

PORTULACA GRANDIFLORA HOOK.: A REVIEW OF BOTANICAL FEATURES, PHYTOCHEMISTRY AND PHARMACOLOGICAL ACTIVITIES

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ABSTRACT

Portulaca grandiflora Hook., commonly known as moss rose or purslane, is an ornamental succulent plant belonging to the family Portulacaceae. Although it is primarily cultivated for its attractive and brightly coloured flowers, increasing scientific interest has focused on its pharmacognostic characteristics, phytochemical constituents and biological activities. Different parts of the plant contain several classes of secondary metabolites, including phenolic compounds, flavonoids, betalains, terpenoids and diterpenoids. Betalain-rich flowers have been investigated extensively for their antioxidant and antimicrobial properties, while experimental studies have also reported wound-healing and cytotoxic potential. The phytochemical composition and biological activity of *P. grandiflora* may vary according to plant part, flower colour, geographical source and extraction conditions. Pharmacognostic studies have provided preliminary parameters useful for identification and standardization of the crude drug. Experimental evidence has demonstrated antioxidant activity in different plant parts, antimicrobial activity against selected microorganisms and wound-healing activity in an animal model. Toxicological investigations of aqueous extracts have also indicated a favourable safety profile under the tested conditions. However, most pharmacological evidence remains preclinical, and further studies involving standardized extracts, isolated compounds, mechanism-based investigations and well-designed clinical studies are required. This review summarizes the botanical characteristics, pharmacognosy, phytochemistry, traditional uses, pharmacological activities, toxicity and future therapeutic prospects of *P. grandiflora*.

KEYWORDS: *Portulaca grandiflora*, Portulacaceae, phytochemistry, betalains, flavonoids, antioxidant, antimicrobial, wound healing, pharmacology.

1. INTRODUCTION

Medicinal plants continue to provide an important source of structurally diverse bioactive compounds and remain relevant to the discovery of new therapeutic agents. Among the plants of pharmacological interest, species of the genus *Portulaca* have attracted attention because of their diverse phytochemical composition and reported biological activities. *Portulaca grandiflora* Hook. belongs to the family Portulacaceae and is widely cultivated as an ornamental succulent because of its attractive flowers occurring in several colours.^[1,2]

Unlike *Portulaca oleracea*, which is extensively documented as a medicinal and edible plant, *P. grandiflora* has historically received greater attention as an ornamental species. Nevertheless, pharmacognostic, phytochemical and pharmacological studies have demonstrated the presence of potentially valuable secondary metabolites in its aerial parts and flowers.^[1,3] Preliminary investigations have reported antioxidant, antibacterial, wound-healing, antimutagenic and other biological effects.^[4-8]

The chemical composition of *P. grandiflora* is particularly interesting because the plant produces betalain pigments as well as phenolic compounds, flavonoids and diterpenoids. Recent metabolite profiling of flower extracts identified numerous betaxanthins, betacyanins and other metabolites, indicating considerable chemical diversity within the species.^[9] The biological activity of the plant may therefore result from the combined effects of several constituents rather than from a single compound.

2. Botanical Description

Portulaca grandiflora is a succulent herb generally characterized by a low-growing and spreading habit. The stems are branched, fleshy and relatively small, while the leaves are cylindrical to linear-subulate, thick and succulent.^[3] The plant is adapted to warm climatic conditions and is commonly cultivated in tropical and subtropical regions.

Parameter	Description
Scientific name	<i>Portulaca grandiflora</i> Hook.
Family	Portulacaceae
Habit	Succulent ornamental herb; spreading to ascending growth
Leaves	Small, fleshy, succulent; alternate, linear to lanceolate
Stem	Branched, succulent; green to reddish depending on cultivar
Flowers	Conspicuous; red, pink, magenta, purple, orange, yellow or white cultivars

The flowers are one of the most distinctive features of the plant. They are relatively large compared with the vegetative portions and occur in different colours, including pink, red, purple, orange and yellow. Variation in flower colour is associated with differences in pigment composition, particularly betalain content.^[9,10] The fruit is a small capsule containing numerous tiny seeds.

