
RESEARCH COMMUNICATION

Do Japanese take more Folate from Traditional Japanese Dish than is Conventionally Estimated? -Actual Folate Contents in Hospital Diets and Marketed Lunch Boxes

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Abstract

Folic acid deficiency is very rare in Japan. However, recent concerns in relation to causal relationships between cancer and low folic acid levels necessitate information on actual folate intake by Japanese, which has hitherto not been well studied. We therefore evaluated folate contents of a hospital diet for 7 consecutive days and of 16 lunch boxes purchased at convenience stores. Dietary intake was assessed for weighed food items after cooking using our previously published data on folate contents of various foods and also by using Standard Tables of Food Composition in Japan (STFCJ). Mean daily folate intake from the hospital diet was 723.9 µg/day using our data but only 359.2 µg/day if calculated using the STFCJ. Twenty-nine % of the total daily folate intake was through rice. Mean folate intake through lunch boxes was 491.7 µg/day by our tabulation and 139.5 µg/day with the STFCJ. Folic acid intake of Japanese is far above the levels taken in other countries and over half of this amount is taken from rice. Levels of folic acid contents (especially in rice) listed in the STFCJ are too low and revision is strongly suggested.

Key Words: Folate - dietary intake - Japan - hospital diet - lunch box - Standard Table of Food Composition in Japan

Asian Pacific J Cancer Prev, 5, 374-378

Introduction

Low folate intake has been associated with higher risk of colon cancer in epidemiological studies (Freudenheim et al., 1991). Such a relation with folate status was also reported in head and neck cancer (Raval et al., 2002). Recently Gao et al (2004) studied the relation between the susceptibility to esophageal and stomach cancer with smoking and polymorphism in thymidylate synthase and methylenetetrahydrofolate reductase genes in Japan. They found higher rate of polymorphism of these genes of folate metabolism and warranted the needs of information on folate intake among Japanese.

Folic acid deficiency is frequent in Europe and North America (Gregory et al., 1990; Sabor et al., 1989). Dietary supplement of folic acid during pregnancy have widely been recommended to reduce incidence of megaloblastic anemia and neural tube defect (Mills, 2000; Neuhauser and Beresfold, 2001). Recently many epidemiological and

studies (Eikerboom et al., 1999) have indicated an association of hyper-homocysteinemia with cardiovascular diseases. Supplementation of folic acid is expected to reduce homocysteine level and prevent cardiovascular diseases (Rimm et al., 1998). Since January 1998, all enriched cereal-grain products in the United States have contained 140 µg folic acid /100g (Food and Drug Administration, 1996). The effect of folic acid fortification has proved to be beneficial in improving folate status (Jacoues et al., 1999; Quinlivan and Gregory III, 2003). In Japan folic acid deficiency is rare (Taguchi, 1978) and incidence of neural tube defect is about half of Europe and America (Taguchi, 1991). Claims that folic acid should be supplemented are appearing also in Japan (Moriyama et al., 2003). We previously suggested the relatively high uptake of folate from common Japanese diet is the reason why folate deficiency is rare (Taguchi, 1978). In order to re-evaluate whether folate uptake from Japanese diet is sufficient or not, we planned to examine folate content of hospital diet and lunch available from convenience stores.

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Materials and Methods

Samples

Each meal (breakfast, lunch and dinner) of a hospital for 7 consecutive days for 27 meals were collected after cooking just the amount as delivered to each patient. Sixteen various prepared dishes for lunch boxes were bought at several convenience stores.

Calculation of folic acid contents of meals

Folate contents of each meal were calculated using the table of folate contents of various foods previously assayed before and after cooking by one of authors (Taguchi et al., 1972, 1973). Folate contents of food items not listed in our tables were calculated based on that listed in the 5th Standard Tables of Food Composition in Japan (STFCJ) (Resources Council, Science and Technology Agency, Japan, 2000).

Table 1. An Example of Calculation of Folate Amount with Weighed Food Items after Cooking

