JOURNAL OF PHARMA INSIGHTS AND RESEARCH ISSN NO. 3048-5428

REVIEW ARTICLE

A Review on Phytochemistry and Pharmacological Activities of *Portulaca oleracea* L

Ramakrishna S*[1], Mufeeda[2], Narayana Murthy G[3]

[1] *Assistant Professor, Department of Pharmacognosy, National College of Pharmacy, Shivamogga, Karnataka, India*
[2] *UG Scholar, Department of Pharmacognosy, National College of Pharmacy, Shivamogga, Karnataka, India*
[3] *Professor and Principal, Department of Pharmacognosy, National College of Pharmacy, Shivamogga, Karnataka, India*

Publication history: Received on 20th July 2025; Revised on 29th Aug 2025; Accepted on 5th September 2025

Article DOI: 10.69613/3qbhdc41

Abstract: *Portulaca oleracea* L. (Purslane) is an annual succulent distributed globally, recognized concurrently as a common potherb and a significant plant in diverse ethnomedicinal systems. Its historical application for treating a spectrum of ailments is increasingly supported by modern pharmacological investigations. The plant harbors a rich and complex phytochemistry, characterized by a variety of bioactive compounds. The main constituents include novel alkaloids (e.g., oleracone, oleraisoindole B), numerous flavonoids and homoisoflavonoids, therapeutic polysaccharides (e.g., POL-P3b), and a notable concentration of omega-3 fatty acids, particularly alpha-linolenic acid. Scientific evaluations have confirmed its potent biological activities, chief among them being significant anti-inflammatory, antioxidant, and neuroprotective properties. Evidence also points to strong antitumor mechanisms, antimicrobial action against various pathogens, and beneficial effects on metabolic disorders, including diabetes and adipogenesis. Moreover, its immunomodulatory and dermatological protective effects are areas of growing interest. This combination of traditional knowledge and contemporary scientific validation shows the substantial potential of P. oleracea as a source for developing novel therapeutic agents and functional food ingredients. More practical investigations, particularly in clinical practice, is necessary to fully harness its therapeutic utility.

Keywords: *Portulaca oleracea;* Phytochemistry; Pharmacological activity; Ethnomedicine; Alkaloids; Polysaccharides.

1. Introduction

Portulaca oleracea L. (common purslane) is a cosmopolitan annual herb, often regarded as a prolific weed, yet it possesses a deep and long-standing history as both a culinary ingredient and a valued component of traditional medicine systems worldwide [6, 20]. Historically, it has been applied to treat a wide array of conditions, including inflammatory disorders, skin ailments, digestive complaints, and infections [2, 7, 20]. The widespread ethnopharmacological use of this plant has prompted extensive scientific inquiry to validate its traditional claims and uncover novel therapeutic properties.

Figure 1. Leaves and Flowers of *Portulaca oleracea* L

* Corresponding author: Ramakrishna S

The plant's biological activities are attributed to its complex chemical matrix, which includes a diverse arsenal of secondary metabolites. Recent isolations of novel alkaloids [1, 3, 15], homoisoflavonoids [4, 10], and complex polysaccharides [5, 11] have provided a mechanistic basis for its observed pharmacological effects. This review evaluates the scientific literature on *P. oleracea*, correlating its phytochemical constituents with its reported biological activities in preclinical models. It aims to provide a clear perspective on its current status as a source of functional foods and potential pharmaceuticals.

2. Botanical Description

2.1. Taxonomy

Portulaca oleracea L., a member of the family Portulacaceae, is a succulent, annual herb. It typically exhibits a prostrate growth habit, with stems spreading radially from a central taproot, though it can achieve heights of up to 40 cm. The stems are smooth, fleshy, and cylindrical, often presenting with a distinct reddish or purplish tinge. The root system consists of a primary taproot supplemented by fibrous lateral roots. The leaves are a key morphological feature: they are fleshy, succulent, smooth, and possess a glossy green surface, frequently displaying reddish-purple margins. Their shape is characteristically obovate to spatulate, measuring approximately 4–28 mm in length and 12–13 mm in width. Leaves are arranged alternately or sub-oppositely, often appearing clustered at the stem joints and ends. The flowers are small, radially symmetrical, and bright yellow, occurring in terminal or axillary clusters. Each flower typically has two sepals and five oblong-obovate petals that are notched at the apex. The fruit is a globular dehiscent capsule, known as a pyxis, which upon maturity opens via a transverse, sub-median line. This dehiscence causes the top portion to fall away like a lid, releasing numerous small, dark, and reniform seeds.

