Factors Affecting the Extraction Components of Artemisia Argyi Volatile Oil

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Abstract: *The main components of Artemisia argyi volatile oil include eucalyptol, camphor, pinene, camphene, borneol, and other active substances. These components exhibit various pharmacological effects such as antibacterial, anticancer, choleretic, antiasthmatic, analgesic, hemostatic, and anti-allergic properties. However, due to variations in Artemisia species, growth environments, and extraction methods, the main components and their concentrations in Artemisia argyi volatile oil can vary. This paper systematically summarizes the factors affecting the composition and content of Artemisia argyi volatile oil, detailing how factors such as the source of Artemisia, harvest time, storage methods, plant parts, and extraction methods influence the essential oil components, providing theoretical references for research on extraction processes and high-value utilization of Artemisia argyi.*

Keywords: *Artemisia; volatile oil; chemical composition; influencing factors*

Introduction

Artemisia argyi volatile oil, extracted from Artemisia argyi leaves, is a complex mixture with high added value as a deep-processing product of Artemisia. The raw material for Artemisia argyi volatile oil is Artemisia argyi Levi. [1] a perennial herbaceous plant in the Asteraceae family, also known as Mugwort, Ai Ye, or Moxa, with various medicinal effects including warming the meridians, reducing inflammation, relieving asthma, stopping coughs, calming the fetus, and alleviating allergies. Artemisia is widely distributed in China, except in extremely arid and high-altitude regions, with wild or cultivated varieties found throughout the country, primarily in Hubei, Henan, and Hebei provinces. China has the largest planting area for Artemisia and is a major producer of Artemisia argyi volatile oil.

Artemisia argyi volatile oil has a distinctive aromatic scent, primarily due to its rich volatile compounds. Its main chemical components include alcohols, ketones, terpenes, and terpenoids, which possess antibacterial, choleretic, antiasthmatic, analgesic, hemostatic, and anti-allergic properties, and are widely used in medicine, food, and cosmetics. The primary components of Artemisia argyi volatile oil can be categorized into three types: monoterpenes, sesquiterpenes, and their derivatives. Components with relatively high concentrations include eucalyptol, camphene, borneol, camphor, and caryophyllene. The composition and relative content of these main components are influenced by factors such as the Artemisia species, source, growth period, plant parts, and extraction methods.

1. Factors Affecting the Composition and Content of Artemisia Argyi Volatile Oil

1.1 Influence of Artemisia Genetic Diversity

In China, there are many varieties of Artemisia species, including Qī Aì, Běi Aì, Hóng Aì, and Hǎi Aì. These varieties not only exhibit highly similar characteristics to counterfeit products in appearance but may also experience hybridization among different species, leading to complex and diverse genetic backgrounds. Due to the genetic diversity and intricate genetic backgrounds, the volatile oil components and their concentrations in these Artemisia species may vary significantly, directly impacting their medicinal value and application potential.

Chen Changjie and colleagues conducted a comprehensive evaluation of 14 quality traits of 100 Artemisia leaf samples. They analyzed the quality and specific traits of different Artemisia leaf resources and eventually categorized the 100 samples into four groups. Among them, the third group was identified as a high-volatile oil variety, with a total volatile oil yield of up to 2.37%. This finding indicates significant differences in volatile oil content among different Artemisia leaf groups, providing a scientific basis for selecting and utilizing high-quality Artemisia leaf resources.

Dong Peng and others performed a fitting analysis of the growth rhythms and biomass of different Artemisia varieties. The results showed significant differences in the accumulation of aboveground dry matter and leaf yield among different sources, which are closely related to their genetic genes. This research highlights the significant differences in growth characteristics among Artemisia varieties and suggests that the genetic traits of the sources should be fully considered when selecting and cultivating Artemisia.

Additionally, Yu Mengjuan[2] and colleagues conducted a systematic cluster analysis of Artemisia from four regions classified by latitude. The results showed that cultivated and wild varieties are closely related, with minimal differences in genetic backgrounds. Furthermore, as latitude changes, the genetic characteristics of Artemisia leaves exhibit a progressive genetic diffusion trend. This result not only reveals the genetic diversity of Artemisia species in different geographic environments but also provides important theoretical support for Artemisia breeding and resource conservation.