The plant is commonly cultivated as an ornamental annual or short-lived perennial under suitable climatic conditions. Its succulent nature and tolerance to relatively dry environmental conditions contribute to its popularity as a garden plant.^[3]

3. Taxonomical Classification

The taxonomical position of *Portulaca grandiflora* Hook. can be summarized as follows:

- **Kingdom:** Plantae
- **Order:** Caryophyllales

- **Family:** Portulacaceae
- **Genus:** *Portulaca*
- **Species:** *Portulaca grandiflora* Hook.

The genus *Portulaca* contains several species, among which *P. grandiflora* and *P. oleracea* are frequently investigated for their phytochemical and biological properties. However, the two species should be distinguished carefully because their phytochemical profiles and reported pharmacological properties are not identical.^[10]

4. Traditional and Ethnomedicinal Uses

Although the medicinal documentation of *P. grandiflora* is less extensive than that of *P. oleracea*, traditional applications have been reported in some regions. Earlier literature described the use of *P. grandiflora* in traditional medicine for conditions such as sore throat and skin disorders, and it has also been associated with traditional detoxification practices.^[3]

Preliminary biological investigations have provided some experimental support for these traditional observations. For example, early screening studies reported antimutagenic activity of water extracts against chemically induced mutagenicity.^[11] Another early investigation evaluated extracts of several medicinal herbs for activity against hepatitis B surface antigen.^[12] However, these early screening studies should be interpreted cautiously because they were not designed to establish clinical efficacy.

5. Pharmacognostic Characteristics

Pharmacognostic evaluation is important for establishing the identity, purity and quality of medicinal plant materials. A pharmacognostic study of the aerial parts of *P. grandiflora* reported characteristic macroscopic and microscopic features together with physicochemical and phytochemical parameters.^[1]

Microscopic examination of the leaves demonstrated structures including trichomes, xylem, fibres, crystals, phloem and anisocytic stomata.^[1] Such anatomical characteristics can be useful for authentication of crude plant material and may help distinguish the plant from morphologically similar species.

Shinde et al. also investigated pharmacognostic standardization of the aerial parts and included morphological, microscopic, physicochemical, fluorescence and preliminary phytochemical evaluation.^[2] Their study additionally examined the antibacterial potential of an alcoholic extract, demonstrating the usefulness of combining pharmacognostic and pharmacological investigations during preliminary evaluation of medicinal plants.

Therefore, establishment of diagnostic microscopic characters, ash values, extractive values, moisture content, fluorescence characteristics and chromatographic profiles may provide useful quality-control parameters for *P. grandiflora*.

6. Phytochemical Composition

Phytochemical investigations have demonstrated that *P. grandiflora* contains several classes of secondary metabolites. Preliminary phytochemical screening has reported the presence of alkaloids, flavonoids, phenolic compounds, tannins, saponins, steroids and triterpenoids in different extracts.^[1,2,10]

The qualitative and quantitative composition varies according to the plant part, extraction solvent and experimental conditions. A study comparing leaves, young stems, old stems and flowers demonstrated significant differences in total phenolic and flavonoid contents among different plant organs.^[13] This observation emphasizes the importance of specifying the plant part when comparing phytochemical results.

6.1 Phenolic Compounds and Flavonoids

Phenolic compounds and flavonoids are among the important phytochemical groups identified in *P. grandiflora*. These compounds are frequently associated with antioxidant activity because of their ability to donate hydrogen or electrons and interact with reactive oxygen species.

Husnawati et al. reported differences in phenolic and flavonoid concentrations among different organs of *P. grandiflora*. The leaves showed comparatively high total phenolic and flavonoid contents, whereas antioxidant activity differed between plant parts.^[13] These findings indicate that the quantity of a particular phytochemical class does not necessarily correspond directly to overall antioxidant activity.