Items	Foods	Amount (g)	Folate content ($\mu\text{g}/100\text{g}$)	Folate intake (μg)	
Breakfast	Rice	200	36.5 {3}	73.0 {6.0}	
	Miso soup	Miso (soy bean paste)	15	41.4 {42}	6.21 {6.3}
		Baked fish paste	8	3.5 {2}	0.28 {0.16}
		Chinese cabbage	15	57.0 {42}	8.55 {6.3}
		Welsh onion	3	34.1 {110}	1.02 {3.3}
		Wakame sea weed	7	16.3 {11}	1.14 {0.77}
		Tangle	0.5	8.4 {17}	0.04 {0.09}
	Natto (fermented soybeans)	50	100 {120}	50.0 {60.0}	
	Salted vegetables	Chinese cabbage	60	57.0 {83}	34.2 {49.8}
		Carrot	10	67.3 {28}	6.73 {2.8}
		Soy source	7	29.6 {33}	2.07 {2.31}
		Canned tuna	7	15.0 {13}	1.05 {0.91}
		Seasoned laver	2	76.3 {44}	1.53 {0.88}
	Milk		207	64.4 {5}	133.3 {10.35}
				Total	319.1 {150.00}
	Lunch	Rice	200	36.5 {3}	73.0 {6}
Grilled pork with vegetables		Pork (boiled)	26	62.7 {2}	16.30 {0.52}
		Cuttlefish (boiled)	12	30.0 {5}	3.60 {0.6}
		Quail egg (boiled)	17	77.8 {46}	13.23 {7.8}
		Shrimp (boiled)	12	50.7 {41}	6.08 {5.0}
		Carrot (boiled)	14	67.3 {22}	9.42 {3.1}
		Chinese cabbage	52	57.0 {42}	29.64 {21.8}
		Welsh onion (boiled)	18	34.1 {11.0}	6.14 {20.5}
		Bamboo root (boiled)	35	4.4 {63}	1.54 {22.05}
Boiled vegetables (Dengaku)		Onion (boiled)	28	50.7 {11}	14.20 {3.08}
		Radish (boiled)	58	67.3 {33}	39.03 {19.14}
		Boiled egg (yolk)	1	167 {110}	1.67 {1.1}
		Miso (soy bean paste)	11	41.4 {42}	4.55 {4.62}
Salted vegetables		Sesame	1	246 {150}	2.46 {1.5}
		Cabbage	26	110 {78}	28.60 {20.08}
Orange			80	29.4 {22}	23.52 {17.6}
			Total	273.0 {154.7}	
Dinner	Rice	200	36.5 {3}	73.0 {6}	
	Raw fish	Tuna	40	48.8 {8}	19.52 {3.2}
		Cuttlefish	24	30.0 {4}	7.20 {1.68}
		Radish	14	91.5 {33}	12.81 {4.62}
		Lemon	16	32.0 {31}	5.12 {4.96}
		Horseradish	1	<u>50.0</u> {50}	0.50 {0.5}
		Soy sauce	6	29.6 {33}	1.78 {1.98}
	Spinach (sauté)	Spinach	54	110 {110}	59.40 {59.40}
		Boiled pea paste	3	3.5 {19}	0.11 {0.57}
	Soup	Green vegetable	3.5	260 {44}	9.10 {1.54}
		Soy source	2	29.6 {33}	0.59 {0.66}
		Tofu (bean curd)	39	<u>18.0</u> {18}	7.02 {7.02}
		Shiitake(dried mushroom)	10	32.0 {24}	3.20 {2.4}
				Total	199.4 {94.53}
			Grand Total	791.5 {399.23}	

{ } folate contents listed in the 5th Standard Tables of Food Composition in Japan (STFCJ) and calculated amount of folate taken from each item. Underlined are folate contents applied from STFCJ.

Folate contents of hospital diet and marketing lunch boxes were also calculated using STFCJ. Each food was weighed after cooking and multiplied by folic acid content from the tables. As folic acid contents were expressed as free and total in those papers by assaying before and after chicken conjugase treatment, total folate amount was employed because it was thought to be similar to Dietary Folate Equivalent (DFE) (Food and Nutrition Board, Institute of Medicine, 1998) because no folic acid fortification of foods have been done in Japan. Folic acid contents of some foods which are not included in the table were referred to from the STFCJ. An example of the calculation is shown in Table 1.

Results

Table 2 shows calculated folate contents of hospital diet

Table 2. Folate Intake of 9 Diets of a Hospital in Japan Sampled over 6 Days

	Breakfast (μg)	Rice	Lunch (μg)	Rice	Dinner (μg)	Rice	Total/day (μg)	Rice	Total/day by STFCJ* (μg)
12-Dec	319.1	22.9%	273.0	26.7%	199.4	36.6%	791.7	27.7%	399.2
12-Dec	259.9	23.5%	176.3	41.4%	238.2	30.6%	674.4	30.7%	343.2
13-Dec	319.0	22.9%	226.8	32.2%	219.5	33.3%	765.3	28.6%	442.2
14-Dec	219.1	33.3%	218.5	30.9%	174.3	41.9%	611.9	34.9%	350.9
15-Dec	283.2	16.1%	233.9	36.7%	207.5	35.1%	724.6	28.2%	383.5
16-Dec	265.2	25.3%	248.1	28.0%	232.1	31.5%	745.4	28.1%	235.5
16-Dec	385.1	15.9%	248.1	28.0%	232.1	31.5%	865.3	23.5%	444.2
17-Dec	254.3	18.4%	172.2	40.7%	174.7	41.8%	601.2	31.0%	243.9
17-Dec	316.9	21.9%	190.3	36.0%	228.4	32.6%	735.6	28.9%	264.1
Means	291.3	22.2%	220.8	33.4%	211.8	35.0%	723.9	29.1%	359.2