1.2 Influence of Different Regions

Dai Weibao and colleagues used steam distillation to extract volatile oils from Artemisia leaves from 12 different regions. The results indicated that while the volatile oils were rich in components, there were significant differences among the regions. Except for the Artemisia leaves from Hebei, all other provinces contained eucalyptol. Among these, the highest percentage of eucalyptol was found in the Artemisia leaves from Nanhui, Guangdong (33.72%). However, the samples from Nanhui, Guangdong, contained only 12 components, and the oil yield was relatively low at 0.35%, with eucalyptol yield also being relatively low (11%). In contrast, the eucalyptol yield in Hubei exceeded 16.0%, with the highest content found in the Artemisia leaves from Qizhou Town, Qichun County, Hubei (19.5%). This batch also contained a large amount of cedrol (23.83%), which was a major component of the batch. The highest cedrol content was found in the Artemisia leaves from Ningxiang, Hunan (36.41%), whereas Artemisia leaves from Hebei Anguo, Anhui Liuan, Gansu Lanzhou, and Guangdong Nanhui did not detect cedrol.

Xiao Yushuo and colleagues identified 155 components from the volatile oils of Artemisia leaves from 5 regions and 13 batches. Among these, 16 components, including pinene, eucalyptol, terpinenes, cedrol, β-caryophyllene, and others, were detected. Notably, the eucalyptol content in the 6 batches of Artemisia leaves from Qichun, Hubei was prominent (33.57%), with unique components such as cedrol, 4-methylbenzyl alcohol, 2-camphol, and borneol being specific to this region. In Jiangsu, cedrol was the main component (Batch 1: 49.16%, Batch 2: 55.60%), significantly higher than in other regions, though the eucalyptol content was low (4.97%). The volatile oil from Taizhou, Zhejiang had fewer components, with only 26 identified, but included unique components such as artemisinin. The highest eucalyptol content was found in the Artemisia from Urumqi, Xinjiang (36.95%).

Li Lihong and colleagues detected 53 substances in the volatile oil of Artemisia leaves from three regions in Henan, with higher levels of eucalyptol and isoborneol in the Fangcheng samples, and eucalyptol being a unique substance. However, the content of ocimene was significantly lower compared to the other two regions. Additionally, Zhao Zhihong and colleagues identified 69 compounds in the Artemisia leaves from Zhengzhou, Henan, with 1,8-cineole being the major component, and reported for the first time the presence of jasmine ketone and β-caryophyllene.

Ren Lingli[3] and colleagues used steam distillation and GC-MS techniques to analyze the chemical components of Artemisia leaves from Nanjing, detecting 117 compounds. The main components were eucalyptol (27.93%), along with diethyl succinate (9.47%), borneol (7.66%), and camphor (6.82%).

1.3 Influence of Different Plant Organs

In Artemisia, various organs such as leaves, stems, and flowers contain certain amounts of active components. However, there are significant differences in the types and concentrations of compounds found in these organs. Artemisia leaves are rich in flavonoids, sesquiterpenes, and alcohols, which play important roles in the plant's metabolism and biological activity. The stems primarily contain sesquiterpenes and alcohols, with relatively lower chemical complexity, but still contribute to the overall function and medicinal value of the plant. The flowers, on the other hand, mainly contain essential oils and flavonoids, which have unique roles in aromatherapy and pharmacological effects.

Sun Zongmiao[4] and colleagues compared the effective components of different parts of Artemisia and found significant differences in the content of these components between the leaves and stems. This finding is consistent with the research results of Xu Junjie and others, who further revealed the differences in essential oil content among Qī Artemisia leaves, flowers, and stems: the essential oil content in Qī Artemisia leaves is as high as 1.44%, significantly higher than that in the flowers (0.95%) and stems (0.59%). Moreover, the chemical components in the essential oil of Qī Artemisia leaves are diverse and have higher relative concentrations compared to the flowers and stems, indicating a significant advantage in terms of chemical diversity and concentration. For example, eucalyptol in Qī Artemisia leaves is present at 18.36%, much higher than in the flowers (10.29%) and stems (4.31%). Conversely, cedrol is found at higher concentrations in the flowers (13.25%) and stems (10.69%) compared to the leaves (6.39%).

