



Comparison of Oxalate Content in Foods and Beverages in Taiwan

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Calcium oxalate is the most-frequently found component of uroliths in Taiwan as well as in the world. Some studies have shown that only 10%~20% of urinary oxalate is derived from food intake, but others have indicated that dietary oxalate has a much higher contribution than previously recognized.

In the present study, we analyzed oxalate contents of foods and beverages that are common in Taiwan. Some of our materials are unique to the Taiwan area. Although most of the materials can be found elsewhere in the world, some are indigenous to this region. The results showed that Chinese *Pennisetum* powder (and juice), spinach, amaranthus, carambola, *Anredera cordifolia* Moq, *Basella rubra*, sweet potato leaves and bitter melon have high oxalate contents.

For patients with oxalate stones or renal failure, proper restrictions of such high-oxalate foods are recommended. (JTUA 16:93-9, 2005)

Key words: urolithiasis, oxalate, food analysis.

INTRODUCTION

Calcium oxalate is the most-frequently found component of uroliths in Taiwan [1]. Hyperoxaluria is a primary risk factor in calcium oxalate stone formation. Elevated oxalate excretion can result from increased dietary intake of oxalate, increased intestinal absorption of oxalate from the diet, and increased endogenous production of oxalate from ingested or metabolically generated precursors.

Urinary oxalate is thought to be derived from 3 sources: 40%~50% is derived from glycine in the hepatic system, 40%~50% is derived from the breakdown of ascorbic acid in the body, and the remaining 10%~20% is from diet [2]. One study showed that glycine was an ineffective source of glyoxylate, and a high glycine concentration was required to obtain detectable synthesis in vitro [3].

Oxalate that a human body absorbs from food was once thought to be an insignificant contributor to urinary oxalate excretion. However, a recent study indicated that dietary oxalate can provide up to 80% of the oxalate excreted [4]. Some risk factors for stone disease are associated with a low calcium intake, and dietary oxalate is believed to be an important contributing factor [5]. Dietary oxalate makes a much greater contribution to urinary oxalate excretion than previously recognized [6].

Current educational pamphlets on the prevention of calcium oxalate stones are incomplete due to a lack of quantitative information on oxalate content of local foods and beverages – especially those that are unique to Taiwan. The present study was aimed at measuring the oxalate content of a wide range of foods and beverage that are common in Taiwan. The results of this study can be used to provide accurate information for the education of urolithiasis patients.

Received: April 29, 2005

Revised: June 9, 2005

Accepted: July 1, 2005

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Table 1. Foods with an oxalate content exceeding 10 mg/100 g of the edible portion

Food	Source	Oxalate content(mg/100 g)	食品名稱
Chinese <i>Pennisetum</i> powder	Dry powder	1575	牧草粉
Green tea powder	Dry powder	630	綠茶粉
Spinach (<i>Spinacia oleracea</i>)	Fresh	412	菠菜
Amaranthus	Fresh	280.62	莧菜
Carambola	Fresh	263.34	楊桃
<i>Anredera cordifolia</i> Moq.	Fresh	231.3	川七
<i>Amaranthus tricolor</i>	Fresh	131.4	紅莧菜
<i>Basella rubra</i>	Fresh	141.21	皇宮菜
Chinese <i>Pennisetum</i> juice	Market	122.13	牧草汁
Mountain bitter melon	Market	60.21	山苦瓜
Sweet potato leaves (<i>Ipomoea batatas</i> (L.) Lam)	Fresh	48.6	蕃薯葉
Fu chai	Market	46.8	福菜
Balsam pear	Market	26.631	白苦瓜
Wild lotus	Market	20.88	野蓮
Star fruit juice	Pack 10%	20.88	楊桃汁
Okra	Fresh	20.547	洋角豆
Green skin balsam pear	Fresh	11.88	綠苦瓜
Soy milk	Pack	10.89	豆漿原汁
Almond tea	Dry powder	10.71	杏仁茶

MATERIALS AND METHODS

Foods and beverages were obtained from markets in the Kaohsiung area, southwestern Taiwan, and all the materials that were tested are listed in Tables 1~3. Ascorbic acid (1 mM) was used as a control to determine if it interferes with the oxalate measurement.

