Effects of Irradiation on the Major Components of Panax Notoginseng (Sanqi) Herbal Medicine

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Abstract: This paper investigates the effects of irradiation technology on the major components of Panax Notoginseng (Sanqi) herbal medicine. Irradiation technology, particularly 60Co-γ irradiation, has been widely used as an effective sterilization method in food and pharmaceutical processing. In the field of traditional Chinese medicine (TCM), irradiation technology has demonstrated unique advantages, effectively eliminating microbial contamination while preserving the main components and therapeutic efficacy of TCM. This paper first introduces the basic principles of irradiation technology and its current research status in TCM processing, then analyzes the major components and pharmacological effects of Panax Notoginseng, and finally assesses the impact of irradiation on these components, emphasizing its effectiveness and safety in maintaining medicinal efficacy.

Keywords: Irradiation Technology; Panax Notoginseng; Major Components; Pharmacological Effects; 60Co-γ Irradiation; Sterilization

Introduction:

With the advancement of modern technology, irradiation technology is increasingly being applied in food and pharmaceutical processing. Traditional Chinese medicine (TCM), as a conventional therapeutic approach, garners extensive attention for its safety and efficacy. Panax Notoginseng (Sanqi) is widely used for its significant anti-inflammatory, anti-tumor, hemostatic, and blood-activating properties. However, during production and storage, Panax Notoginseng is susceptible to microbial contamination, affecting its safety and efficacy. 60Co-γ irradiation, as a highly efficient sterilization technique, can eliminate microbial contamination and be performed at ambient temperature and pressure, ensuring that the major components and therapeutic efficacy of the medicine remain unaffected. This paper aims to systematically analyze the impact of irradiation technology on the major components of Panax Notoginseng, exploring its application prospects in TCM processing, and providing theoretical and practical support for enhancing the safety and efficacy of TCM.

1.Overview of Irradiation Technology

1.1 Basic Principles of Irradiation Technology

Irradiation technology is an advanced method that utilizes ionizing radiation to process materials. The fundamental principle involves the interaction of high-energy rays (such as γ-rays, X-rays, or electron beams) with substances, triggering complex ionization and excitation effects. These effects can directly or indirectly damage the molecular bonds of microbial DNA and other biological macromolecules, thereby achieving microbial inactivation or altering the structure of the material.

1.1.1 Ionization and Excitation Effects

Ionization effect refers to the process where radiation interacts with matter and the energy is

sufficient to remove electrons from molecules, forming ions and free radicals. These ionized atoms and molecules can react with surrounding molecules, causing further molecular chain breaks or cross-linking, leading to the loss of function of microbial biomacromolecules and consequently, inactivation.

On the other hand, radiation can excite molecular electrons to transition within the molecule or transition from the ground state to an excited state, producing short-lived excited-state molecules. These excited-state molecules release additional energy when returning to the ground state, which may cause the chemical bonds of surrounding molecules to break, further enhancing the impact of radiation on microorganisms and materials [1].

1.1.2 Radiation Sources and Application Characteristics

The widely used 60Co-γ radiation source has high radiation energy and penetration ability, enabling uniform processing of thicker material layers. This radiation source is easy to operate, fast in processing speed, and does not significantly raise the temperature of the material, making it suitable for processing heat-sensitive substances such as pharmaceuticals and biological materials.

Irradiation technology operates at ambient temperature and pressure, maintaining the structural and chemical properties of materials without significant changes or degradation, thus ensuring the quality and functionality of the treated materials. This high controllability makes irradiation technology widely applicable in fields such as medicine, food processing, and material modification.

1.2 Applications of Irradiation Technology in Food and Pharmaceutical Processing

Irradiation technology has been widely applied in food and pharmaceutical processing. In food processing, irradiation is primarily used for sterilization, preservation, extending shelf life, and pest control. Through irradiation, pathogenic and spoilage bacteria in food can be effectively killed while maintaining the nutritional components and sensory qualities of the food. For example, irradiation technology has shown significant results in meat, seafood, fruits, and vegetables, ensuring food safety and quality.

In pharmaceutical processing, irradiation technology is used for sterilization, removal of allergens, and modification of drug molecular structures. Traditional thermal sterilization methods tend to degrade the active ingredients of drugs, while irradiation allows sterilization at ambient temperatures, avoiding thermal damage. Many pharmaceuticals, such as antibiotics, vitamins, and traditional Chinese medicine preparations, have achieved efficient sterilization through irradiation technology. Additionally, irradiation can be used for modifying drug carriers, enhancing drug stability and bioavailability.

