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Review

Research and application of *Portulaca oleracea* in pharmaceutical area

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ABSTRACT

Portulaca oleracea, a plant species used as medicine and food, is widely spread in most areas of China. It is also a popular food in some Europe and Mediterranean countries. Purslane contains a variety of chemical constituents with pharmacological activities, such as antitumor, hypoglycemic, antioxidant, antibacterial, anti-inflammatory activities. It is also full of plenty of nutrients serving as a diet food or healthy food. Here we reviewed purslane in the following aspects: botanical resources, ethnopharmacological function, chemical constituents, pharmacology and pharmacokinetics, safety evaluation and toxicity, and clinical applications.

Contents

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1. Introduction

Portulaca oleracea L. (Purslane), a macrobiotic vegetable, has a long history of application in China which was first recorded in *Bencao Jing Jizhu* by Hong-jing Tao in the Liang Dynasty. According to Compendium of Materia Medica (*Bencao Gangmu*), the arrangement of leaves of purslane is similar to the teeth of a horse, and its property is to clear evil heat and remove toxins, which is the same as amaranth. Purslane is also used as food such as sandwich, salad, and sauce in some of Europe and Mediterranean countries (Wei & Zhou, 1995). Purslane is a homologue of medicine and food in 78 types of wild plants designated by the Ministry of Health in China. Purslane is often used as wild food due to a rich nutritional value and low calories. As an easily cultivated natural green food, purslane also can help people lose weight quickly and safely, so it is a high quality diet for people who are overweight or obese (Fu, Lv, & Li, 2011). In addition, purslane can be prepared into drinks, tea or noodles. Purslane has been used to treat acute eczema, herpes zoster, verruca plana, metrorrhagia, diarrhea and mammary abscess in clinical application. Recent researches have suggested that purslane has hypoglycaemic, lipid-lowering, antioxidant, anti-inflammatory, antibacterial and antitumor effects. In this review, we introduced the botanical resources, chemistry, ethnopharmacology and pharmacology and clinical applications of purslane.

2. Botanical resource

Purslane (*Portulacae Herba*) is the dried aerial part of *Portulaca oleracea* L., which is a member of the family Portulacaceae (Fig. 1). Purslane is an annual herbaceous plant collected in summer and autumn. Purslane should be cleaned of its roots and impurities, washed, steamed briefly or treated in boiling water and then dried under the sun. Dried purslane is always crumpled and rolled into masses. The stems are cylindrical and the longest are up to 30 cm long and 1 – 2 mm in diameter. The surface is yellowish-brown and has a distinct longitudinal furrow. Leaves are distributed oppositely or alternately and easily broken. The whole leaf is obovate, at 1 – 2.5 cm long and 0.5 – 1.5 cm wide. The leaf colour is greenish-brown. The leaf shape is obtuse or slightly notched at the apex and along the entire margin. Flowers are small, growing in groups of 3 – 5 at the branchlet terminals. The flowers have five petals and are yellow in colour. The fruit contains many minute seeds and is conical in form at approximately 5 mm long. It has a slight odour and tastes slightly sour Pharmacopoeia Committee of PR China (2015). Purslane is native to India and is widely distributed in temperate and tropical regions. Purslane has now spread all over the world. In China, purslane grows up beside houses, in roadside gardens and uncultivated fields except alpine areas (Li & Wang, 2007).

3. Ethnopharmacological function

The property of this drug is cold and its flavour is sour. The channel-tropism of this medicine is the liver and large intestine meridians. Purslane plays multiple-roles, such as heat-clearing, detoxification, blood-cooling, blood-stanching and treating dysentery. Purslane is often used for treating dermatosis, intestinal diseases, gynecopathy and pediatric diseases (Li & Miao, 2014). In Korea and Japan, purslane is mostly used to make cosmetics that can be used to treat skin diseases.

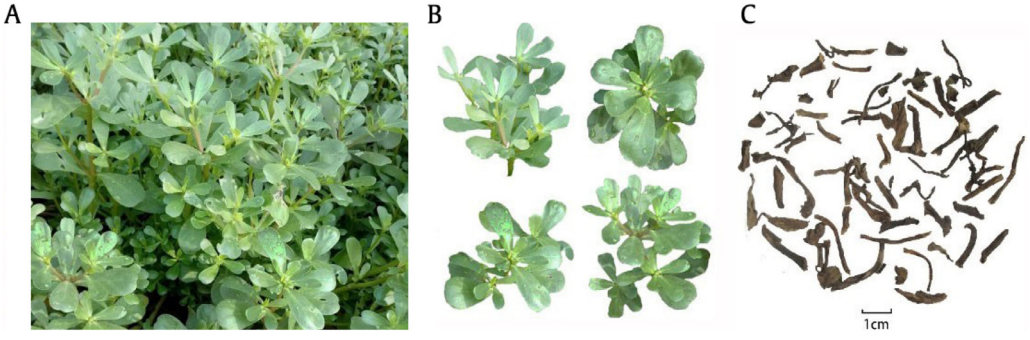


Fig. 1. Representative plants (A), fresh aerial parts (B) and dried aerial parts (C) of *P. oleracea*.

