

Exploration of Plant Composition Analysis Technology and its Application in Medicinal Plants

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Abstract: Plant composition analysis technology is of great significance and value in the study of medicinal plants. Through this technology, we can have a deep understanding of the chemical composition of medicinal plants, explore their pharmacological effects and efficacy mechanism, and provide theoretical support for the development of new drugs. At the same time, plant composition analysis technology is also a key means of quality control, which can help us accurately identify the quality of medicinal plants and ensure the stability and effectiveness of medicinal materials. With the development of rapid analysis technology, this technology has higher efficiency and accuracy, and can complete the analysis of large numbers of samples in less time, which is particularly important for the research of medicinal plants requiring large data support.

Keywords: Plant Composition Analysis Technology; Medicinal Plant Research; Chemical Composition; Drug Effect; Quality Control.

1. Introduction

1.1. Necessity of Plant Composition Analysis Techniques

With the deep exploration and understanding of human nature, the analysis of the technology of plant composition has gradually shown its importance. Through this technology, we can have an in-depth understanding of the chemical composition of medicinal plants, explore their pharmacological effects and efficacy mechanisms, and provide theoretical support for the research and development of new drugs. At the same time, plant composition analysis technology is also a key means of quality control, which can help us accurately identify the quality of medicinal plants and ensure the stability and effectiveness of medicinal materials. In addition, understanding the chemical composition and content of medicinal plants is also of guiding significance for clinical drug use, which can help doctors to choose appropriate drugs, improve the efficacy of drugs and reduce the occurrence of adverse reactions. With the development of rapid analysis technology, this technology has higher efficiency and accuracy, and can complete the analysis of large numbers of samples in less time, which is particularly important for medicinal plants that need a large amount of data support [1].

1.2. Development Process of Plant Composition Analysis Technology

The development of plant composition analysis dates back to the late 19th century, when scientists have been separating and analyzing the chemical composition of plants. With the continuous progress of science and technology, this technology has gradually developed and improved. From the early 20th century, scientists used organic solvents to extract phytochemicals, and then gradually developed more efficient extraction methods, such as supercritical fluid extraction and microwave-assisted extraction techniques. By the middle of the 20th century, separation and purification techniques also began to be widely used, such as chromatography,

electrophoresis, high performance liquid chromatography and gas chromatography, which were able to separate and purify the chemical components in plants more precisely. With the development of science and technology, more kinds of detection methods appeared in the late 20th century, such as spectroscopy, chromatographic technology, ultraviolet visible spectroscopy and mass spectrometry, which can more accurately detect and analyze the chemical composition in plants. By the beginning of the 21st century, the rise of bioinformatics enabled scientists to use computer technology and database technology to analyze and organize plant composition, thus improving the efficiency and accuracy of plant composition analysis [2]. Therefore, the development of plant composition analysis technology has gone through multiple stages, with each stage making an important contribution to the improvement of accuracy and reliability.

1.3. Significance of Plant Composition Analysis Techniques in the Study of Medicinal Plants

Plant composition analysis technology can help us to have a deep understanding of the chemical composition of medicinal plants, which may include alkaloids, flavonoids, volatile oils, organic acids, polysaccharides, etc., with a variety of pharmacological effects, such as anti-inflammatory, antioxidant, anti-tumor, antibacterial and other [3]. Through the analysis and study of these chemical components, we can understand the efficacy and mechanism of action of medicinal plants, and provide ideas and enlightenment for the research and development of new drugs. Plant composition analysis techniques can be used for the quality control of medicinal plants. The quality of medicinal plants is affected by various factors, such as origin, variety, growth environment, etc. Through composition analysis, we can formulate strict quality control standards, evaluate and control medicinal plants, and ensure the stability and effectiveness of medicinal materials. This is of great significance to ensure the safety and effectiveness of drugs. Plant composition analysis techniques can also promote interdisciplinary integration. Plant composition analysis is not only about the separation and

identification of compounds, but also needs to be combined with plant biology, pharmacy and other disciplines to deeply explore the relationship between compounds and biological activities. This interdisciplinary crossover integration can provide more comprehensive support and reference for medicinal plant research and other related fields, and promote the development and innovation of disciplines. By analyzing the composition of medicinal plants, we can understand their impact on the environment and their role in the ecosystem, which contributes to the development of more scientific environmental protection strategies and ecological restoration programs. Through the rational utilization of medicinal plant resources, the sustainable utilization of resources can be promoted, which is of great significance for the protection of ecological environment and sustainable development.

