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Application of automatic boiling equipment in the research and development of Yunnan white ointment

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Abstract: *This study explores the application of automated decoction equipment in the development of Yunnan Baiyao ointment. As a representative traditional Chinese medicine formulation, Yunnan Baiyao ointment traditionally relies on manual operations, which pose challenges such as low production efficiency and inconsistent preparation quality. To address these issues, this paper introduces automated decoction equipment and analyzes its application effectiveness in the production process. The results show that automation technology not only enhances the production efficiency and consistency of Yunnan Baiyao ointment but also significantly reduces preparation costs, providing new technological support for the modernization of Chinese medicine production.*

Keywords: *automated decoction equipment; Yunnan Baiyao ointment; Chinese medicine preparation; production efficiency*

1. Introduction

Chinese medicine holds significant medical and cultural value worldwide, with Yunnan Baiyao ointment being renowned for its unique medicinal efficacy and preparation techniques since ancient times. However, traditional manual preparation methods have limitations in improving production efficiency and product consistency. With advancements in modern technology, the application of automation equipment in Chinese medicine preparation has gradually gained attention, bringing new possibilities and opportunities to traditional preparation methods. This paper aims to explore the application effectiveness of automated decoction equipment in the development of Yunnan Baiyao ointment, analyze its advantages and challenges over traditional preparation methods, and discuss the prospects for future technological development. Through this study, not only can the application value of automation technology in Chinese medicine manufacturing be deeply understood, but it can also promote the process of modernizing Chinese medicine production, enhancing its position and influence in the global health industry.

2. Yunnan Baiyao Ointment Preparation Methods

2.1. Overview of Traditional Manual Preparation Process

Yunnan Baiyao ointment, as a traditional Chinese medicine formulation with a long history, embodies rich medicinal preparation experience and traditional craftsmanship. The traditional manual preparation process begins with the selection and processing of medicinal herbs. Key steps include grinding and blending the herbs to precise ratios, followed by heating and boiling to form the ointment. Initially, the finest raw materials with specific pharmacological properties such as Chuanxiong and licorice are selected and meticulously mixed in strict proportions. Subsequently, the herbs are ground to increase their surface area, facilitating the extraction of medicinal components during the boiling process[1]. Traditional refining pots are employed to heat the mixture, controlling the temperature to dissolve active ingredients from the herbs completely, ultimately achieving the desired concentration and viscosity of the ointment. This meticulous and intricate manual process not only demands extensive experience and skill from pharmaceutical practitioners but also emphasizes the accuracy and meticulousness of each step to ensure the quality and stability of the final product. However, traditional manual preparation methods face challenges in terms of production efficiency and consistency, particularly when meeting modern market demands for stability in quality and large-scale production.

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2.2. Key Steps and Technical Requirements in the Preparation Process

The preparation process of Yunnan Baiyao ointment involves several critical steps, each significantly impacting the quality and efficacy of the final product. Firstly, the selection and preparation of medicinal herbs directly determine the efficacy and safety of the ointment. Traditionally, herbs used in Yunnan Baiyao ointment such as Chuanxiong and licorice undergo careful screening and processing to meet pharmacological requirements. Secondly, precise blending and grinding processes are crucial to control the exact proportions of each herb, ensuring stable efficacy and consistency in the final product. Herb grinding is typically performed using traditional stone mills or modern grinders to increase the surface area of herbs, facilitating subsequent boiling processes. During boiling, controlling the heating temperature and duration is critical to ensure complete dissolution of active ingredients from the herbs. Traditionally, refining pots regulate temperature by adjusting flame size and burner position, requiring precise operations based on herb characteristics and formulation requirements. Additionally, regular stirring during boiling ensures uniform dissolution of herbs, preventing clumping or scorching during the process. In terms of technical requirements, traditional preparation methods rely on the extensive experience and mastery of pharmaceutical practitioners, particularly in temperature control and herb processing. However, with advancements in modern technology, the introduction of automated decoction equipment has gradually alleviated the limitations of traditional preparation methods, enhancing production efficiency, and ensuring product quality stability, representing a significant trend in the modernization of Chinese medicine production[2].

2.3. Analysis of Limitations in Traditional Preparation Methods

While traditional manual preparation methods for Yunnan Baiyao ointment have accumulated rich historical experience, they also exhibit significant limitations. Firstly, manual preparation relies on the manual operations and experience of pharmaceutical practitioners, resulting in low production efficiency and susceptibility to human factors, which challenge the consistency and quality assurance of products. The grinding and heating control during herb processing require high technical proficiency from operators, limiting production scale and stability. Secondly, traditional methods are time-consuming and resource-intensive, particularly costly in large-scale production. In mass production scenarios, manual boiling processes can lead to issues such as high labor intensity and complex working environments, affecting production efficiency and employee health. Furthermore, traditional methods face difficulties in quality control. Due to variations in manual operations and process variability, fluctuations in product efficacy and consistency may occur, posing challenges for long-term product quality assurance. Finally, with increasing market demands and consumer health awareness, traditional preparation methods struggle to meet modern requirements for large-scale production and quality management. Therefore, the introduction of modern automated decoction equipment represents a crucial approach and development direction to enhance production efficiency and ensure product quality stability for Yunnan Baiyao ointment[3].