4. Chemical constituents

4.1. Nutritional ingredients

The water, crude protein, crude fat, total sugar, dietary fiber and ash contents in fresh purslane were 88.9, 2.8, 0.6, 3.2, 5.6 and 1.4 g/100 g, respectively. In addition to the total sugar content, the other main nutrients in purslane occur at higher concentrations than those in summer spinach, celery, lettuce and you-mai vegetables. The total amino acid content of purslane is 22.23 mg/g, that of essential amino acids is 8.99 mg/g and that of aspartate is up to 3.24 mg/g. The contents of β-carotene, ascorbic acid and mineral elements are generally higher than those in celery, lettuce and you-mai vegetables. The contents of potassium and iron are 340.0 and 2.1 mg/100 g, respectively. Additionally, lead and cadmium contents are only 0.08 and 0.12 mg/kg, respectively. The content of nitrous acid is far below the national standard in China, which is limited at 4 mg/kg. However, the content of nitrate reaches the third level of the hygienic standard. Particularly, purslane cannot be eaten raw. It has to be blanched or cooked. Therefore, we should pay attention to the methods to produce edibility. Purslane is a wild plant with many characteristics, such as strong vitality, high nutritional value, being pollution-free and having a unique flavour and good medicinal properties. In conclusion, purslane is a healthy wild vegetable containing abundant nutrients (Zhou, 2009).

4.2. Bioactive ingredients

4.2.1. Flavone ingredients

Purslane contains apigenin-4′-*O*-α-*L*-rhamnopyranoside, which has a hypoglycaemic effect, and its mechanism may be improving the insulin resistance of HepG2 cells by reducing the Akt phosphorylation level to increase glucose consumption (Jin, Xu, & Chen, 2015).

Quercetin (**1**) (Wang & Kong, 2016), kaempferol (**2**) (Yao, Meng, Song, & Ding, 2007), hesperidin, myricetin (**3**) (Yang, Zheng, & Xiang, 2007), apigenin (**4**), luteolin (**5**), portulacanone A (**6**) (2′-hydroxy-5,7-dimethoxy-3-benzyl-chroman-4-one), portulacanone B (**7**) (2′-hydroxy-5,6,7-trimethoxy-3-benzyl-chroman-4-one), portulacanone C (**8**) (5,2′-dihydroxy-6,7-dimethoxy-3-benzyl-chroman-4-one), and portulacanone D (**9**) (5,2′-dihydroxy-7-methoxy-benzylidene-chroman-4-one) (Yan et al., 2012), daidzein (**10**), genistein (**11**), genistin (**12**) (Yang et al., 2007) have been isolated from this plant (Fig. 2).

4.2.2. Polysaccharide ingredients

The active ingredients were isolated and purified from purslane by different methods. Studies showed that portulaca polysaccharide exhibited the strongest promotion of the small intestine and improved defecation (Yuan, 2016).

4.2.3. Organic acids

The low and medium polarity fractions of the active constituents in purslane were analyzed by GC–MS. The fractions contained a large number of fatty acids. α-Linolenic acids account for more than 10% of the active fraction and can be converted into $\omega-3$ (also name n-3) polyunsaturated fatty acids which are the essential acid for the human and cannot be synthesized by the human body. $\omega-3$ Polyunsaturated fatty acids can lower cholesterol and reduce blood lipids. These compounds also have antithrombotic, cardiovascular and cerebrovascular disease prevention effects, and they can be metabolized into eicosapentaenoic acid and docosahexaenoic acid within the body. Various free radicals in the human body increase as people age. Owing to quantity degradation and lesser activity of glutathione peroxidase (GSH-Px) and superoxide dismutase (SOD), the content of malondialdehyde (MDA), the metabolites of free radicals, will also increase, along with cell damage and decreased activity of tissues and organ function (Hou, 2008). If the activities of GSH-Px and SOD can be enhanced, the level of MDA will be decreased. When α-linolenic acid is dosed to the human body, anti-oxidation and anti-aging effects are improved (Li, Zhang, & Luo, 2006).

In addition to α-linolenic acid (**13**), purslane also contains linoleic acid (**14**), palmitic acid (**15**), myristic acid (**16**), oleic acid, arachidic acid (**17**), behenic acid (**18**) (Liu, Guo, An, Jin, & Wu, 1995), citric acid (**19**), ascorbic acid (**20**), malonic acid, fumaric acid, acetic acid (Gao, Liu, & Fu, 1996), benzoic acid (**21**) (Liu, Yu, Ye, & Zhou, 2007), erucic acid, lauric acid (**22**), succinic acid (**23**) (Table 1), mono-methyl succinate, *L*-malic acid, *L*-1-methyl malate, *L*-4-methyl malate, *L*-dimethyl malate, *L*-6-ethyl citrate, *L*-1-methyl citrate, *L*-1,5-dimethyl citrate, 4-hydroxy-5-methylfuran-3-carboxylic acid, 5-hydroxymethyl-furoic acid, stearic acid

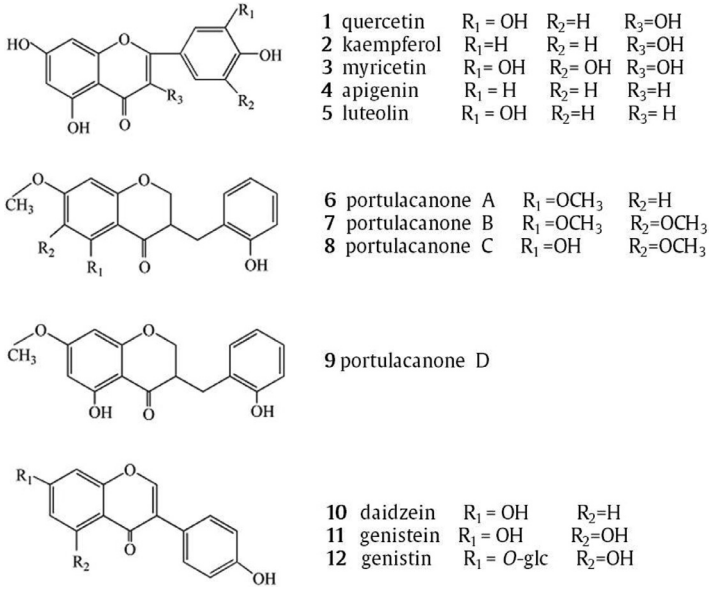
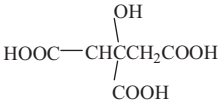
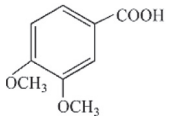
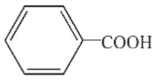
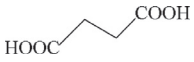


