Iodine Content of Various Meals Currently Consumed by Urban Japanese

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Summary Various meals being currently consumed by urban Japanese were determined for iodine. The meal samples were collected in 1982 and 1984. The habitual daily home meals of 4 middle-aged Japanese living in urban areas contained 45–1,921 μg (mean; 362, 361, 429 and 1,023 μg , respectively) of iodine per day. The regular meals served in two university hospitals contained 95–287 μg (mean; 195 μg) and 89–4,746 μg (mean; 1,290 μg) of iodine per day, respectively, and the diets for diabetes mellitus contained 59–144 μg (mean; 96 μg) of iodine per day. In the daily meals containing iodine exceeding *ca.* 300 μg , some kinds of seaweeds and, in some cases, several foods containing a red food color with low iodine bioavailability, erythrosine, provided a large portion of iodine. The iodine contents of refectory meals in a university were 47–203 μg (mean; 113 μg) per meal and those of lunches in two elementary schools were 25–31 μg (mean; 27 μg) and 18–43 μg (mean; 36 μg) per lunch, respectively. These results suggest that the current daily iodine intake of urban Japanese is not great and that erythrosine elevates the iodine content of meals.

Key Words iodine, iodine intake, habitual home meal, university hospi-

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In 1960, Katsura and Nakamichi(1) estimated the iodine intake of the Japanese to be 500–1,000 μg or more per day from the data on iodine levels in diets and in the urine of adult Japanese. Also, Koshiyama(2) reported a mean value of 706 μg iodine excretion in the urine per day in 623 adult Japanese in 1962. These data therefore have led to a general concept that the iodine intake of the Japanese is adequate when compared with the recommended daily dietary allowance of 150 μg iodine for adults as given by the U.S. National Research Council(3).

However, we recently examined the urinary iodine excretion of Japanese university students over 15 consecutive days and found a daily mean value of 357 μg iodine(4), which is considerably lower than the value given by Koshiyama(2).

In the present study, we directly determined the iodine levels in meals currently being eaten by Japanese living in urban areas to obtain more information on the iodine intake of modern Japanese.

MATERIALS AND METHODS

Meal samples. Habitual home meals were prepared according to menus recorded by 4 middle-aged Japanese (35–45 yr) living in urban areas near Tokyo, over 7 consecutive days in autumn, 1982. Regular meals and the diets for diabetes mellitus in a university hospital (Tokyo) were collected over 5 consecutive days in autumn, 1982, and regular meals in another university hospital (Kanagawa) over 10 consecutive days in summer, 1984. A one-day meal ready to eat was prepared by mixing the breakfast, lunch and supper of a particular day. The energy and protein levels of the one-day meals were respectively 1,260–2,470 kcal (mean; 1,800 kcal) and 41–98 g (mean; 67 g) for the habitual home meals, 1,890–2,110 kcal (mean; 2,040 kcal) and 78–92 g (mean; 84 g) for the university hospital regular meals collected in 1982, and 1,230–1,520 kcal (mean; 1,310 kcal) and 56–81 g (mean; 63 g) for the university hospital diets for diabetes mellitus. University refectory meals were bought in 4 refectories of a university (Ibaraki) on a particular day in July, 1984. In two elementary schools located in urban areas (Kanagawa), school lunches were collected over 5 consecutive days in summer and autumn, respectively, 1984. The meal samples were homogenized thoroughly in a multi-blendor mill (Model BL-1, Nihon Seiki Co., Ltd., Tokyo) and then lyophilized. Demineralized water was added to the samples with a low moisture content prior to homogenization.

Chemical analyses. Iodine in the lyophilized meal samples was determined by the modified method of Lauber(5) with the dry alkaline incineration of samples, as illustrated in Scheme 1. Standard KI solution containing 0, 25, 50, 100 or 200 ng

Scheme 1. Procedure for dry alkaline incineration of samples and subsequent photo-metric determination of iodine.^a Potassium hydroxide reagent: Dissolve 10 g KOH in 10 ml H₂O. ^b As reagent: Dissolve 0.4 g As₂O₃ and 0.4 g KOH in 100 ml H₂O and 0.1 ml 36% HCl. ^c Ce reagent: Dissolve 0.4 g (NH₄)₄Ce(SO₄)₄ · 2H₂O in 40 ml 61% HNO₃, 60 ml H₂O and 4 ml 98% H₂SO₄.