3. Phytochemical Constituents

The therapeutic efficacy of *P. oleracea* is rooted in its rich and varied phytochemistry, which includes several classes of bioactive compounds.

3.1. Alkaloids

Alkaloids represent a significant class of active compounds in this plant. Recent investigations have led to the isolation and characterization of several novel structures. These include oleraisoindole B, an isoindole alkaloid that demonstrated anti-inflammatory activity at low concentrations [1], and oleracone, another novel alkaloid that also exhibited potent anti-inflammatory effects and favorable pharmacokinetics in rat models [15]. Moreover, the alkaloid oleraurea was identified and, along with other known compounds from the plant, showed notable antiacetylcholinesterase activity, suggesting a potential mechanism for traditional neurological applications [3].

3.2. Flavonoids and Homoisoflavonoids

The plant is a rich source of flavonoids and related phenolic structures. Oleracone F, a new homoisoflavone, was isolated and found to possess strong antioxidant activity, as measured by its ability to neutralize DPPH (2,2-diphenyl-1-picrylhydrazyl) free radicals [4]. Other homoisoflavonoids isolated from *P. oleracea* have been evaluated for their effects on metabolism. Specific compounds from an 85% aqueous methanol fraction demonstrated anti-adipogenic activity in 3T3-L1 preadipocyte cells. These compounds reduced fat accumulation, decreased glucose consumption, and suppressed the expression of key genes involved in lipogenesis, thereby indicating potential for anti-obesity applications [10].

3.3. Polysaccharides

Complex polysaccharides extracted from *P. oleracea* have shown potent and diverse biological activities, particularly related to immunomodulation, gastrointestinal health, and oncology. A specific water-soluble polysaccharide, designated POL-P3b, was found to exert antitumor activity on HeLa cervical cancer cells. Its mechanism was linked to the induction of apoptosis via the TLR4/NF-κB signaling pathway [5]. This same polysaccharide fraction also demonstrated protective effects on intestinal dendritic cells in mouse models of cervical cancer [17] and promoted the phenotypic and functional maturation of murine bone marrow-derived dendritic cells. This suggests its potential utility as an adjuvant for DC-based cancer vaccines [18]. In the context of gastrointestinal health, *P. oleracea* polysaccharides (POP) have been shown to alleviate dextran sulfate sodium (DSS)-induced ulcerative colitis in animal models. The mechanism involved regulating intestinal homeostasis, modulating gut microbiota, and reducing the inflammatory response [11].

3.4. Fatty Acids, Terpenoids, and Other Constituents

Beyond the major classes, *P. oleracea* is famously recognized for its nutritional profile. It is one of the richest terrestrial plant sources of omega-3 fatty acids, particularly alpha-linolenic acid (ALA). It also contains vitamins (notably vitamin C and vitamin E), carotenoids, and minerals [8]. More recently, new cerebrosides (portulacerebrosides B-D) and a new ceramide (portulaceramide A)

were isolated. These compounds exhibited significant antibacterial effects against pathogens responsible for dysentery, providing a chemical basis for its traditional use in treating bacillary dysentery [7]