Phytochemical group	Importance
Flavonoids	Reported in screening and quantitative studies; relevant to antioxidant and wound-healing research.
Phenolic compounds	Detected in phytochemical and metabolomic studies; contribute to antioxidant capacity.
Tannins	Detected in preliminary screening and metabolomic profiling; may contribute to protein interaction and antimicrobial effects.
Alkaloids	Reported in several preliminary screening studies.
Saponins	Reported in preliminary screening (e.g., foam test).
Terpenoid-type compounds	Detected in screening and natural-product investigations (e.g., lupeol, β -sitosterol).
Betalains	Betacyanins and betaxanthins identified, especially in colored flowers; major pigments with antioxidant potential.
Fatty acids, / lipid metabolites	Detected in modern metabolomic profiling; may influence membrane and anti-inflammatory effects.

A comparison between *P. grandiflora* and *P. oleracea* also demonstrated differences in phytochemical composition and antioxidant capacity. Both plants contained several secondary metabolite classes, but their antioxidant responses differed according to the analytical method used.^[10]

6.2 Betalains

Betalains are characteristic nitrogen-containing pigments found in several members of the order Caryophyllales. *P. grandiflora* flowers are particularly rich in these pigments, which contribute to their characteristic colours.

Piattelli et al. reported two betalain compounds from *P. grandiflora*, expanding the knowledge of pigment chemistry in the species.^[14] More recent metabolomic investigations using HPLC-DAD-ESI-MS and high-resolution mass spectrometry demonstrated extensive chemical diversity in betalain-rich extracts. Nineteen betaxanthins and two betacyanins were detected by HPLC-DAD-ESI-MS, while a broader analysis identified 71 compounds, including numerous betaxanthins and other metabolites.^[9]

The concentration of betalains varied considerably according to flower colour. Orange flowers showed high betaxanthin levels, whereas purple flowers contained higher betacyanin concentrations.^[9] This colour-dependent variation is important when selecting plant material for phytochemical or pharmacological investigations.

6.3 Diterpenoids

Diterpenoids represent another important group of specialized metabolites reported from *P. grandiflora*. Ohsaki et al. isolated the clerodane diterpenoid portulide from the plant and characterized its structure using spectroscopic and chemical methods.^[15]

Further investigations identified several diterpenoid congeners related to portulal, including portulic lactone, 3-hydroxyportulol ether, 5-hydroxyportulal and 5-hydroxyportulic acid.^[16] Additional diterpenes containing a bicyclo[5.4.0] undecane skeleton were subsequently isolated and discussed in relation to the biosynthesis of portulal.^[17]

These studies demonstrate that *P. grandiflora* is a chemically interesting source of clerodane-type diterpenoids and related compounds.

6.4 Portulene Acetal and Related Constituents

Portulene acetal was reported as a minor constituent of *P. grandiflora* and was investigated in relation to the biosynthetic pathway of portulal.^[18] The identification of such structurally unusual compounds highlights the importance of *P. grandiflora* in natural-product chemistry.

7. Variation in Phytochemical Composition

One of the important factors affecting the biological evaluation of *P. grandiflora* is chemical variability. Phytochemical composition can differ according to plant organ, flower colour, cultivar, geographical conditions, harvesting stage and extraction method.^[9,10,13]

Husnawati et al. demonstrated that leaves, young stems, old stems and flowers possess different phenolic and flavonoid concentrations.^[13] Similarly, metabolite profiling of different flower colours showed substantial variation in betalain composition and antioxidant activity.^[9]

Nurcholis et al. also investigated different *P. grandiflora* mutants and reported differences in total phenolic content, flavonoid content and antioxidant activity.^[19] Such findings indicate that genetic variation may contribute to phytochemical variability.

Consequently, future pharmacological studies should clearly report the cultivar or variety, flower colour, geographical source, plant part, harvesting conditions, extraction solvent and extraction method.

8. Pharmacological Activities

8.1 Antioxidant Activity

Antioxidant activity is one of the most extensively investigated biological properties of *P. grandiflora*. Phenolic compounds, flavonoids, betalains and other secondary metabolites may contribute to the observed antioxidant effects.