Fig. 2. Chemical structures of flavones from purslane.

Table 1
Organic acids from purslane extracts.

No.	Names	Chemical structures
13	linolenic acid	$CH_3CH_2CH{=}CHCH_2CH{=}CH_2{=}CH(CH_2)_7COOH$
14	linoleic acid	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$
15	palmitic acid	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$
16	myristic acid	$C_{13}H_{27}COOH$
17	arachidic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_3COOH$
18	behenic acid	$C_{21}H_{43}COOH$
19	citric acid	
20	ascorbic acid	
21	benzoic acid	
22	lauric acid	$C_{11}H_{23}COOH$
23	succinic acid	

(Jin et al., 2016), caprylic acid, pelargonic acid, capric acid, hendecanoic acid, *n*-hexadecane acid, margaric acid, *n*-eicosanoic acid, heneicosanoic acid, docosanoic acid, *n*-tricosanoic acid, lignoceric acid, pentacosanoic acid, palmitoleic acid, 5,8,11,14,17-eicosapentaenoic acid (EPA), 4,7,10,13,16,19-docosahexenoic acid (DHA), 9,12,15-linolenic acid, hexadecanoic acid, 9-hexadecenoic acid, 9,12-octadecadienoic acid, 11-eicosenoic acid, and 13-docosenoic acid (Zou, 2004).

4.2.4. Coumarin and other phenolic compounds

Studies showed that phenolic compounds in purslane have strong anti-oxidant activities. They can remove DPPH free radicals and reduce Fe^{3+} significantly. Their anti-oxidant abilities were higher than that of the synthetic anti-oxidant butyl hydroxyl toluene (Li, Jia, Du, & Yao, 2010).

6,7-Dihydroxy-coumarin was found to be one of the coumarin components in purslane. The phenol ingredients were identified as 3-hydroxy-1-(2-hydroxyethyl)phenyl-4-*O*-β-*D*-glucopyranoside, 2-(3,4-dihydroxyphenyl) ethyl-*O*-β-*D*-glucopyranoside (Seo, Shin, & Lee, 2003), vanillin, *p*-hydroxybenzaldehyde, protocatechualdehyde, *p*-hydroxybenzoic acid, ferulic acid, methyl-4-hydroxyphenylacetate, isovanillic acid, *trans*-*p*-hydroxycinnamic, iseluxine, portulacatone, and oleracein E (Yue, 2016).

4.2.5. Alkaloid ingredients

Alkaloids are alkaline nitrogenous organic compounds, which extracted from this plant. These compounds have antibacterial, anti-inflammatory, antitumor, anti-hypertensive and antidepressant effects.

Dopamine (**24**), dopa, 2,5-dicarboxyl-pyrrole, 5-hydroxyl-2-carboxyl pyridine (Ding, Li, & Song, 2009), succinimide, uracil (Jin et al., 2016), 3-isobutyl-6-methylpiperazine-2,5-dione, 3-sec-butyl-6-methylpiperazine-2,5-dione, 3-(4-hydroxybenzyl)−6-benzylpiperazine-2,5-dione (Xiang, 2006), *N*-*N*'-dicyclohexylurea, allantoin (Rasheed, Afifi, Shaedah, & Taha, 2004), noradrenaline (**25**) (Feng, Haynes, & Magnus, 1961), *N*-*trans*-feruloyltyramine (Masanori, & Yasuyuki, 1998), oleacrein A (**26**), oleacrein B (**27**), oleacrein C (**28**), oleacrein D (**29**), oleacrein E (**30**) (Xiang, Xing, & Wang, 2005), oleacrein F (**31**), oleacrein G (**32**), adenosine, (Liu, 2011), oleacrein H (**33**), oleacrein I (**34**), oleacrein K (**35**), oleacrein L (**36**), oleacrein N (**37**), oleacrein O (**38**), oleacrein P (**39**), oleacrein Q (**40**), oleacrein R (**41**), oleacrein S (**42**) (Liu, Shen, & Xiang, 2011) are alkaloids that have been identified in purslane. In addition, cyclodipeptide components, for instance, cyclic-(leucine-phenylalanine) (Ding et al., 2009), cyclic-(phenylalanine-tyrosine) (**43**), cyclic-(alanine-leucine) (**44**), cyclic-(alanine-isoleucine) (**45**) (Xiang et al., 2007), cyclic-(tyrosine-leucine) (**46**), cyclic-(alanine-tyrosine), cyclic-(phenylalanine-isoleucine) (Liu, 2011), oleraciamide A (**47**), oleraciamide B (**48**) (Li et al., 2017), and *L*-isoleucine (**49**) (Jin et al., 2016) have also been isolated from this plant (Fig. 3).

