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Research Progress on the Active Ingredients and Mechanism of Action of Shenling Baizhu San in the Treatment of Ulcerative Colitis

Xiaoyan Zhang[1], Yi Li[2,*]

[1]Shaanxi University of Chinese Medicine, Xianyang 712046, Shaanxi, China
[2]Affiliated Hospital of Shaanxi University of Chinese Medicine, Xianyang 712000, Shaanxi, China
**Correspondence Author*

Abstract: ***Ulcerative colitis (UC) is a chronic, non-specific inflammatory bowel disease that occurs in the mucosa and submucosa of the colorectum and the terminal part of the ileum. Its pathogenesis is related to multiple factors such as environment, genetics, immune dysregulation and intestinal flora disorders. According to the traditional Chinese medicine, this disease belongs to the category of "diarrhea", "diarrhea" and other diseases, and its main etiology is spleen deficiency and dampness. In the clinical diagnosis and treatment of UC, Western medicine commonly used aminosalicylic acid preparations, glucocorticoids and other drugs, but long-term use of easy to lead to drug resistance and metabolic disorders. In recent years, traditional Chinese medicine (TCM), especially Ginseng and Atractylodes Macrocephalae, has shown unique advantages in relieving clinical symptoms, immunomodulation and improving the quality of life of patients with UC. In this paper, we systematically review the pharmacological effects of the active ingredients (ginsenosides, porinic acid, atractylenolide, etc.) in ginseng saponin and atractylenolide, and elucidate its multi-target mechanism of inhibiting inflammatory response, repairing the intestinal mucosal barrier, and regulating the intestinal bacterial homeostasis through the modulation of the NF-κB, JAK/STAT and other pathways. This paper provides a theoretical basis for the clinical application of ginseng-lingbaijusan and the modernization of compound Chinese medicine, as well as ideas for exploring novel therapeutic protocols for UC and providing more diversified therapeutic options for UC patients.***

Keywords: Ulcerative colitis, Ginseng-lingbaijusan, Inflammatory injury, Multi-target mechanism, Intestinal flora.

1. Pathogenesis and Current Treatment Status of Ulcerative Colitis

Ulcerative colitis (UC) is a chronic non-specific inflammatory bowel disease characterized by mucosal inflammation, ulcers, and bleeding. The lesions mostly start from the anal end of the rectum and develop reversibly towards the proximal end. It often clinically presents as recurrent diarrhea, bloody and mucopurulent stools, and abdominal pain. The condition varies in severity, recurs repeatedly, and has a lifelong tendency for relapse and carcinogenesis [1]. Its incidence is increasing worldwide [2,3]. The pathogenesis mainly involves genetic susceptibility, epithelial barrier defects, immune response dysregulation, and environmental factors [4], and is closely related to abnormal activation of the NF-κB pathway, Th1/Th2 immune imbalance, and damage to the intestinal epithelial barrier. Recent studies indicate that various genetic alterations causing abnormal intestinal mucosal immune function and barrier defects may be the main reasons for the occurrence and repeated episodes of UC [5,6].

Traditional Chinese medicine classifies UC under disease categories such as "Xiexie" (diarrhea) and "Xiali" (dysentery), believing its main pathogenesis is spleen deficiency with dampness obstruction, and it is often treated with Shenling Baizhu San. This formula was first recorded in the "Taiping Huimin Heji Jufang" from the Song Dynasty. After improvements over multiple dynasties, its toxic side effects have significantly reduced, adverse reactions are relatively minor [7,8], and it has high safety. Meanwhile, related studies show that Shenling Baizhu San has the effects of strengthening the spleen and replenishing qi, resolving dampness and stopping diarrhea, leading to a healthy spleen with dampness removed, stasis and stagnation cleared, and intestinal membrane repair, showing good efficacy against ulcerative colitis [9]. Western medicine often uses aminosalicylate preparations, glucocorticoids, and other drugs. Although they act quickly, they have shortcomings such as significant side effects, large individual differences in efficacy, and easy recurrence [10]. In recent years, through multi-component, multi-pathway, multi-target holistic regulatory effects, the efficacy of traditional Chinese medicine in UC treatment has been significantly enhanced [11]. Wu Kerui et al. [10] believe that Shenling Baizhu San combined with aminosalicylate preparations in treating UC can significantly reduce the recurrence rate (RR=0.52, $P<0.01$). The combined application of Chinese and Western medicines for this disease is a complementary advantage, worthy of clinical exploration and promotion [12,13].

