Research Progress of Trace Elements in Gardenia Fructus

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Abstract. Gardenia Fructus was one of the first batch of edible-medicinal Traditional Chinese Medicine (TCM). Besides chemical composition, its trace elements have been studied extensively. In this paper, the related reports of trace elements in Gardenia Fructus were summarized, which can provide theoretical support for the further development and utilization of Gardenia Fructus.

Introduction

Gardenia Fructus is the fruit with dry and mature of rubiaceae Gardenia jasminoides Ellis. It has the functions that purging fire and removing vexation, clearing heat, diuresis, cooling blood, detoxification and so on[1]. Gardenia Fructus as one of TCM, it belongs to the first batch of edible-medicinal resources which is issued by the ministry of health[2]. Its major producing regions are Jiangxi, Hunan, Zhejiang, Sichuan and other provinces[3].

Trace elements (TE) refers to rarely and even trace in human body. It not only has nutritional role, but can improve the biological activity. At present, it has been confirmed that there are 20 kinds of TE related to human life and health[4]. The Gardenia Fructus, gardenia, gardenia leaf, gardenia pigment are rich in TE. And the kinds and contents of TE were diverse in Gardenia Fructus from different areas and processing methods. This paper summarize the research progress of TE in Gardenia Fructus from many literatures.

Study on trace elements of Gardenia Fructus

Gardenia Fructus contains many kinds of TE. The main kinds of TE, the relationship between the TE and the main chemical components in Gardenia Fructus all will be generalized. And the TE in Gardenia Fructus from different areas will be compared. Jianping Han[5] et al. studied the relationship between 12 kinds of TE and the geniposide. She found that Mg made the largest contribution to the variation of geniposide, and the content of Zn was negatively correlated with geniposide. Zhaoxiang Zhou[6] et al. determined the TE in Gardenia Fructus and gardenia pigments, and 20 kinds of TE were found, such as Cu Fe Zn Mn Ni Mo V Sb Pb Sn Bi Ca Ag Cd Co Ba Be B Zr Ti. After studying of 14 kinds of TE in Gardenia Fructus from Hunan, Jiangsu, Jiangxi, and market, Haiping Liu[7] found that the contents of Na was higher in Hunan, the content of Ba was higher in Hunan, and the content of Cr was the highest in commercially available Gardenia Fructus. Xiaofeng Liao[8] et al. measured the TE in water extract of Gardenia Fructus. The result showed that Gardenia Fructus contained a variety of TE, such as Fe Zn Mn Mg Cu and so on, in which the content
of Mg was the highest. Yuncan Li et al. determined the contents of B Co Cr Fe Mn Si Zn Cu Se Ca Mg K Na P, and found that the contents of K Ca Mg P were higher.

Study on trace elements in different processed products of Gardenia Fructus

The efficacy of medicine will be changed after processing according to the clinic needs, which will be more benefit to the treatment of disease. Although the researches on processed products of Gardenia Fructus have been started early, they mainly concentrated on the chemical composition, the researches on TE were less. So it is necessary to strengthen the research on TE in different processed products of Gardenia Fructus. Shuping Li et al. studied 32 kinds of TE in Gardenia Fructus, ginger gardenia, salt gardenia, scorched gardenia, carbonized gardenia and found that the content of TE changed at different levels after processing. The content of TE changed after ginger juice processing. The content of TE all reduced after salt processing. The content of Cr had significantly lower after frying, whereas others increased. The contents of Cr Ti obviously decreased after carbonizing, while others increased compared with crude.

Study on trace elements in different parts of Gardenia Fructus

Study on trace elements in gardenia peel and kernel

The separated use of gardenia pell and kernel were recorded in “Standards of Diagnosis and Treatment”. “Removing the heart hot with gardenia kernel, removing the surface heat with gardenia peel, and removing the upper and middle warmer with the whole Gardenia Fructus, removing the lower warmer clear gardenia pell.” The efficacy and the content of TE were diverse in different parts of Gardenia Fructus. Shuping Liu et al. studied on TE in gardenia peel and kernel, and found that the TE was obviously different. All the content of TE in Gardenia peel is greater than the kernel except p. The content of TE in gardenia pell and kernel are different, So it will be more benefit to its medicinal function if we use them separately.

