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Evaluation of mineral content of Chinese medicinal herbs used to improve kidney function with chemometrics

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ABSTRACT

Mineral elemental concentrations of 50 Chinese medicinal herbs in acid digests were determined by flame atomic absorption spectroscopy. The data were subjected to chemometric assessment to understand the association between the elements and to classify the herbal samples. Chemometric techniques, such as principal component analysis (PCA) and hierarchical cluster analysis (HCA) were used as classification techniques. PCA generated two principal components that explained 62% of the total variance in the data. HCA disclosed two significant groups of samples based on their elemental concentrations.

1. Introduction

Kidneys are a pair of vital organs that perform many functions including keeping the blood clean and chemically balanced. Kidney function depends on the ability of the kidneys to filter blood that is estimated using glomerular filtration rate (GFR). Progressive loss of kidney function leads to chronic kidney disease (CKD) (Li & Frierman, 2006). The health burden of CKD is high for patients and health services worldwide. Millions of people around the world suffer from kidney diseases. The presence of kidney damage is indicated by proteinuria, haematuria, or reduced glomerular filtration rate (GFR). A study conducted by Australian Diabetes Kidney reported that age, diabetes mellitus, and hypertension were independently associated with proteinuria; age, gender and hypertension with haematuria; and age, gender and hypertension with reduced GFR. The study reported that approximately 16% of the Australian population has either proteinuria, haematuria, and/or reduced GFR, indicating the presence of kidney damage (Chadban et al., 2003). In the view of Chinese medicine, kidney is considered as a system that include the functions of the urinary system and reproductive system (Xu, Lawson, Kras, & Ryan, 2005). Chinese herbalism has claimed an increasing share of the public's awareness. Herbal preparations have been used in China for over three thousand years that involved plant, mineral and animal substances to treat ailments (Williams, 1996). Seventy to eighty percent of the population in many developed countries used some form of traditional medicine.[1] According to World Health Organization the percentage of the population that has used traditional medicine at least once is 48% in Australia, 70% in Canada, 42% in USA, 38% in Belgium and 75% in France.[2]

Medicinal plants can synthesise a large variety of chemical substances that are of physiological importance. Therefore medicinal plants are a group of plants whose plant parts contain pharmacologically active compounds that can be used for the synthesis of useful drugs (Odebiyi & Sofowora, 1978). In the human body, the chemical constituents of medicinal plants interact directly or indirectly with the body chemistry. Once the active constituents are absorbed into the blood stream, these constituents circulate and influence the blood system to derive the required benefits. For example, the chemical constituents present in the plant that include vegetable bases comprising alkaloids and amines, glycosides,

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[1] <http://www.who.int/mediacentre/factsheets/fs134/en/>. Date last assessed: 07/07/2010.
[2] World health organisation (2002). Traditional medicine strategy (2002–2005). <http://whqlibdoc.who.int/hq/2002/WHO_EDM_TRM_2002.1.pdf/>. Date last assessed: 07/07/2010.

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essential oils are responsible for medicinal properties like characteristic odour of the plants. Regarding the toxic properties of plants chemical constituents are also responsible for toxic substances such as toxalbumin, resins and antibiotics. The trace elements play a very important role in the formation of these active compounds. One important aspect for the formation of active constituents in medicinal plants are the trace elements because the trace elements are known to play an important role in plant metabolism and the active constituents of medicinal plants are metabolic products of plant cells (Serfor-Armah et al., 2001).

For human beings trace elements are essential nutrients with a gamut of functions. Trace elements are incorporated in the structures of proteins, enzymes, and the complex carbohydrates to participate in biochemical reaction. Trace elements with enzymes, for example, are necessary for the functioning and maintenance of the immune system (Bang et al., 2002). Zinc is a critical nutritional component required for normal development and maintenance of immune functions in humans and animals. Zinc is also essential for the activity of numerous enzymes. Iron is an essential element for living cells, and a lack of iron is associated with anaemia. Magnesium plays a major role in overall cell functions. An adequate serum magnesium concentration may be necessary to maintain renal function and protect the kidneys from damage. Two of the most abundant ions that are controlled in dialytic patients are sodium and potassium. Sodium is the major indicator of body tonicity. Potassium is the most important intracellular cation that maintains the cell's osmotic pressure and acid–base balance in the human body. Calcium helps to form and maintain healthy bones (Bogden & Klevay, 2000). Studies have shown a high prevalence of zinc deficiency in CKD patients, particularly those under either dialytic or conservative treatment (Bozalioglu, Özkan, Turan, & Simsek, 2005; Mafra, Cuppari, & Cozzolino, 2002). Other studies reported dialytic patients with low serum Iron, potassium and manganese levels (Kiziltas, Ekin, & Erkoc, 2008; Krachler, Scharfetter, & Wirnsberger, 1999; Zima, Tesar, Mestek, & Nemecek, 1999). Kiziltas et al. (2008) also reported high serum magnesium, potassium and normal sodium levels in dialytic patients. Studies indicate that calcium supplementation appears to be partially effective in people with CKD (Carter, O'Riordan, Eaglestone, Delaney, & Lamb, 2008).

