluctuations (Broadhead *et al.*, 1965) and differences in the method of estimation. Such a conclusion was also drawn in other studies by Koutras *et al.* (1970) and Fischer and Carr (1974). Ramalingaswamy (1973) reported iodine contents of water samples to be less than $3.0\,\mu g$ litre^{-1} in the goitre-endemic areas of India, Nepal and Sri Lanka. However, Krishnamachari (1974) reported 9–36$\,\mu g$ litre^{-1} from the goitre belt of the Aurangabad district, Maharashtra, which is almost similar to the values observed in the present study. The water iodine content of 3.0–31.5$\,\mu g$ litre^{-1} encountered in the present study is much below the values of 30–50$\,\mu g$ litre^{-1} from non-endemic areas of Gujarat, Maharashtra, Mysore and Madhya Pradesh reported by Tulpule (1969). Similar high water iodine contents have been reported by Mahesh *et al.* (1989) from other non-endemic areas such as Hyderabad.

Caughey and Follis (1965) have observed a high incidence of goitre in areas where iodine concentration in drinking water was from 3 to $7\,\mu g$ litre^{-1} as compared with non-endemic regions with water iodine contents of $20\,\mu g$ litre^{-1} or more. The lowest range of iodine content in water 3–12.6$\,\mu g$ litre^{-1}) was encountered in Sikkim, where the incidence of goitre was reported to be 54% (Pulger *et al.*, 1992). According to various reports, the goitre rates in northeast India ranged from 25 to 54% (Health Information of India, 1993; ICMR task force study, 1989; Pulger *et al.*, 1992). In the Gilghit district of Pakistan, the iodine content of water ranges from 1.2 to $13.0\,\mu g$ litre^{-1} with goitre rates of 25.2–76.5% (Siraj-ul-Haq Mahmud, 1986). The low iodine content of water and high incidence of goitre, prevalent in the sub-Himalayan belt, can be observed in the Gilghit district of Pakistan as well as in northeast India. Weak but significant negative correlations have been reported between drinking water iodine concentration and goitre prevalence (Das *et al.*, 1989). The distribution of environmental iodine deficiency in northeast India is more or less similar. The water iodine content of all the

Table 2. Iodine content of cereals (μg per 100 g)

	Rice (*Oryza sativa*)	Maize (*Zeas mays*)	Finger millet (*Eleusine coracana*)	Job's tears (*Coix lacrymus*)
Arunachal Pradesh	8.9 ± 2.6	7.5 ± 3.8	7.5 ± 3.8	—
Assam	12.9 ± 2.6	8.3 ± 2.5	7.6 ± 2.0	—
Manipur	10.5 ± 2.1	8.4 ± 2.5	7.5 ± 2.6	8.4 ± 1.3
Meghalaya	12.1 ± 2.4	8.5 ± 2.7	7.1 ± 2.3	—
Mizoram	10.3 ± 1.9	7.9 ± 3.1	7.8 ± 2.0	—
Nagaland	9.3 ± 2.3	8.1 ± 2.0	7.1 ± 2.5	8.1 ± 1.3
Sikkim	8.8 ± 3.0	7.0 ± 3.5	6.5 ± 3.0	—
Pooled data	10.4 ± 2.9	8.0 ± 2.9	7.3 ± 2.6	8.25 ± 1.3
Hyderabad[a]	40.0 ± 3.36	33.0 ± 1.2	—	—

Mean ± SD of 6–8 samples.
[a]Data of Mahesh (1993).

Table 3. Iodine content of leguminous seeds (μg per 100 g)

State	Soyabeans (*Glycine max*)	Rice beans (*Vigna umbellata*)	Field beans (*Dolichos lab lab*)	Green gram (*Phaseolus aureus*)	Cowpea (*Vigna catjang*)	Black gram (*Phaseolus mungo*)	Red gram (*Cajanus cajan*)
Arunachal Pradesh	14.8 ± 2.3	7.3 ± 2.2	23.7 ± 3.2	9.4 ± 2.5	16.2 ± 2.3	17.8 ± 2.5	20.6 ± 2.4
Assam	25.8 ± 2.5	—	28.5 ± 3.8	16.7 ± 2.4	22.5 ± 2.9	15.9 ± 7.8	21.7 ± 2.6
Manipur	18.2 ± 2.8	8.3 ± 2.8	19.5 ± 2.4	12.4 ± 2.6	13.7 ± 2.8	20.1 ± 2.6	18.2 ± 2.3
Meghalaya	22.5 ± 3.8	11.2 ± 1.9	21.0 ± 1.9	14.7 ± 2.1	15.6 ± 2.7	12.1 ± 2.5	20.4 ± 2.3
Mizoram	14.5 ± 3.1	9.5 ± 2.4	17.8 ± 2.9	10.1 ± 2.2	16.9 ± 3.0	11.2 ± 2.8	18.3 ± 2.5
Nagaland	15.7 ± 2.6	10.5 ± 3.1	18.0 ± 2.6	8.6 ± 1.9	17.0 ± 2.7	17.0 ± 2.7	18.0 ± 2.7
Sikkim	13.7 ± 2.4	7.5 ± 2.4	12.9 ± 2.4	8.1 ± 3.1	12.5 ± 2.7	8.3 ± 3.1	20.4 ± 3.2
Pooled data	17.6 ± 5.0	9.1 ± 2.9	20.1 ± 5.6	11.8 ± 3.9	16.3 ± 4.1	14.8 ± 5.5	19.6 ± 2.9
Hyderabad[a]	49.0 (45–53)	—	52.0 (48–56)	25.0 (23–26)	39.0 (36–42)	47.0 (46–48)	28.0 (26–30)

Mean ± SD of 4–6 samples. Values in parenthesis indicate range.
[a]Data of Mahesh (1993).

