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Review of the Botanical Characteristics, Phytochemistry, Pharmacology and Anti-Cancer Research Progress of Astragalus membranaceus (Huangqi)

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Abstract: Astragalus (Astragalus membranaceus), as a traditional Chinese herbal medicine, has been widely used in clinical treatment of various diseases, especially known for its pharmacological effects such as immune regulation, antioxidant, anti-inflammatory and neuroprotective. In this paper, the botanical characteristics, chemical constituents, pharmacological actions and anticancer research progress of Astragalus astragalus were reviewed. The botanical characteristics of Astragalus membranaceus show that it is mainly distributed in northern China and other Asian regions, with strong growth adaptability, and the common medicinal part is its root. Astragalus Astragalus is rich in a variety of bioactive chemical components, among which Astragalus polysaccharides, flavonoids and Astragalus saponins are the main pharmacological active components, which play an important role in enhancing immunity, antioxidant, anti-inflammatory and neuroprotection. Astragalus can enhance the body's defense against pathogens by enhancing the function of immune cells such as T cells and NK cells. Astragalus also has significant antioxidant effect by enhancing the activity of antioxidant enzymes, reducing the damage of oxidative stress on cells. Astragalus also shows anti-inflammatory effects by regulating immune factors, suppressing inflammatory responses and reducing the symptoms of diseases caused by chronic inflammation. In terms of neuroprotection, Astragalus provides protection to the nervous system through antioxidant, anti-inflammatory and other mechanisms, helping to delay the development of neurodegenerative diseases. Astragalus plays an anticancer role by inhibiting tumor cell proliferation, inducing cancer cell apoptosis and reducing tumor angiogenesis. Especially when used in combination with chemotherapy drugs, Astragalus can improve the therapeutic effect and reduce side effects.

Keywords: Astragalus membranaceus, plant characteristics, chemical composition, pharmacological action.

1. Introduction

Astragalus membranaceus (MPaceUS), as an important medicinal material in traditional Chinese medicine, has been used for thousands of years. Its roots are widely used in traditional Chinese medicine prescriptions and are known as the "medicine for invigorating qi" [1]. Astragalus plays an important role in ancient Chinese medical literature, which is recorded in detail in Compendium of

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Materia Medica. It is believed that Astragalus has many effects, such as supplementing qi and strengthening surface, supporting poison and expending pus, reducing edema and so on. With the continuous development of science and technology and the deepening of the integration of traditional Chinese and Western medicine, the pharmacological effects and clinical applications of Astragalus have been more widely studied and recognized. Modern medical research has found that Astragalus not only performs well in traditional applications, but also shows important pharmacological value in immune regulation, antioxidant, anti-inflammatory, neuroprotection, etc., which makes the potential of Astragalus in disease prevention and treatment get more attention and attention [2].

The traditional application of astragalus mainly focuses on strengthening physical strength, improving immunity, delaying aging and so on. According to the "Shennong Herbal Classic" records, astragalus is believed to have the functions of tonifying qi and blood, supporting poison and expelling pus, treating deficiency of sweating, etc., and is often used to treat immune hypothermia, weakness, weakness and other symptoms caused by deficiency of qi. Astragalus can be found in many traditional Chinese medicine prescriptions, such as the classic prescription "four Junzi Decoction" and "Buzhong Yiqi Decoction", which contain Astragalus, its role is to regulate the body's qi and blood, and promote the healthy operation of the immune system.

Modern medical research shows that astragalus does have the multiple functions described by traditional Chinese medicine theory. Astragalus can effectively relieve some chronic diseases and immune system diseases, such as hypertension, diabetes, liver disease and tumor, by regulating the immune system, antioxidant and anti-inflammatory effects [3]. In terms of immune regulation, Astragalus can enhance the function of T cells, B cells, natural killer cells (NK cells) and other immune cells, and enhance the immune defense ability of the body against diseases. In terms of antioxidant, Astragalus protects cells from free radical damage and delays the aging process by inhibiting oxidative stress. The anti-inflammatory effect of Astragalus helps to alleviate the chronic inflammatory response caused by immune overactivity and improve the symptoms of a variety of diseases caused by immune disorders. Astragalus polysaccharides, saponins, flavonoids and other components are considered to be the main source of its anticancer effect. Astragalus components can inhibit the proliferation of cancer cells by regulating the cell cycle. Astragalus saponins can reduce the number of cancer cells by affecting the G1 phase of cancer cells to stop cell division. Astragalus polysaccharides and saponins can induce the programmed death of cancer cells by regulating the intracellular apoptotic signaling pathway. Astragalus can inhibit the expression of Bcl-2 family proteins, promote the release of apoptosis proteins in cancer cells, and induce the apoptosis of tumor cells.

