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EXPERIMENTAL STUDY

Oxalate contents of commonly used Chinese medicinal herbs

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James Huang, Chris Huang, University of California at Berkeley, Berkeley 94720, United States of America**Michael Liebman**, Department of Family and Consumer Sciences, University of Wyoming, Laramie 82072, United States of America**Correspondence to: Prof. Michael Liebman**, Department of Family and Consumer Sciences, University of Wyoming, Laramie 82072, United States of America. Liebman@uwyo.edu**Telephone:** +1-307-399-9519; +1-307-766-5597**Accepted:** October 16, 2014**Abstract****OBJECTIVE:** To assess the total and soluble oxalate contents of commonly used Chinese medicinal herbs.**METHODS:** Twenty-two Chinese medicinal herbs were extracted in both acid and water prior to determination of total and soluble oxalate, respectively. Oxalate was assayed in herbal extracts using a well-established enzymatic procedure.**RESULTS:** Among the 22 medicinal herbs, there was significant variation in oxalate content; *Houttuynia cordata* contained the highest amount of soluble oxalate (2146 mg/100 g) and *Selaginella doederleinii* contained the lowest amount (71 mg/100 g).**CONCLUSION:** The results indicated that different Chinese medicinal herbs, even from the same family, contain significantly different amounts of oxalate. In susceptible individuals, the use of medicinal herbs with the highest oxalate contents could increase risk of kidney stone formation.**Key words:** Drugs, Chinese herbal; Oxalates; Kidney calculi**INTRODUCTION**

Oxalate is a naturally occurring substance found in plants and in the human body.¹ In chemical terms, oxalate belongs to a group of molecules called organic acids. Certain body tissues routinely convert other substances into oxalate, which is an end product of human metabolism. For example, vitamin C can be converted into oxalate. In addition to its endogenous synthesis, oxalate can also be absorbed into the body from various food sources.¹ For example, fruits and vegetables such as kiwi, olives, beet greens, parsley, rhubarb, spinach, and Swiss chard are foods high in oxalate; others include wheat bran, almonds, cashews, sesame seeds, and foods which contain cocoa powder² (Liebman, unpublished data). It is interesting to note that the leaves of a plant usually contain higher oxalate levels than its roots, stems, and stalks.

Several recent studies have reported the oxalate contents of a variety of foods.^{2,3} Grain-based flours are moderate sources of oxalate, with values ranging from 37 mg/100 g for brown rice flour to 269 mg/100 g for buckwheat flour. The range of total oxalate for nuts is 42 to 469 mg/100 g and for legumes is 4 to 80 mg/100 g of cooked weight.² Plant tissues contain soluble oxalate sources such as sodium and potassium oxalate and insoluble oxalate salts such as calcium and magnesium oxalate.¹ The efficiency of oxalate absorption is an important determinant of whether the consumption of a particular food significantly increases urinary oxalate excretion. The type of oxalate salt present in food may be important because soluble oxalate appears to be more bio-available than insoluble oxalate.^{1,4}

Chinese medicinal herbs have long been used for thousands of years to treat a variety of diseases. Each medicinal herb has its own specific function. Some medicinal herbs come from stems only and others are from both

leaves and stems. In the present study, we summarized the functions of 22 Chinese medicinal herbs that are commonly used by Chinese medical doctors to treat patients (where applicable, we indicate the comparable over-the-counter drug that can be purchased at a regular pharmacy). These 22 medicinal herbs are commonly used to cure a variety of problems, such as typical cough, head cold, pain, fever, skin diseases, high blood pressure, mucus, jaundice, diarrhea, poison ivy, and poison oak, and in some cases may be used to prevent or help treat cancer and heart disease. Chinese medicinal herbs are typically used in a 3:1 ratio; that is, patients cook herbs with three cups of water until one cup of the herbal water remains, which is then drunk. As food oxalate content is a predictor of urinary oxalate excretion, which in turn has been directly linked to kidney stone formation,^{1,5,6} the objective of this study was to assess the total and soluble oxalate content of typical Chinese medicinal herbs. We assumed that different Chinese medicinal herbs from the same families would contain very different amounts of soluble and insoluble oxalate.