2. Composition Principles and Main Active Components of Shenling Baizhu San

2.1 Compatibility Theory and the "Sovereign, Minister, Assistant, Envoy" Framework

Shenling Baizhu San uses Si Jun Zi Tang (comprising Ginseng Radix, Atractylodis Macrocephalae Rhizoma, Poria, and Glycyrrhizae Radix) as the "Sovereign" drugs to strengthen the spleen and replenish qi. The "Minister" drugs (Dioscoreae Rhizoma, Nelumbinis Semen) enhance the spleen-tonifying effect. The "Assistant" drugs (Coicis Semen, Lablab Semen Album, Amomi Fructus) promote diuresis to remove dampness, stop diarrhea, and move qi to resolve stagnation. The "Envoy" drug (Platycodonis Radix) diffuses the lung qi and carries the other herbs' effects upward. Combined, the formula simultaneously addresses supplementation and drainage, and balances drying and

moistening, making it a classic prescription in Traditional Chinese Medicine for dispelling dampness and fortifying the spleen. This aligns perfectly with the core pathogenesis of UC, namely "Spleen Deficiency with Dampness Encumbrance." Originating from the *Taiping Huimin Heji Jufang*, and refined through clinical practice from the Song Dynasty to the present day, its formulation is rigorous and its medicinal properties are mild, embodying the TCM academic principles of "treatment based on pattern differentiation" and "holistic regulation."

2.2 Quality Markers and Chemical Component Profile

Traditional Chinese Medicine posits that "without dampness, there is no diarrhea," considering the spleen and stomach as the pivot for the transportation and transformation of fluids and food. If the spleen is deficient and the stomach weak, pathogenic factors invade the body, leading to abnormal distribution of essential nutrients, resulting in diarrhea. This formula combines methods for supplementing qi and strengthening the spleen with dispelling dampness and stopping diarrhea. Based on Si Jun Zi Tang, it additionally incorporates herbs that strengthen the spleen and resolve dampness to achieve its effects of fortifying the spleen, boosting qi, percolating dampness, and checking diarrhea.

Lu Guangying [14] summarized research progress on the chemical composition, pharmacological actions, and clinical applications of Shenling Baizhu San. Based on the "Five Principles" for quality markers, the following were selected and confirmed as its quality markers: Ginsenoside Rg1, Ginsenoside Re, Ginsenoside Rb1, Pachymic acid, Batatasin I, Liensinine, Neferine, Triolein, β-Sitosterol, Platycodin D, Glycyrrhizic acid, Glycyrrhetinic acid, Liquiritin, Atractylenolide I, Atractylenolide III, and Bornyl acetate. This establishes a quality traceability system, providing a foundation for the formula's research and development. Furthermore, Jiang Li et al. [15] suggested that most of the components contained in this formula—such as ginsenosides, ginseng polysaccharides, pachyman, pachymic acid, atractylenolides, neferine, yam polyphenols, coix seed polysaccharides, platycodins, platycodon polysaccharides, glycyrrhizic acid, and volatile oils from Amomi Fructus — possess anti-inflammatory or intestinal disease-treating effects. As shown in Table 1, components like Ginsenosides (Rg1, Re, Rb1), Pachymic acid, and Atractylenolides found in Shenling Baizhu San exhibit combined anti-inflammatory, immunomodulatory, and mucosal repair activities.