3. Automatic Brewing Equipment Technical Characteristics

3.1. Basic Working Principle of the Equipment

Automatic brewing equipment achieves automated management and control of the medicinal herb brewing process through advanced control systems and process workflows. Its fundamental working principle involves preset programs and parameters to automatically control key processes such as heating, stirring, and timing, ensuring that medicinal herbs undergo brewing under suitable temperature and time conditions. The equipment typically includes precise temperature sensors and control systems to monitor and adjust temperature changes in real-time during brewing. Depending on the characteristics of the herbs and formulation requirements, the equipment can precisely control the heating power and duration of the brewing pot, avoiding overheating or undercooking of the herbs, and ensuring maximum extraction of medicinal components and product consistency. Furthermore, the automatic brewing equipment is equipped with efficient stirring systems to uniformly mix herbal solutions, preventing clumping or sedimentation during the brewing process, thus ensuring the uniformity and stability of the final product. These advanced technical features not only enhance the precision and efficiency of the brewing process but also significantly reduce dependency on manual operation and error rates, marking a notable technological advancement and production advantage in traditional Chinese medicine preparation[4].

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3.2. Equipment Structure and Design Features

The structure and design features of automatic brewing equipment directly impact its efficiency and reliability during medicinal herb brewing processes. Generally, automatic brewing equipment encompasses several key structures and design features:

1) Brewing Pot and Heating System: The equipment is typically equipped with specially designed brewing pots that exhibit excellent thermal conductivity and high-temperature resistance. The heating system employs advanced electric heating technology or other heat sources capable of rapid heating and precise temperature control, ensuring that herbs are brewed within the appropriate temperature range.

2) Control System: Automatic brewing equipment features highly intelligent control systems encompassing functions such as temperature control, timer settings, and stirring speeds. The control system automatically executes various operations during the brewing process according to preset recipes and process workflows, significantly reducing manual intervention and errors.

3) Stirring and Mixing System: The equipment is equipped with efficient stirring systems that uniformly mix herbs and solutions, ensuring thorough dissolution of medicinal components and maintaining uniformity. Advanced equipment may include multi-stage stirrers or vortex mixing technologies to enhance mixing efficiency and production throughput.

4) Safety Protection and Clean Design: Equipment design considerations for pharmaceutical production hygiene requirements typically involve materials that are easy to clean and disinfect. This ensures quick and effective equipment cleaning and disinfection before and after each production cycle. Additionally, the equipment is equipped with safety protection devices and emergency shutdown systems to safeguard operator and equipment safety[5].

Through these structural and design features, automatic brewing equipment not only enhances the automation level and stability of production processes but also effectively reduces production costs and labor inputs, providing crucial support and assurance for the modernization of traditional Chinese medicine manufacturing.

3.3. Advantages of Automation Compared to Traditional Preparation

Automatic brewing equipment offers significant advantages over traditional manual preparation methods, primarily evident in the following aspects:

1) Increased Production Efficiency: Automated equipment achieves continuous and efficient production operations through preset programs and automated control systems. In contrast, traditional manual preparation methods are limited by human resources and operational skills, typically resulting in lower production efficiency and susceptibility to human errors.

2) Ensured Stability and Consistency of Product Quality: Automated equipment ensures precise control over key factors such as temperature, time, and stirring speed during the brewing process through advanced control and monitoring systems. This enhances the stability and consistency of product quality compared to traditional preparation methods, which are prone to fluctuations due to differences in operator skills and manual processes.

3) Reduced Human Error in Operations: Automated equipment minimizes human intervention and errors through automated control and monitoring systems, thereby enhancing the reliability and stability of production processes. Traditional preparation methods rely heavily on operator experience and skills, making it challenging to avoid operational errors that may impact product quality.

4) Lower Production Costs: Despite higher initial investments, automated equipment ultimately lowers overall production costs by improving production efficiency, reducing energy consumption, and minimizing labor costs. In contrast, traditional preparation methods often incur higher production costs due to labor-intensive processes and lower efficiency.

5) Adaptation to Modern Production Demands: With increasing market demands for product quality stability and large-scale production, automated equipment better adapts to modern production requirements and challenges, providing businesses with a competitive technological advantage. Traditional preparation methods face significant limitations in meeting demands for large-scale production and quality management.

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In summary, automatic brewing equipment, with its efficient, stable, and reliable production characteristics, is becoming a crucial technological means and trend for modernizing traditional Chinese medicine manufacturing.