Chinese herbs are commonly used together in the form of decoctions according to the herbal formulae in which the properties of herbs and the effects of combining them have been observed and recorded over many centuries (Williams, 1996). In this study, we have analysed 50 Chinese herbs that are used commonly in Chinese formulae related to the regulation or improvement of kidney function. The Chinese and English names of the herbs are listed in Table 1. These herbs were analysed for calcium, iron, magnesium, manganese, potassium, sodium and zinc by atomic absorption spectroscopy (AAS). Standard reference material (SRM) was analysed for data validation. Data analysis was done by common chemometrics, such as analysis of variance (ANOVA), correlation analysis (CA), principal component analysis (PCA) and hierarchical cluster analysis (HCA).

Table 1
The operating parameters for working elements.

Elements	Wavelength (nm)	Lamp current (mA)	Slit (nm)
Ca	422.7	10	0.5
Fe	248.3	5	0.2
Mg	285.2	4	0.5
Mn	279.5	5	0.2
K	404.4	5	0.5
Na	330.3	5	0.5
Zn	213.9	5	1

2. Experimental

2.1. Solutions and reagents

Doubly de-ionised water with a specific sensitivity of 18 MΩ obtained from Millipore- Milli-Q water purifier system (Milford, USA). Plant digests were prepared using HNO_3 (*Trace* SELECT, 69%) from Sigma–Aldrich, Australia. Stock standard solutions of

Table 2
English names of the analysed Chinese herbs.

Chinese herbs	English Name
Leaves	
She Wei (No. 1)	Pyrrosia leaves
Yin Yang Huo (No. 2)	Epimedium, Horny goat weed
Whole plant/Stem/Twig/Bark	
Bian Xu Cao (No. 3)	Knotweed, Polygonum
Che Qian Cao (No. 4)	Herba plantaginis
Deng Xin Cao (No. 5)	Lamp wick herb
Du Zhong (No. 6)	Gutta-percha tree, Chinese rubber tree
Gu Sui Bu (No. 7)	Drynaria rhizome
Hai Jin Sha (No.8)	Japanese climbing fern spore
Han Lian Cao (No. 9)	Herba ecliptae
Huang Jing (No. 10)	Dropberry, Solomon seal
Jin Qian Cao (No. 11)	Lysimachia
Mu Tong (No. 12)	Akebia caulis
Suo Yang (No. 13)	Herba cynomorii
Tong Cao (No. 14)	Ricepaper plant pith
Xian Mao (No. 15)	Golden eye-grass rhizome
Yin Chen (No. 16)	Red stem wormwood
Ze Xie (No. 17)	Water plantain rhizome
Root	
Ba Ji Tian (No. 18)	Morinda root
Bi Xie (No. 19)	Dioscorea root
Chuan Niu Xi (No. 20)	Cyathula root
He Shou Wu (No. 21)	Chinese knotweed, Flowery knotweed
Mu Dan Pi (No. 22)	Peony root
Shan Yao (No. 23)	Cinnamon vine, Chinese yam
Shu Di Huang (No. 24)	Rehmannia Root
Xi Yang Shen (No. 25)	American Ginseng
Xu Duan (No. 26)	Teasel root
Seeds	
Che Qian Zi (No. 27)	Plantain seed
Chi Xiao Dou (No. 28)	Rice bean
Dong Gua Ren (No. 29)	Wintermelon seed
Hei Zhi Ma (No. 30)	Black sesame
Sha Yuan Zi (No. 31)	Flatstem milkvtech seed
Tu Si Zi (No. 32)	Chinese dodder seeds
Yi Yi Ren (No. 33)	Job's Tears
Yi Zhi Ren (No. 34)	Cardamon
Fruits	
Bu Gu Zhi (No. 35)	Psoralea fruit
Di Fu Zi (No. 36)	Kochia fruit
Gou Qi Zi (No. 37)	Chinese wolfberry
Nu Zhen Zi (No. 38)	Ligustrum, privet fruit
Sang Shen (No. 39)	Mulberry fruit
Shan Zhu Yu (No. 40)	Japanese Cornelian Cherry
Fossil	
Bie Jia (No. 41)	Turtle Shell
Gu jia jiao (No. 42)	Colla Plastrum Testudinis
Long Gu (No. 43)	Dragon's bone
Lu jiao jiao (No. 44)	Deer horn gelatine
Zi He Che (No. 45)	Dried human placenta
Fungus	
Dong Chong Xia Cao (No. 46)	Caterpillar fungus
Fulingpi (No. 47)	Indian bread
Ling Zhi (No. 48)	Reishi mushroom
Zhu Ling (No. 49)	Polyporus fungus
Peel	
Dong Gua Pi (No. 50)	Chinese waxgourd peel