2. Overview of the Techniques for Plant Composition Analysis

2.1. Definition and Classification of Plant Composition Analysis Techniques

Plant composition analysis technology refers to the qualitative and quantitative analysis of various chemical components in the plant body. These techniques can include chromatography, optical spectroscopy, mass spectrometry, nuclear magnetic resonance, etc. According to the purpose and requirements of the analysis, different analysis methods can be selected. According to the characteristics and application of plant composition analysis techniques, they can be divided into the following categories:

Qualitative analysis: to determine the chemical structure of plant components through separation and identification. Common methods include chromatographic techniques, spectroscopic techniques, and mass spectrometry techniques.

Quantitative analysis: The content is determined by measuring and calculating the plant composition. Common methods include HPLC, gas chromatography, UV-visible spectrophotometry, etc.

Metabolomics analysis: it can be used in the study of medicinal plants. Through the analysis of the metabolites in plants, we can understand the metabolic process and metabolic mechanism of plants, and provide ideas and enlightenment for the research and development of new drugs. Commonly used metabolomics analysis methods include NMR technology, liquid-mass coupling technology, etc.

Bioactivity analysis: through the bioactivity test of plant components, to understand their efficacy and mechanism of action. Commonly used methods include cell test, animal test, etc.

According to the different analysis objects, the plant composition analysis techniques can also be divided into macroscopic analysis and micro-analysis. Macroscopic analysis refers to the analysis of the composition of the whole plant body to understand the overall properties and efficacy of the plant. Microscopic analysis is the analysis of a certain part or component of a plant to understand its specific components and efficacy mechanism.

2.2. Advantages and Disadvantages of Plant Composition Analysis Techniques

Plant composition analysis technology has many advantages, such as the ability to isolate and identify various chemical components in plants, which can understand the chemical composition and structure of plants, and provide the

basis for drug development and plant resource utilization. Plant composition analysis techniques can also be used to assess the quality and purity of plants, and provide a guarantee for plant research and production [4]. However, the plant composition analysis techniques also have some disadvantages. First, different plant composition analysis methods have different applicable ranges and limitations, and appropriate methods according to specific situations. Secondly, plant composition analysis technology needs the use of a large number of chemical reagents and equipment, the analysis process is more complex, need professional technical personnel to operate and analyze. Moreover, the high cost of plant composition analysis techniques may be unaffordable for some small businesses and research institutions. When applying the plant composition analysis techniques, it is necessary to choose the appropriate analysis methods according to the specific situation, and pay attention to the applicable scope and limitations of the analysis technology. At the same time, factors such as analysis cost, technical level and actual demand should be comprehensively considered to choose the most appropriate analysis method.

3. Application of Plant Composition Analysis in Medicinal Plants

3.1. Type and Composition Characteristics of Medicinal Plants

Medicinal plants are very rich, and their chemical composition and efficacy are also different. Common medicinal plants include ginseng, astragalus, licorice, baicalensis, etc., which have different ingredients and mechanisms of action. For example, ginseng mainly contains saponins, nourishing, calming mind and relieving intelligence; Astragalus, mainly contains flavonoids, strengthening qi, diuresis and detoxification; licorice mainly contains glycyrrhizic acid, clearing heat and detoxifying, removing phlegm and relieving cough. There are many kinds of medicinal plants, with different chemical composition and efficacy, which provide rich resources for drug research and development. The components of these plants have multiple biological activities and are able to treat different diseases, reflecting the diversity and universality of medicinal plants. However, the efficacy mechanism of medicinal plants is relatively complex, often requiring the action of multiple components and multi-targets to exert their efficacy, which brings challenges to drug design and development [5]. Therefore, we need to deeply explore the composition characteristics, efficacy and mechanism of action of medicinal plants, so as to make better use of medicinal plant resources to serve human health.

3.2. Analysis Method of the Main Active Ingredients in Medicinal Plants

3.2.1. Chromatographic Technique

GC is often used to isolate and identify volatile compounds, such as aromatic compounds, terpenoids, esters, etc. Liquid chromatography can be used to analyze non-volatile components, such as flavonoids, alkaloids, etc. Chromatography has the advantages of good separation effect, fast analysis speed and high sensitivity, and enables the separation and analysis of complex multicomponent mixtures.