METHODS

Twenty-two commonly used Chinese medicinal herbs were selected for this study, including *Perilla frutescens*, *Nelumbo nucifera*, *Hedyotis diffusa*, *Heliotropium peruvianum*, *Siegesbeckia orientalis*, *Glechoma hederacea*, *Eupatorium cannabinum*, *Scutellaria barbata*, *Orthosiphon spiralis*, *Houttuynia cordata*, *Selaginella doederleinii*, *Plantago asiatica*, *Eclipta prostrata* (Linn.), *Leonurus artemisia*, *Folium Eriobotryae*, *Agastache*, *Schizonepeta*, *Folium Isatidis*, *Hypericum sampsonii*, *Taraxacum officinale*, *Artemisia indica*, and *Mentha arvensis*. These medicinal herbs were obtained from Hung Kuo Shin Medicinal Herb, Inc. (Taiwan, China).

The 22 Chinese medicinal herbs were first ground to a fine power using a coffee grinder. Then, 0.5 g of ground, dry herb was placed into a 250-mL flask; 50 mL of HCL was then added to one set of weighed samples and 50 mL of distilled de-ionized water added to another set of samples. Extraction in acid yielded an estimate of total oxalate, whereas extraction in water yielded an estimate of soluble oxalate. Flasks were placed in an 80 °C shaking water bath for 30 min after which 50 mL of distilled ionized water was added to the solutions and mixed by swirling. Approximately 10 mL of the solutions were transferred into a 15-mL centrifuge tube. The samples were then centrifuged at approximately centrifugal force of $1778 \times g$ for 10 min and filtered with Whatman filter paper #1 into storage containers. The oxalate contents of all samples were determined by an enzymatic procedure using an oxalate kit (Trinity Biotech, Jamestown, NY, USA). In this procedure, oxalate is oxidized to carbon dioxide and hydrogen perox-

ide by oxalate oxidase. The hydrogen peroxide then reacts with 3-methyl-2-benzothiazolinone hydrazone (MBTH) and 3-(dimethylamino) benzoic acid (DMAB) in the presence of peroxidase to yield an indamine dye that has an absorbance maximum at 590 nm. The following procedure was used:

Sample preparation: a 1.0-mL volume of herbal extracts was pipetted into labeled glass culture tubes. A 1.0-mL volume of sample diluent (containing Ethylenediaminetetraacetic acid (EDTA) and a 7.6 pH buffer) was pipetted into the glass culture tubes containing the herbal extract and mixed using a vortex. pH levels outside of the range 5.0-7.0 were adjusted to this range using 5.0 N NaOH. The diluted herbal extracts were poured into labeled sample purifier tubes (containing activated charcoal). Each tube was vortexed for a few seconds and then placed in a metal rack mounted on a shaker and mixed for 5 min. The tubes were then centrifuged for 10 min at approximately a centrifugal force of $1178 \times g$. Using a Pasteur pipette, an aliquot of the clear supernatants (at least 100 μ L) was transferred from the purifier tubes into labeled microcentrifuge vials.

Oxalate determination: reagents A and B were allowed to reach room temperature. Reagent A contained DMAB (3.2 mmol/L), MBTH (0.22 mmol/L), and buffer (pH 3.1). Reagent B contained oxalate oxidase (Barley, 3000 u/L) and peroxidase (horseradish, 100 u/L). A 10- μ L volume of de-ionized water (for the blank), oxalate standard, or the herbal extract supernatants were pipetted to predesignated wells in the microplate. A total of 200 μ L of reagent A and 20 μ L of reagent B were pipetted into each well and mixed by gently tapping one side of the microplate. After 5 min, the absorbance was read at 590 nm using a microplate reader (Model EL 311, Bio-Tek Instruments, Winooski, Vermont).