Table 1: Quality markers and main active ingredients of each medicinal ingredient in Shenling Baizhu Powder

Medicinal Herb	Quality Markers	Main Active Components
Ginseng	Ginsenoside Rg1, Re, Rb1	Saponins, Polysaccharides
Poria	Pachymic acid, Carboxymethylpachymaran	Triterpenes, Polysaccharides
Atractylodis Macrocephalae Rhizoma	Atractylenolide I, III	Polysaccharides, Volatile Oils
Glycyrrhizae Radix	Glycyrrhizic acid, Liquiritin	Triterpenes, Flavonoids
Dioscoreae Rhizoma	Batatasin I, III	Polysaccharides, Polyphenols
Nelumbinis Semen	Neferine	Alkaloids
Coicis Semen	Triolein, β-Sitosterol	Polysaccharides, Fatty Acids
Lablab Semen Album	Lablab lectin	Proteins
Amomi Fructus	Bornyl acetate, Camphor	Volatile Oils
Platycodonis Radix	Platycodin D	Saponins

3. Main Active Components and Mechanisms of Action of Shenling Baizhu San

Shenling Baizhu San contains abundant bioactive components (such as saponins, polysaccharides, lactones, etc.) that intervene in the pathological process of UC through multi-target and multi-pathway approaches. The primary mechanisms are as follows:

3.1 Immuno-inflammatory Regulation

3.1.1 Saponins (Ginsenosides Rg1, Rb1, Rg3; Platycodin D)

Ginsenosides are steroidal saponins derived from ginseng, known for their tonic effects. Long You [16] found that they possess immunomodulatory properties from the cellular to the organismal level. Miao Zhiwei et al. [17] discovered that Ginsenoside Rg3 can regulate intestinal immunity by inhibiting NF-κB activation, downregulating TNF-α/IL-6, upregulating IL-10 levels, and modulating the Th1/Th2 balance. It synergizes with Pachymic Acid (PA) to inhibit the NF-κB and cGAS-STING pathways, thereby effectively reducing colonic epithelial cell apoptosis and inflammatory damage in UC rats [18], forming the core mechanism of the compound's immunomodulation. Meanwhile, PA also acts on JAK2 to regulate cell proliferation and exert anti-inflammatory effects by modulating cell cycle and apoptosis-related factors [19].

Platycodin D also inhibits the secretion of cytokines IL-1β, IL-18, TNF-α, and IL-6, and suppresses oxidative stress responses via the NF-κB signaling transduction pathway [20]. Qi Ting et al. [21] confirmed through research that Platycodin D can downregulate the COX-2/NF-κB signaling pathway, reducing cell apoptosis, migration, and inflammatory response. Additionally, Wu Hao et al. [22] found that Platycodin D can regulate oxidative stress by mediating the PI3K/Akt/mTOR signaling pathway.

3.1.2 Polysaccharides (Ginseng Polysaccharide, Poria Cocos Polysaccharide, Yam Polysaccharide, Coix Seed Polysaccharide, Platycodon Polysaccharide)

Ginseng polysaccharide exerts a protective effect against DSS-induced inflammatory bowel disease in mice by inhibiting the JAK2/STAT1/NLRP3 inflammasome signaling pathway, reducing cytokine levels in tissues, and enhancing the body's antioxidant capacity [23]. Poria Cocos Polysaccharide (PCP) can constitute up to 80% of the dry weight of Poria. It enhances the body's immunity by promoting the secretion of immune factors, inhibiting the expression of inflammatory mediator genes, and the release of inflammatory factors [24]. Zhang Yue [25] established a rat model of spleen deficiency using the "dietary irregularity + overwork method" to investigate the regulatory effects of PCP on immune function and gut microbiota in spleen-deficient rats. It was found that PCP effectively improved the immune function of spleen-deficient rats by promoting the secretion and expression of serum IgG, IgM, IL-2, IL-4, and IFN-γ,

among other pathways.