Different plant organs have demonstrated antioxidant activity, although the magnitude of activity varies among leaves, stems and flowers.^[13] In a comparative study, *P. grandiflora* extract showed antioxidant activity in ABTS and CUPRAC assays, although the relative activity differed according to the assay employed.^[10]

Metabolite profiling of flower extracts demonstrated antioxidant activity among yellow, orange, purple and red varieties, with variation according to flower colour.^[9] Importantly, the authors observed that betalains alone could not fully explain the antioxidant activity, suggesting contributions from flavonoids, phenolic derivatives, fatty-acid derivatives and other metabolites.^[9]

Therefore, the antioxidant effect of *P. grandiflora* is likely to involve multiple phytochemical constituents rather than a single active principle.

8.2 Antibacterial Activity

Antibacterial activity has also been investigated in *P. grandiflora*. Shinde et al. evaluated an alcoholic extract of aerial parts and reported antibacterial potential against selected microorganisms.^[2]

More detailed investigation of betalain-rich flower extracts demonstrated differences in antimicrobial activity according to flower colour. Yellow and orange extracts showed comparatively greater activity against Gram-positive bacteria, whereas red and purple extracts showed somewhat greater activity against selected Gram-negative bacteria.^[9]

These findings suggest that pigment composition and other secondary metabolites may influence antimicrobial activity. However, the available evidence remains primarily in vitro, and further studies are required to identify the active constituents and establish their mechanisms of action.

8.3 Wound-Healing Activity

Recent evidence has provided experimental support for the wound-healing potential of *P. grandiflora*. Budiawan et al. evaluated extracts obtained from different flower varieties in a rabbit skin-wound model.^[4]

Extracts prepared from magenta- and pink-flowered varieties produced reduction in wound size and healing under the experimental conditions. The study also demonstrated differences in total flavonoid content between the varieties.^[4]

Interestingly, the variety showing greater wound-healing activity did not simply correspond to the variety with the highest flavonoid concentration, suggesting that other constituents may contribute to the effect.

The antioxidant and antimicrobial properties of the plant may also be relevant to wound repair because oxidative stress and microbial contamination can interfere with normal wound healing.^[4,9] Nevertheless, the wound-healing evidence for *P. grandiflora* remains limited, and further mechanistic and formulation-based studies are required.

8.4 Antimutagenic Activity

An early screening study evaluated water extracts from 102 Chinese medicinal herbs for antimutagenic effects. *P. grandiflora* was among the plants showing activity against aflatoxin B1-induced mutagenicity in the Ames test, and activity against cyclophosphamide-induced mutagenicity in mice was also reported.^[11]

These findings provide preliminary evidence for antimutagenic potential. However, the study was an early screening investigation and does not establish a clinically relevant chemopreventive effect. Further molecular and in vivo studies are required to characterize the responsible constituents and mechanisms.

8.5 Antiviral Potential

The antiviral potential of *P. grandiflora* has been explored in early screening investigations. Zheng and Zhang evaluated 300 herbal extracts using an ELISA-based approach for anti-hepatitis B surface antigen activity, and *P. grandiflora* was included among the extracts examined.^[12]

More recent metabolite-based studies have also examined the antiviral properties of *P. grandiflora* extracts. However, activity has not been consistently demonstrated across viral systems. Therefore, the available evidence should be considered preliminary rather than evidence of established antiviral efficacy.

8.6 Cytotoxic and Anticancer Potential

Betalain-rich extracts of *P. grandiflora* have also been investigated for cytotoxic activity. Spórna-Kucab et al. reported that the extracts were not toxic to normal VERO cells under the tested conditions, while the purple flower extract demonstrated selective activity toward RKO colon carcinoma cells.^[9]

These findings indicate potential for further investigation but should not be interpreted as evidence of anticancer efficacy in humans. Additional studies involving purified compounds, cancer-cell panels, molecular mechanisms, selectivity indices and animal models are required.

9. Extraction and Standardization

The biological activity of medicinal plants is strongly influenced by extraction conditions. Solvent polarity, extraction temperature, extraction time, plant part and processing conditions can alter the recovery of phenolic compounds, flavonoids and other metabolites.

Haryoto et al. investigated microwave-assisted extraction of *P. grandiflora* flowers and demonstrated that solvent composition affected total phenolic and flavonoid recovery as well as antioxidant activity.^[20] Their optimization study identified a mixture of acetone and methanol as an effective solvent system under the specific experimental conditions used.