RESULTS

The functions of the 22 medicinal herbs are summarized in Table 1 and their average total and soluble oxalate contents are shown in Table 2. Among all 22 medicinal herbs, *Nelumbo nucifera* (Number 2 in the tables), *Houttuynia cordata* (10), and *Folium Eriobotryae* (15) contained the highest total oxalate levels. *Houttuynia cordata* and *Eclipta prostrata* Linn. (13) contained the highest soluble oxalate levels. *Houttuynia cordata* contained the highest total and soluble oxalate levels (3204 and 2146 mg/100 g, respectively), and *Selaginella doederleinii* (11) contained the lowest levels of total and soluble oxalate (165 and 71 mg/100 g, respectively).

DISCUSSION

Twenty-two commonly used Chinese medicinal herbs were analyzed to determine their total and soluble oxalate contents. These herbs are used to treat typical prob-

Table 1 Functions of each Chinese medicinal herb⁷⁻²³

No.	Name	Function	Over-the-Counter Drugs
1	<i>Perilla frutescens</i>	A. Uses: head cold, pain relief, coughing, anti gas, salad dressing and seasonings B. Natural preservative	Tylenol
2	<i>Nelumbo nucifera</i>	A. Uses: sun stroke, diarrhea, anti germ, skin allergic B. Natural vitamin C, potassium, vitamin B6, phosphorus, copper, and manganese	Imodium
3	<i>Hedyotis diffusa</i>	A. Uses: tonsillitis, throat, jaundice, pain relief, reduces swelling B. Natural diuretic	Theraflu
4	<i>Heliotropium peruvianum</i>	A. Uses: sun stroke, headache, sinus cancer, kidney infection, mucus relief B. Natural pain relief, diuretic	-
5	<i>Siegesbeckia orientalis</i>	A. Uses: coughing, rash, anti-infection B. Natural blood pressure reducer	Benadryl
6	<i>Glechoma hederacea</i>	A. Uses: diuretic, astringent, kidney diseases, indigestion B. Natural high nitrogen content	-
7	<i>Eupatorium cannabinum</i>	A. Uses: sun stroke, diarrhea, head cold, pain relief B. Natural anti infection	Imodium
8	<i>Scutellaria barbata</i>	A. Uses: pain relief, mucus remover, swollen reducer B. Specially for angina, and asthma C. Natural diuretic	Mucinex
9	<i>Orthosiphon spiralis</i>	A. Uses: kidney stone, vesical calculus B. Natural diuretic	Advil or motrin
10	<i>Houttuynia cordata</i>	A. Uses: pneumonia, antiviral, antibacterial and antileukemic activities, odor remover B. Uses: cooking seasonings	-
11	<i>Selaginella doederleinii</i>	A. Uses: coughing, constipation, pneumonia, anticancer agent, cardiovascular diseases B. External use to stop bleeding	Dimetapp
12	<i>Plantago asiatica</i>	A. Uses: coughing, mucus, jaundice, bronchitis B. Anti-histamine, anti-inflammatory	Mucinex
13	<i>Eclipta prostrata</i> (Linn.)	A. Uses: bronchitis, chronic infected skin diseases, jaundice B. Natural antiasthmatic, antifatulent, vitamin A, volatile oil	-
14	<i>Leonurus artemisia</i>	A. Uses: high blood pressure, poison ivy, poison oak, diuretic, oliguria B. Natural vision, menstrual, aberration	Benadryl
15	<i>Folium eriobotryae</i>	A. Uses: inflame, coughing, stomach flu B. Natural antioxidant, vitamin B and C	Pedialyte
16	<i>Agastache</i>	A. Uses: fever, diarrhea, angina B. Natural mint substitute	Tylenol
17	<i>Schizonepeta</i>	A. Uses: headache, headcold B. Natural d-menthone, 1-pulegone, schizonepet aside	Tylenol
18	<i>Folium Isatidis</i>	A. Uses: headache, tonsillitis, encephalitis, hepatitis B B. Natural	Tylenol
19	<i>Hypericum sampsonii</i>	A. Uses: constipation, menstrual aberration B. Natural yellow gland	Dulcalax
20	<i>Taraxacum officinale</i>	A. Uses: oliguria, rheumatism B. Natural vitamin A and C, mineral, potassium	Lasix, osmitrol
21	<i>Artemisia indica</i>	A. Uses: breast cancer, anti germ B. Uses: salads and soups	-
22	<i>Mentha arvensis</i>	A. Uses: headache, gasp, and asthma B. Natural peppermint	Xopenex