Yam Polysaccharide (YP) is one of the main active components of Chinese yam [26-27]. With ongoing research, YP has been found to effectively inhibit the gene transcription levels of inflammatory factors IL-1β, IL-6, and TNF-α, significantly alleviating a series of pathological symptoms induced by Dextran Sulfate Sodium (DSS), including weight loss, watery diarrhea, and bloody stools [28]. This indicates that YP can effectively inhibit inflammation, significantly alleviate intestinal mucosal damage, thereby exerting a therapeutic effect on UC.

Coix Seed Polysaccharide (Coixan) possesses pharmacological activities such as hypoglycemic, antitumor, immunomodulatory, anti-inflammatory, antioxidant, and regulation of gut microbiota [29-34]. Studies found that Coixan exerts anti-inflammatory effects by downregulating the expression of pyroptosis-related factors NLRP3, Caspase-1, GSDMD-N, and IL-1β, thereby reducing pro-inflammatory cytokines [35]. It also improves cellular immune function by regulating JAK3, signal transduction, and STAT5 phosphorylation levels, activating the IL-2-mediated JAK3/STAT5 signaling pathway, and promoting T lymphocyte proliferation [36].

Platycodon Polysaccharide significantly downregulates the expression levels of IL-1β, NEK7, and NLRP3 proteins, reduces the production of inflammatory factors, and alleviates LPS/ATP-induced inflammatory damage in 3D4/21 cells [37]. Research shows that Platycodon Polysaccharide can significantly ameliorate cyclophosphamide-induced immunosuppression, improve liver damage, significantly increase the levels of cytokines such as IL-2, IL-4, and TNF-α, and has an immune-enhancing effect [38].

3.2 Anti-inflammatory and Antioxidant Effects

3.2.1 Triterpenes (Pachymic Acid, Glycyrrhizic Acid, Glycyrrhetinic Acid)

Pachymic Acid (PA) can inhibit the cGAS-STING pathway, reducing epithelial cell apoptosis and inflammatory damage [18]. It also regulates multiple signaling pathways such as NF-κB and Shh/Gli1, acts on JAK2 to regulate cell proliferation, and exerts anti-inflammatory effects [19] (see section 3.1.1 for details). Glycyrrhetinic Acid (GA) can inhibit the mRNA expression of IL-6 and IL-1β, reduce the secretion of pro-inflammatory factors, and lower oxidative stress and inflammatory response by inhibiting the NADPH/ROS/phosphorylated p38 signaling pathway [39]. Additionally, GA can exert anti-inflammatory effects by downregulating TNF-α/MMPs/COX-2/PGE2 and other mechanisms, reducing prostaglandin-mediated inflammation [40].

3.2.2 Polyphenols (Yam Polyphenols)

Yam polyphenols can affect key proteins to protect the intestinal mucosa, inhibit cyclooxygenase-2 expression, reduce colonic epithelial cell apoptosis, and have a preventive effect on intestinal mucosal damage [41]. Furthermore, yam polyphenols [42] can promote the secretion of nerve growth factor (NGF), inhibit NO production in LPS-activated BV2 cells, and exhibit certain anti-neuroinflammatory effects.

3.2.3 Polysaccharides (Atractylodes Macrocephala Polysaccharide, Yam Polysaccharide)

Atractylodes Macrocephala Polysaccharide (PAMK) reduces LPS-induced oxidative stress via ferroptosis-related pathways, decreases iron content and the degree of ferroptosis in spleen tissue [43], affects mitochondrial and death receptor pathways, reduces LPS-induced cell apoptosis, and alleviates inflammatory response and oxidative stress [44]. Studies also show that PAMK can alleviate LPS-induced duodenal intestinal barrier damage [45].

Yam Polysaccharide (YP) inhibits the NF-κB inflammatory signaling pathway and NLRP3 inflammasome activation [46], reduces the production of pro-inflammatory cytokines TNF-α and IL-1β, alleviates intestinal mucosal damage by inhibiting the gene transcription levels of inflammatory factors and cyclooxygenase expression, and significantly reduces intestinal inflammation. Other studies indicate that YP, as one of the main active components of yam, possesses activities such as anti-inflammatory, antioxidant, anti-aging, and maintaining gut microbiota balance [47].