4.2.6. Terpene ingredients

The sediment from purslane extracts showed anti-hypoxia activity. This effect may be the synergistic effect of terpenoids and unsaturated fatty acids in the drug (Chen, 2010).

At present, the identified terpene compounds in purslane include friedelin (**50**), 4α-methyl-3β-hydroxylfriedelan (**51**), lupeol (**52**), daucosterol (Yao et al., 2007), linalool, 3,7,11,15-tetramethyl-2-hexadecenol (Liu, Jin, Guo, & An, 1994), (-)-dehydrovomifoliol, (-)-epiloliolide (Jin et al., 2016), (2α,3α)−3-{[4-*O*-(β-*D*-glucopyranosyl)-β-*D*-xylopyranosyl]oxy}−2,23-dihydroxy-30-methoxy-30-oxoolean-12-en-28-oic acid, (2α,3α)−2,23,30-trihydroxy-3-[(β-*D*-xylopyranosyl)oxy]olean-12-en-28-oic acid (Xin, Xu, & Hou, 2008), portulene (Elkhayat, Ibrahim, & Aziz, 2008), [(3*S*)−3-(3,7-dimethylocta-1,7-dien 6-onyl)-β-*D*-glucopyranoside] (Naomi, Kyouko, & Michi, 1996), (3*S*)−3-*O*-(β-*D*-glucopyranosyl)−3,7-dimethylocta-1,6-dien-3-ol, (3*S*)−3-*O*-(β-*D*-glucopyranosyl)−3,7-dimethylocta-1,5-dien-3,7-diol, and (3*S*)−3-*O*-(β-*D*-glucopyranosyl)−3,7-dimethyl-7-hydroperoxyocta-1,5-dien-3-ol (Seo, Shin, & Cha, 2003), portuloside A (**53**) (Naomi et al., 1996) (Fig. 4).

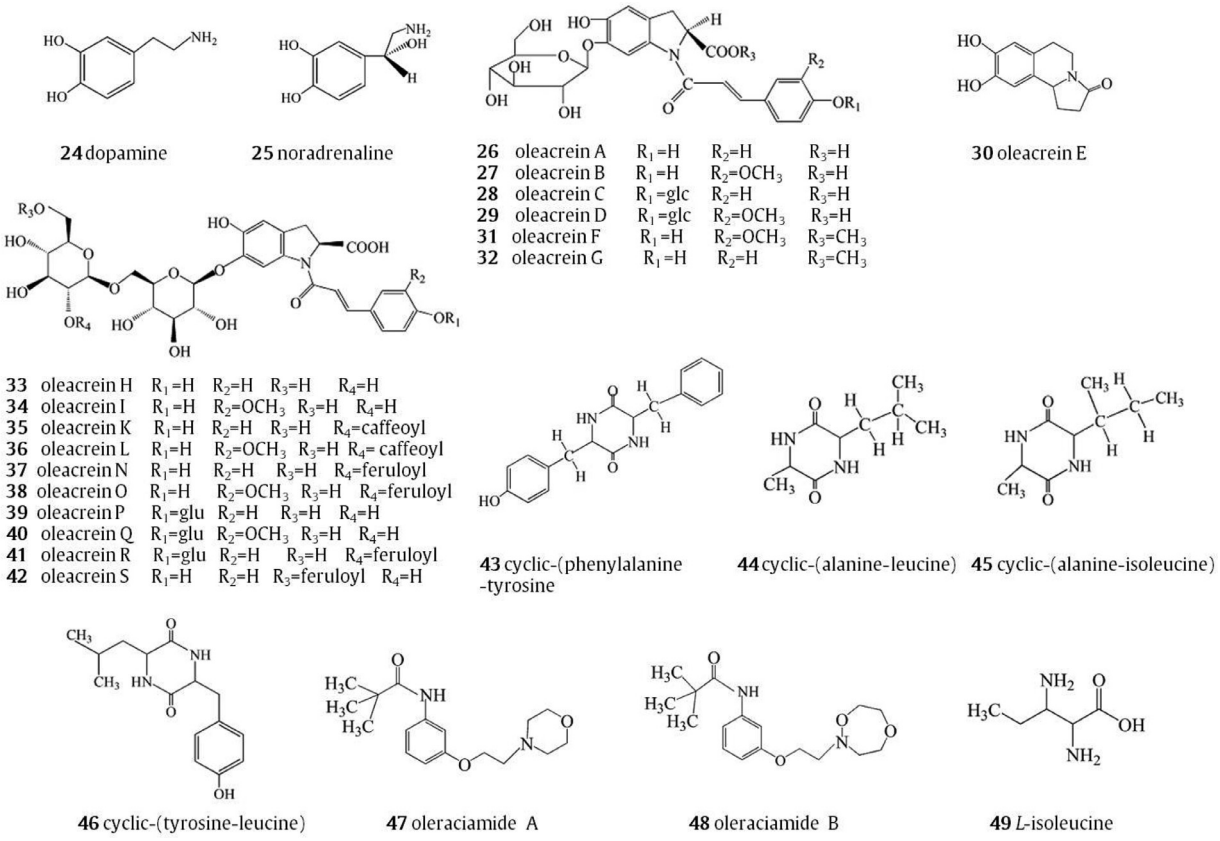


Fig. 3. Alkaloids from purslane extracts.

