

# Development Status of Chemical Constituents and Pharmacological Effects of *Portulaca Oleracea* L

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**Abstract.** *Portulaca oleracea* L. is the dry aerial part of the *Portulaca oleracea* L. plant of the family *Portulaca oleracea* L. It is a common Chinese herbal medicine with the same origin as medicine and food. It is cold in nature and sour in taste. It has pharmacological effects such as bacteriostatic, hypoglycemic, hypolipidemic, antitumor, antioxidant and so on. The chemical components such as flavonoids and polysaccharides contained in *Portulaca oleracea* L. are inseparable from their functions. In view of the remarkable clinical effect of *Portulaca oleracea* L. on the prevention and treatment of various diseases, the research on the chemical constituents, pharmacological effects and mechanisms of *Portulaca oleracea* L. has become a hot spot in the field of traditional Chinese medicine. This article only makes a review of the research status and clinical application of *Portulaca oleracea* L. at home and abroad in recent years.

**Keywords:** *Portulaca Oleracea* L, Chemical constituents, Pharmacological action, Clinical application.

## 1. Introduction

*Portulaca oleracea* L. is the dry aboveground part of *Portulaca oleracea*, a plant in the family *Portulaca*. It is cold in nature, sour in taste, and belongs to the large intestine and liver meridians. *Portulaca oleracea* L. has the effects of cooling blood to stop bleeding, clearing heat and detoxifying, and relieving dysentery that is often used to treat blood dysentery due to heat toxin, erysipelas, carbuncle and furuncle, eczema, snake and insect bites, metrorrhagia, blood in the stool, hemorrhoids and other diseases[1]. In recent years, domestic and foreign scholars have conducted a series of studies on the chemical composition and pharmacological effects of *Portulaca oleracea* L., and found that the whole plant of *Portulaca oleracea* L. contains amino acids, L-norepinephrine, vitamins, flavonoids, fatty acids and polysaccharides, etc[2]. In addition to the efficacy recorded in ancient medical books, *Portulaca oleracea* L. also has antiviral, antioxidative, antibacterial, hypolipidemic, antitumor, hypoglycemic, antiatherosclerotic and immune-enhancing effects[3-6].

## 2. Chemical composition

As a commonly used traditional Chinese medicine, *Portulaca oleracea* L. contains a variety of complex and diverse chemical components. Its main secondary structural components, such as coumarins, alkaloids, organic acids, terpenes and sterols, flavonoids, polysaccharides, etc., have been confirmed to play a therapeutic role in the treatment of various diseases. In addition, it also contains mineral elements, proteins, small molecular amino acids and volatile oils.

### 2.1 Alkaloids

Some common alkaloid compounds found in *Portulaca oleracea* L. mainly include norepinephrine, adenine [7], dopamine, uracil [8], adenosine [9], N,N-dicyclohexylurea, beet red pigment (ie *Portulaca oleracea* L. I, II) [10], cyclodipeptide [11], cyclodipeptide, oleraciamide C [12], *Portulaca oleracea* L. amide, dopa, allantoin, 2,5-dicarboxypyrrole, 5-hydroxy 2-carboxypyridine [13], nasturtine [14], 3-sec-butyl-6-methylpiperazine-2,5-dione, 3-isobutyl-6-methylpiperazine-2,5-dione,

3-(4-hydroxybenzyl)-6-benzylpiperazine-2,5-dione [15], p-hydroxyphenethylamine[16], N-cis-feruloyl tyramine, N-trans-feruloyl tyramine [8] [17], N-trans-feruloyl-norsynphrine, 3-quinolinecarboxylic acid, N-cis-feruloyl-nor Synephrine, indole-3-carboxylic acid, and also discovered a new isoindole alkaloid 6-hydroxy-2-(2-hydroxy-2-(4-hydroxyphenyl)ethyl)-4-(4-hydroxy-3-methoxy)-7-methoxy-1H-benzo [f] isoindole-1,3(2H)-dione and a novel alkaloid 6-acetyl-2, 2, 5-trimethyl-2, 3-dihydrocycloheptanone [b] pyrrole-8(1H)-one and so on.