4. Automatic decoction equipment in the development of Yunnan Baiyao ointment

4.1. Introduction of Equipment Application Cases

Automatic decoction equipment has been widely applied in the research and production of Yunnan Baiyao ointment. Here is a specific case study: In a pharmaceutical company specializing in traditional Chinese medicine preparation, advanced automated decoction equipment was introduced to enhance the production efficiency and product quality stability of Yunnan Baiyao ointment. This equipment utilizes advanced control systems and efficient heating and stirring technologies to precisely control the temperature and stirring speed of the decoction pot, achieving a fully automated decoction process. In practical applications, the equipment first automatically adds medicinal herbs according to preset formulas and process parameters, accurately measuring the proportions of various herbs. Subsequently, the equipment initiates the heating system, automatically adjusting the heating power of the decoction pot according to the set temperature curve, ensuring uniform decoction of the herbs within the appropriate temperature range. Moreover, the equipment is equipped with efficient stirrers that evenly mix the herbal solution, preventing clumping and precipitation during the decoction process. This automated decoction equipment not only significantly improves the production efficiency of Yunnan Baiyao ointment, enabling the production of large quantities per hour, but also greatly enhances the stability and consistency of product quality. Through precise temperature control and effective stirring, it effectively preserves the active ingredients of the herbs, enhancing the efficacy and safety of the products. Overall, this case demonstrates the significant application of automated decoction equipment in the modernization of traditional Chinese medicine production, maintaining competitive advantages in a fiercely competitive market[6].

4.2. Effect Evaluation in Application Cases

The introduction of automated decoction equipment in the development of Yunnan Baiyao ointment has achieved significant effects, mainly reflected in the following evaluation results:Enhanced Production Efficiency: The application of automated equipment significantly enhances production efficiency. Traditional manual preparation is limited by manual operations and restrictive production conditions, often resulting in slow production speeds and susceptibility to the skill levels and physical fatigue of operators. The introduction of automated equipment has greatly enhanced the production capacity of Yunnan Baiyao ointment, significantly shortening the production cycle and increasing the hourly production output.Stability of Product Quality: Automated decoction equipment significantly improves the stability and consistency of product quality through precise temperature control and effective stirring. Studies show that automated equipment can more accurately control temperature curves and heating power during the decoction process, avoiding product quality fluctuations caused by human operational errors in traditional preparation methods.Optimization of Cost Efficiency: Despite the higher initial investment of automated equipment, it achieves significant cost efficiency optimization by enhancing production efficiency and optimizing production processes. Automated equipment reduces labor costs and energy consumption, and by precisely controlling the use of medicinal herbs and reducing waste, it lowers overall production costs.Reduction of Operator Burden: The use of automated equipment reduces dependence on operator skill levels, allowing operators to focus more on monitoring production data and quality control during equipment monitoring and adjustment. This not only enhances operational efficiency but also reduces the possibility of human operational errors, further ensuring product quality and stability.In summary, the application of automated decoction equipment in the development of Yunnan Baiyao ointment demonstrates clear advantages and practical application value in the field of traditional Chinese medicine preparation, through analysis focusing on enhancing production efficiency, optimizing cost efficiency, and improving the stability of product quality[7].

4.3. Cost-Benefit Analysis and Production Efficiency Enhancement

The introduction of automated decoction equipment in the development of Yunnan Baiyao ointment has not only significantly increased production efficiency but also optimized cost efficiency, as

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analyzed below:Increased Production Efficiency: The application of automated decoction equipment has greatly increased the production efficiency of Yunnan Baiyao ointment. Traditional manual preparation methods are limited by manual operations and production conditions, often resulting in long production cycles. With automated equipment, through preset programs and precise control systems, the equipment achieves continuous and efficient production operations, significantly shortening the production cycle and increasing hourly production output. Cost-Benefit Analysis: Despite the higher initial investment of automated equipment, it achieves significant cost efficiency optimization by enhancing production efficiency and optimizing production processes. Automated equipment reduces labor costs, lowers energy consumption, and through precise control of herbal materials usage and reduced scrap rates, reduces raw material waste, thereby lowering overall production costs.Enhancement of Quality Stability: Automated decoction equipment enhances the stability and consistency of Yunnan Baiyao ointment products through precise temperature control and stirring effects[8]. The equipment ensures precise control of key parameters such as temperature, time, and stirring speed during the decoction process, avoiding product quality fluctuations caused by human operational errors in traditional preparation methods.Improved Operational Efficiency: The application of automated equipment reduces dependence on operator skill levels. Operators can focus more on quality control and production management during equipment monitoring and adjustment, enhancing operational efficiency and work quality.In conclusion, the application of automated decoction equipment in the development of Yunnan Baiyao ointment demonstrates significant advantages and practical application value in the field of traditional Chinese medicine preparation, through analysis focusing on enhancing production efficiency, optimizing cost efficiency, and improving product quality stability.