Similarly, differences in chemical composition between plant organs and flower colours demonstrate the need for standardized raw materials before pharmacological evaluation.^[9,13]

For future development of *P. grandiflora*-based formulations, standardization should include botanical authentication, determination of moisture and ash values, extractive values, chromatographic fingerprinting and quantitative estimation of selected marker compounds. Depending on the intended product, HPTLC, HPLC, LC-MS or other analytical techniques may be employed.

10. Toxicological Studies

Safety evaluation is an important component of the pharmacological development of medicinal plants. Chavalittumrong et al. investigated the chronic toxicity of an aqueous extract of *P. grandiflora* in male and female Wistar rats for six

months.^[5] Animals received 10, 100 or 1000 mg/kg/day of the aqueous extract. Under the conditions of the study, no treatment-related detrimental effects or histopathological lesions were observed.

A phase I study involving healthy human volunteers also investigated the safety of an aqueous extract of *P. grandiflora*. Participants received 500 mg/day for two months, and no major adverse effects were reported during the study period.^[6]

These findings provide preliminary safety information for the aqueous preparation studied. However, they should not be generalized to all extracts, doses, formulations or routes of administration. Safety evaluation of standardized extracts and isolated constituents remains necessary before therapeutic application.

11. Recent Advances and Research Gaps

Recent studies have substantially improved understanding of the phytochemical diversity of *P. grandiflora*. Advanced analytical methods have revealed numerous betalains and other metabolites in the flowers [9]. At the same time, studies on different plant organs, varieties and mutants have demonstrated considerable variation in phytochemical content and antioxidant activity.^[13,19]

Despite these advances, several research gaps remain. First, many reported biological activities are based on crude extracts, making it difficult to identify the compounds responsible for the effects. Second, the relationship between phytochemical concentration and biological activity is not always direct. Third, relatively few studies have investigated pharmacological mechanisms using molecular or biochemical approaches.

Future research should therefore focus on bioassay-guided fractionation, identification of active constituents, quantitative chromatographic standardization and mechanism-based pharmacological studies. The development of standardized topical formulations may also be explored for applications such as wound management, particularly in view of the preliminary wound-healing evidence.^[4]

12. Future Perspectives

Portulaca grandiflora represents a potentially useful source of natural pigments, phenolic compounds, flavonoids and diterpenoids. Its antioxidant and antimicrobial properties, together with preliminary wound-healing findings, provide a basis for further investigation.^[4,9]

Future investigations should include:

1. Isolation and structural characterization of bioactive constituents.
2. Quantitative HPLC/LC-MS-based standardization of extracts.
3. Evaluation of seasonal, geographical and varietal phytochemical variation.
4. Mechanistic investigation of antioxidant, antimicrobial and wound-healing effects.
5. Bioassay-guided fractionation to identify active fractions.
6. Evaluation of standardized extracts in validated animal models.
7. Development of suitable topical formulations for wound-related applications.
8. Detailed acute, subacute and chronic toxicity studies of standardized preparations.
9. Pharmacokinetic and bioavailability investigations of promising compounds.
10. Carefully designed clinical studies after adequate preclinical validation.

13. CONCLUSION

Portulaca grandiflora Hook. is an ornamental plant with increasing pharmacological and phytochemical interest. Pharmacognostic investigations have established useful diagnostic characteristics, while phytochemical studies have identified phenolic compounds, flavonoids, betalains and several diterpenoid constituents.^[1,9,15-18] Experimental studies indicate antioxidant, antibacterial and wound-healing potential, with additional preliminary evidence for antimutagenic and cytotoxic activities.^[2,4,9,11] However, the available evidence is predominantly preclinical, and considerable variation exists according to plant part, flower colour, variety and extraction conditions. Therefore, standardized extracts, identification of active constituents and mechanism-oriented studies are required to establish the therapeutic potential of *P. grandiflora*. The plant may provide a promising basis for future natural-product research, particularly in the areas of antioxidant and topical wound-care applications.

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