According to the different textures of the materials, foods and beverages were processed in different ways: beverages were diluted based on a priori knowledge of their oxalate contents. Solid food was crushed into a pulp with a vegetable grinder. The pulp was then made into juice with distilled water and was homogenized with a glass tissue homogenizer.

The oxalate kit made by Trinity Biotech (Wicklow, Ireland) was then used to measure the oxalate concentration of each sample. Before measuring, the pH value of each sample was adjusted to between 5 and 7 using either 1 N of an HCl or NaOH solution. All of the samples were diluted with a diluent which contained EDTA for the purpose of chelating calcium within the sample. Diluted samples were purified with sample-purifying tubes which contained activated charcoal. After centrifuging samples in sample-purifying tubes, the supernatant was collected via filtering through filter pa-

per. Fifty microliters of purified supernatant was added into 1 ml of reagent A and then 200 μ l reagent B was added. The O.D. value at a wavelength of 590 nm was then measured. The oxalate concentration was calculated by multiplying of the dilution factor with the reading obtained by comparing the measured O.D. value with that of a standard solution (1 or 0.5 mmol standard solution of oxalate). If the initial O.D. ratio exceeded that of the 1 mmol oxalate standard solution, the sample was further diluted and the measurement was redone. The process was repeated until the reading was within range. The calcium measurement was performed on foods with high oxalate contents in a biochemistry lab.

RESULTS

In our measurements, the O.D. ratio of 1 mM ascorbic acid was invariably near 0 and thus it is safe to say that the food ascorbic acid did not interfere with the oxalate reading. The results are listed in Tables 1~3. We also measured the calcium contents of such high-oxalate foods as those listed in Table 1. However, none of the foods was found to have any detectable amounts of calcium.

Table 2. Foods with oxalate contents of 1~10 mg/100 g

Food	Source	Oxalate content (mg/100 g)	食品名稱
Leek flower	Fresh	9.63	韭菜花
Celery	Fresh	9.504	芹菜
<i>Hylocereus polyrhizus</i> (Weber) Britt. & Rose	Fresh	8.532	紅龍果
Vegetable sponge (luffa)	Fresh	7.866	菜瓜
Chayote leaves	Fresh	6.03	龍鬚菜
Lotus root	Fresh	5.6691	蓮藕
Black tea	Pack	4.824	紅茶
Green tea	Pack	4.59	綠茶
Hotbed chives	Fresh	4.05	韭黃
Lemon grass green tea	Tea bag	3.78	檸檬綠茅綠茶
Bird's-nest fern (<i>Asplenium nidus</i>)	Fresh	3.591	山蘇
Eggplant (<i>Solanum melongena</i>)	Fresh	3.51	茄子
Herbal tea	Market	3.375	青草茶
Wax gourd (<i>Benincasa hispida</i>)	Fresh	2.7	冬瓜
Chinese yam (<i>Rhizoma dioscoreae</i>)	Fresh	2.691	山藥
Stone tea	Market	2.601	化石草
Papaya	Fresh	2.025	木瓜
Bitter tea	Market	2.33	苦茶
Lemon Grass	Tea bag	1.7	檸檬香茅
Pure wheatgrass juice	Market	1.70	小麥草原汁
Malt	Bottle	1.6	黑麥汁
Mixed Carrot Juice	Pack	1.50	果菜汁-波蜜
Passionfruit	Fresh	1.0	百香果

DISCUSSION

Little information on the oxalate content in foods is available to urologists and the general public in Taiwan. When it comes to oxalate, only spinach and sugar beets are commonly cited; although the former is a widely consumed vegetable, the latter is not commonly available in Taiwan.

High oxalate content in pasture grass was first reported in 1976 [7]. Recently, Chinese *Pennisetum alopecuroides* juice has gained popularity in Taiwan as an organic, natural food while in reality it is a pasture forage crop for cattle. Due to its organic nature, it is advocated as a health food; it is sold as a pure juice or as dried powder in drug stores and health food stores. The problem with this highly purified product – either the juice or dry powder – is its high content of oxalate. In our study, the oxalate content in dry powder was as high as 1.6%. Freshly prepared pure juice is available in markets. Drinking a glass of 500 ml of pure juice is equivalent to an intake of 600 mg of oxalate at one time. This is too high by any standard. For safer consumption, it is recommended that one either liberally dilute the

juice or take a smaller quantity each time. Another shortcoming of this food is its low calcium content. Because of this, the oxalate will not form insoluble calcium compounds, and thus it is easily absorbed in the gastrointestinal tract. As a result, oxalate intoxication may occur, especially in the case of a fasting individual taking large quantities of the juice. Recently, oxalate intoxication cases have been reported in newspapers and among our patients.