*STFCJ; Standard Tables of Food Composition in Japan

Table 3. Folate Content of 16 Lunch Boxes Obtained at Convenience Stores

Items	Rice (g)	Other foods	Total (g)	Folate intake (μg)	Folate from rice (%)	From rice (μg)	Folate intake by STFCJ (μg)
Rice with baked meat and grilled vegetables	241.0	116.0	357.0	168.4	88.0	52.2	87.1
Rice with baked salmon, fried egg and fried vegetables	151.0	174.0	325.0	118.6	55.1	46.5	39.8
Rice with fried chicken and boiled vegetables	219.0	110.5	329.5	158.9	79.9	50.3	48.8
Rice with baked eel, baked meat, boiled and fresh vegetables	220.0	180.5	400.5	251.7	80.3	31.9	65.7
Rice with grilled chicken, fried egg, and grilled vegetables	189.0	247.5	436.5	117.4	69.0	58.8	28.8
Rice with baked salmon, fried egg, and cooked vegetables	233.0	160.0	393.0	162.1	85.0	52.5	35.2
Rice with fried chicken, baked mackerel and grilled vegetables	222.0	202.0	424.0	163.2	81.0	49.7	29.5
Rice with baked salmon, fried fish, hamburger, fresh vegetables	290.0	207.0	497.0	201.9	105.9	52.4	56.8
Ham sandwich	70.0	43.5	113.5	79.3	25.6*	32.2	28.5
Sushi (conger eel, squirrel, shrimp, fried egg), cooked beef and fresh vegetables	187.8	262.6	450.4	245.0	68.5	28.0	105.5
Rice with grilled beef and onion	224.0	227.0	451.0	150.8	81.8	54.2	13.7
Rice, baked buckwheat, hamburger, fried fish, ham, fried potato	286.0	83.0	369.0	197.8	104.4	52.8	31.2
Rice with fried horse mackerel, and fresh vegetables	224.0	227.0	451.0	183.1	81.8	44.7	39.6
Rice mixed with shrimp, green peas, minced chicken and scrambled egg	197.0	149.0	346.0	111.2	71.9	64.7	12.7
Rice with baked salmon, fried chicken, baked fish and grilled vegetables	242.0	153.0	395.0	156.4	88.3	56.5	34.4
Rice with baked mackerel with grilled vegetables	199.0	225.0	424.0	156.8	72.6	46.3	85.9
Means	226.3	173.0	399.3	163.9	92.9	56.7	46.5

*Italics: Bread

of 27 meals of 9 consecutivedays. Total daily folate intake was 601.2-865.3 μg (mean; 723.9). Means for breakfast, lunch and dinner were 291.3, 220.8 and 211.8 μg , respectively. Percentages of folate taken from rice and bread (italic) were also shown in the table. Mean percentage of folate taken from rice was 29.1% (breakfast; 22.2%, lunch; 33.4%, dinner 35.0%). For comparison, calculated daily folate intakes of these hospital meals for 9 days using STFCJ were also listed. Mean daily folate intake was 359.2 μg (range; 235.5-444.2). The level was far lower than that obtained from values using our table.

As shown in Table 3, folate contents of marketing lunch boxes varied from 79.3 to 251.7 μg (mean; 163.9). Calculated daily intake is 491.7 μg . Folate contents of these 16 lunch boxes assessed using STFCJ were also listed and mean of them was 46.5 μg (range; 12.7-105.5). Calculated daily intake through these lunch boxes is 139.5 $\mu\text{g}/\text{day}$. Mean percentage

Table 4. Comparison of Folate Taken from Rice Between the Hospital Lunch and Lunch Boxes Obtained from Convenience Stores

	Mean total folate content (μg)	Folate taken from rice (μg)
Hospital lunch (n=9)	220.8 \pm 34.82	97.3 (33.4%)
Convenience store lunch boxes (n=16)	163.9 \pm 46.0*	73.0 (56.0%)

*p=0.0038

Table 5. Comparison of Folate Contents of Rice Among 3 References

Taguchi et al		STFCJ*		USFDA**	
Raw	Cooked	Raw	Cooked	Raw***	Cooked***
123.2	36.5	12.0	3.0	387.0	96.8

Values ($\mu\text{g}/100\text{g}$) *Standard Table of Food Composition in Japan

**United States Food and Drug Administration

***Enriched with folic acid

of folate taken from rice was 56.7%. As shown in Table 4, higher percentage of folate taken from rice in the lunch boxes from convenience stores may be due to lower amount of other food items than rice.