lems such as cough, headache, head cold, pain, fever, skin diseases, blood pressure, excess mucus, jaundice, diarrhea, poison ivy, and poison oak, and may be used to prevent or help treat cancer and heart disease.

The results showed that different Chinese medicinal herbs, even those from the same family, contain different amounts of oxalate. The total oxalate contents for the 22 herbs ranged from 165 to 3204 mg/100 g,

which is much higher than the oxalate content of daily foods such as various flours (37 to 269 mg/100 g) and nuts (42 to 469 mg/100 g).²

Among all 22 medicinal herbs, *Houttuynia cordata* had the highest total and soluble oxalate content (3204 and 2146 mg/100 g, respectively). This Chinese herb is commonly used as a fresh herbal garnish. The leaf has an unusual taste that is often described as fishy, so it is

Table 2 Average total and soluble oxalate contents in 22 herbs (mg/100 g dry weight; means of $n = 22$)

No.	Name	Family	Parts analyzed	Total oxalate	Soluble oxalate
1	<i>Perilla frutescens</i>	Lamiaceae	Stems and leaves	908	176
2	<i>Nelumbo nucifera</i>	Nelumbonaceae	Leaves	3066	211
3	<i>Hedyotis diffusa</i>	Rubiaceae	Stems	857	152
4	<i>Heliotropium peruvianum</i>	Boraginaceae	Leaves	1503	719
5	<i>Siegesbeckia orientalis</i>	Asteraceae	Stems and leaves	2034	165
6	<i>Glechoma hederacea</i>	Lamiaceae	Stems and leaves	1389	154
7	<i>Eupatorium cannabinum</i>	Asteraceae	Stems and leaves	1003	110
8	<i>Scutellaria barbata</i>	Lamiaceae	Stems and leaves	258	123
9	<i>Orthosiphon spiralis</i>	Lamiaceae	Stems and leaves	499	197
10	<i>Houttuynia cordata</i>	Saururaceae	Stems and leaves	3204	2146
11	<i>Selaginella doederleinii</i>	Selaginellaceae	Leaves	165	71
12	<i>Plantago asiatica</i>	Plantaginaceae	Stems and leaves	511	83
13	<i>Eclipta prostrata</i> (Linn.)	Asteraceae	Stems and leaves	521	1218
14	<i>Leonurus artemisia</i>	Lamiaceae	Stems and leaves	1332	429
15	<i>Folium eriobotryae</i>	Rosaceae	Leaves	3203	93
16	<i>Agastache</i>	Lamiaceae	Stems and leaves	1482	340
17	<i>Schizonepeta</i>	Lamiaceae	Stems and leaves	213	134
18	<i>Folium isatidis</i>	Acanthaceae	Leaves	569	127
19	<i>Hypericum sampsonii</i>	Hypericaceae	Leaves	192	101
20	<i>Taraxacum officinale</i>	Asteraceae	Leaves and flowers	168	104
21	<i>Artemisia indica</i>	Compositae	Leaves	1340	462
22	<i>Mentha arvensis</i>	Lamiaceae	Leaves	245	167

not enjoyed as universally as basil and mint. However, *Houttuynia cordata* has been used by Chinese scientists to tackle severe acute respiratory syndrome, as it is conventionally used to treat pneumonia. However, this herb should be used with caution for patients sensitive to oxalate; as it has high levels of total and soluble oxalate, ingestion is likely to lead to a marked increase in urinary oxalate because of the relatively high bio-availability of soluble oxalate.