Table 4. Iodine content of spices, roots and tubers (μg per 100 g)

State	Ginger (*Zinziber officinale*)	Garlic (*Allium sativum*)	Red chillies (*Capsicum annucem*)	Colocasia (*Colocassia antiquoram*)	Sweet potato (*Ipomoea batatas*)	Topiaca (*Manihot esculenta*)
Arunachal Pradesh	15.1	6.3	12.0	4.9	8.1	—
Assam	18.7	8.2	15.3	5.4	—	8.6
Manipur	13.6	4.9, 6.3	16.3, 14.9	5.5	—	6.8
Meghalaya	14.2	7.4	15.3	5.8, 6.4	6, 8, 7.6	—
Mizoram	10.4	7.2, 9.0	13.2	6.1, 4.9	—	7.6
Nagaland	12.8, 9.6	5.2	14.1	4.5, 5.9	6.9	—
Sikkim	13.7	6.0, 5.4	11.5	4.1	7.4	5.2
Pooled data	13.5 ± 2.8	6.6 ± 1.3	14.1 ± 1.7	5.4 ± 0.7	7.4 ± 0.5	7.1 ± 1.4
Hyderabad[a]	56 (2)	12 (2)	38 (3)	11 (2)	17 (2)	—

Values in parenthesis indicate number of samples.
[a]Data of Mahesh (1993).

states varied within a narrow range with 82% of the samples from 5.0 to 10 μg iodine litre^{-1} and a pooled mean of 7.38 ± 2.7 μg litre^{-1}.

Iodine content of foods

Cereals
In cereals (Table 2) the mean iodine content of rice from the goitre-endemic states of northeast India was lowest in Sikkim (8.8 ± 3.0 μg per 100 g) and highest in Assam (12.9 ± 2.6 μg per 100 g). The iodine content of rice in northeast India varied within a narrow range with a pooled mean of 10.4 ± 2.9 μg per 100 g in contrast to samples from non-endemic areas such as Hyderabad (40.0 ± 3.36 μg per 100 g). Similarly, pooled mean iodine contents of other cereals such as maize (8.0 ± 2.9 μg per 100 g), millet (7.3 ± 2.6 μg per 100 g) and Job's tears (8.25 ± 1.3 μg per 100 g) from the goitre-endemic states of northeast India were around 25% of the values reported from non-endemic areas such as Hyderabad. A low iodine content of cereals was also reported from other goitre-endemic areas such as Baiga Chak, Madhya Pradesh by Mahesh (1993).

Legumes
Among the legumes analysed (Table 3) red gram contained relatively high iodine (18.0–21.7 μg per 100 g). However, these values were still lower by 23–36% compared with non-endemic areas such as Hyderabad. More than 80% of the legume samples from the goitre-endemic states of northeast India exhibited a mean iodine content below 20 μg per 100 g in contrast to non-endemic areas such as Hyderabad, where the iodine content was reported to be in the range of 25–50 μg per 100 g. The pooled mean iodine content of individual legumes from the states of northeast India such as soyabeans (17.6 ± 5.0 μg per 100 g), rice beans (9.1 ± 2.9 μg per 100 g), field beans (20.1 ± 5.6 μg per 100 g), Green gram (11.8 ± 3.9 μg per 100 g), cowpea (16.3 ± 4.1 μg per 100 g), Black gram (14.8 ± 5.5 μg per 100 g), and Red gram (19.6 ± 2.9 μg per 100 g) were 30–80% less than the values encountered from non-endemic areas such as Hyderabad.

Spices, roots and tubers
The general tendency of a lower iodine content of staple foods in endemic areas was also seen in other food constituents (Table 4) such as spices, roots and tubers. Iodine content in spices such as ginger (13.5 ± 2.8 μg per 100 g), garlic (6.6 ± 1.3 μg per 100 g) and red chillies (14.1 ± 1.7 μg per 100 g) were 45–76% lower than samples from non-endemic areas such as Hyderabad. Iodine content of 5.4 ± 0.7–7.4 ± 0.5 μg per 100 g in roots and tubers were much lower than the values reported from Calcutta (non-endemic area) by Sengupta and Pal (1971).

All the foods analysed from northeast India showed that the area is highly deficient in iodine with 45% of the foods falling below 10 μg iodine per 100 g sample and 100% below 30 μg iodine per 100 g sample. It is clear that the foods from endemic areas such as northeast India have much lower iodine contents compared with non-endemic areas, thus reflecting the genuine differences in the iodine content of the environment.

Iodine deficiency is a major obstacle to the human and social development of communities living in iodine-deficient environments. Correction of iodine deficiency would thus be a major contribution to the development of societies in an iodine-deficient environment. The data obtained in the present study on the commonly consumed foods and water from the states of northeast India show markedly low iodine levels. Despite all the states in northeast India being put under salt-iodization programmes about three decades ago and the import of non-iodized salt banned, the region is still goitre-endemic (ICMR multicentric study, 1989). Whether this is due to the inaccessibility of iodized salt or the loss of iodine during storage and transportation, or the effect of dietary goitrogens on iodine metabolism, requires further investigation.

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