Study on trace elements in the exocarp, endocarp and seed of Gardenia Fructus

Ying Hu et al. mensurated TE in calyx, exocarp, endocarp and seed of 6 kinds of dry Gardenia Fructus. The results showed that the TE were diverse in different cultivars, and different parts of dried fruits. The exocarp is significantly higher than the endocarp on the TE types and contents. The rare earth element La and and heavy metals Ti Co W were only found in the seeds. The results further confirmed the scientificity for using each part of Gardenia Fructus separately.

Study on trace elements in different areas of Gardenia Fructus

The quality of TCMin different origins is diverse, which was affected by the soil, climate, water, minerals distribution. So the active ingredients of TCM from different areas are different, the contents of TE also changed. Therefore it has practical significance to evaluate Gardenia Fructus from different areas from the aspect of TE. Lei Chen et al. measured the contents of Fe Mn Ca Mg Zn Cu to assess Gardenia Fructus from 10 different areas. The results showed that there were some different in the content of TE, but the contents of Ca Mg Cu were all higher. Mingdi Liu et al. processed the date from reference [9] for principal component analysis by SPSS13.0 technology. The results showed that the quality of Gardenia Fructus from Henan Tanghewas the best, which had the highest score.

Trace elements in Gardenia Pigment

Besides medicine, Gardenia Fructus also can be used to extract gardenia pigment. Gardenia pigment is one of natural pigment. Its advantages are safe non-toxic, and so on compared with synthetic pigment. The TE in gardenia pigment has a certain influence on its stability. Zhaoxiang Zhou et al. studied on the relationship between Fe Cu Sn Al and gardenia yellow pigment, and found that Fe$^{3+}$ can
make the color of pigment fade. \( \text{Cu}^{2+} \) accelerate the destruction and fading of the pigment, \( \text{Sn}^{2+} \) had precipitation phenomenon in gardenia yellow pigment, but \( \text{Al}^{3+} \) can improve the stability of gardenia yellow pigment. Qingxin Zhou\(^{[16]} \) found that \( \text{Na}^{+} \) \( \text{K}^{+} \) \( \text{Fe}^{2+} \) \( \text{Mg}^{2+} \) \( \text{Ca}^{2+} \) \( \text{Zn}^{2+} \) had no bad effects on gardenia pigment while the \( \text{Fe}^{3+} \) \( \text{Cu}^{2+} \) \( \text{Al}^{3+} \) \( \text{Sn}^{2+} \) can make the gardenia red pigment precipitate, in which the \( \text{Fe}^{3+} \) \( \text{Al}^{3+} \) had the biggest effect. Donghong You\(^{[17]} \) et al. studied the effects of ten metal ions on the stability of gardenia pigment, he found that the effects of \( \text{Sn}^{2+} \) \( \text{Fe}^{3+} \) were greater. Ruiying Liu\(^{[18]} \) studied the effects of metal ions on the stability of gardenia yellow pigment, and found that \( \text{Mg}^{2+} \) had less effect, while the effects of \( \text{Sn}^{2+} \) \( \text{Fe}^{3+} \) were greater.

**Determination of heavy metal elements in Gardenia Fructus**

The heavy metal elements in the medicinal materials will cause great harm to the human body, even endanger life. In recent years, the study of heavy metal elements has been paid enough attention, and it has been viewed as an important link to evaluate the quality of medicinal materials." Green Standards for the Import and Export of Medicinal Plants and Preparations", which was promulgated in 2001, ruled the limit standard for heavy metals: \( \text{Pb} \leq 5.0 \text{mg} \cdot \text{kg}^{-1} \) \( \text{Cd} \leq 0.3 \text{mg} \cdot \text{kg}^{-1} \) \( \text{As} \leq 2.0 \text{mg} \cdot \text{kg}^{-1} \) \( \text{Hg} \leq 0.2 \text{mg} \cdot \text{kg}^{-1} \). Chen Lei\(^{[19]} \) et al. determined the contents of \( \text{Pb} \) \( \text{Cd} \) \( \text{As} \) in Gardenia Fructus from different regions by graphite furnace atomic absorption spectrometry. Hydro-cold atomic absorption method was used to measure \( \text{Hg} \). All samples meet the above criterias. Shu Zhou\(^{[20]} \) and Yi Liu\(^{[21]} \) determined heavy metals in Gardenia Fructus, the results were also meet the limit standard.