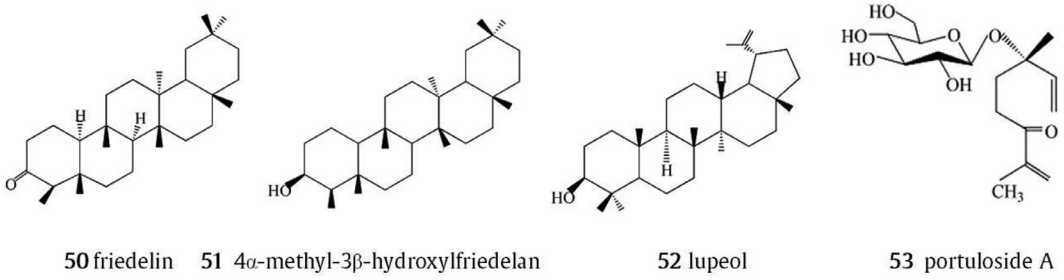


Fig. 4. Terpene compounds from purslane.

4.2.7. Steroid ingredients

Steroid ingredients have strong physical activities and are often used for anti-inflammatory, antivirus, anti-allergic and antishock treatments in clinic. Those compounds can relieve or treat the collagenous disease, anaphylactic shock and endocrine diseases such as Addison's disease. Steroid ingredients play an important role in curing breast cancer and prostate cancer (Lin, 2009).

β-sitosterol and β-sitosteryl-glucoside are the steroid ingredients that have been reported from research (Rasheed et al., 2004; Yao et al., 2007).

5. Pharmacology and pharmacokinetics

5.1. Pharmacology

5.1.1. Anti-dementia

Large doses of *D*-gal/$NaNO_2$ by ip could induce the normal neuronal cells in mice apoptosis, downregulate the expression of Bcl-2, upregulate the expression of Bax and Caspase, leading to the learning and memory ability injury in Alzheimer's disease (AD) mice. After treated with high doses of oleacrein E (H-OE) at 15 mg/(kg·d), the Bcl-2 protein expression can be up-regulated, and the Bax and Caspase protein expression can be down-regulated in the AD mice. The changes of protein expression may be of its mechanisms. (Wang, 2014) (Fig. 5).

5.1.2. Anti-oxidant capacity

Research shows that the crude polysaccharides of purslane can remove hydroxyl free radicals following an obvious quantity-effect relationship. When the mass concentration of crude polysaccharides of purslane was 3.5 mg/mL, the clearance rate was 50%. When the mass concentration was 17.6 mg/mL, the clearance rate was up to 90% (Zhu, Wu, Yang, Fan, & Mao, 2007).

The scavenging ability of purslane flavonoids for hydroxyl radicals and superoxide anions and the inhibitory effect against the oxidation of lard were determined. The results showed that the removal efficiency of hydroxyl radicals was related to the concentration of flavonoids within the test range. The clearance rate of

hydroxyl radicals reached 68.33% and the removal rate of superoxide anions peaked at 82.26% when the flavone concentration was 0.56 mg/mL. In addition, purslane flavonoids can significantly inhibit the increase of the peroxide value in lard (POV) (Su & Zhang., 2010).

5.1.3. Reducing blood lipids

New functions of wild purslane in lowering hematic fat have been found. Results indicated that purslane can reduce low-shear apparent viscosity in whole blood and medium-shear apparent viscosity in plasma. Purslane can significantly reduce total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDL-C) in serum, and increase high density lipoprotein cholesterol (HDL-C) in serum. Through this activity, purslane has certain effect in preventing atherosclerosis (He, Liu, You, Wang, & Wu, 1997).

5.1.4. Antibacterial activity

The bacteriostatic effect of purslane flavonoids toward *Escherichia coli, Staphylococcus aureus* and yeast were measured by a filter method. In this method, reductions of the sugar content, soluble protein content and conductivity changes in the bacterium fluid should be determined. Studies showed that the antibacterial mechanism of purslane flavonoids mainly occurs through destroying bacterial cell membranes, causing extravasation (Chen, Sun, Yan, & Liu, 2015).

5.1.5. Anticancer effect

A study showed that liver cancer in mice could be induced by *N*-nitrosodiethylamine (NDEA) through the PI3K/AKT/mTOR and Nrf2/HO^{-1}/the NF−κB signaling pathways. Purslane could adjust the proteins involved in the above signaling pathways; up-regulation of the protein levels of Nrf2/HO^{-1} can decrease the activities of ALT and AST, and down-regulation of the protein expressions of PI3K/AKT/mTOR and p-NF-κBp65 can increase SOD bioactivity and decrease levels of MDA, interleukin-6 (IL-6), IL-1β, and tumour necrosis factor-α (TNF-α). Therefore, this drug can play an important role in the treatment of liver cancer (Zheng et al., 2017) (Fig. 6).

Li examined different concentrations of the active ingredients in purslane to treat cancer cells *in vitro*, using a brominated dimethyl thiazole diphenyl four azole nitrogen (MTT) method to determine the proliferation of the cancer cells. At the same time, the active ingredients were also used to treat S_{180} tumour mice, observing their weights, tumour weights, mortality and the inhibition rate. The results showed that purslane alkaloids had obvious inhibitory effects on the proliferation of human lung adenocarcinoma cancer cells *in vitro* (A-549), one type of throat epidermoid cancer cells (Hep-2) and a cervical cancer cell line (Hela). Purslane polysaccharides exhibited strong inhibition of the cervical cancer Hela cell line. Fatty acids showed certain inhibition of the laryngeal epidermoid cancer type Hep-2 cells. Flavonoid ingredients had a strong inhibitory effect toward a malignant embryonic cardiac