3.2.2. Mass Spectrometry Technique

Mass spectrometry is a technique that uses ion sources to

convert samples into ions and analyze the mass-charge ratio by a mass analyzer, thus in qualitative and quantitative analysis of the sample. In medicinal plant studies, mass spectrometry can be used to identify the molecular weights and molecular formulas of unknown compounds, as well as to infer their structures.

3.2.3. Spectral Technology

Spectrum is a technique that detects and analyzes the characteristics of the emitted or absorbed light of a sample. UV visible spectrum is a technique that uses UV and visible light to conduct qualitative and quantitative analysis by detecting the absorption and reflection of light. Infrared spectrum is a kind of technology that uses infrared light to irradiate the sample and detect the absorption of the infrared light.

3.2.4. Biological Methods

The biological method is mainly to observe the physiological response of the organism and select the active ingredients of Chinese herbal medicine. This approach generally requires the addition of herbal extracts or single components to the cell culture medium followed by changes in the growth status, and metabolic levels and functions of cells. For example, oral rosemary extract of xanthine derivatives is able to reduce the growth rate of breast cancer cells.

3.2.5. Physical and Chemical Methods

Physicochemical method is an intuitive and rapid screening method. It mainly selects the active ingredients by observing and testing the color, taste and feel of Chinese herbal medicine. For example, flavonoids in yellow cypress, which can be selected by color change after cooking.

3.3. Application Cases of Plant Composition Analysis Technology in Medicinal Plant Research

3.3.1. Research Background

Pharmaceutical plant Aristolochia is a common Chinese herbal medicine, with the effects of clearing away heat and detoxification, dispelling wind and relieving pain, and is often used in the treatment of rheumatoid arthritis, rheumatoid arthritis and other diseases. However, certain compounds in Aristolochia may cause adverse effects to humans, such as nephrotoxicity, so an in-depth analysis of the components of Aristolochia is needed to understand the efficacy and the mechanism of adverse effects.

3.3.2. Study Methods

Chromatography, mass spectrometry and spectroscopy were used to perform qualitative and quantitative analysis of the chemical composition in Aristolochic. First, flavonoids in Aristolochic were isolated and identified by high performance liquid chromatography and their structure was determined by NMR. Second, GC-MS combined with Aristolochic was used to analyze the volatile compounds and screen the chemical components related to their efficacy and adverse reactions. Finally, spectroscopy was used to detect and analyze other compounds in Aristolochia.

3.3.3. Study Findings

Through the plant composition analysis technology, it was found that aristolochia mainly contains flavonoids, volatile compounds and other types of compounds. Among them, flavonoids have obvious antioxidant and anti-inflammatory effects, while volatile compounds have obvious analgesic

effects. Meanwhile, some compounds with nephrotoxicity were also found, possibly related to the adverse effects of Aristolochic [6].

3.3.4. Conclusion

The application of plant composition analysis technology in the research of medicinal plants can help us to deeply understand the chemical composition and efficacy of medicinal plants, and provide important support for drug development and the utilization of medicinal plant resources. At the same time, it can also help us to understand the adverse reaction mechanism of medicinal plants, and provide a basis for the evaluation of drug safety and effectiveness.

4. Challenges and Prospects of Plant Composition Analysis Techniques in the Study of Medicinal Plants

4.1. Challenges of Plant Composition Analysis Techniques in the Study of Medicinal Plants

The chemical components in medicinal plants are complex and diverse, simultaneously containing many types of compounds, such as flavonoids, alkaloids, volatile oils, etc., and the interaction and influence between these components bring difficulties to the analysis. Due to the different physical and chemical properties of plant components, different sample processing and extraction methods are needed for different components, while also considering how to improve the accuracy and repeatability of the analysis. In addition, although modern analytical instruments provide more means for plant composition analysis, there are still limitations in the sensitivity, resolution and stability of some instruments, and there may be difficulties in the analysis of some trace components. Plant composition analysis produces a large amount of data and complex data, and how to effectively process, parse and interpret these data is a challenge, requiring computer science, statistics and artificial intelligence. Finally, there are many kinds of medicinal plants, and the plant composition may vary in different regions and different varieties. How to achieve standardization and standardized analysis is a problem, and relevant standards and norms need to be established and improved.