Fig. 1. Typical calibration curve for determination of iodine.

iodine was incinerated in a similar manner and subjected to the measurement of absorbance. A typical calibration curve is shown in Fig. 1. Erythrosine (FD & C Red No. 3), an approved food color containing *ca.* 58% (w/w) of iodine, was extracted from several kinds of foods and analyzed qualitatively by paper chromatography (6).

RESULTS

The recovery test for iodine, which was carried out by means of addition of standard KI solutions containing 25–150 ng iodine to the various meal samples, gave good values of 97.4–105.7% of recovery.

Table 1. Iodine contents of pooled one-day habitual home meals taken by several middle-aged Japanese living in urban areas.

The meal samples were prepared according to the menus used by middle-aged Japanese A, B, C and D. A one-day meal was prepared by mixing breakfast, lunch and supper ready to eat.

Day	Home			
	A	B	C	D
	Iodine content ($\mu\text{g}/\text{one-day meal}$)			
1	1,240 ^a	64	218	57
2	1,921 ^b	879 ^{a,c}	62	1,561 ^b
3	45	163	119	548 ^a
4	515 ^c	68	362 ^e	295 ^e
5	858 ^{c,d}	57	182	194
6	916 ^a	58	1,098 ^{a,c,e}	296 ^e
7	1,667 ^b	1,244 ^a	488 ^a	52
Mean	1,023	362	361	429

^{a-e} In these meals, Vienna sausage (a), hijiki (b), wakame (c), canned cherries (d) and red-colored boiled fish-paste (e) were included.

Table 2. Iodine contents of pooled one-day regular meals and diets for diabetes of university hospitals.

A one-day meal was prepared by mixing breakfast, lunch and supper ready to eat. The 10 regular meals of B University hospital consisted of 3 low-iodine and 7 high-iodine meals.

Meals	Number of samples	Iodine content ($\mu\text{g}/\text{one-day meal}$)	
		Mean	Range
A University			
Regular	5	195	95-287
For diabetes	5	96	59-144
B University			
Regular	10	1,290	89-4,746
(Low iodine)	(3)	(107)	(89-149)
(High iodine)	(7) ^a	(1,797)	(455-4,746)

^a These meals included one or two of the foods such as kombu, hijiki, wakame, canned cherries and red-colored boiled fish-paste.

Daily habitual home and hospital meals

Habitual home meals contained 45-1,921 μg of iodine per day, as summarized in Table 1. In home A, the highest mean value of 1,023 μg of iodine was found, but

in the other 3 homes mean values were 362, 361 and 429 μg . The one-day meal samples, showing an iodine content of more than about 300 μg , included one or more of the red-colored Vienna sausage, canned cherries and boiled fish-paste, and seaweeds such as hijiki (*Hizikia fusiformis*) and wakame (*Undaria pinnatifida*). Table 2 shows the iodine contents of one-day regular meals and the diets for diabetes mellitus in two university hospitals. The regular meals of University A contained 95–287 μg (mean; 195 μg) of iodine, whereas those of University B contained 89–4,746 μg (mean; 1,290 μg) of iodine per day. Out of the 10 regular meals of University B, 7 meal samples showed a high mean value of 1,797 μg of iodine per day and included one or two of the red-colored canned cherries and boiled fish-paste, and seaweeds such as kombu (*Laminaria japonica*), hijiki and wakame. The iodine content of the diets for diabetes mellitus was 59–144 μg (mean; 96 μg) per day.

University refectory meals and elementary school lunches

As seen in Table 3, the mean iodine content of refectory meals of University C was 113 μg (47–203 μg) per meal, of which 31–99 μg was derived from the wakame-miso soup used in the meals. The lunches of Elementary Schools D and E gave mean iodine content values of 27 μg (25–31 μg) and 36 μg (18–43 μg) per lunch, respectively. Two hundred ml of milk was generally served for these lunches and the milk provided 15 and 24 μg of iodine for Elementary School D and E lunches, respectively. Six brands of milk manufactured in Japan were also found to contain 15–29 μg (mean; 22.5 μg) of iodine per 200 ml.

Erythrosine in meals

Several meal samples, though they did not include seaweeds, showed a high iodine content over *ca.* 300 μg . Some red-colored foods such as Vienna sausage,

Table 3. Iodine contents of university refectory regular meals and elementary school lunches.

