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OXALATE CONTENT IN COMMON JAPANESE FOODS

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The radioenzymatic method was used to determine the oxalate contents in common Japanese foods. High concentrations of oxalate were detected in spinach, *Perilla frutescens*, pepper, sesame, chocolate, and tea. Beer and coffee also contained some oxalate. Fruit and meat were low in oxalate content. Therefore, among the common Japanese foods, the most important foods to be avoided to restrict oxalate intake are chocolate, tea, and spinach.

Key words: Oxalate, Ca, Mg, P, Japanese foods

INTRODUCTION

Oxalate is well known to exert a very important effect on urinary-oxalate supersaturation. There are a variety of factors which influence the urinary concentration of oxalate. The quantity of oxalate in the diet is one factor; absorption increases urinary excretion[1,2]. The calcium (Ca) present in food interferes with the absorption of oxalate, and vice versa. Dietary carbohydrate, vitamin C, and glycine have been studied as means of increasing urinary-oxalate excretion[3]. Urinary-oxalate excretion reaches its peak around noon, with some increase after each meal[4]; this suggests that diet is closely related to urinary-oxalate excretion.

It is important to understand the oxalate contents of the Japanese diet in order to decrease urinary oxalate excretion in stone-formers. However, there is some difficulty in determining the oxalate content in foods accurately because the quantity varies with the time and place of harvest. However, it is not always necessary to know the exact value; just a general determination of some foods which contain much oxalate will help in avoiding high-oxalate diets. Also, dietary calcium (Ca), magnesium (Mg) and phosphorus (P) all play at least some role in calcium-oxalate stone-formation and so are of interest in understanding stone-formation and in treating stone-formers. Therefore, we measured the oxalate, Ca, Mg, and P in common Japanese foods.

MATERIALS AND METHODS

The standard solutions of Ca and Mg for atomic absorption spectroscopy were purchased from Kanto Chemicals, Ltd. while the standard solution of P was specially made by the same company. The other chemicals were obtained from Wako Pure Chemicals, Ltd. The oxalate decarboxylase (Sigma Chemicals Co.) had a specific activity of 2.68 Unit/mg protein (lot 119 C-6820). The [^{14}C] oxalic acid was obtained from RCC Amersham.

Three-gram portions of cooked or raw solid materials were homogenized in 15 ml of 3 M HCl by means of an ultrasonic disintegrator, and 2 ml of the supernatant was used for oxalate determination by means of a radioenzymatic assay[5]. As for liquids, 3-ml portions of beverages were mixed with 15 ml of 3 M HCl; 2 ml of its supernatants was diluted 100-fold, and the Ca, Mg, and P were then measured by ICP-spectroscopy[6] (Jarrell-Ash Plasma Atom Comp Direct-Reading Spectrometer Systems).

RESULTS

High concentrations of oxalate were

Table 1. Oxalic acid, Ca, Mg and P contents of foods (mg/100 g)

Fruit	Oxalic acid	Ca	Mg	P
Apple	ND	79.4	4.6	77.3
Avocado	8.6	44.4	35.2	46.7
Banana	8.9	26.7	28.5	16.7
Grapefruit	2.0	36.8	16.2	ND
Iyokan orange	17.7	59.4	17.5	26.6
Jujube	63.9	113.4	69.6	81.6
Kiwi fruit	19.7	47.9	14.5	27.8
Lemon	46.5	128.3	12.8	0.3
Mango	14.1	40.2	15.0	0.3
Muskmelon	1.9	37.4	20.3	19.7
Papaya	3.1	68.4	57.3	5.7
Pear	ND	74.9	8.8	86.0
Persimmon	17.0	82.8	6.4	84.5
Strawberry	23.4	41.4	17.8	23.4
Tangerine	4.4	87.6	11.8	77.7

detected in spinach, *Perilla frutescens* (beefsteak plant), pepper, sesame, chocolate, and tea. Generally, green vegetables were rich in oxalate. The oxalate concentrations in fruit, fish, and meat were low. The concentrations of oxalate, Ca, Mg, and P in various Japanese foods are shown in Table 1~5. The oxalate concentrations of the foods analysed were in agreement with previous reports[7~11].