The second-highest oxalate content in the present study was found in green tea powder. If diluted 100-fold, its oxalate content is 0.6 mg/100 ml, about the same as commercially packaged green tea or black tea. For patients with calcium oxalate stones, it is unsafe to drink green tea powder without adequate dilution.

Spinach (*Spinacia oleracea*) is a well-known high-oxalate vegetable; it belongs to the family Chenopodiaceae. Another well-known high-oxalate food in this family is sugar beet (*Beta vulgaris*). Both of them are widely consumed by people [8] worldwide, although sugar beet is rarely seen in Taiwan.

Many vegetables from the family Amaranthaceae are high in oxalate content. “Amaranth” is used as a general term for all members of the plant genus

Table 3. Foods with oxalate contents below 1 mg/100 g

Food	Source	Oxalate content (mg/100 g)	食品名稱
Tangerine	Fresh	0.765	金桔原汁
Roselle	Tea bag	0.6894	洛神汁
Cucumber (<i>Cumis sativus</i>)	Fresh	0.45	大黃瓜
Cactus juice	Pack	0.27	仙人掌茶
White radish	Fresh	0.135	白蘿蔔
Rape (<i>Brassica campestris</i>)	Fresh	0.1	小松油菜
Mustard green	Fresh	0.1	芥菜
Coconut juice	Fresh	0.040	椰汁
Rye juice	Bottle	0	黑麥汁
Calabash gourd (<i>Lagenaria sicerariae</i>)	Fresh	0	葫瓜

Amaranthus (family Amaranthaceae). The leaves and seeds of *Amaranthus* species are edible. Both *Amaranthus* (莧菜) and *Amaranthus tricolor* (紅莧菜) are high in oxalate content, and they are similar in appearance; the difference between them is that *tricolor* has purplish leaves. Recent reports showed that *Amaranthus* can reduce calcium absorption in rice-based diets due to its high oxalate content [9]. For urolithiasis and osteoporosis patients, intake of such foods should be restricted.

Carambola (*Averrhoa carambola*) is locally known as star fruit. The fruit can induce seizures in uremic patients due to oxalate intoxication and many cases have been reported in the Taiwan area [10]. One of our patients developed acute renal failure after drinking more than 2 L of homemade carambola juice at once. Electron microscopy of the renal biopsy showed oxalate crystal deposition in the renal tubules. As a side experiment, we induced oxalate crystals in rats that were given carambola juice as a source of drinking water. A high oxalate content was also found in commercial star fruit drinks which are popular in Taiwan. For patients with chronic renal failure or those who are receiving hemodialysis, the intake of star fruit should be kept to a minimum.

We have also found that plants in family Basellaceae (落葵科) contain high oxalate. The highest one was *Anredera cordifolia* Moq. (落葵薯屬, 川七), which is known to be an important ingredient in the famous powdered medicine, *Yunnan Bai Yao*, and is used to stop bleeding. Its tender leaves are used as a vegetable. The leaf also contains moderately high oxalate. But as the leaves are light weight, the amount ingested in a typical meal is low. The second-highest oxalate content in this group is Ceylon spinach or Malabar spinach (*Basella rubra*, 落葵, 皇宮菜). It should be noted that in spite of its English name, it does not belong to the spinach family.