These research findings suggest that Artemisia leaves are undoubtedly the best choice for essential oil extraction. This is not only due to their high essential oil content and rich chemical composition but also because the diversity of components ensures better quality and safety of the essential oil. Therefore, using leaves as the primary raw material for essential oil extraction can enhance the efficacy and stability of the product and maximize the medicinal value and market potential of Artemisia.

1.4 Influence of Different Harvesting Times

Jin Ran and colleagues analyzed the essential oil from Artemisia leaves harvested at different times over three years in Qīchūn, Hubei. Their results indicated that the optimal harvesting period is around 20 days before and after the Dragon Boat Festival, during which the essential oil components generally increase, with a higher presence of less volatile substances. However, the content of compounds like cedrol showed considerable variation with no discernible pattern, suggesting that the levels might be influenced by the weather on the day of harvest.

Gao Li [5]and others also studied Hubei Artemisia leaves, preparing essential oils from leaves harvested in May, June, September, and October. They used steam distillation and headspace solid-phase extraction techniques combined with gas chromatography-mass spectrometry (GC-MS) to analyze the chemical composition of the volatile components in each period. Their findings revealed that the percentage of essential oil was highest in June, followed by September, May, and October. Notably, the variety of volatile substances increased significantly in September and October, while the relative percentage of eucalyptol was higher in May and June.

Hong Zongguo and colleagues analyzed essential oils from six batches of Artemisia leaves harvested one month before the Dragon Boat Festival in Qīchūn, Hubei. They observed that the color of the essential oils ranged from light green to light yellow, with the oil content peaking three weeks before the festival (0.953%). In this batch, the concentrations of active pharmacological components like camphor, 4-terpineol, and eucalyptol were higher than in other batches, accounting for a total of 37.87%. Additionally, the content of β-cedrol, which has negative effects on the nervous system, was lower. This study identified the best harvest period as the Grain in Ear solar term rather than the traditional lunar Dragon Boat Festival.

Zhang Yuan and others compared the essential oil from Qīchūn Artemisia leaves harvested before and after the Dragon Boat Festival. They found that the oil content increased steadily before the festival, peaking around May 20th, and then gradually decreased. The number of chemical components also increased over time, from 69 on May 8th to 82 on June 16th, with 41 common components. The main volatile components, such as camphor, eucalyptol, and menthol, had the highest relative content on May 27th at 92.61%, while cedrol and menthol reached their lowest levels on June 9th, at 0.7% and 7.39%, respectively.

1.5 Influence of Different Storage Methods

Different storage methods significantly affect the extraction and composition of essential oils from Artemisia leaves. Research indicates that optimizing storage conditions can not only improve the extraction rate of essential oils but also influence their chemical composition, thereby altering their pharmacological properties.

Ren Lingli[6] and colleagues conducted experiments on essential oil extraction from fresh and aged Artemisia leaves. They identified 117 compounds in the fresh leaves and 124 compounds in the aged leaves. Although the concentration of most compounds decreased during aging, some components increased, and new compounds even emerged. This suggests that the storage method and duration have a significant impact on the composition of essential oils, potentially initiating a series of complex chemical reactions that alter the overall chemical structure of the essential oil.

Miao Likun and others used orthogonal design to explore the effects of storage temperature, humidity, and duration on the extraction efficiency of Artemisia essential oil. They determined the importance of these factors in the following order: storage temperature > storage humidity > storage time. Their results showed that under storage conditions of 40°C, 40% humidity, and 8 months, the average extraction rate of Artemisia essential oil reached 0.645%, with major components including eucalyptol (31.54%), camphor (8.94%), menthol (6.12%), and caryophyllene (6.09%). These findings provide a scientific basis for the optimal storage conditions for Artemisia essential oil and reveal the significant impact of different storage methods on the concentration of key components.

Lang Shiyue and colleagues further investigated the effects of different treatment methods on the composition of Artemisia essential oil. They analyzed fresh, stir-fried, and vinegar-baked Artemisia leaves and identified a total of 41 compounds. The study showed that both stir-frying and vinegar-baking preserved the pharmacological activity of Artemisia leaves while significantly reducing their hepatotoxicity. These treatment methods offer new approaches and techniques for the safe application of Artemisia in traditional medicine, demonstrating the potential for regulating the efficacy components through different storage and processing methods.