Discussion

The importance of folate intake in cancer protection was first demonstrated in oral cavity cancer (Sankaranarayanan et al., 1989) and then explored in colon cancer (Freudenheim et al., 1991, Giovannucci et al., 1995), cervical cancer (Butterworth, 1992), breast cancer (Zhang et al., 1999) and head and neck cancer (Raval et al., 2002). Recently association of polymorphism in genes of enzyme of folate metabolism and the susceptibility to esophageal and stomach cancer is suggested in Japan (Gao et al., 2004). Thus necessity for information of folate intake of Japanese is increasing.

This study revealed and re-confirmed our former assertion that the folate intake of Japanese is sufficient. The mean total folate content of hospital diet was 723.9 μg , far greater than the recommended daily intake (RDI) of the USA. Even folate amount of marketing lunch boxes (163.9 μg ; if taken 3 times) daily intake is calculated as 491.7 μg which also exceeds RDI.

Comparing the results of folate intake from the diet in western nations {277 $\mu\text{g}/\text{day}$, USA 1994-1996 (Rimm, et al., 1998), 274 $\mu\text{g}/\text{day}$, US adolescent (Cavadini et al., 2000), 200 plus-minus 73 $\mu\text{g}/\text{day}$, Ireland (Cuskelly et al., 1999), 318 $\mu\text{g}/\text{day}$, elderly German (Wolters et al., 2003), 290 $\mu\text{g}/\text{day}$, young and 268 $\mu\text{g}/\text{day}$, old Danish women (Rasmussen et al., 2000)} and other countries {200 $\mu\text{g}/\text{day}$, Hungary (Czeizel and Merhala, 1998), 86 $\mu\text{g}/\text{day}$, Mexico (Villalpando et al., 2003)}, folate intake of Japanese is quite greater. This may be the reason why folate deficiency is very rare in Japan.

In the 6th revised RDI in Japan (Research Group for

Health and Nutrition Information, 2000), RDI of folate was decided as 200 μg as it is difficult to take 400 μg through Japanese diet although RDI for pregnant women was set at 400 μg . Folate contents of hospital diet and commercially sold lunch boxes showed far lower level if calculated using STFCJ than those using our table. The main cause of this discrepancy seems to be the amount of folate in rice, the staple food in Japan, as shown in Table 5. The amount of folate in cooked rice in the table with the STFCJ is less than 1/10th of that with our table. We can not explain the reason for this difference. According to the explanation of STFCJ, the assay method for folate in food was a microbiological assay using *Lactobacillus rhamnosus* ATCC 7469 (formerly *Lactobacillus casei*), the same method as Taguchi et al. (1972, 1973). Confirmatory assays of rice using a newly established liquid chromatography method (Konings et al., 2001) are clearly warranted. Hiraoka (2001) calculated folate intake from 3 day weighed food records obtained from 156 female Japanese students aged 21-23 and concluded that only 34% of them took above 200 $\mu\text{g}/\text{day}$ (the Japanese RDI for folate). Imaeda et al. (2002) calculated daily folate intake of Japanese female dietitians and found that their folate intake was mainly from vegetables, fruit and green tea. As they used STFCJ contribution of rice may be underestimated. Tanaka et al. (2002a, 2002b) also reported mean folate intake of pregnant women as 43.5 $\mu\text{g}/\text{day}$, in spite of normal serum folate levels. Kondo et al. (2003) calculated folate intake and assayed serum folate levels on 61 normal Japanese women, 66 mothers of spina bifida children, 18 pregnant women, 32 spina bifida patients and 45 students of a nursing school and reported mean oral folate intake was 293 $\mu\text{g}/\text{day}$ and mean serum folate levels of 8.1 ng/ml. They are recommending 400 $\mu\text{g}/\text{day}$ of folate supplement to pregnant women from 4th to 12th pregnant weeks because 72% of pregnant women's folate intake during this period was below the RDI of Japan during pregnancy (400 $\mu\text{g}/\text{day}$).

All these discrepancies between the satisfactory serum folate levels and low folate intake from the diet were caused by inadequate folate contents of foods especially that of rice in STFCJ. Considering the rarity of folate deficiency among Japanese, we think the table of STFCJ may give quite erroneous information leading an unnecessary proposal that we should also enrich rice with folate in Japan. We strongly recommend a revision of the STFCJ for folate contents of Japanese foods.

As shown in Tables 2, 3, 4, the primary characteristic of the Japanese diet is a very high percentage of rice as the staple diet. About one third (hospital diet) to 56.7% (lunch boxes sold at convenience stores) of the daily folate was obtained from rice. Indeed from our calculations, 210 μg (hospital diet) and 271.3 μg (lunch boxes) of folate were taken only from rice. The actual folate intake in the Japanese diet obviously exceeds this basic level due to rice because of the consumption of extra foods such as fish and vegetables, meaning at least a doubling. We therefore propose that there is no need to supplement rice or other cereals with folic acid in Japan.

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