3.3 Mucosal Barrier Repair

3.3.1 Lactones (Atractylenolides)

Atractylenolides are the main material basis for the anti-inflammatory activity of Atractylodes macrocephala [48-49]. Atractylenolide III (AT-III) activates the AMPK/SIRT1/PGC-1α signaling pathway [50], prevents mitochondrial dysfunction, alleviates epithelial barrier disruption, and inhibits inflammatory response and oxidative stress, thereby relieving UC symptoms. Additionally, the key target Arp2/3 of AT-III can reverse TGF-β-induced epithelial-mesenchymal transition and repair the mucosal barrier [51], thus alleviating LPS-induced UC [52-53]. It acts synergistically with Atractylodes Macrocephala Polysaccharide (PAMK) to alleviate LPS-induced intestinal barrier damage.

3.3.2 Fatty Acids (Coixenolide)

Coixenolide can inhibit the activation of the Wnt/β-catenin signaling pathway by suppressing the expression of IL-6 and MMP13, thereby achieving repair of bone damage [54]. Coixenolide can effectively inhibit the production of pro-inflammatory cytokines—Tumor Necrosis Factor-alpha (TNF-α) and Interleukin-1 beta (IL-1β)—and increase the production of anti-inflammatory cytokines—Interleukin-10 (IL-10) and Transforming Growth Factor-beta (TGF-β)—to achieve inhibition of endothelial cell inflammatory response [55].

3.4 Gut Microbiota Regulation

3.4.1 Polysaccharides (Carboxymethyl Poria Cocos Polysaccharide, Amomum Villosum Polysaccharide)

Carboxymethyl Poria Cocos Polysaccharide promotes the secretion and expression of IgG, IgM, IL-2, IL-4, and IFN-γ,

effectively enhances the body's immune regulation function, reduces the abundance of harmful gut bacteria, and remodels gut microbiota homeostasis [25]. Research indicates a close connection between the body's microbial flora and the immune system; gut microbiota can directly or indirectly shape the host's immune system. Poria Cocos Polysaccharide can significantly increase gut microbiota diversity, alleviate changes in gut microbiota structure, and markedly improve gut microbiota dysbiosis [56]. Furthermore, Poria Cocos Polysaccharide protects against CTX-induced intestinal mucosal injury by reducing inflammatory mediator levels, inhibiting the expression of apoptotic factors, while increasing the expression of immune cytokines IL-4, IL-5, IL-10, IL-13, IL-22, and reducing the expression of the tissue inflammatory mediator MPO. It exerts its protective effect on intestinal mucosal injury by regulating the gut microbiota SCFAs-GPR41/43-MAPK pathway. Therefore, Poria Cocos Polysaccharide protects the intestinal mucosa by inhibiting epithelial cell apoptosis, enhancing intestinal mucosal immunity, and regulating gut microbiota [57].

4. Integration of Signaling Pathway Regulatory Networks of Various Components in Shenling Baizhu San

The therapeutic effect of Shenling Baizhu San is not a simple superposition of the components of individual herbs, but rather a holistic treatment outcome achieved through the "sovereign, minister, assistant, envoy" compatibility, which enables multi-component synergy and multi-pathway regulation. The sovereign herbs (Ginseng, Atractylodis Macrocephalae Rhizoma, Poria, Glycyrrhizae Radix) strengthen the spleen and replenish qi, establishing an immunological foundation. The minister herbs (Dioscoreae Rhizoma, Nelumbinis Semen) enhance the spleen-tonifying effect. The assistant herbs (Coicis Semen, Lablab Semen Album, Amomi Fructus) promote diuresis to remove dampness, stop diarrhea, and move qi to resolve stagnation. The envoy herb (Platycodonis Radix) diffuses the lung qi, carries the effects of the other herbs upward, and guides the medicinals to the diseased site.