## 2.2 Terpenes and Sterols

Studies[18-19] showed that portulaca oleracea contains terpenoids and sterols. For example, glycyrrhetic acid, dandelion terpenol, ursolic acid, oleanolic acid, betulinic acid, Portulaca oleracea L. monoterpene A, Portulaca oleracea L. monoterpene B, lupanol, 3-acetylaleurone acid, lutein, carotenin, acetyl Alenritolic acid, Portaraxeroic acid A, Portaraxeroic acid Acid B, xylosterone[13-14],  $\beta$ -sitosterol, epigenol, 4 $\alpha$  -methyl-3 $\beta$ -hydroxy-xylohydrane, (3S)3-O( $\beta$ -d-glucopyranoglucose, 7-dimethyl-oct-1, 5-diene-3,7-diol, carrot glycosides[11][20], table cork alcohol[21], alpha of vinegar alcohol, (3S) 3-O (-D-pyran glucose) -3,7-dimethyl-symplectic-1,6-diene-3-alcohol[22], pakitol,  $\beta$ -aromanol, butanyl cetyl alcohol, cycloatanol, 24-methylene cycloatanol[23], 24-Methylene-24-dihydroparkol,  $\beta$ -sitosterol, stigmastere-4-ene-3-one[23-24], glustere-4-ene-3-ol, glustere-5-ene-3-ol[25], glustere-5-ene-3-ol, glucosterol Glucoside 7[26]et al.

## 2.3 Coumarins

The main coumarin compounds contained in Portulaca oleracea L. are isanisolide, trans-p-coumarin[14], bergamot lactone, scopolamine, 6,7-dihydroxycoumarin[15], umbelliferone, Eucalyptus grandis[19], lonchocarpic acid and loncho-carpenin.

## 2.4 Flavonoids

The total flavonoid content in the whole plant of Portulaca oleracea is about 7.67% [27], mainly including daidzein, kaempferol [14], quercetin, myricetin, genistein, genistein, hesperidin [28], luteolin, apigenin [29] and so on. In addition, a research team obtained 3 new flavonoid monomers from the extract of Portulaca oleracea L.: 5-hydroxy-3-(2-hydroxybenzyl)-7-methoxy-4H-benzopyran-4-Ketone (oleracone D), (3S)-5-hydroxy-3-(2-hydroxybenzyl)-7-methoxybenzodihydropyridine-4-one (oleracone C) and 1-(2-hydroxy-4,6-dimethoxyphenyl)-3-(2-hydroxyphenyl)-1-propanone (oleracone E).

## 2.5 Organic acids

Portulaca is rich in organic acid compounds, among which phenolic acid compounds are trans-3-lupeol palmitate ferulic acid, 2,2'-dihydroxy-4',6'-dimethoxy Kichalcone[8], 3,4-dihydroxybenzoic acid[14], caffeic acid[28], p-hydroxybenzoic acid[30], ferulic acid, 4-hydroxy-5-methylfuran-3-Carboxylic acid, 5-hydroxymethylfuroic acid[31], vanillic acid, salicylic acid, protocatechuic acid, gallic acid, coumaric acid, p-hydroxybenzoic acid; low molecular weight organic acid compounds include citric acid, succinic acid acid[15], oxalic acid, monomethyl succinate[31], 5-dimethylcitric acid, malic acid[32], fumaric acid, L4-methylmalate, L-methyl citrate, apple acid L-dimethyl ester, methyl malate, benzoic acid; fatty acids are tetracosanoic acid[7], tridecanoic acid, octanoic acid, 9,12-octadecadienoic acid, eicosatrienoic acid, behenic acid, linolenic acid, octadecane[29], palmitic acid[34], stearic acid[31][35]and linoleic acid. At the same time, it was detected that Portulaca oleracea L. contains arachidonic acid and DHA, which are extremely rare in other plants. Through GC-MS analysis, it was analyzed that the whole plant of Portulaca oleracea also contained 14-octadecenoic acid, fatty acid components octanoic acid, arachidic acid, and 9-carbonyl-nonanoic acid.