The purpose of this study was to investigate the botanical characteristics, chemical composition, pharmacological action and anti-cancer research progress of Astragalus, and to provide theoretical support for clinical application of Astragalus. Through systematic literature review and experimental data analysis, we reveal the multiple pharmacological effects of Astragalus in modern medicine, especially its potential in cancer treatment.

2. Botanical characteristics of Astragalus

2.1. Classification and Distribution

Astragalus membranaceus is a genus of membranaceus in the legume family, widely distributed in China, Mongolia, Korea and some countries in Central Asia. China is the origin of Astragalus, but also the main production area of Astragalus, especially in northern Inner Mongolia, Shanxi, Gansu, Shaanxi and other places have relatively rich resources [4]. Astragalus mainly grows in temperate and subcold zones, and is adaptable and can grow in different climates and soil conditions, but it is best to grow in dry, sunny and well-drained soil.

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2.2. Morphological Characteristics

Astragalus is a typical herb that usually has a strong root system and a relatively small above-ground portion. The roots are thick, long and strong, with a yellow or light yellow surface and a hard texture, and a uniform pulp structure is usually seen when cut. The above-ground portion of Astragalus is usually relatively low, with branched stems and relative pinnate compound leaves that are green and shiny [5]. The inflorescence is usually a raceme with small white flowers that open in the summer and may lag to form brown or black pods. Astragalus seeds are small, the seed coat is hard, and the mature seeds can remain active for a long time in dry climates.

2.3. Growth Environment and Ecological Requirements

Astragalus has relatively low requirements for the growing environment, but prefers dry, well-drained, sandy soil rich in organic matter. Under natural growth conditions, Astragalus usually grows in mountainous or plain areas at higher altitudes, especially in dry grasslands in temperate areas. Astragalus has a strong drought tolerance and can still grow under water shortage, but in humid environments, the root system of Astragalus may rot, resulting in plant death. Therefore, planting Astragalus requires good land drainage and suitable soil pH value. A sunny, warm environment helps it grow, while a cold climate may inhibit it.

3. Chemical Composition of Astragalus

Astragalus aceus as a traditional Chinese medicine, its efficacy is mainly due to its rich chemical composition. After years of research, scientists have identified a variety of bioactive substances in Astragalus, such as flavonoids, polysaccharides, saponins, amino acids, trace elements and so on. The combined action of these components has an important influence on its pharmacological action [6].

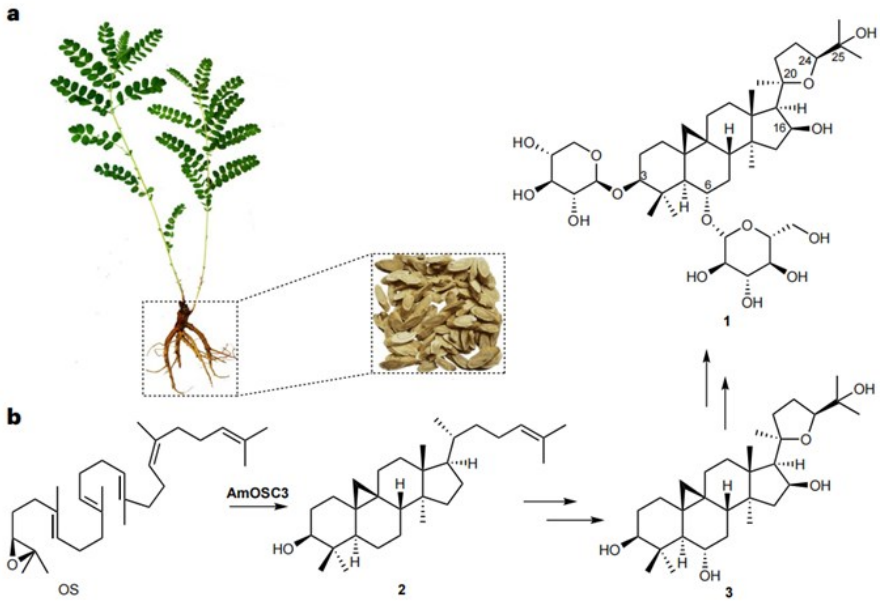

Figure 1: Chemical composition [6].

Astragalus polysaccharide (APS) is a high molecular weight polysaccharide containing multiple sugar units connected by different glucoside bonds. Studies have shown that Astragalus polysaccharide has significant immunomodulatory effects, which can enhance the immune function

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of the body, promote the activity of macrophages, increase the proliferation of T cells, and then improve the body's resistance to pathogenic microorganisms.

Flavonoids in Astragalus mainly include flavonoids, flavonols, flavanols and other components, these compounds have strong antioxidant effects. By inhibiting lipid peroxidation, flavonoids remove free radicals, protect the stability of cell membrane, and reduce the damage caused by oxidative stress [7]. Astragalus saponins mainly include Astragalus A, Astragalus B and other types, among which Astragalus A is considered to be the most important pharmacological component. Astragalus saponins have a wide range of pharmacological effects in immune regulation, anti-oxidation, anti-inflammation, anti-tumor and so on (Figure 1).