Additionally, Hubei Daqi Biological Technology Co., Ltd. developed a novel preservation method for Artemisia leaves, involving ozone and X-ray treatments followed by drying, compressing, and freezing storage. This method effectively extends the shelf life of Artemisia leaves, helps maintain the active components, and reduces the degradation and loss of essential oil components. This preservation technology provides technical support for the long-term storage and market promotion of Artemisia products.

1.6 Influence of Different Extraction Techniques on Essential Oil Composition and Content

Different extraction techniques significantly affect the composition and content of essential oils from Artemisia leaves. Research indicates that optimizing extraction process parameters can effectively improve the extraction rate and concentration of pharmacologically active components, thereby enhancing their medicinal value and application potential.

Chen Hou[7] and colleagues studied the impact of various process parameters in steam distillation on the composition and content of Artemisia essential oil. Their research showed that the best extraction results were achieved under conditions of a condensation temperature of 20° C, a collection temperature of 10° C, a heating temperature of 280° C, a solvent-to-material ratio of 1:15, and after grinding. Under these conditions, the concentrations of key active components in Artemisia, such as camphor, eucalyptol, and caryophyllene, were linearly related to factors such as distillation temperature, condensation temperature, and material particle size. This indicates that precise control of process parameters can effectively enhance the extraction efficiency of key components in essential oils.

Sun Wuqian and others further explored the effects of combining steam distillation with azeotropic distillation on the extraction of Artemisia essential oil. Their results showed that steam distillation had an extraction rate of 0.502%, with 42 components identified, including a pharmacologically active component, eucalyptol, at 19.68%. In contrast, the azeotropic distillation method achieved an increased extraction rate of 0.596%, although the number of separated components decreased to 28, the proportion of pharmacologically active components increased significantly to 32.27%. This study indicates that azeotropic distillation not only improves extraction rates but also optimizes the concentration of active components, providing a clear advantage in terms of extraction efficiency and component retention.

Shen Yanhong and colleagues compared the effectiveness of headspace solid-phase microextraction, steam distillation, and subcritical low-temperature extraction methods in extracting Artemisia essential oil. The research showed that headspace solid-phase microextraction could detect 45 major components, while steam distillation had an extraction rate of 0.13% and isolated 37 components. In comparison, the subcritical low-temperature extraction combined with molecular distillation showed a higher extraction rate of 0.25% and isolated 42 components. This technique demonstrated a significant advantage in retaining active components compared to steam distillation, highlighting its potential application value in essential oil extraction.

Huang Yumei[8] and colleagues employed a semi-bionic enzymatic method to extract essential oil from Artemisia leaves. The experimental results showed that under conditions of an extraction temperature of 60° C, an extraction time of 2 hours, and a material-to-solvent ratio of 1:12, the extraction rate of essential oil reached 2.23%. This method not only shortened the extraction time but also significantly improved extraction efficiency while retaining more of the complete components of Artemisia leaves, making it highly practical and economical for industrial production.

Additionally, Wu Lu and others researched the extraction of Artemisia essential oil using microwave-assisted extraction. The results indicated that under conditions of microwave power at 300W, a material-to-solvent ratio of 1:8, and a reflux time of 45 minutes, the yield of essential oil reached 0.45%. Microwave-assisted extraction not only achieved a higher extraction efficiency but also completed the process in a shorter time, thus saving energy and reducing time costs.

Conclusion

Artemisia, a traditional Chinese medicinal herb with a long history, contains active components primarily found in its leaves, such as sesquiterpenes, ketones, alcohols, and esters. These essential oils impart unique pharmacological effects to Artemisia, including anti-inflammatory, antiviral, antioxidant, and anticancer properties, which offer broad application prospects in medicine, cosmetics, and health supplements.

The composition and content of Artemisia essential oil are influenced by various factors, including species, origin, collection time, extraction process, and storage methods. Notably, the origin, harvesting time, and extraction technique significantly impact the essential oil. Therefore, when extracting essential oil from Artemisia leaves, it is crucial to consider these factors thoroughly to maximize its application efficacy.

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