## 2.6 Polysaccharide

The researchers extracted Portulaca oleracea L. polysaccharide by ultrasonic extraction method, and further separated and purified the crude polysaccharide by Deae-cellulose anion exchange

method and Seph-adex gel permeation chromatography, and obtained three fractions, which were named as POL1, POL2, POL3. The molecular weights of the three components were measured, and the results showed that the molecular weights of POL1, POL2, and POL3 were 18 KD, 55 KD, and 108 KD, respectively[36]. Some researchers have also isolated a polysaccharide with a relative molecular mass of 57 KD composed of glucose, fructose, mannose, xylose, galactose and arabinose from *Portulaca oleracea* L.[37-38], and polysaccharide (POP)[39].

## 2.7 Protein and Amino Acids

The content of protein in the dried product of *Portulaca oleracea* L. is 19.1%, and the content of most amino acids is higher than that in cultivated vegetables[2]. Amino acids contain a variety of essential amino acids including glutamic acid[31], aspartic acid, tyrosine, alanine, serine, threonine, phenylalanine, valine, arginine, histidine, lysine, methionine, isoleucine, proline, leucine[40] and glycine. At the same time, it is also rich in cyclic dipeptide components including cyclo(tyrosine-alanine)[7], cyclo(leucine-phenylalanine)[13], cyclo(alanine-isoleucine), cyclo(phenylalanine-tyrosine), cyclo(alanine-leucine), cyclo(tyrosine-leucine)[31] and cyclo(phenylalanine-isoleucine).

## 2.8 Alcohols and Esters

*Portulaca* also contains alcohol and ester compounds inositol [9], n-hexadecanol, linoleic acid triglyceride, ryegrassin, (-)-dehydrovomifoliol, n-triacontanol [16], alpha - Palmitic acid monoglyceride [26], 3, 4-dihydroxyphenethyl alcohol [31]; in addition, it also contains syringin [33] and portulacoside A [38], a new compound - *Portulaca* Amaranthine B, C, D, methyl 4-hydroxyphenylacetate [30], portulaceramide A [41].

## 2.9 Mineral element

Rich mineral elements can be detected from *Portulaca oleracea* L., including potassium, iron, strontium, zinc, calcium, aluminum, titanium, magnesium, molybdenum, etc. The content of harmful elements such as mercury, lead, cadmium, arsenic is very low, less than millionth [42]. The mineral elements Ca, K, and Mg, which are necessary for the human body, are relatively high in content, followed by Zn, Mn, Fe, and Cu [43].

## 2.10 Other ingredients

*Portulaca oleracea* L. also contains other ingredients such as volatile oil. There are also highly active substances [44] anthraquinone glycosides, cardiac glycosides, etc., and aldehyde compounds such as p-hydroxybenzaldehyde and protocatechuic aldehyde [36] have also been confirmed to exist, as well as another confirmed active ingredient  $\beta$ -carotene,  $\alpha$ -tocopherol, ascorbic acid, lutein, glutathione [45].

## 3. Pharmacological effects

### 3.1 Bacteriostatic effect

Ding Huaiwei[2] and other experiments showed that the ethanol extract of *Portulaca oleracea* L. has an antibacterial effect, and has an extremely high inhibitory effect on dysentery bacteria, *Proteus* bacteria, *Escherichia coli*, typhoid fever, and paratyphi bacteria. It also has different degrees of inhibitory effect on *Staphylococcus aureus*, fungi such as *Mycobacterium tuberculosis*, *Microbacillus audulanum*, etc., and has a mild inhibitory effect on *Pseudomonas aeruginosa*[46]. In addition, the water extract of *Portulaca oleracea* L. has in vitro antibacterial effect on two dermatophytes, *Trichophyton rubrum* and *Trichophyton mentagrophytes* [47]. The experiment of ZhangXJ[48] et al. obtained the same result. Zhu Dan[49], Chen Guoni[50] and others studied the inhibitory effect of flavonoids in *Portulaca oleracea* L. extract on common microorganisms. The experimental results showed that the minimum inhibitory concentrations were: *Bacillus subtilis*, *Escherichia coli*, Yeast,