**Trace elements in other parts of gardenia**

**Gardenia**

Besides highly ornamental value, gardenia also can be used for health food, even medicine\(^{[22]} \). Gardenia healthcare effect has often been overlooked, and the study found that the contents of TE in gardenia were more abundant than the Gardenia Fructus, which provided theoretical support for the development and utilization of gardenia. Jiajian Zhang\(^{[22]} \) et al. mensurated the contents of \( \text{Ca} \) \( \text{Zn} \) \( \text{Cu} \) \( \text{Mn} \) \( \text{Cr} \) \( \text{Mg} \) \( \text{Fe} \) in the gardenia and Gardenia Fructus, the results showed that the contents of TE in gardenia were higher. Kaiquan Li\(^{[23]} \) et al. determined 13 kinds of TE in gardenia, the data showed that the content of TE were as follows: \( \text{Cu} > \text{Ca} > \text{P} > \text{Mg} > \text{K} > \text{Fe}, \text{Mo} > \text{Co} > \text{Na} > \text{Se} > \text{Zn} > \text{Mn} > \text{Ge} \).

**Gardenia Pollen**

Gardenia pollen is rich in nutrients, which can be used as trophic food for disease prevention and treatment\(^{[24]} \). Besides nutrients, Meizhu Chen\(^{[24]} \) et al. measured the contents of \( \text{K} \) \( \text{Na} \) \( \text{Mn} \) \( \text{Ca} \) \( \text{Mg} \) \( \text{Fe} \) \( \text{Cu} \) \( \text{Zn} \) \( \text{Se} \) in yellow gardenia pollen. The results showed that the contents of TE were rich in gardenia pollen, and \( \text{Fe}, \text{Zn} \) were higher.

**Gardenia Leaf**

Gardenia leaf is not used for medicinal purposes, but its TE is helpful to estimate the effective components of Gardenia Fructus. Fang Liu\(^{[25,26]} \) et al. mensurated the contents of \( \text{Fe} \) \( \text{Mn} \) \( \text{Zn} \) \( \text{Se} \) in gardenia leaves to calculate the main effective constituents of Gardenia Fructus by establishing mathematical model.
The determination method of trace element

There are many methods for testing the TE with the advance of the research, the testing equipment is more advanced. It provides a strong technical support for scientific research. In order to measure the TE conveniently, it is necessary to convert the metal compounds into ionic state firstly.

The sample preparation

The frequently-used sample pretreatment includes high-pressure sealed digestion method (pressure digestion tank digestion method), dry ashing and wet digestion\(^{[27]}\). Yuncan Li\(^{[9]}\) et al. pretreated Gardenia Fructus by microwave digestion. Lei Chen\(^{[12]}\) et al. further studied the different digestion methods of HNO\(_3\)+HCl, HNO\(_3\)+H\(_2\)O\(_2\), HNO\(_3\)+HClO\(_4\), HNO\(_3\)+HF, who found that the method of HNO\(_3\)+H\(_2\)O\(_2\) digested completely, solution clarification, and stimulating and corrosive was low, so the digestion method of HNO\(_3\)+H\(_2\)O\(_2\) was the best.