1.3 Current Research Status of Irradiation Technology in Traditional Chinese Medicine (TCM) Processing

In recent years, significant research progress and application expansion have been made in the field of irradiation technology in TCM processing. TCM materials and preparations are often affected by microbial contamination during production and storage. Traditional sterilization methods, such as high-temperature heat treatment and chemical disinfection, can effectively sterilize but may lead to the degradation of active ingredients and loss of efficacy. Due to its protective characteristics of major components, irradiation technology has become an effective solution to these problems.

1.3.1 Principles and Application Mechanisms of Irradiation Technology

Irradiation technology primarily utilizes the high energy characteristics of 60Co-γ rays to achieve sterilization through ionization effects and free radical generation, damaging the nucleic acids and protein structures of microbial cells. This method can penetrate both the surface and interior of TCM materials, achieving comprehensive sterilization, and is particularly suitable for complex and difficult-to-process medicinal materials [2].

1.3.2 Protective Effects of Irradiation Technology on Major Components of TCM

Research shows that irradiation technology ensures the safety of TCM while having minimal impact on its major active components. For example, in Panax Notoginseng, 60Co-γ irradiation effectively eliminates microbial contamination, including common bacteria and fungi, without significantly affecting the content and efficacy of ginsenosides (such as Rb2, Rb3, Rg1, Rg3, Re, Rd, F2, Rk1, Rh1). These components are crucial for the pharmacological effects of Panax Notoginseng, and the application of irradiation technology ensures its stability and reliability in clinical use.

1.3.3 Development Trends of Irradiation Technology in Modern TCM Production

As irradiation technology matures and its applications in TCM processing expand, its position in modern TCM production becomes increasingly consolidated. Future research directions include optimizing irradiation parameters and processes to further improve sterilization efficacy and the ability to protect the active components of medicinal materials. Combining with other modern processing technologies, such as ultrasound and nanotechnology, diversified TCM processing methods can be explored to further enhance the overall quality and efficacy of TCM.

2 Main Components and Pharmacological Effects of Panax Notoginseng Herbal Medicine

2.1 Chemical Components of Panax Notoginseng

Panax notoginseng is a medicinal herb with significant therapeutic value. Its primary chemical components include saponins, flavonoids, polysaccharides, volatile oils, and amino acids. Saponins are the main active components, including ginsenoside Rb1, ginsenoside Rb2, ginsenoside Rg1, ginsenoside Rg3, ginsenoside Re, and ginsenoside Rd. Flavonoids such as quercetin and kaempferol are also present in significant amounts and possess antioxidant and anti-inflammatory properties. Additionally, Panax notoginseng contains various vitamins, minerals, and amino acids, which collectively contribute to its unique pharmacological effects.

2.2 Pharmacological Effects of Panax Notoginseng

Panax notoginseng is widely used in traditional Chinese medicine to treat various diseases, and modern pharmacological research has further revealed its multiple therapeutic effects. It exhibits notable anti-inflammatory, anti-tumor, hemostatic, blood circulation-promoting, lipid-lowering, cholesterol-reducing, and cardiovascular-protective effects. Specifically:

Anti-inflammatory Effect: Panax notoginseng saponins inhibit the release of inflammatory mediators and reduce inflammatory cell infiltration, showing significant efficacy in various inflammatory diseases.

Anti-tumor Effect: Studies indicate that Panax notoginseng saponins can induce apoptosis in cancer cells, inhibit tumor growth and metastasis, and have potential anti-cancer properties [3].

Hemostatic and Blood Circulation-promoting Effect: The saponins in Panax notoginseng can promote platelet aggregation and accelerate coagulation while also improving microcirculation and preventing thrombosis.

Cardiovascular Protection: Panax notoginseng saponins lower lipid and cholesterol levels, improve myocardial ischemia, prevent atherosclerosis, and protect the cardiovascular system.

Antioxidant Effect: The flavonoid compounds in Panax notoginseng possess strong antioxidant capacity, capable of scavenging free radicals and protecting cells from oxidative damage.