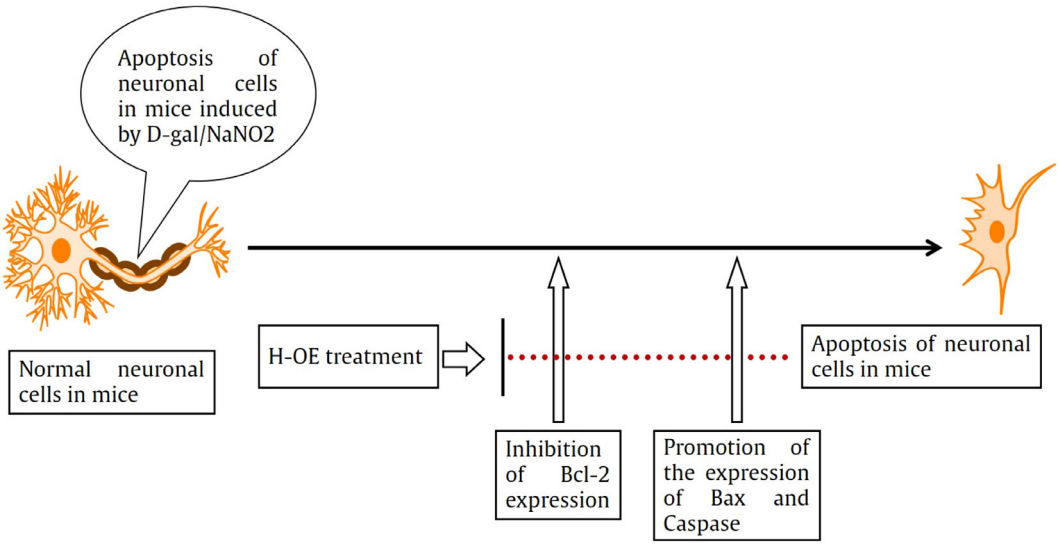


Fig. 5. Inhibitory mechanism of H-OE against apoptosis of neuronal cells.

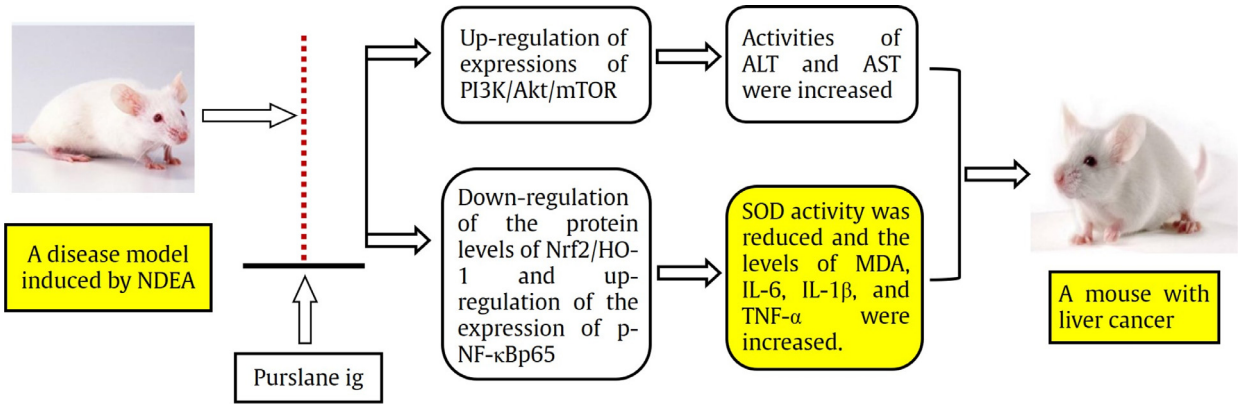


Fig. 6. Pharmaceutical mechanism of purslane in liver cancer mice.

rhabdomyoma RD cell line. All ingredients mentioned above had dose effect relationships based on their solution concentration, wherein high concentrations yielded strong inhibition. Moreover, according to the experimental results, the active ingredients of purslane can reduce the mortality of mice with S_{180} and increase the tumor inhibition rate (Li et al., 2009).

5.1.6. Anti-inflammatory effect

The contents of interleukin-1 (IL-1β and IL-1α) and TNF-α, produced *in vivo* in response to endotoxin stimulation in nine healthy volunteers were determined by a radioimmunoassay method. In this study, 18 g fish-oil, which included a high concentration of n-3 fatty acids, was added into the normal western diet of volunteers per day for 20 weeks, and at the end of this study, the content of IL-1β, IL-1α and TNF-α returned to the same level as that of volunteers not given endotoxin. The result showed that n-3 fatty acids may mediate the production of IL-1β, IL-1α and TNF-α. α-Linolenic acid, an n-3 fatty acid, can reduce inflammatory effects (Endres et al., 1989).

5.1.7. Hypoglycaemic effect

Diabetes causes serious harm to human health. Jiang found that purslane health granules had a hypoglycaemic effect. In one study, 30 normal Kumming mice were divided into three groups at random, including a normal control group and two purslane groups (125, 500 mg/kg). Fasting blood glucose levels at 0, 120 and 180 min were obtained after purslane gavage administration in the three groups of mice, respectively. In another study, 50 diabetic mice were randomly divided into five groups, a model control group, a metformin group and three purslane groups (125, 250 and 500 mg/kg). Fasting blood glucose levels at 0, 7, and 14 d were determined after purslane gavage administration in the five groups of mice, respectively. The results of the two experiments showed that in the diabetic model group, blood glucose levels at the 7th and 14th days in the purslane (125, 250, 500 mg/kg) and metformin groups were significantly decreased in the diabetic model group ($P < 0.05$). However, the sugar levels showed no significant difference in normal mice between groups given the granule or not (Jiang et al., 2016).