In addition to polysaccharides, flavonoids and saponins, Astragalus also contains a variety of amino acids, trace elements, phytosterols, volatile oils and other components. Amino acids such as glutamic acid and aspartic acid in Astragalus have certain nutritional support and immune regulation effects on human body. Astragalus also contains calcium, magnesium, iron, zinc and other mineral elements, these components to maintain the normal physiological function of the body and enhance the activity of the immune system are essential. In addition, Astragalus also contains a certain amount of plant sterols, such as β-sitosterol, which has antioxidant, anti-inflammatory, regulating cholesterol metabolism and other effects (Table 1).

Table 1: Other chemical components of Astragalus

Serial number	Category	Ingredient
1	Amino acid	Gamma-aminobutyric acid, threonine, aspartate, aspartate, serine, glutamic acid, alanine, proline, alanine, glycine, cystine, methionine, isolein Amino acid, leucine, lysine, arginine, tyrosine, valine, leucine, histidine, cysteine, phenylalanine, etc.
2	Trace element	Sc, Se, Cr, Cu, Zn, Mn, Co, Si, Mo, Ca, P, Cs, La, Ce, Fe, K, Rb, Sm, etc.
3	Other	Sucrose, mucous, picrin, amylase, coumarin, Vitamin D, riboflavin, vanillic acid, isoferulic acid, ferulic acid, chlorogenic acid, linolenic acid, caffeic acid, niacin, Coumarin, niacin, Starch E, Carotene, betaine, niacinamide, linoleic acid, folic acid, lupinol, beta-sitosterol, palmitic acid, rosmarinic acid, protocatechu Acid, 4-hydroxybenzoic acid, hypericin, hesperidin, etc.

4. Pharmacological Effects of Astragalus

4.1. Immunoregulatory Effects

Astragalus in traditional Chinese medicine is widely believed to have the role of "supplementing qi and strengthening surface", which can enhance the body's immunity, prevent the invasion of external evil, and promote the body's self-repair. The immunomodulatory effect of Astragalus membranaceus is one of its most prominent pharmacological properties, mainly through regulating the function of immune cells and the secretion of immune factors to enhance immune response [8].

Studies have shown that Astragalus can significantly improve the body's non-specific immune response. For example, Astragalus polysaccharide (APS), as one of the main bioactive components of Astragalus, can enhance the function of the immune system by enhancing the phagocytosis of macrophages and promoting the proliferation and activation of white blood cells [9]. Astragalus can enhance the function of T cells and enhance the synergistic effect of humoral immunity and cellular

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immunity by activating Th cells and cytotoxic T cells (CTL). Astragalus can also stimulate the activity of natural killer cells (NK cells) and macrophages, promote their release of interferon (IFN-γ), interleukin (IL-1, IL-2) and other cytokines, effectively enhance the immune response.

4.2. Antioxidant Effect

Modern medical research has found that oxidative stress is a key factor in many chronic diseases and the aging process, and excessive free radicals (especially reactive oxygen species) play a crucial role in cell damage, inflammatory response, vascular diseases, neurodegenerative diseases, and so on. Astragalus contains rich bioactive ingredients, especially flavonoids, saponins and polysaccharides, and has strong antioxidant capacity [10].

The antioxidant mechanism of Astragalus membranaceus is mainly embodied in scavenging free radicals and improving the activity of antioxidant enzymes. Studies have shown that Astragalus can enhance the antioxidant capacity of cells by increasing the activities of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) in vivo. Astragalus flavones, especially Astragalus flavones, have strong free radical scavenging effect and can directly react with free radicals to reduce cell oxidative damage.

4.3. Anti-inflammatory Effect

Inflammation is a normal immune response to external stimuli, but excessive or chronic inflammation can lead to a variety of diseases, such as arthritis, cardiovascular disease, diabetes, and more. The anti-inflammatory effect of Astragalus is realized by inhibiting the release of inflammatory mediators and regulating inflammatory response. Astragalus reduces the secretion of pro-inflammatory cytokines (such as TNF-α, IL-6, IL-1β) by inhibiting the activation of inflammatory cells [11]. Studies have shown that Astragalus can inhibit the expression of pro-inflammatory factors and reduce inflammation by regulating the nuclear factor κB (NF-κB) signaling pathway. Secondly, Astragalus can inhibit the infiltration of inflammatory cells (such as neutrophils, macrophages, etc.) and reduce the inflammatory damage of local tissues. Flavonoids and saponins in Astragalus have strong anti-inflammatory effects, which can reduce inflammation by inhibiting the synthesis and release of inflammatory mediators.