In contrast, *Selaginella doederleinii* contains the lowest levels of total and soluble oxalate. This herb is used in Chinese medicine as a bactericide, an anticancer agent, and to treat cardiovascular diseases. As this medicinal herb can provide significant benefits and has low oxalate content, more research is recommended to assess its overall effectiveness as a therapeutic agent.

Among the 22 Chinese medicinal herbs tested, the properties of some are of particular interest.⁷⁻²³ *Eclipta prostrata* (Linn.) is commonly used to treat bronchitis, chronic infected skin diseases, ringworm, and tinea versicolor. The juice from the stem can also be used to treat jaundice. This herb has the second highest soluble oxalate content (1218 mg/100 g) among the 22 herbs. *Plantago asiatica* has the second least soluble oxalate content (83 mg/100 g). *Plantago* species have been

used since prehistoric times as herbal remedies. This herb has astringent, antitoxic, antimicrobial, anti-inflammatory, and antihistamine properties, and is also a demulcent, expectorant, stypitic, and diuretic. Externally, a poultice of the leaves is useful for insect bites, poison ivy rashes, minor sores, and boils. It is also claimed to be able to cure snake bites.

Artemisia indica can be used in salads and soups. This herb can be added to glutinous rice dumplings to impart a pleasant color and flavor. *Artemisia indica*, after water extraction, has been found to inhibit the growth of a specific line of breast cancer cells.²⁴ The soluble oxalate content is in the middle range (462 mg/100 g). This medicinal herb should be studied further because of its possible role in the inhibition of breast cancer.

In Asian cuisine, *Nelumbo nucifera* is used as a vegetable in soups and is popular in salads containing prawns, sesame oil, and coriander leaves. Its roots are rich in vitamin C, potassium, thiamin, vitamin B₆, phosphorus, copper, and manganese, and very low in saturated fat. This herb has a very low soluble oxalate content (211 mg/100 g); therefore, it could be used more widely as a salad ingredient to take advantage of its high nutrient content.

Agastache is native to eastern Asia and North America. The flowers are usually white, pink, and purple and the

leaf tips can be eaten and made into teas. Its soluble oxalate content is in the middle range (340 mg/100 g).

Leonurus artemisia, or Chinese motherwort, is one of the fifty fundamental herbs used in traditional Chinese medicine.⁸ This herb has been used for preventing postpartum hemorrhage after Caesarian section. It has been also used for menstrual disorders, delayed or absent menses, irregular menses, amenorrhea, endometriosis, fertility, lower abdominal pain, and postpartum abdominal pain due to blood obstruction. The leaves are a diuretic and are placed in water to relieve itching and painful shingles. The dried flowers are also used post-pregnancy to help expel the placenta after giving birth. The soluble oxalate content of this herb is 429 mg/100 g dried weight.

The flowers of Taraxacum officinale are often used to make wine. It has long been used in the UK to make a popular soft drink (Dandelion & Burdock) and authentic versions are still sold by health food shops. The soluble oxalate content of Taraxacum officinale is very low (104 mg/100 g). Its roots have been used to make coffee-like drinks and the plant was used by Native Americans as a medicine. The root is also a registered diuretic drug in Canada. The leaves are very high in vitamin A, vitamin C, and iron, containing more iron and calcium than spinach.

Hypericum sampsonii is used as a common treatment in homeopathy and to treat mild and moderate depression. However, high dosages of this herb should be avoided because of its high antibiotic content. This herb has a very low soluble oxalate content (101 mg/100 g dried weight).

Folium Eriobotryae has the third lowest soluble oxalate content and is often used to treat cough and asthma. This herb is bitter in taste and slightly cool in nature and has been used in combination with other medicinal herbs to treat whooping cough, nausea, and vomiting.

ACKNOWLEDGEMENTS

We would like to express our sincere thanks to Mrs. Su Huichi who provided us with the 22 Chinese medicinal herbs for this study.

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