Other research has suggested that purslane extract increased β-cell mass and improved glucose metabolism. In this study, the signaling of β-cells stimulated by purslane may yield a therapeutic strategy for diabetes prevention (Ramadan, Schaalan, & Tolba, 2017).

5.1.8. Other effects

Research has shown that purslane has some anti-leishmanial effects. Purslane extract can stop the growth of parasites compared with the effects of glucantime in the experiment (Eskandari, Doudi, & Abedi, 2016).

Cui found that purslane polysaccharides could increase the number of T lymphocytes in mice and inhibit the proliferation of human SMMC7721 cell lines *in vitro*. This type of compounds could significantly reduce the index of S_{180} mitotic ascites and dramatically inhibit the growth of transplanted sarcoma in mice *in vivo* (Cui, Yin, & An, 2002).

5.2. Pharmacokinetics

Phenolic compounds might have strong anti-oxidant activities. Yue obtained a phenol compound, a tetrahydroisoquinolin ketopyrrolidone alkaloid (oleacrein E, OE), of which the structure was similar to that of the neurotransmitter dopamine. An experiment proved that OE had a good ability to remove DPPH free radicals.

The plasma concentrations of OE in Wistar rats were determined to inspect the pharmacokinetic characteristics of the compound by an HPLC-UV method with an internal standard. The detection wavelength was set at 287 nm, and the mobile phase was methanol-0.1% formic acid water (28:72). The concentration time curve of OE was measured after gavage administration (ig) and tail intravenous injection (iv) in rats.

From single doses of ig 10.5 mg/kg and iv 6.4 mg/kg, the pharmacokinetic parameters of OE were as follows: $AUC_{(0-\infty)}$ = (14.91 ± 6.11) g/(mL·min^{-1}), C_{max} = (0.31 ± 0.11) μg/mL, T_{max} = 15 min, $t_{1/2z}$ = (23.90 ± 9.86) min, V/Zf = (26.20 ± 8.79) L/kg; $AUC_{(0-\infty)}$ = (23.20 ± 11.78) μg/(mL·min^{-1}), C_{max} = (3.14 ± 1.92) μg/mL, and $t_{1/2z}$ = (3.90 ± 0.68) min, V/zF = (1.950 ± 1.05) L/kg by DAS 1.0 software analysis, respectively (Yue, 2016) (Fig. 7).

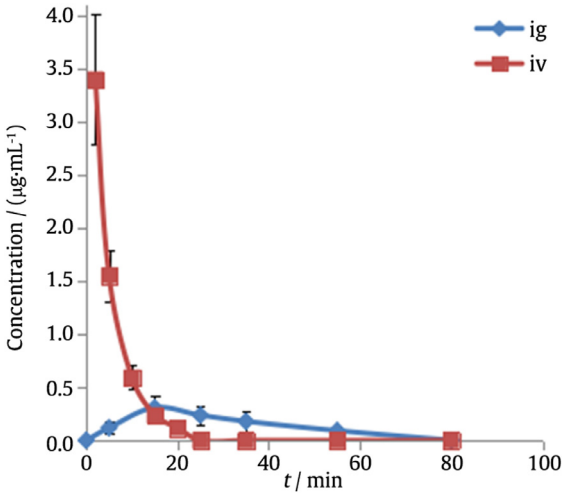


Fig. 7. Curves of blood concentration in rats after ig administration of OE-0.5% CMC-Na and iv injection with OE, respectively.

6. Safety and toxicity evaluation

A study used cytotoxicity experiments to determine the effects of purslane polysaccharide on the inhibition sensitivity of 3T3-L1 preadipocyte proliferation. The results showed that the polysaccharides had an inhibitory effect on the proliferation of 3T3-L1 preadipocytes at the concentration of 0.01–0.50 mg/mL ranged from day 1 to day 5. The preadipocyte proliferation rate was significantly lower than that in the control group ($P < 0.01$), when 3T3-L1 cells were treated with polysaccharides at 0.01 mg/mL for one day, as determined by an MTT method and an LDH method. The rate was also significantly lower than that in the control group ($P < 0.05$) when 3T3-L1 cells were treated with polysaccharides using a NRU method for 3 d. However, the preadipocytes showed toxic effects when the concentration of purslane polysaccharides was increased to 0.5 mg/mL and the treatment time was up to 5 d (Han et al., 2015).

7. Clinical application

7.1. Dermatosis

A cream mask containing purslane as the main active component had an effect on chloasma and the marked efficiency was 89.3% (Li, Miao, & Xue, 1996).

Purslane is a folk remedy to treat allergic dermatitis. The infected area must be cleaned before using the mashed fresh drug (Shen & Mu, 2016).

Zhang et al. randomly divided 130 patients with neuralgia after herpes zoster into two groups, a control group and an observation group. Each group contained 65 cases. The control group was treated with gabapentin and the observation group was treated with a nerve blocking drug in combination with purslane for external application, a purslane topical treatment. The treatment used in the observation group had a better effect in relieving pain than that used in control group ($P < 0.05$) (Zhang, 2017).

