Journal of Clinical and Nursing Research, 2025, Volume 9, Issue 4
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Exploration on the Chemical Constituents and Pharmacological Effects of Korla Fragrant Pears

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Abstract: Korla fragrant pears are one of the "famous, excellent, and special" fruits in Xinjiang. They belong to the white pear variety in the genus Pyrus of the Rosaceae family. With a long-standing planting history and strong regional characteristics, they are mainly produced in southern Xinjiang. Due to unique natural conditions such as large temperature differences between day and night and sufficient sunlight, Korla fragrant pears have a crispy texture, a sweet but not cloying taste, and their flesh is delicate and juicy, with excellent quality. Korla fragrant pears contain a variety of bioactive substances, mainly including polysaccharides, polyphenolic compounds, flavonoid compounds, triterpenoids, and sterols. They have medical effects such as "moistening the lungs, calming the heart, reducing phlegm, anti-inflammation, relieving cough, and resolving carbuncle toxins". Uyghur and Mongolian medicine often use them as a good dietary therapy product. Based on recent literature reports, this paper reviews the main chemical constituents and pharmacological effects of Korla fragrant pears, aiming to provide references for the research and utilization of the deep processing of Korla fragrant pears.

Keywords: Korla fragrant pears; Chemical constituents; Antioxidation; Immunomodulation; Pharmacological effects

Online publication: April 29, 2025

1. Introduction

Korla fragrant pears are representative varieties of the Xinjiang pear system, mainly distributed in southern Xinjiang. In recent years, research has shown that their fruits contain a variety of active ingredients, including polysaccharides, polyphenolic compounds, flavonoid compounds, triterpenoids, and sterols [1, 2]. Domestic research mainly focuses on the pharmacological effects, content determination, and extraction processes of components such as polysaccharides, while foreign research mostly pays attention to the compositional analysis of soluble solids in fragrant pear flowers and fruits [3].

Korla fragrant pears have the effects of nourishing Yin and moistening the lungs, relieving fatigue and improving intelligence, protecting the liver, and improving eyesight. They are a natural green food. Modern

research shows that they have significant effects in reducing cholesterol, preventing atherosclerosis, reducing oxidative damage, delaying aging, and enhancing immunity [4]. Given their unique nutritional and medicinal values, Korla fragrant pears have become an ideal raw material for the development of functional foods. Researchers have explored deep-processing technologies for them and developed functional foods with specific health-care functions, providing scientific basis and practical support for promoting the research of Korla fragrant pears in the field of food-medicine homology and their application in the health field.

2. Research progress on the chemical constituents of Korla fragrant pears

In recent years, systematic research on the chemical constituents of Korla fragrant pears has shown that their main active ingredients include polyphenols, polysaccharides, triterpenoids, and sterols. At the same time, they also contain a variety of nutrients such as volatiles, esters, vitamins, amino acids, and minerals. These components not only endow Korla fragrant pears with unique flavors and nutritional values but also provide a scientific basis for their food-medicine dual-use functions.

(1) Polyphenols

Polyphenolic compounds are a class of secondary metabolites rich in Korla fragrant pears, mainly including phenolic acids, flavonoids, tannins, lignans, and coumarins [3, 5]. Among them, flavonoid compounds such as quercetin, kaempferol, and their glycoside derivatives are important active ingredients in Korla fragrant pears, with a total flavonoid content of 0.5–1.2mg/g (fresh weight). Research shows that phenolic acid compounds are not only closely related to the sensory characteristics of fruits such as color, flavor, and texture but also have significant antioxidant, anti-inflammatory, and anti-cancer activities [6, 7].

(2) Polysaccharides

Polysaccharides are important functional components in Korla fragrant pears, mainly composed of pectin, cellulose, hemicellulose, and starch, with a molecular weight range of 10–200kDa. Research shows that Korla fragrant pear polysaccharides are mainly pectin-type polysaccharides and arabinogalactans. They have significant immunomodulatory effects, can promote intestinal health, and may play a prebiotic function by regulating the gut microbiota. In addition, polysaccharide compounds also exhibit antioxidant and anti-tumor activities, providing theoretical support for the development of functional foods.

(3) Terpenoids and sterols

Terpenoid compounds are important active ingredients in Korla fragrant pears, mainly including monoterpenoids, sesquiterpenoids, diterpenoids, and triterpenoid derivatives. These components have anti-inflammatory, antibacterial, and anti-tumor cell proliferation activities. In addition, Korla fragrant pears are rich in β-sitosterol, a sterol compound widely distributed in the plant kingdom. It can regulate cholesterol metabolism and play a lipid-lowering function, providing potential application value for the prevention of cardiovascular diseases.