4.2. Development Prospects of Plant Composition Analysis Technology in the Study of Medicinal Plants

With the continuous emergence of analytical instruments with high sensitivity, high resolution and high stability, the accuracy and reliability of plant composition analysis have been further improved. For example, the continuous development of advanced technologies such as mass spectrometry, nuclear magnetic resonance technology and infrared spectroscopy provides a more powerful means for the analysis and identification of trace components in medicinal plants [7]. With the continuous development of computer science, statistics and artificial intelligence, the data processing ability of plant composition analysis has been greatly improved. Through data mining and analysis, we can have a deeper understanding of the chemical composition, efficacy and effect of medicinal plants and their action mechanism, so as to provide more inspiration and guidance for the research and development of new drugs and the utilization of medicinal plant resources. With the continuous

development of biotechnology, genomics, proteomics and other emerging fields have also provided new ideas and methods for the research of medicinal plants. Through the discovery and research of biomarkers, we can have a deeper understanding of the efficacy and adverse reaction mechanisms of medicinal plants, and provide more basis for the evaluation of drug safety and effectiveness. With the continuous expansion of the global natural medicine market and the increasing concern about natural drugs, the research and development of medicinal plants has become a rapidly developing field. Therefore, the application prospect of plant composition analysis technology in medicinal plants research is very broad, and there will be more innovations and breakthroughs. In short, the development prospect of plant composition analysis technology in medicinal plant research is very broad, and there will be more innovation and development. The application and development of plant composition analysis techniques in medicinal plants research can be further promoted by continuously improving the sensitivity, accuracy and reliability of analytical techniques, strengthening the cross-cooperation with other disciplines, and establishing and perfecting the relevant standards and specifications.

4.3. Future Development Trend and Research Direction of Plant Composition Analysis Technology

Future developments in plant composition analysis technology will move towards high throughput, high sensitivity, intelligence and automation. With the progress of science and technology, new analytical instruments and technologies will continue to emerge, making the analysis process of plant components more rapid and efficient, while the more trace components can be detected, revealing the complexity and diversity of plant components. Multi-omics joint analysis will become an important direction of plant composition analysis, combining genomics, proteomics, metabolomics and other technologies with plant composition analysis, can provide a more comprehensive understanding of plant components and their mechanism of action. It will also be a trend to study medicinal plants from a systems biology perspective, allowing a more comprehensive understanding of the interactions between plant components and their effects on organisms, and provide more enlightenment for drug development and the utilization of medicinal plant resources. With the deepening of the research on medicinal plants, the plant composition analysis technology will further standardization and standardization in the future, improve the accuracy and comparability of the analysis results, and promote the further development of medicinal plant research. In addition, interdisciplinary cooperation will become an important trend in the development of plant composition analysis technology, and cooperation with computer science, statistics, artificial intelligence and other fields will help to introduce more technologies and methods and promote the innovation and development of plant composition analysis technology.

5. Conclusion

5.1. Importance and Application Value of Plant Composition Analysis Technology in the Study of Medicinal Plants

The analysis technology of plant composition is of great significance and value in the study of medicinal plants. First, medicinal plants are an important part of natural resources, and their complex compound composition and growth environment will have an impact on their composition. Therefore, plant composition analysis technology is an important work in pharmaceutical research, which can deeply understand the chemical composition and efficacy mechanism of medicinal plants, and provide theoretical support for the research and development of new drugs. Secondly, the plant composition analysis technology can be used for quality control to ensure the stability and effectiveness of medicinal materials. For example, the determination of different components in honeybee flowers using infrared spectroscopy can evaluate the quality of honeybee flowers. In addition, through the analysis of the composition of medicinal plants, we can understand their environmental impact and their role in the ecosystem, which contributes to the development of more scientific environmental protection strategies and ecological restoration programs [8].