4.4. Neuroprotective effect

Oxidative stress and inflammation are the pathogenesis of many nervous system diseases, and Astragalus, as a natural antioxidant and anti-inflammatory drug, has a certain protective effect on the nervous system. Especially in Alzheimer's disease, Parkinson's disease, stroke sequelae and other neurodegenerative diseases, the neuroprotective effect of astragalus has been widely studied. Astragalus alleviates oxidative damage of nerve cells and protects neurons from free radical damage through antioxidant action. Studies have shown that Astragalus can increase the expression of antioxidant enzymes and enhance the tolerance of neurons to oxidative damage by activating Nrf2/ARE signaling pathway. Astragalus reduces the inflammatory response of nerve cells by inhibiting neuroinflammation. In neurodegenerative diseases such as stroke and Alzheimer's disease, Astragalus can effectively inhibit the release of pro-inflammatory cytokines and reduce the damage of neuroinflammation to brain tissue. Astragalus can also promote the recovery of nerve function by promoting the proliferation and repair of nerve cells, especially during the rehabilitation process after nerve injury.

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5. Progress in Anticancer Research of Astragalus

In recent years, the research of Astragalus membranaceus (MPaceUS) in the field of anti-cancer has made remarkable progress. As a traditional Chinese medicine, Astragalus has a variety of bioactive components, among which polysaccharides, flavonoids and saponins are considered to be the main anticancer components. Studies have shown that Astragalus exerts anti-cancer effects through various mechanisms, including inhibiting the proliferation of tumor cells, inducing apoptosis of cancer cells, inhibiting tumor angiogenesis, and regulating immune response [12]. The anticancer effect of astragalus polysaccharide (APS) is particularly concerned. It can enhance the anti-tumor ability of the body by regulating the immune system, promote the activity of immune cells such as T cells, macrophages and natural killer cells (NK cells), and thus improve the body's ability to remove cancer cells. In addition, astragalus flavonoids can reduce the generation of free radicals, reduce oxidative damage, and further inhibit the proliferation and spread of tumor cells through antioxidant effects.

Astragalus saponins have also shown potential in anticancer studies, especially in inhibiting tumor growth and reducing tumor metastasis. It has been found that astragalus saponin can achieve its anticancer effect by inhibiting the proliferation of cancer cells, promoting apoptosis of cancer cells, and slowing down tumor angiogenesis. The anti-cancer effect of Astragalus is not only reflected in inhibiting the proliferation of tumor cells, but also through regulating the tumor microenvironment, reducing the inflammatory response caused by cancer, reducing the aggressiveness of cancer cells, and further exerting the anti-tumor effect.

In recent years, several clinical and animal experimental studies have also confirmed the potential of astragalus in cancer treatment, especially when used in combination with chemotherapy drugs, to significantly improve efficacy and reduce side effects. In general, the research of astragalus in the field of anticancer provides a new idea for cancer treatment, especially as an adjuvant therapy drug, and has a greater clinical application prospect.

6. Conclusion

In summary, Astragalus membranaceus (MPaceUS), as a traditional Chinese medicine with a long history, has attracted much attention in modern medical research due to its rich chemical composition and a variety of pharmacological effects. The main active ingredients of Astragalus, such as Astragalus polysaccharides, flavonoids and saponins, have shown strong immunomodulatory, antioxidant, anti-inflammatory and neuroprotective effects, providing new therapeutic ideas and drug development directions for the treatment of many diseases. Especially in the regulation of immune system, Astragalus can enhance the body's defense against external pathogens by enhancing the function of immune cells and promoting antigen presentation. In terms of antioxidant, Astragalus can protect cells from oxidative damage by scavenging free radicals and enhancing the activity of antioxidant enzymes. In terms of anti-inflammatory and neuroprotection, Astragalus can effectively inhibit inflammatory response, reduce nerve damage, promote nerve repair, and show potential therapeutic effects on neurodegenerative diseases.

The anti-cancer research of astragalus has also made remarkable progress. Astragalus has demonstrated its anticancer potential through multiple pathways, including inhibiting the proliferation of tumor cells, inducing apoptosis of cancer cells, and inhibiting tumor angiogenesis. Especially when used in combination with chemotherapy drugs, Astragalus can enhance the efficacy and reduce the side effects of chemotherapy, providing a new adjuvant treatment scheme for cancer patients. However, the anti-cancer mechanism of astragalus is not yet fully understood, and further basic research and clinical trials are needed to further explore its specific mechanism and clinical application.

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In general, Astragalus, as a natural medicine, with its multiple pharmacological effects and good safety, has shown great potential in immune regulation, antioxidant, anti-inflammatory, neuroprotective and anticancer aspects. With the deepening of scientific research, the application of astragalus in disease prevention and treatment will be more extensive, and it may become an important adjuvant therapy drug in the future, and make greater contributions to improving human health.

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