(4)Vitamins and minerals

Korla fragrant pears are rich in a variety of vitamins and minerals, which are the core of their nutritional value. The vitamin C content is prominent (about 5–8mg/100g), and they also contain B-group vitamins (B1, B2) and a small amount of vitamin E. In terms of minerals, Korla fragrant pears are rich in potassium (120–150mg/100g), calcium, magnesium, iron, and other elements. Potassium plays an important role in regulating blood pressure and maintaining electrolyte balance. It is worth noting that due to the selenium-

rich soil in the Xinjiang production area, the selenium content of Korla fragrant pears in this area is significantly higher than that in other production areas, further enhancing their nutritional value and health-care functions.

(5) Other components

The unique aroma of Korla fragrant pears comes from esters (such as ethyl acetate), aldehydes (such as hexanal), and terpenoid compounds. Yuan L *et al*. analyzed the mature fruits of 10 pear varieties from 5 species and identified 18 primary metabolites and 144 volatiles. The results showed that Korla fragrant pears had the richest content of volatiles and esters [8]. In addition, Korla fragrant pears also contain 17 amino acids, with high contents of glutamic acid and aspartic acid. The proportion of umami-tasting amino acids is about 40%, which contributes significantly to the formation of their flavor characteristics.

3. Research progress on the pharmacological effects of Korla fragrant pears

3.1. Antioxidant effect

Korla fragrant pears are rich in a variety of antioxidant components, including polyphenols, flavonoids, and polysaccharides. These components have a strong scavenging ability against superoxide anion radicals, hydroxyl radicals, DPPH radicals, etc. Flavonoid compounds can not only reduce the generation of free radicals by chelating metal ions but also directly scavenge free radicals, thus exerting an antioxidant effect. Polyphenolic substances can provide hydrogen atoms to combine with free radicals due to the multiple phenolic hydroxyl groups in their molecular structure, stabilizing the free radicals and interrupting the oxidative chain reaction.

Research shows that the neutral polysaccharides PSNP-1 and PSNP-2 in Korla fragrant pears have significant antioxidant activities [8]. Their mechanism of action may be related to regulating the expression levels of proteins related to the TLR4/NF-κB signaling pathway, thereby inhibiting the production and release of inflammatory factors. Among them, the antioxidant activity of PSNP-1 is better than that of PSNP-2, which may be related to its larger molecular weight and more effective groups. Natural plant polysaccharides have become ideal raw materials for the development of functional foods and drugs due to their high activity and low side effects. Therefore, the neutral polysaccharides PSNP-1 and PSNP-2 of Korla fragrant pears are expected to be used as low-toxicity and high-efficiency antioxidant components in the development of health products or in combination with other drugs to improve the quality of life of patients. Zhou *et al.* evaluated the scavenging abilities of Korla fragrant pear polysaccharide components (PSNP-1, PSNP-2, PSAP-1, and PSAP-2) against DPPH radicals, hydroxyl radicals, superoxide radicals, and ABTS+ radicals. The results showed that although their scavenging abilities were lower than those of vitamin C at the same concentration, Korla fragrant pear polysaccharides still exhibited good antioxidant activities overall [9].

The scavenging rates of total polyphenols in the peel, pulp, exocarp, and core of Korla fragrant pears against DPPH radicals are 85%, 60%, 67%, and 72% respectively. The antioxidant ability of the peel is the strongest (with the lowest IC50 value), indicating that the peel of Korla fragrant pears is an important source of antioxidant active ingredients [10].

3.2. Immunomodulatory effect

Components such as polysaccharides in Korla fragrant pears can significantly stimulate the proliferation of RAW264.7 macrophages and enhance the phagocytic ability of macrophages, thus more effectively

clearing foreign substances such as pathogens. Wu *et al.* confirmed the enhancing effect of polysaccharides on the phagocytic ability of mononuclear macrophages in immune organs by studying the effects of crude polysaccharides from Korla fragrant pears on serum immune factors in immunosuppressed mice, indicating that they have significant immunomodulatory functions [11].

In terms of the immunological effects of cytokines, the crude polysaccharides of Korla fragrant pears can regulate the levels of T-lymphocyte subsets and enhance the mechanisms of IL-2 and IFN-1, showing good immune-enhancing effects [12].