The herbal components act synergistically to collectively regulate multiple signaling pathways, including NF-κB, JAK/STAT, cGAS-STING, AMPK/SIRT1/PGC-1α, Wnt/β-catenin, PI3K/Akt/mTOR, ROS/p38 MAPK, the NLRP3 inflammasome, TGF-β/Smad, and SCFAs-GPR41/43-MAPK. This integrated action inhibits inflammatory responses, counteracts oxidative stress, repairs the intestinal mucosal barrier, and modulates the gut microbiota, thereby alleviating the pathological process of UC through multiple dimensions.

Table 2: Integration of Active Components and Signaling Pathways of Constituents in Shenling Baizhu San

Signaling Pathway	Main Active Components	Regulatory Mechanism	Pathological Effect on UC
NF-κB Pathway	Ginsenoside Rg3, Platycodin D	Inhibits NF-κB activation, downregulates TNF-α, IL-6, IL-1β, upregulates IL-10, and restores Th1/Th2 immune balance.	Alleviates colonic mucosal inflammation and inhibits the release of pro-inflammatory factors [17-18, 20].
JAK/STAT Pathway	Poria Cocos Polysaccharide, Coix Seed Polysaccharide	Activates the JAK3/STAT5 pathway to promote T lymphocyte proliferation; regulates STAT1/STAT3 phosphorylation levels.	Enhances local intestinal immunity, inhibits NLRP3 inflammasome activation, and alleviates inflammatory injury [25, 36].
cGAS-STING Pathway	Pachymic Acid, Ginsenoside Rg3	Inhibits cGAS-STING pathway activity, reducing epithelial cell apoptosis and DNA damage-mediated inflammatory responses.	Protects intestinal epithelial barrier integrity and alleviates oxidative stress and inflammatory bowel injury [18].
AMPK/SIRT1/PGC-1α Pathway	Atractylenolide III	Activates the AMPK/SIRT1/PGC-1α pathway, improves mitochondrial function, and inhibits ROS generation.	Mitigates intestinal mucosal mitochondrial dysfunction, repairs energy metabolism imbalance, and reduces epithelial barrier disruption [50-51].
Wnt/β-catenin Pathway	Coixenolide	Inhibits Wnt/β-catenin signaling transduction and reduces MMP13 expression, decreasing mucosal degradation.	Suppresses intestinal fibrosis and ulcer formation, promoting mucosal healing [54].
PI3K/Akt/mTOR Pathway	Platycodin D, Glycyrrhetinic Acid	Activates the PI3K/Akt/mTOR pathway, inhibits oxidative stress, and regulates the expression of autophagy-related proteins.	Reduces intestinal epithelial cell apoptosis, enhances antioxidant capacity, and alleviates intestinal oxidative damage [22, 39].
ROS/p38 MAPK Pathway	Glycyrrhetinic Acid, Yam Polyphenols	Inhibits NADPH oxidase activity, blocks the ROS/p38 MAPK signaling cascade, and reduces the release of pro-inflammatory factors.	Alleviates intestinal oxidative stress and protects the intestinal mucosa from free radical damage [39, 41].
NLRP3 Inflammasome Pathway	Ginseng Polysaccharide, Yam Polysaccharide	Inhibits NLRP3 inflammasome assembly, reduces Caspase-1 activation, and decreases IL-1β and IL-18 secretion.	Blocks pyroptosis and alleviates DSS-induced colitis symptoms (e.g., bloody stools, diarrhea) [23, 28].
TGF-β/Smad Pathway	Atractylenolide III	Inhibits TGF-β-mediated Smad2/3 phosphorylation and reverses epithelial-mesenchymal transition (EMT).	Maintains intestinal epithelial cell polarity and prevents mucosal barrier disruption and fibrosis [51].
SCFAs-GPR41/43-MAPK Pathway	Poria Cocos Polysaccharide, Amomum Villosum Polysaccharide	Activates GPR41/43 receptors via short-chain fatty acids (SCFAs) and inhibits MAPK inflammatory signaling.	Regulating the metabolic products of intestinal flora, enhancing the intestinal mucosal immune defense, and repairing damage related to dysbiosis [57].