5. Technical Innovation and Development Trends

5.1. Future Development Directions of Automation Technology in Traditional Chinese Medicine Preparation

Driven by technological advancements and the trend towards manufacturing intelligence, automation technology has shown broad prospects in the field of traditional Chinese medicine preparation. In the future, the development directions of automation technology in traditional Chinese medicine preparation mainly focus on the following aspects:Intelligent Control Systems: Future automation equipment will emphasize the development and application of intelligent control systems. By integrating advanced technologies such as artificial intelligence and big data analytics, these systems will enable self-learning and optimized adjustments, further enhancing the flexibility and adaptability of production processes. Intelligent control systems will automatically adjust process parameters based on real-time data and environmental changes, ensuring the quality and stability of each batch of products.Process Optimization and Automation Process Improvement: Future automation equipment will prioritize process optimization and automation process improvements. By optimizing herbal ingredient ratios, process flows, and production scheduling, efficiency and yield will be further enhanced. Automation equipment will facilitate intelligent production scheduling and resource utilization to meet the demands of rapid market changes and personalized customization.Sustainable Development and Green Manufacturing: Against the backdrop of environmental protection and sustainable development, future automation technologies will focus more on green manufacturing and resource conservation. Through optimized energy use, reduced waste emissions, and improved equipment efficiency, production processes will become more environmentally friendly and resource sustainable, meeting modern societal expectations for corporate responsibility and sustainability.Integration and Platform Development: Future automation equipment will trend towards integration and platform development. These devices will be more flexible and modular, seamlessly integrating with other production equipment and information systems to achieve information-based management and intelligent control of production processes. Such integrated and platform-based developments will provide traditional Chinese medicine manufacturers with enhanced technical support and opportunities for business growth.In summary, the future development of automation technology in traditional Chinese medicine preparation will continue to pursue intelligent, green, and sustainable directions. This will elevate production efficiency, optimize product quality, reduce production costs, and further propel the transformation of the traditional Chinese medicine industry towards modernization and intelligence.

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5.2. Potential Improvements and Future Research Directions

Future improvements and research directions for automation technology in traditional Chinese medicine preparation include, but are not limited to, the following aspects:Precision Herbal Ingredient Blending and Mixing Technology: Further research and development of precision herbal ingredient blending and mixing technologies to enhance efficacy and stability. Advanced measurement and blending techniques will ensure precise control of ingredient proportions in each batch, mitigating fluctuations in product quality due to herbal quality variations.Efficient Energy Use and Environmentally Friendly Technologies: Development of automation equipment with efficient energy utilization and environmentally friendly technologies to reduce energy consumption and environmental pollution. Implementation of energy-saving techniques and clean energy sources will optimize equipment structure and process flows, enhancing energy efficiency during production and environmental protection standards.Smart Manufacturing and Data-Driven Decision Making: Promotion of smart manufacturing and data-driven decision making through big data analytics and artificial intelligence technologies to achieve automated monitoring and optimized adjustments in production processes. Real-time data analysis will enable quick responses to market demand changes, improving production efficiency and product quality consistency.Integrated Production Systems and Smart Factory Construction: Establishment of integrated production systems and smart factories for comprehensive information management and automated control of production processes. Advancing modular design of equipment and intelligent interconnections will facilitate seamless integration and resource sharing among production equipment, enhancing overall production efficiency and flexibility.Human-Machine Collaboration and Workplace Safety: Research on human-machine collaboration technologies and workplace safety management to optimize interaction interfaces and safety control systems between automation equipment and operators. Ensuring the safety and reliability of automated production processes will enhance operational efficiency and working conditions for personnel.By continually advancing these improvements and future research directions, automation technology in traditional Chinese medicine preparation will become more intelligent, efficient, and sustainable, providing robust technical support and innovation momentum for industry progress and development.

6. Conclusion

Based on the application of automated brewing equipment in the research and development of Yunnan Baiyao ointment, along with its future development trends, this study draws the following conclusions: The introduction of automated equipment has significantly improved production efficiency. Through precise control systems and optimized production processes, it has drastically shortened production cycles and enhanced the market competitiveness of enterprises. Simultaneously, the use of this equipment has effectively improved product quality stability and consistency, avoiding human errors inherent in traditional preparation methods, thus meeting consumer demands for high-quality products. Despite the initial high investment, cost-benefit analysis demonstrates significant cost savings and increased production efficiency during long-term operation of automated equipment. Looking ahead, with the further development of intelligent control systems, environmentally friendly technologies, and data-driven decision-making, automation technology will continue to propel the field of traditional Chinese medicine preparation towards intelligence, environmental friendliness, and sustainability. This will inject new momentum and vitality into the industry's development.

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