3.3. Expectorant and antitussive effects

Sputum is a mixture of mucus secreted by the glands and goblet cells of the trachea and bronchi and the fluid, electrolytes, and antibacterial substances secreted by the submucosal glands of the airway mucosa. This mucus can adsorb pathogens in the airway and be discharged from the body through ciliary movement, thus playing a role in protecting the respiratory tract.

By establishing a cough mouse model, it was found that the crude polysaccharides of Korla fragrant pears could significantly increase the excretion of phenol red in the trachea of mice, indicating their expectorant effect. Compared with the blank control group, the three dose groups of the crude polysaccharides of Korla fragrant pears could significantly reduce the number of coughs in mice ($P < 0.05$), and the effect of the high-dose group was equivalent to that of the positive control group. In addition, Korla fragrant pear polysaccharides also showed significant antitussive effects on cough models induced by concentrated ammonia water and sulfur dioxide, further confirming their potential in the treatment of respiratory diseases [13].

3.4. Anti-inflammatory effect

Korla fragrant pear polysaccharides can inhibit the expression of cell-pyroptosis-related genes such as IL-1β and IL-18 and proteins such as NLRP3 and GSDMD, exerting an anti-inflammatory effect. In addition, they can also intervene in the TLR4/NF-κB signaling pathway to inhibit cell pyroptosis, thereby improving airway inflammation in allergic asthma mice.

Research has found that Korla fragrant pear polysaccharides can significantly inhibit the inflammatory response in the cell-pyroptosis model of RAW264.7 cells induced by lipopolysaccharide (LPS) and adenosine triphosphate (ATP). Compared with the model group, the cell proliferation rate of the drug-intervention group was significantly increased ($P < 0.01$), indicating that Korla fragrant pear polysaccharides can enhance the immune-protective ability of cells, inhibit the expression of GSDMD proteins and genes, and thus reduce cell swelling death and the release of inflammatory factors [14].

In addition, flavonoid compounds in Korla fragrant pears can reduce oxidative stress by scavenging free radicals, thereby reducing the production of inflammatory factors. They can also inhibit inflammation-related enzymes such as COX and reduce the synthesis of inflammatory mediators such as prostaglandins. For example, flavonoids such as rutin can effectively reduce the inflammatory response [15].

3. Conclusions and prospects

As a typical representative of “food-medicine homology”, Korla fragrant pears have a scientific basis for their traditional edible value due to their rich chemical constituents and diverse pharmacological activities. At the

same time, they also lay a foundation for the development of new functional foods and natural drugs. In recent years, with the continuous in-depth research on Korla fragrant pears, their pharmacological effects in antioxidant, immunomodulation, anti-inflammation, expectorant, and antitussive aspects have gradually been revealed, showing broad application prospects in the health field.

However, although some progress has been made in existing research, there are still many mysteries in the pharmacological mechanism of Korla fragrant pears. For example, the mechanisms of action of their potential anti-cancer and anti-tumor effects have not been fully elucidated, and the "component-efficacy-mechanism" relationship between active ingredients and biological effects remains in a "black box" state. In addition, the synergistic mechanism of multiple active ingredients (such as polysaccharides, polyphenols, flavonoid compounds, etc.) in Korla fragrant pears and their metabolic pathways in the human body remain to be further explored.

In summary, the research on Korla fragrant pears not only has important scientific significance but also has significant economic value and social benefits. Through the in-depth integration of interdisciplinary research (such as food science, pharmacology, molecular biology, etc.) and technological innovation, it is expected to make breakthroughs in the following aspects in the future:

(1) In-depth analysis of the pharmacological mechanism: Clarify the action targets and molecular pathways of the active ingredients of Korla fragrant pears, providing a theoretical basis for their pharmacodynamics.

(2) Development and optimization of functional products: Develop functional foods or natural drugs with specific functions such as antioxidant, immunomodulation, and anti-inflammation based on their active ingredients.

(3) Industrial application and promotion: promote the transformation of Korla fragrant pears from basic research to industrialization, realize the high-value utilization of Xinjiang's characteristic resources, and contribute to the sustainable development of the regional economy.

These research results will not only provide new solutions for human health but also inject new vitality into rural revitalization and regional economic development, with far-reaching social significance and application prospects.

Funding

Science and Technology Achievements Transformation Project of the Autonomous Prefecture (Project No.: 202401)

National College Students' Innovation and Entrepreneurship Training Program (Project Title: "Li Zhiyun · Ku Li Chun" – Pioneer in Promoting National Geographic Brand, Project Number: 202513561005). The article constitutes the theoretical analysis outcome of this research initiative.

Disclosure statement

The authors declare no conflict of interest.

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