DISCUSSION

High concentrations of oxalate were found in spinach, chocolate, pepper, sesame, and tea. In spinach, the Ca content is lower than the oxalate content when it is eaten in a low-Ca diet. It is, therefore, wise to garnish spinach with small fish or dried bonito when preparing it Japanese style, and to cook the spinach with milk when preparing it Western style. Plain chocolate is also rich in oxalate, with a relatively small amount of Ca; milk chocolate is, therefore, recommended for stone-formers, though special care must be taken not to eat even that after a fast. It is not common to take excessive amounts of pepper and sesame, but on some festival occasions rice dumplings covered with sesame or bean flour are served. Green pepper does not contain very much oxalate. One of the most common beverages in Japan is green tea, which contains a rather high amount of oxalate. It is also wise to serve black tea with milk and to serve cake before drinking strong tea at a Japanese tea ceremony; these practices may decrease oxalate absorption. However, most Japanese people love to drink green tea without any milk or any cake, and some urologists encourage stone-formers to drink tea. The oxalate concentration in green tea, 100 mg/dl, is relatively high compared with that in urine, though; if this amount is completely absorbed in an empty stomach, it is likely to do some harm. It is perhaps no coincidence that the two prefectures in Japan (Kyoto-fu and Shizuoka-ken) which are famous for tea-leaf production have been reported to have an unusually high incidence of urinary stones[12]. Black coffee also has a rather high oxalate content. Therefore, it is recommended that tea and coffee be taken with milk rather than without milk. That is, the net oxalate content, which consists of the gross oxalate content minus the calcium content

Table 2. Oxalic acid, Ca, Mg and P contents of foods (mg/100 g)

Vegetables	Oxalic acid	Ca	Mg	P
Asparagus	14.6	50.0	25.2	133.4
Bamboo sprout	49.0	39.7	4.5	10.2
Beefsteak plant	154.5	272.9	77.2	140.3
Beans (adzuki, cooked)	4.7	49.4	28.2	69.8
(broad)	7.5	103.0	28.3	148.9
(kidney)	45.6	104.2	21.7	114.8
(soybean, fermented)	38.3	75.7	60.4	117.8
(soybean, flour)	101.5	294.7	334.0	673.2
(soybean, curd)	20.8	154.9	29.8	98.8
Bean sprouts	7.2	88.6	9.5	99.7
Bracken	4.9	40.9	10.1	9.4
Burdock	39.0	171.6	56.5	72.1
Cabbage	2.2	79.9	20.3	90.7
Chinese cabbage	2.3	116.4	11.7	114.0
Carrot	48.5	87.2	14.4	112.0
Cauliflower	4.5	114.5	15.6	123.9
Celery	35.0	43.0	17.4	42.6
Chestnut	1.6	88.6	40.1	129.2
Corn	12.3	28.5	27.8	69.0
Cucumber	1.4	75.8	11.7	91.1
Devil's tougue	10.9	95.1	9.1	8.0
Eggplant	15.3	76.3	13.4	95.0
Fern	1.7	41.4	10.8	12.3
Gourd (dried, shavings)	20.6	222.2	88.3	174.2
Lettuce	2.0	89.9	6.7	76.7
Lotus	22.9	41.6	16.8	63.4

and which is available to be absorbed, should be decreased as much as possible at each meal and at tea time.

There are not many fruits which have a net oxalate content exceeding the urinary oxalate concentration. However, one question which remains to be solved is whether fruit intake really decreases urinary oxalate, through its high content of vitamin C. Recently, Harris and Richardson reported that glycolate plays an important role in increasing urinary oxalate. Their experiment using rats fed with [1−^{14}C] glycolate showed that glycolate is readily absorbed from the digestive tract, and [1−^{14}C] oxalate was recovered from the urine. Significant amounts of glycolate were found in common foods, and they recommended that restricting the intake of glycolate may be beneficial for stoneformers[13]. Quite recently we also confirmed their results by a preliminary experiment in which rats fed with a 3% glycolate diet formed stones in the kidney, while rats fed with a 3% oxalate or a control diet did not form any stones. It would take a more complex study to list all the food contents which may be metabolized to oxalate, such as carbohydrates, vitamin C, glycine, glycolate, and glyoxylate. However, in this communication attention has been paid especially to the net oxalate content, with some reference to the Mg and P contents.

In conclusion, there are several food materials which contain much oxalate

Table 3. Oxalic acid, Ca, Mg and P contents of foods (mg/100 g)