both were 0.0625%; and *Staphylococcus aureus* had a lower inhibitory concentration, which was 0.031%, which proved that its flavonoids had strong inhibitory effects on the growth and reproduction of bacteria and fungi. Chen Wanping[51] studied the antibacterial effect of *Portulaca oleracea* L. extract on four kinds of bacteria including *Staphylococcus aureus* and *Enterococcus* in vitro by geometric dilution method. The antibacterial effect of bacteria and *Shigella* is relatively significant, but the effect on Gram-positive bacteria is relatively weak. As the content of the extract increases from low to high, its function can also be transformed from bacteriostatic to bactericidal. Zhou Lixia et al[52] found that the combined application of *Portulaca oleracea* L. and Agrimony can improve the killing effect on pathogenic bacteria such as *Escherichia coli* and *Shigella dysenteriae*.

### 3.2 Hypoglycemic effect

Diabetes mellitus is a metabolic disease that is characterized by chronic hyperglycemia and is influenced by environmental factors, genetic factors, etc., which can lead to insufficient insulin secretion or insulin resistance. Its morbidity rate is high, and if it is not controlled, it will often lead to failure complications of kidneys and feet. Since 1980, the prevalence of diabetes has increased from less than 1% at that time to about 10% today, and it has become the third largest "killer" that can damage human health after cardiovascular disease and tumor[53]. Li Fenglin[54] and others used the method of establishing a diabetic mouse model to study the hypoglycemic effect of *Portulaca oleracea* L. polysaccharide, and the results proved that its polysaccharide can indeed effectively alleviate the weight loss symptoms of diabetic mice, but it does not capable of completely correcting the metabolic disturbances of all substances due to diabetes, i.e. it is dose-responsive. The polysaccharide of *Portulaca oleracea* L. can increase the serum insulin level in diabetic mice and reduce the fasting blood sugar level in mice, and the effect is better when the dose is 400 mg/kg • bw. A number of animal experiments[55-57] indicated that the hypoglycemic mechanism of polysaccharides from Purslane may be related to liver protection, immune function enhancement, glucose tolerance enhancement, secretion of insulin and serum C-peptide, utilization of peripheral blood glucose, reduction of damage to pancreatic  $\beta$  cells, and reduction of production of reactive oxygen species. Gao Hongmei[58] and other studies have proved that both the water decoction of *Portulaca oleracea* L. and the water-decocted alcohol precipitation solution have certain hypoglycemic effects on diabetic rats caused by intraperitoneal injection of streptozotocin (STZ). *Portulaca oleracea* L. contains more vitamin E, vitamin C, *Portulaca oleracea* L. polysaccharide and bioflavonoids and various trace elements. Xiao Fengying[59] and others believe that the flavonoids in *Portulaca oleracea* L. can effectively adjust and correct the metabolism of carbohydrates. Qin Xinmei[60] and others have confirmed through research that chemical trace elements such as Zn, Se, Li, Mn can not only relieve the typical symptoms of DM, reduce blood sugar levels, but also maintain insulin secretion at a certain level. Zheng Zhiyin[61] and others studied the hypoglycemic effect of *Portulaca oleracea* L. and found that the alkaloids, polyphenols and polysaccharide components of fresh *Portulaca oleracea* L. have obvious hypoglycemic effects. From the overall administration point of view, the effect of alkaloids, polyphenols and polysaccharides on hypoglycemia is better. Tang Zhaofeng[62] and others took *Portulaca oleracea* L. formula granules for the clinical treatment of diabetic patients, and found that the granules also had obvious hypoglycemic effect on diabetic patients ( $P < 0.05$ ), and did not show obvious toxic and side effects, indicating that *Portulaca oleracea* L. is a good hypoglycemic drug worth studying and popularizing.