Determination analysis method

Atomic Absorption Spectrometry

Atomic absorption spectrometry (AAS) is divided into flame atomic absorption spectrometry (FAAS) and graphite furnace atomic absorption spectrometry (GFAAS), cold atomic absorption spectrometry (CAAS), hydride generation atomic absorption spectrometry (HGAAS)\(^{[28]}\). The FAAS can determine more kinds of elements, but the sensitivity of GFAAS is more higher. Xiaofeng Liao\(^{[8]}\) et al. measured TE in gardenia extract by AAS. Lei Chen\(^{[9]}\) et al. determined TE in Gardenia Fructus from different areas by FAAS. Jiajian Zhang\(^{[22]}\) et al. used AAS to determine TE in gardenia and raw Gardenia Fructus. Kaiquan Li\(^{[23]}\) et al. determined Fe Mn Zn Cu Mo Ca Mg K Na by FAAS, and determined Mo Co Ge Se by GFAAS. Fang Liu\(^{[25,26]}\) et al. measured the contents of Fe Mn Zn Se in gardenia leaves by FAAS.

Atomic Emission Spectrometry

Atomic emission spectrometry (AES) is an analysis method which is according to the characteristic spectral lines. The lines are emitted by the atom of elements which are measured from the excited state to the ground state. Meizhu Chen\(^{[24]}\) et al. used this method to determine the content of TE in gardenia pollen.

Colorimetry

Colorimetric method has the advantages of simple equipment and convenient operation, but the accuracy is not high enough. Kaiquan Li\(^{[23]}\) et al. determined the content of P in gardenia by colorimetric method.

Atomic Fluorescence Spectrometry

Atomic fluorescence spectrometry (AFS) is a method that the ground state atomic is emitted to the upper state after it absorb specific frequency radiation, then it launch characteristic wavelength fluorescence in the form of ray radiation. This method has high sensitivity. Ying Hu\(^{[11]}\) et al. measured the TE in each parts of dried Gardenia Fructus by AFS.

Ultraviolet Spectrophotometry

Ultraviolet spectrophotometry (US) is a method for determining the contents of metal elements. It has a color and absorption phenomenon in the ultraviolet lamp after the reaction of the metal element with the specific reagent. Zhaoxiang Zhou\(^{[15]}\) et al. used US for the determination of TE in gardenia pigment.
Inductively Coupled Plasma Atomic Emission Spectrometry

Inductively coupled plasma atomic emission spectrometry (ICP-AES) is a spectral analysis method which is based on inductively coupled plasma as excitation source. It has the advantages of high accuracy, high precision, low detection limit, rapid determination, wide linear range, simultaneous determination of various elements and so on. Jianping Han et al. and Yuncan Li et al. measured the TE in Gardenia Fructus by ICP-AES. Shuping Liu et al. also used ICP-AES in the test of TE in different processed products. The method is simple and reliable.

Inductively Coupled Plasma Mass Spectrometry

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) is a highly sensitive analytical technique with unique interface technology which combines the advantages of the high temperature ionization characteristics of ICP and the sensitive and rapid scanning of MS. Haiping Liu determined TE in Gardenia Fructus by ICP-MS.

Research prospect

Gardenia Fructus has abundant TE. At present, 37 kinds of TE in Gardenia Fructus were determined. Based on the current literature, though the study of Gardenia Fructus is extensive, there are still many deficiencies and gaps. The chemical components and the pharmacological effects of Gardenia Fructus were different in diverse harvest times, the content of TE may also be different, so the study of TE can be used as an auxiliary judgment of Gardenia Fructus’s best harvest time. The correlation between TE and pharmacological action of Gardenia Fructus can also be studied. The current researches on TE are Gardenia Fructus, Gardenia, Gardenia leaf, there is no correlativereport of TE in gardenia root though it can also be used as medicine. Researching on it can provide scientific basis for the further development and utilization of Gardenia roots. Moreover, the present researches are mainly concentrated on the mountain Gardenia Fructus, water Gardenia Fructus are less. It is controversial that whether it can be used as medicine. So the determination of TE may help judge its medicinal value. It will be more conducive to the use of Gardenia Fructus if we accelerate the relevant research, which can provide more support for people's lives and health.

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References

[4] Z.M. Huang, X. Huang, Trace Elements and Human Helth, Studies. Trace Elements&