5.2. Limitations and Direction of Improvement of Plant Composition Analysis Technology

The complexity and diversity of plant components bring great challenges to the analysis. Plants contain a wide variety of compounds, some with structures and very similar properties that are difficult to distinguish and identify. Therefore, developing more refined and accurate separation and analytical methods are needed to improve the discrimination of complex mixtures. There may be errors and disturbances during plant composition analysis. For example, factors such as contamination during sample collection and processing, and instrument error may have an impact on the analytical results. Therefore, enhanced quality assurance and standardized operations are needed to improve the accuracy and reliability of the analysis. Plant composition analysis techniques need to be constantly updated and improved. With the continuous development and progress of science and technology, new analytical methods and instruments continue to emerge, and it is necessary to constantly follow up and learn new technologies and methods to improve the efficiency and accuracy of analysis[9]. Plant composition analysis technology also needs to strengthen the interdisciplinary integration with other disciplines such as biology and pharmacy. Plant composition analysis is not only the separation and identification of compounds, but also needs to be combined with plant biology, pharmacy and other disciplines to explore the relationship between compounds and biological activities, so as to provide more comprehensive support for the research and development of new drugs and the utilization of medicinal plant resources.

5.3. Prospect of the Development Trend and Prospect of the Research Field of Medicinal Plants

As people can recognize and utilize medicinal plants to improve, more medicinal plants will be discovered and

utilized in the future. Through the in-depth exploration and research of medicinal plants, more new drug active ingredients can be found, providing more options for the research and development of new drugs [10]. Medicinal botany will be more deeply integrated with other related disciplines, such as chemistry, biology, pharmacy, etc. This multidisciplinary integration will provide more ideas and methods for the research and development of medicinal plants, and accelerate the research and application process of medicinal plants. As people pay more attention to environmental protection and health, the development of green drugs is getting more and more attention. Green drugs refer to drugs extracted from natural plants, which have the advantages of good curative effect, less side effects and less harm to human body. Therefore, the research and development of green drugs will be an important direction in the future. With the increasing scarcity of medicinal plant resources and the changing environment, the protection and sustainable utilization of medicinal plant resources are becoming increasingly important. In the future, more research will pay attention to the protection and sustainable utilization of medicinal plant resources, and the stable supply of medicinal plant resources will be guaranteed through scientific planting and ecological restoration. In short, the field of medicinal plant research has broad development prospects and trends. In the future, more scientists and researchers will invest in this field to make greater contributions to the cause of human health. At the same time, we also need to pay attention to the protection and sustainable utilization of medicinal plant resources, so as to ensure the long-term utilization and development of human medicinal plant resources.

References

- [1] Xiang Yun, Li Lijun. Role of liquid chromatography-mass spectrometry in composition analysis of medicinal plants [J]. *Journal of Pharmacy*, 2002,37 (5): 7.
- [2] Qin Yongping. Application and Prospect of high-performance liquid chromatography in Plant Composition Analysis and Isolation and Purification [C] // 2001 Annual Meeting of Chinese Pharmaceutical Society. 0[2023-12-12].
- [3] Luo Yuping, Deng Pengfei. TLC and its use in the study of medicinal plants [J]. *Anhui Agricultural Science*, 2011,39 (06): 3309-3312.
- [4] Li Shengshuo, Li Jia, Kang Shuhe, etc. Prediction analysis of research progress and quality markers of medicinal plants in China [J]. *Chinese Journal of Bioengineering*, 2022,42 (11): 27-42.
- [5] Tan Renxiang, Meng Juncai, Chen Daofeng, et al. *Plant composition analysis* [J]. Science Press, 2004.
- [6] Analysis of plant composition [J]. *Plant Magazine*, 2002 (2): 18.
- [7] Li Donghao, Yang Cui, Wang Juan, et al. Microextraction Technology in Plant Composition Analysis [C] // The 19th National Chromatography Academic Report. 2013.
- [8] Liang Jing, Fan Guoquan, Fang Tao, etc. Antibacterial activity screening of 21 medicinal plant extracts and their chemical composition analysis [J]. *Research and Development of Natural Products*, 2023,35 (04): 562-572.
- [9] Zhang Ke, Gong Xingcheng, Cao Libo, etc. Comparative analysis of phytochemical composition of three medicinal categories [J]. *Chinese Journal of Traditional Chinese Medicine*, 2020,45 (13): 3175-3182.
- [10] Gao Guozhen, Cao Wengen, Liu Xiaoyang, etc. Analysis of nutrient composition and medicinal value of the two medicinal plants [J]. *Journal of Huaibei Coal Normal College (Natural Science edition)*, 2003, (01): 44-46.