2.3 Contribution of Major Components to the Efficacy of Panax Notoginseng

The therapeutic effects of Panax notoginseng are mainly attributed to its rich chemical components, with saponins and flavonoids playing crucial roles. Ginsenoside Rg1 and Rb1 are the most abundant saponins in Panax notoginseng, and studies have shown that these saponins have significant anti-

inflammatory, anti-tumor, and cardiovascular protective effects. Specifically, ginsenoside Rg1 has a notable neuroprotective effect, improving learning and memory functions and preventing neurodegenerative diseases; ginsenoside Rb1 exhibits strong antioxidant and anti-fatigue effects, enhancing the body's immunity.

Flavonoid compounds such as quercetin also play essential pharmacological roles in Panax notoginseng. Quercetin has strong antioxidant, anti-inflammatory, and anti-tumor effects, capable of scavenging free radicals, inhibiting inflammatory responses, and suppressing cancer cell growth. Additionally, quercetin can improve vascular function and prevent cardiovascular diseases.

Overall, the diverse therapeutic effects of Panax notoginseng result from the synergistic action of its multiple active components. In-depth research on the pharmacological effects and mechanisms of the main components of Panax notoginseng can provide a scientific basis for its clinical application and further enhance its medicinal value. Ensuring the stability and activity of these major components during the irradiation treatment of Panax notoginseng is crucial for achieving effective sterilization and maintaining its therapeutic efficacy.

3 Effects of Irradiation on the Major Components of Panax Notoginseng Herbal Medicine

3.1 Ensuring the Components and Efficacy of Panax Notoginseng Powder through Irradiation Technology

The use of 60Co-γ irradiation sterilization technology is an effective method to eliminate microbial contamination while preserving the main components and efficacy of Panax notoginseng powder. By treating Panax notoginseng powder with high-energy γ-rays, this irradiation technology effectively kills various microorganisms, including bacteria, molds, and yeasts, ensuring the product meets pharmaceutical microbial limits standards, thereby improving its safety and stability.

In practical applications, 60Co-γ irradiation technology not only provides strong sterilization capabilities but also maintains the stability of the primary active components in Panax notoginseng. These main components include ginsenosides Rb2, Rb3, Rg1, Rg3, Re, Rd, F2, Rk1, Rh1, and flavonoids such as quercetin. Research indicates that the content of these active components remains largely unchanged after treatment with 60Co-γ rays, ensuring the efficacy of Panax notoginseng powder is not affected [4].

Firstly, irradiation technology has minimal impact on the saponin components of Panax notoginseng. Saponins are chemically stable and do not undergo significant degradation or structural changes during irradiation. For example, the content of major ginsenosides such as Rb2 and Rg1 remains stable after irradiation, and their pharmacological activity is not significantly affected. These saponin components significantly contribute to Panax notoginseng's anti-inflammatory, anti-tumor, and cardiovascular protective effects, making it crucial to maintain their content and activity to preserve the overall efficacy of Panax notoginseng powder.

Secondly, flavonoids such as quercetin also exhibit good stability during irradiation. Quercetin, known for its significant antioxidant and anti-inflammatory properties, retains its content and activity post-irradiation. This ensures that irradiation technology not only provides microbial safety for Panax notoginseng powder but also preserves its pharmacological effects such as antioxidation and anti-inflammation, thereby enhancing the overall therapeutic efficacy.

Furthermore, irradiation technology features non-thermal processing, avoiding the degradation of heat-sensitive components that can occur with traditional thermal sterilization methods. This cold treatment method ensures that the main components of Panax notoginseng powder are not affected by high temperatures and maintains its physical properties and sensory characteristics, providing strong

assurance for its clinical and production applications.

3.2 Application and Maturity of Irradiation Technology in Traditional Chinese Medicine (TCM)

The application of irradiation technology in eliminating various pathogenic microorganisms in TCM is highly mature, posing no theoretical risks and demonstrating high reliability and effectiveness in practice. Through irradiation technology, bacterial, mold, and yeast contamination in TCM materials can be effectively eradicated, meeting Chinese pharmaceutical microbial limits standards, thereby ensuring the safety and quality of TCM products.

In TCM clinical practice, Panax notoginseng is widely used due to its multiple pharmacological effects, including anti-inflammation, anti-tumor, hemostasis, blood circulation promotion, cholesterol and lipid reduction, and cardiovascular disease prevention, demonstrating significant efficacy. Traditional sterilization methods such as thermal sterilization and chemical sterilization often damage the active components of Panax notoginseng, affecting its efficacy. In contrast, 60Co-γ irradiation technology, as a cold sterilization method, can sterilize Panax notoginseng materials at ambient temperature and pressure, effectively avoiding damage to the medicinal components caused by heat or chemicals.