Meals	Number of samples	Iodine content of meals		Iodine derived from	
		Mean ($\mu\text{g}/\text{meal}$)	Range	Wakame-miso soup ($\mu\text{g}/\text{cup}$)	Milk ($\mu\text{g}/200\text{ ml}$)
C University refectory meals	13	113	47–203	31–99	
D Elementary School lunches	5	27	25–31		15
E Elementary School lunches	5	36	18–43 ^a		24

^a One of the 5 meal samples did not include milk.

Table 4. Iodine contents of several foods containing red food colors. These foods were purchased from a supermarket.

	Iodine content ($\mu\text{g/g}$)		
	Whole	Colored portion	Casing portion
Vienna sausage (A) ^a	45		333
Vienna sausage (B)	3.2		
Vienna sausage (C)	3.6		
Canned cherries	113		
Red-colored boiled fish-paste ^a	8.0	44	

^a The casing portion of Vienna sausage (A) and the colored portion of boiled fish-paste were also determined for iodine.

Fig. 2. Paper chromatogram of erythrosine extracted from several foods. a, erythrosine (standard); b, Vienna sausage(A); c, Vienna sausage(A)—casing portion; d, boiled fish-paste—red colored portion; e, canned cherries. Paper: Toyo No. 50 (Toyo Kagaku Sangyo Co., Ltd., Tokyo). Solvent system: *n*-BuOH—anhyd. EtOH—1% NH_4OH = 6:2:3.

canned cherries and boiled fish-paste were included in these meals. Since it was assumed that these red-colored foods might contain erythrosine (an iodine compound) as a red food color, they were subjected to the determination of iodine and the qualitative analysis for erythrosine. As shown in Table 4, one of 3 Vienna sausages as well as canned cherries contained fairly high amounts of iodine. The iodine content of the boiled fish-paste was not very high; however, its colored portion showed a high iodine content. Erythrosine was extracted from these high iodine-containing foods and identified by paper chromatography (Fig. 2).

DISCUSSION

The pooled one-day habitual home and university hospital meals had a wide range of iodine content. It was also shown that some seaweeds, which are known to be a major source of iodine in Japanese meals (1, 7, 8), and erythrosine are both contributive to the elevation of iodine content of meals. On the other hand, university refectory meals and elementary school lunches contained relatively low amounts of iodine. This was due to the inclusion of no or only a little seaweeds and erythrosine.

According to the National Nutrition Surveys of the Japanese in the years studied (9), the consumption of seaweeds per capita is lower in urban areas than in rural. Furthermore, although the total consumption of seaweeds per capita during the years is approximately the same as that in the 1960's (9, 10), the consumption of kombu per capita in urban communities has been reported in the Food Balance Sheet (11) to be decreasing whereas that of wakame to be increasing since the 1960's. Since kombu is well known to be highly superior to wakame as a source of iodine (1, 4, 7), the dietary iodine intake of urban Japanese may be decreasing, and there might be a state of considerably low intake of iodine for people ingesting habitual meals free of high-iodine foods such as seaweeds.

The daily intake of iodine for adults in other countries has been presented in recent years; *i.e.*, 696 μg in the U.S.A. (12), 323 μg in Great Britain (13), 210 μg in The Netherlands (14), 340 μg in Finland (15), 305 μg in New Zealand (16), 446 μg in Canada and 108 μg in Yugoslavia (17). Seeing from the iodine contents of the various meals examined here and from our previous finding showing a mean daily urinary iodine excretion of 357 μg for university students (4), the iodine intake of urban Japanese may be estimated to be comparable with those in other countries mentioned above and to be not as great as the 500–1,000 μg or more reported in the 1960's (1). However, further broad and detailed investigation is needed to ascertain the iodine intake of modern average Japanese including people in rural and fishery areas.

In the estimation of dietary iodine intake, it seems to be of importance to take into consideration the bioavailability of iodine ingested, as Park *et al.* (12) have discussed. We therefore have studied the absorption and urinary excretion of iodine in rats and humans for some seaweeds, high-iodine eggs (18–20) and two red food colors, erythrosine and rose bengal which is also permitted in Japan. It was found that a high bioavailability of iodine was exerted for kombu and high-iodine eggs but not for the two red food colors. These data have been briefly presented (21–23) and detailed data will be published elsewhere.

In conclusion, the present results suggest that the daily iodine intake of urban Japanese is relatively low and that erythrosine, a red food color with low iodine bioavailability, contributes to increasing the iodine level in meals.

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