5. Overall Mechanism of Action

The abundant bioactive components in Shenling Baizhu San exert pharmacological effects such as antioxidant, anti-inflammatory, immunomodulatory, and intestinal microbiota regulation through multiple pathways [14, 58-60]. Li Zihui [61] et al. experimentally confirmed that this formula significantly reduces serum TNF-α, IL-6, and IL-1β levels in UC model rats, inhibits the expression of NF-κB p65 and IκKβ in colon tissue, and upregulates IκBα protein, indicating that it alleviates intestinal mucosal inflammatory damage by blocking the activation of the IκK/IκB/NF-κB signaling pathway. Li Xiaobing [62] et al. found that Shenling Baizhu San significantly increases the proportion of intestinal

CD4+CD25+Foxp3+ Treg cells, reduces TNF-α and IL-1β levels in the intestinal mucosa, and promotes the secretion of the anti-inflammatory cytokine IL-10, thereby restoring intestinal immune homeostasis. Shi Yang [63] et al. observed that Shenling Baizhu San can upregulate serum IL-2, IL-12, TNF-α, and intestinal secretory IgA (sIgA) levels in spleen deficiency model mice, enhancing their immune defense capacity and promoting mucosal injury repair. Xu Xuyang [64] et al., through metabolomic analysis, found that the formula regulates colonic metabolites (such as short-chain fatty acids), improves mucosal morphology, and reduces inflammation levels by modulating the expression of core inflammation - related target genes. Zeng Enjin [65], through clinical trials, found that the formula, by modulating short-chain fatty acids (SCFAs) synthesized by the gut microbiota, significantly improved patients' diarrhea and stool characteristics, with stable clinical efficacy and high safety.

In recent years, with in-depth research, ferroptosis, a novel form of cell death, has been found to be closely related to the occurrence and development of UC. Atractylodes macrocephala polysaccharides in Shenling Baizhu San can alleviate intestinal oxidative stress and inflammatory responses by regulating ferroptosis-related pathways [43, 59]. Furthermore, the role of the neuro-immune axis in UC has gradually gained attention. Components such as Chinese yam polyphenols can influence neuro-immune crosstalk by modulating factors like Nerve Growth Factor (NGF), thereby regulating intestinal inflammation [42]. Integrated analysis of metabolomics and microbiomics also provides new perspectives for revealing the overall regulatory mechanism of Shenling Baizhu San [64].

6. Summary and Outlook

The active components of Shenling Baizhu San (such as ginsenosides, poricoic acid, Atractylodes macrocephala polysaccharides, atractylenolide, etc.) alleviate the UC pathological process multi-dimensionally by inhibiting inflammatory pathways like NF-κB and JAK/STAT, enhancing Treg cell function, repairing the intestinal mucosal barrier, and regulating the microbiota-SCFAs axis. Its synergistic "multi-component, multi-target, multi-pathway" mechanism of action reflects the advantage of holistic regulation in Traditional Chinese Medicine.

However, due to the numerous herbal components and complex pharmacological activities of this formula, several challenges remain in its use for treating UC, such as the complexity of its mechanism of action and significant individual variability. It is necessary to conduct larger-scale, multi-center clinical trials to explore the efficacy and safety of the formula and optimize treatment protocols based on clinical feedback, such as adjusting dosage, administration methods, processing methods, and herbal combinations. Simultaneously, greater emphasis should be placed on developing personalized diagnosis and treatment plans for UC patients. Utilizing multi-omics technologies like genetic testing, gut microbiota analysis, and metabolomics can provide more precise diagnostic and therapeutic strategies for UC patients. Furthermore, further in-depth research on the mechanism of Shenling Baizhu San in cutting-edge areas such as regulating ferroptosis and the neuro-immune axis is warranted. This aims to improve the comprehensive therapeutic efficacy for UC and promote the development and progress in the field of UC treatment.

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