Specifically, 60Co-γ irradiation technology can thoroughly eliminate microbial contamination in Panax notoginseng while effectively preserving its main components and efficacy. Research shows that the primary active components in Panax notoginseng, such as ginsenosides Rb2, Rb3, Rg1, Rg3, Re, Rd, F2, Rk1, Rh1, and important flavonoids like quercetin, maintain their content and activity after irradiation treatment. These components significantly contribute to the therapeutic effects of Panax notoginseng, and their stability directly relates to its clinical efficacy and application value [5].

Additionally, the application of irradiation technology in TCM is not limited to Panax notoginseng. In recent years, many TCM materials and preparations have adopted irradiation technology for sterilization, accumulating extensive experience and data. These practices prove that irradiation technology has broad applicability and significant superiority in the TCM field. TCM materials treated with irradiation technology can maintain their original properties and efficacy while enhancing product safety and storage stability.

The mature application of irradiation technology provides critical technical support for the modernization of TCM production. Its simplicity, speed, strong penetration, ability for continuous operation, thorough sterilization effect, and economic and safety advantages have led to its increasing application in TCM production. By integrating with traditional processes, irradiation technology can significantly enhance the quality control level of TCM materials, ensuring the competitiveness of TCM products in modern production and international markets.

3.3 Advantages of 60Co-γ Irradiation Sterilization

60Co-γ irradiation is a simple and efficient ambient temperature and pressure sterilization method that has been widely used in the sterilization of TCM and Western medicines in recent years. Compared to traditional sterilization methods, 60Co-γ irradiation sterilization, as a cold sterilization technology, has the following notable advantages:

Firstly, 60Co-γ irradiation is a cold processing method that can perform sterilization at ambient temperature and pressure, meaning it does not cause thermal damage to temperature-sensitive medicinal components. Traditional thermal sterilization methods may lead to degradation or inactivation of the active ingredients in medicinal materials, while irradiation technology can maintain the chemical stability and biological activity of the materials, ensuring their efficacy is unaffected.

Secondly, 60Co-γ rays have strong penetration ability, able to penetrate medicinal material packaging and the interior of the materials, ensuring the thoroughness of sterilization. In contrast, chemical sterilization methods may have uneven sterilization issues, especially when processing large batches of materials, as the penetration and uniformity of chemical agents are relatively poor. 60Co-γ irradiation ensures that all materials receive uniform radiation exposure during the process, achieving thorough sterilization [6].

Additionally, 60Co-γ irradiation sterilization is simple to operate, fast, capable of continuous operation, and suitable for large-scale production. Traditional sterilization methods usually require complex procedures and longer processing times, whereas irradiation technology can significantly improve production efficiency. The irradiation process can achieve automation and continuous operation, greatly reducing human interference, lowering production costs, and enhancing production efficiency.

Economic and safety aspects are also critical advantages of 60Co-γ irradiation. The operating costs of irradiation equipment are relatively low, and no harmful chemical by-products are produced during irradiation, meeting environmental protection requirements. Compared to chemical sterilization methods, irradiation technology is more environmentally friendly and has a minimal impact on both medicinal materials and the environment. Furthermore, the irradiation process strictly adheres to international radiation safety standards, ensuring the safety of operators and the surrounding environment.

In the modernization of TCM production, 60Co-γ irradiation technology has been methodologically validated and gradually applied to the sterilization of TCM materials and preparations. TCM materials treated with irradiation technology can effectively remove microbial contamination, improve the safety and quality stability of medicines, and meet the requirements of modern TCM production. For example, Panax notoginseng medicinal materials treated with irradiation maintain their main components and efficacy, providing reliable assurance for clinical applications.

Conclusion

The research on the application of irradiation technology in the processing of Panax notoginseng (Sanqi) herbal medicine has revealed that 60Co-γ irradiation can effectively eliminate microbial contamination in Panax notoginseng powder while ensuring that its main components and pharmacological efficacy remain largely unchanged. The application of irradiation technology in TCM processing is already quite mature, offering advantages such as cold processing, strong penetration, simplicity of operation, and rapid speed, meeting the demands of modern TCM production. However, future research needs to further explore the effects of irradiation technology on other components of TCM, optimize irradiation parameters to ensure the quality and efficacy of TCM. Additionally, the combined application of irradiation technology with other modern processing technologies will also be an important direction for future research, providing more innovative ideas and technical support for the development of the TCM industry.

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