Vegetables	Oxalic acid	Ca	Mg	P
Mushroom (edible fungus)	2.0	29.2	10.0	38.9
(enokidake)	23.4	21.8	20.6	106.7
(Jew's ear)	9.5	33.7	10.9	17.1
(shiitake)	3.9	25.3	15.1	26.7
(shimeji)	11.0	17.7	19.6	170.7
Okra	49.8	99.5	44.2	58.4
Onion	7.3	40.7	9.0	19.5
(spring)	10.8	32.0	9.0	25.3
(eshalot)	11.6	37.3	16.6	25.6
Parsley	41.8	75.2	18.7	17.9
Pepper (green)	18.1	28.6	16.1	25.3
Pea (field)	41.3	103.3	34.6	154.5
Potato	23.7	45.3	21.6	50.2
(sweet)	21.5	94.5	26.1	120.7
(taro)	3.1	34.4	16.3	35.1
(yam)	7.8	41.0	28.3	28.8
Pumpkin	4.9	82.2	19.9	112.9
Radish (Japanese)	4.6	47.4	10.8	13.9
Spinach	362.1	106.6	46.6	110.7
Turnip	4.3	120.9	22.6	103.6
Yeast plant	18.1	77.5	118.4	622.2

and which should thus be restricted in the diets of stone-formers. In order to decrease the urinary oxalate excretion, efforts should be made to neutralize oxalate by Ca in order to decrease absorption from the digestive tract and also to avoid taking in excessive amounts of Ca.

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Table 4. Oxalic acid, Ca, Mg and P contents of foods (mg/100 g)

Spice and seasoning	Oxalic acid	Ca	Mg	P
Garlic	5.4	31.2	11.0	63.9
Ginger	69.4	71.3	18.2	83.6
Hamburger relish	5.6	78.7	18.3	23.6
Horseradish (Japanese)	3.0	192.4	67.2	109.8
Miso	9.8	78.3	61.2	143.6
Moromiso	19.7	62.8	60.7	128.9
Mustard	5.6	78.7	18.3	23.6
Pepper (red)	1112.4	1403.1	476.6	362.6
Sesame (black)	887.9	1305.0	303.5	528.3
(white)	708.8	1024.2	316.5	615.6
Seaweed				
Laver	61.3	139.4	177.1	303.7
Scraped tangle	22.2	945.7	529.7	131.7
Sea tangle	21.3	599.6	599.5	215.9
Wakame seaweed	7.5	107.5	82.3	2.8
Cereals and confections				
Agar	143.3	785.2	204.6	27.0
Bread	20.0	50.5	25.5	67.4
Chocolate	167.4	202.5	139.6	208.3
Jelly	5.9	77.6	7.7	1.6
Noodle (soba)	25.1	42.5	43.8	80.5
(Japanese)	6.7	21.0	5.8	8.8
Rice (cooked)	8.2	38.0	9.1	19.3
(glutinous)	11.5	39.1	41.6	118.7
Spaghetti	14.9	39.0	19.8	44.1

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Table 5. Oxalic acid, Ca, Mg and P contents of foods (mg/100 g)

Egg, fish & meat	Oxalic acid	Ca	Mg	P
Beaf	9.6	29.7	21.8	144.2
Chicken	5.9	59.9	20.1	104.6
Chicken liver	7.4	33.2	17.2	107.3
Cod roe	20.0	40.7	25.6	305.5
Bonito (cooked)	6.8	74.9	37.9	130.4
(dried)	ND	34.4	18.8	108.1
Egg white (fried)	10.1	168.4	14.5	40.4
Egg yoke (fried)	17.5	59.1	15.3	15.1
Lard	ND	24.2	4.6	9.6
Squid (smoked)	3.8	28.7	44.1	233.1
Beverages				
Cocoa (powder)	51.5	57.0	64.6	77.9
Coffee beans	55.5	180.0	246.0	182.3
Tea leaves (and brown rice)	151.1	228.3	83.2	112.2
(Ceylon)	285.5	336.7	151.4	130.2
(Jasmine)	321.6	234.8	145.4	117.8
(Green)	447.3	238.7	137.8	210.2
(mg/dl)				
Beer	3.0	7.6	42.2	123.2
Calpis	6.2	127.7	48.5	138.7
Coffee	6.5	47.5	88.3	65.5
Coca-Cola	ND	36.9	8.7	110.2
Sake	2.6	0.4	20.1	39.6
Tea (green)	27.5	15.4	13.8	11.5
(Ceylon)	48.5	19.9	12.9	4.9

和文抄録

食物中の蓚酸含有量の測定

順天堂大学医学部泌尿器科学教室（主任：北川龍一教授）
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本邦における通常の食卓で用いられる食物中の蓚酸含有量を radioenzyme 法を用いて測定した．高蓚酸食物としてはほうれんそう，紫蘇，唐辛子，胡麻，チョコレートとお茶であった．ビールおよびコーヒーも相当量の蓚酸を含んでいた。果物および肉類の蓚酸含有量は少なかった。われわれの結果によると本邦における食物を用いて低蓚酸食を作る場合に，注目すべきものとしてはチョコレート，お茶とほうれんそうである．