### 3.3 Hypolipidemic effect

With the development of the era of science and technology and the establishment of a comprehensive well-off society, people's clothing, food, housing, transportation, and other aspects have been greatly improved, and the incidence of hyperlipidemia has also increased significantly. At present, lipid-lowering drugs on the drug market have common side effects, and long-term use may have a greater impact on the human body. Therefore, finding non-toxic and efficient lipid-lowering substances has important clinical significance for the development of medicine and pharmacy. Zhang

Jing[63] and others studied the regulating effect of *Portulaca oleracea* L. extract on hyperlipidemia rats by experimenting with *Portulaca oleracea* L. extract obtained by 70% ethanol. Experiments show that the higher the dose, the lower the serum total cholesterol (TC) and triglyceride (TG) levels in rats. It can be proved that *Portulaca oleracea* L. can treat hyperlipidemia to a certain extent. Wang Xiaobo[64] and others verified the efficacy of *Portulaca oleracea* L. on hyperlipidemia from two aspects: fresh *Portulaca oleracea* L. water extract and dried *Portulaca oleracea* L. decoction. The results proved that the conjecture was correct, *Portulaca oleracea* L. did have a strong hypoglycemic effect on high-fat rats. The content of superoxide dismutase (SOD) and high-density lipoprotein cholesterol (HDL-C) increased significantly. The contents of TG and TC in low-density lipoprotein cholesterol (LDL-C), high cholesterol and high-fat diet rats were significantly reduced. The experiment believes that *Portulaca oleracea* L. can reduce the damage of endothelial cells by anti-inflammatory and inhibit the formation of lipid peroxides, inhibit the metabolism of lipids in the liver, and have preventive effects on the occurrence of arteriosclerosis and coronary heart disease in rats. Li Fenglin[55] and others found that the polysaccharide components of *Portulaca oleracea* L. can reduce the TC and TG values of diabetic mice, increase the HDL-C value, and have a strong regulatory effect on blood lipid metabolism by establishing a mouse diabetes model. Liu Hao[65] and others conducted research on *Portulaca oleracea* L. powder by establishing a high-fat model of rats. The results showed that *Portulaca oleracea* L. powder could significantly reduce LDL-C, TC, and TG in experimental model rats. It can effectively prevent hyperlipidemia in rats. He Shengwen[66] and others found that wild *Portulaca oleracea* L. has a significant preventive and therapeutic effect on its symptoms in the study of the hypolipidemic effect of *Portulaca oleracea* L. on hyperlipidemia rabbits. Xu Yuancui[67] established an insulin-resistant rat model and concluded that the alcohol extract of *Portulaca oleracea* can reduce blood pressure and blood lipids in insulin-resistant rats, and its mechanism of action may be related to the influence of the RAS system. He Guoping[68] found that *Portulaca oleracea* L. can significantly reduce serum total TC, TG and LDL-C in hyperlipidemia rabbits and increase HDL-C. At the same time, the sclerosis index of the experimental animals also decreased to a certain level, so the number of foam cells formed correspondingly decreased, thereby reducing the lipids inside and outside the cells. And it can also significantly reduce the hyperlipidemia in rabbits and inhibit the formation of lipid peroxides.

### 3.4 Anti-tumor effect

Cui Min et al. [69] showed that *Portulaca oleracea* L. polysaccharide could increase the number of T lymphocytes in mice, inhibit the increase of liver cancer cells SMMC7721 and reduce the division index of ascites tumor in S180 tumor-bearing mice. Li Yuping et al. [70] found that the alkaloids, polysaccharides and fatty acids in *Portulaca oleracea* L. had different degrees of inhibitory effects on different carcinogens. For example, the alkaloids in *Portulaca oleracea* L. had strong inhibitory effects on the growth and reproduction of lung cancer cells and A-549 Hela cells. But polysaccharides and fatty acids were different. Polysaccharides had obvious anti-tumor effect on Hela cells, while fatty acids had certain inhibitory effect on Hep-2 cells. Flavonoids were even more different, their inhibitory effect on RD cells was very strong, and the inhibitory effect increased with the increase of concentration, that was, they had a concentration-dose effect. Wang Xiaobo et al.[71] used a combination of in-vivo and in-vitro experiments to show that the polysaccharide in *Portulaca oleracea* L. could inhibit the growth of tumor cells by directly acting on human liver tumor cells, and could also inhibit the growth of S180 tumor-bearing mice by intraperitoneal administration. The research results of Zhao Rui et al.[72] showed that *Portulaca oleracea* L. polysaccharide could enhance the immune function of cervical cancer tumor-bearing mice and significantly reduce the tumor volume of tumor-bearing mice. Ding Hong et al.[73] found that *Portulaca oleracea* L. polysaccharide could also inhibit the growth of cervical cancer transplanted tumor. Niu Guangcai et al. [74] found that *Portulaca oleracea* polysaccharides POP II and POP III had significant anti-tumor and immunity improving effects. It was speculated that the antitumor mechanism of *Portulaca oleracea* L. polysaccharide might be achieved through the indirect effect of improving the cellular immune