Some of our study materials belong to the family Cucurbitaceae. In this family, only bitter melon (*Mo-*

mordica charantia L. 苦瓜) showed high oxalate content. As a traditional Chinese herbal medicine, bitter melon is thought to be able to reduce hot sensations and promote the appetite in summer. It is sometimes used as an antidote to certain kinds of poison according to traditional Chinese medical concepts. Pure bitter melon juice is popular in summer; it is made by grinding the melon and adding honey (not water). A 500 ml glass of bitter melon juice contains up to 130 mg of oxalate. The oxalate content in a wild variety of bitter melon (*Momordica charantia* L. var. *abbreviata* Seringe 山苦瓜) was found to be 3 times higher. Because of the bitterness, the melon is seldom sold in the form of pure vegetable juice. Another type of bitter melon is green skin bitter melon. As the name suggests, it has a green color skin, and its oxalate content is only half that of regular bitter melon. Other vegetables in the family Cucurbitaceae do not have high oxalate contents; they include vegetable sponge (*Luffa aegyptiaca* P. Mill.), wax gourd (*Benincasa hispida*), chayote leaves (*Sechium edule* [Jacq.] Sw.), garden cucumber (*Cucumis sativus* L.), and calabash gourd (*Lagenaria siceraria* [Molina] Standl.).

Sweet potato belongs to the family Convolvulaceae; its root is used as a common staple food in Taiwan and its leaves as a vegetable. The leaf used to have a bitter taste, but after years of breeding improvement it is now a popular dish on the dinner table. The oxalate content of sweet potato leaf was found to be 48.6 mg/100 g. For urolithiasis patients, intake of this vegetable should be restricted.

Heart-shaped, false pickerelweed (*Monochoria vaginalis* [Burm. f.] K. Presl ex Kunth) is known as *Fu Chai* (福菜) in southern Taiwan. In the past this water plant was used as fodder for geese and ducks. Recently it has become a favored item in Hakkaness cuisine. Its oxalate content was found to be 46.8 mg/100 g. Another water plant well known for its high content of oxalate is water lettuce (*Pistia stratiotes*). This plant contains large

quantities of calcium oxalate crystals in special cells called crystal idioblasts [11]. It is not suitable for human consumption.

A bitter taste of a substance does not always imply a high oxalate content. In spite of its taste, bitter tea is thought to be capable of neutralizing hepatic toxins, and yet it does not contain high oxalate. Tea beverages that are sold in supermarkets and convenience stores have oxalate contents of about 5 mg/dl. Black tea and green tea have similar oxalate contents. However, the tea leaf itself has a relatively high oxalate content. The tea made at home by pouring hot water on tea leaves has much higher oxalate content than its commercial counterpart, several-folds higher in some cases. Since tea-drinking is an everyday thing in Taiwanese and Chinese culture, its impact on oxalate calcium stone formation is an area that deserves further investigation. For patients who need to restrict their intake of oxalate, we recommend replacing tea with plain water.

Lemon grass has gained popularity in recent years; it is presented to consumers in the form of lemon grass green tea. In our study, pure lemon grass itself is low in oxalate when compared with the commercial product.

Another organic food which looks similar to Chinese *Pennisetum* juice is wheatgrass juice. Its commercial form is the pure juice itself. It is relatively low in oxalate content – about 1/3 that of commercial tea preparations. Imported organic rye juice (黑麥汁) packaged in bottles has only a trace of oxalate.

Beside oxalate stone formation, high oxalate intake has other effects on human beings. Small doses of oxalate in the body may cause headaches, pain and twitching in muscles, and cramps [12]. Larger doses can cause a weak and irregular heartbeat, a drop in blood pressure, and signs of heart failure [13]. Large doses of oxalate can rapidly put a person in a shock-like state, causing convulsions, coma, and possibly death. The mean lethal dose for an adult is about 15 to 30 g, but the lowest reported lethal dose is only 5 g (or about 70 mg/kg) [14]. A delayed effect of oxalate ingestion is kidney damage, which can lead to renal failure due to deposition of calcium oxalate crystals [15].

CONCLUSIONS

In the present study, we measured the oxalate content of various local foods and beverages. It was found that several kinds of foods and beverages that are indigenous to Taiwan have high oxalate contents. We hope the data obtained herein can help urologists to instruct the public on urolithiasis prevention.

ACKNOWLEDGEMENTS

This research was supported by a grant (VGHKS 91-101) from Kaohsiung Veterans General Hospital. The paper was reviewed by Hsiu-Hua Huang from the Clinical Nutrition Section, Kaohsiung Veterans General Hospital, and the English was corrected by Dr. Liang-Bee Lin.

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