Zhang et al. divided 92 patients with acute eczema syndrome into two groups at random, a control group and a treatment group. Each group contained 46 cases. A loratadine dispersible tablet was used in the control group. A combination of a purslane mixture with a loratadine dispersible tablet was used in the treatment group. The course of treatment for each group was 8 d. The results showed that the combination therapy was superior to the loratadine dispersible tablet alone for acute eczema syndrome treatment and could reduce the content of interleukin-18 in serum (Zhang, Wang, & Zhang, 2017).

In another study, 64 patients with verruca plana were randomly divided into a treatment group and a control group, with 32 patients per group. In the control group, bacillus calmette guerin polysaccharide nucleic acid injections were given by intramuscular injection. In the treatment group, a purslane mixture was given orally and a purslane cream was used for external application. After 4 weeks of treatment, the total effectiveness rate in the treatment group was higher than that in the control group, which proved that the clinical efficacy of flat wart was much better in combination with the purslane mixture and purslane cream (Yang, 2014).

7.2. Treatment of intestinal diseases

In one study, 62 patients with acute intestine bacterium dysentery infection were treated with the active ingredients of water extracts from purslane, and the effectiveness rate was 96.77% (Lu, 2009).

7.3. Gynecological disease

Xu selected 35 women of childbearing age who were treated with purslane decoction addition and subtraction from January to June 2014. The total effectiveness rate was 94.29% (Xu, 2015).

A combination of a purslane mixture and purslane cream had a significant clinical efficacy in 25 women with early mammary abscess. The total effectiveness rate was 96% (Peng, Liu, & Zuo, 2012).

7.4. Paediatric diseases

A group of 92 children with intractable diarrhea were constantly treated with 50 mL purslane decoction for 5 d and were observed over 15 d. The effectiveness rate was 76.1% which showed the obvious effect of the treatment in rehabilitation of the children (Zhang & Feng, 2003).

7.5. Dietary method

Purslane porridge can treat dysentery and postpartum disorder in women. To make this porridge, purslane is washed, cut, boiled in water and cooked into a porridge with rice, then the proper amounts of salt, and soy sauce are added. Warm purslane porridge can be eaten for breakfast and dinner.

Purslane has heat-clearing, detoxifying and swelling relief effects. Purslane is suitable for people with constipation and/or short term red urine. Purslane can be washed, cut, and boiled in water until cooked thoroughly. Then the water in the purslane should be removed. Not only proper amount of salt, but mashed garlic, stirred sesame, and scallion can be added according to personal tastes. In addition, cooked purslane can be used for filling stuffed buns or dumplings (Liu, 2015).

7.6. Purslane patent products

7.6.1. Cosmetics

Cosmetics composed of *sacha inchi* and *P. oleracea* have anti-aging, wrinkle improvement, skin whitening and acne improvement effects (Kim, Han, Oh, & Lee, 2016)

7.6.2. Purslane beverage

A type of purslane drink can be prepared as follows: The first step is to remove the impurities from fresh purslane, washing with water to clean it. The second step is to steam, then sterilize the purslane. After this step, preparation of the purslane beverage was completed. This drink can contain various nutrients and effective components of purslane. The drink has good antioxidant activity and a, high clearance rate of DPPH because of the high extract rate of active ingredients. The drink has good taste, with few species and a low amount of additives (Wang, Mao, Zeng, Zhang, & Zhang, 2016).

7.6.3. Purslane tea

One invention describes a type of pumpkin flower purslane tea. The tea is composed of 50% pumpkin flowers, 20% *Grosvenor momordica* flowers and 30% purslane, which were cut into 1 – 2 mm fragments, treated for deactivation of enzymes, dried and packaged. This is the processing procedure of the pumpkin flower purslane tea. The tea has heat-clearing, detoxifying and anti-cancer effects. Purslane can eliminate fatigue, enhance activity of the body, prevent cardiovascular diseases, promote cell metabolism, improve sleep, regenerate youthful vigour in older people, promote children develop physical and intellectual development, and renew energy in young and middle aged people with long-term consumption (Chen & Mo, 2017).

7.6.4. Purslane nutrition noodles

These noodles consist of 10%–14% purslane, 6%–10% soybean powder, 65%–75% wheat flour, and 8%–12% buckwheat flour. The noodles are nutritious and have heat-clearing and detoxification effects, relieve water retention by promoting diuresis, reduce swelling by dispersing blood, and produce an antiphlogistic analgesic effect (Zhao & Dong, 2016).

8. Discussion

Purslane, has been widely used for thousands of years in China as medicine and food. However, there are many challenges in its actual application and therapeutic mechanisms.

Firstly, food products of purslane are few in the market. Although there are many patent products of purslane such as preserves, noodles, beverage, bread, etc., they are absent from supermarkets or online shops. Only fresh herbs, dried herbs or purslane tea can be found. Secondly, system studies should be carried on therapeutic mechanisms and safety of purslane. It has been reported the mechanism of treating mice with hepatocellular carcinoma cells and improving spatial memory ability of aged mice. However, there are no reports about kidney-preserving, hypoglycemic, antimicrobial and anti-inflammatory effects, and the clinical mechanism of application has not been studied. Moreover, safety of this herb should be explored in depth, such as application of the crowd and safe consumption. Thirdly, as a drug, the correlation between active ingredients and harvesting time has not been reported. There is fresh plant used in food and dried plant used in drug. No report on the difference of ingredients between fresh and

dried plant has been found. And correlation between active ingredients and disease spectrum has not been reported systematically.

Purslane has vast economic and social efficiency owing to its low calorie, profuse nutrition and a variety of pharmacological activities. We hope this review could provide some useful information for further research of this herb.

Conflict of interest

The authors declare no conflict of interest.

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