function in vivo and the direct effect of inducing apoptosis of tumor cells [69][74][75]. Guo Gai et al. [76] found that *Portulaca oleracea* L. seed oil (PSO) also had a strong inhibitory effect on tumor cell proliferation, and the inhibitory effect increased with the increase of time and dose. Yang Guiqin et al. [77] studied the anti-tumor effect of *Portulaca oleracea* L. from the combination of betacyanin and cyclophosphamide, and found that the betacyanin of *Portulaca oleracea* L. did have the effect of inhibiting tumors, especially on S180 sarcoma in mice, and at the same time, it had an enhanced therapeutic effect on anti-S180 mice with cyclophosphamide and could reduce the toxic and side effects of the medicine.

### 3.5 Antioxidant action

*Amaranthus horsetail* has a stronger oxygen resistance. Chemical ability and antioxidant effect are of great clinical significance to modern people not only to delay aging and beauty health, but also to treat many chronic oxidative stress-induced diseases. Free radical is one of the important factors that cause the aging of the human body. It has strong oxidative ability and can cause irreversible damage to the human body. Therefore, the ability to remove free radical is often used to evaluate antioxidant activity. Li Daifeng[78] et al. studied the antioxidant activity of *Amaranthol* extract by DPPH method, TBA method and trivalent iron ion reduction. The results showed that *Amaranthol* extract had a higher ability to remove DPPH radical and Fe reduction than BHT. Duan Yufeng[79] et al. 91 studies pointed out that the polysaccharide component POL III has a high inactivation effect on hydroxyl radicals. ZijuanY[80] et al. isolated three DPPH groups from *amaranthus horseradish*. All three groups had strong scavenging ability and also obtained phenolic alkaloids, a component of inhibiting peroxidation in rats. Su Rui[81] et al. also confirmed that the flavonoids of *Portulaca oleracea* L. have better inhibition and elimination effects on hydroxyl radicals and superoxide anions. Li Xiao[82] et al. showed that *Amaranth* polysaccharide had strong antioxidant activity in vitro, polysaccharide had strong effect on hydroxyl radical and superoxide anion, and polysaccharide had different effect on lipid peroxidation and hydrogen peroxide. Sun Xiyun[83] pointed out that the flavonoid component of *Amaranthus horsetail* has strong removal effect on hydroxyl radical and oxygen radical, and the removal ability is increasing with increasing concentration of solution. Shi Hongfei[84] et al. further verified the correctness of the conclusion by experimenting with gastric infusion of *amaranth* extract in mice. Ni Aiwei[85] et al. studied the effect of *Amaranth* extract (39.7% total flavonoid in extract) on the antioxidant system of D-galactose aging model mice. The results showed that the extract could significantly increase the SOD content in liver, brain and serum. The research and development of cosmetics based on purslane is based on its antioxidant effect. Zhu Qingshu[86] et al. found that the antioxidant active components in *Amaranthus horsetailus* may be compounds containing sugar groups such as triterpene saponin, steric saponin and flavonidine, or compounds with moderate polarity such as alkaloids, diterpene and flavonidine.

## 4. Conclusion

The application of *Portulaca oleracea* L. in my country has a history of thousands of years, and the research on the pharmacological effects of its components has also made great progress in recent years. However, there are relatively few studies on substances that act on *Portulaca oleracea* L. at present, and mainly focus on two types of substances: polysaccharides and flavonoids. How to further clarify the active sites and mechanisms of its various pharmacological effects and establish a more complete and complete evaluation standard has become a field worthy of further study. Therefore, the research on the pharmacological effects of *Portulaca oleracea* L. can be strengthened in the future to provide a more in-depth scientific theoretical basis for the new development of natural medicines.

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