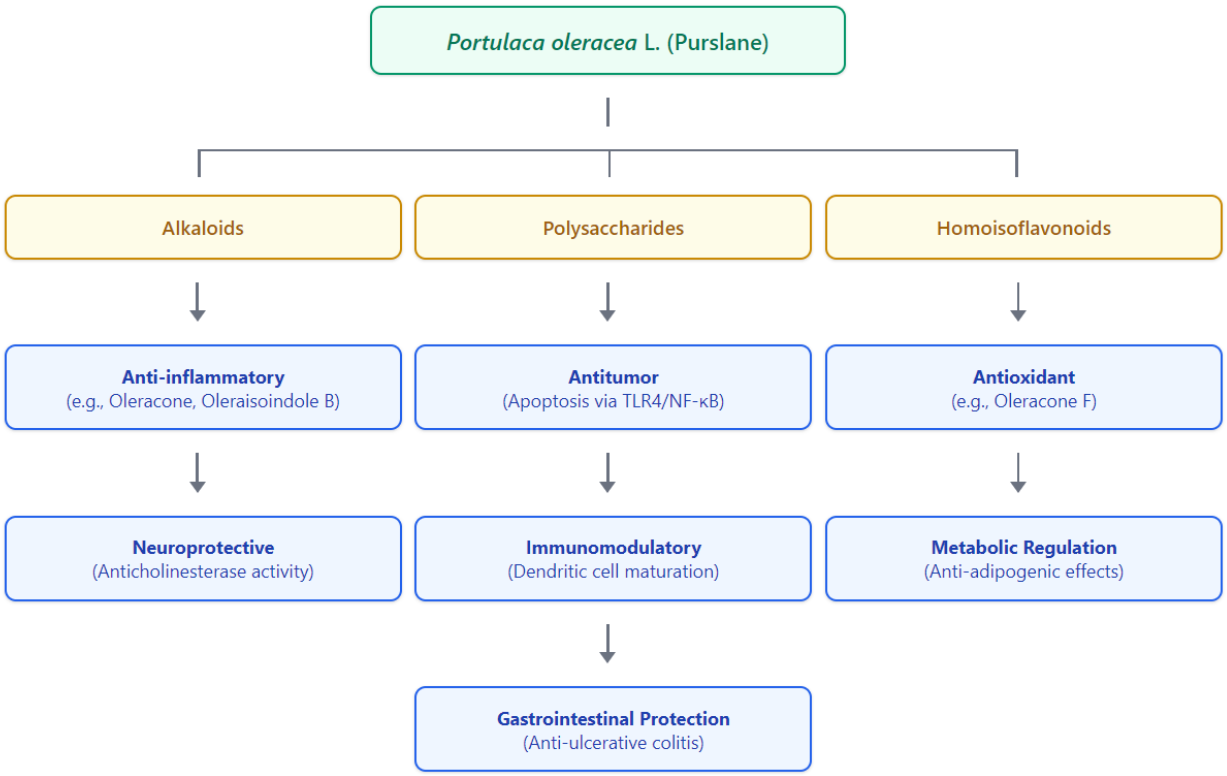

Figure 2. Phytochemical Classes in *Portulaca oleracea* and Their Biological Activities

Table 1. Bioactive Phytochemicals Isolated from *Portulaca oleracea*

Compound Class	Specific Compound(s)	Biological Activity	Reference(s)
Alkaloids	Oleracone	Anti-inflammatory, high bioavailability	[15]
	Oleraisoindole B	Anti-inflammatory	[1]
	Oleraurea	Antiacetylcholinesterase activity	[3]
Homoisoflavonoids	Oleracone F	Antioxidant (DPPH radical scavenging)	[4]
	Various	Anti-adipogenic (reduced fat accumulation)	[10]
Polysaccharides	POL-P3b	Antitumor (induces apoptosis via TLR4/NF-κB)	[5]
	POL-P3b	Immunomodulatory (matures dendritic cells)	[18]
	POP (general)	Anti-ulcerative colitis	[11]
Cerebrosides/Ceramides	Portulacerebrosides B-D	Antibacterial (against dysentery pathogens)	[7]
	Portulaceramide A	Antibacterial	[7]

4. Pharmacological Properties

The extensive traditional use of *P. oleracea* has been substantiated by a large volume of preclinical research. These studies validate its role in treating conditions related to inflammation, metabolic imbalance, microbial infections, and neurological issues.

4.1. Anti-inflammatory and Analgesic Activity

Inflammation is the main pathological process in many diseases, and *P. oleracea* has long been used as a traditional anti-inflammatory agent. This activity is strongly supported by modern studies. The novel alkaloids oleracone and oleraisoindole B, isolated from the plant, have both demonstrated significant anti-inflammatory effects, with oleracone also showing rapid absorption and high bioavailability in animal models [1, 15]. Further studies investigating crude extracts confirmed potent analgesic and anti-inflammatory properties, particularly when administered topically or via injection. The efficacy of the extract was found to be

comparable to that of the non-steroidal anti-inflammatory drug (NSAID) diclofenac sodium, lending strong support to its traditional application for pain and inflammation relief [20].

4.2. Neuroprotective and Central Nervous System Effects

The plant's application in nervous system disorders is an area of growing scientific interest. Extracts have been shown to possess significant neuroprotective potential, with relevance for conditions such as Alzheimer's, Parkinson's, and generalized hypoxic injury [6, 22]. One identified mechanism for these effects is anticholinesterase activity, which was observed from the alkaloid oleraurea and other known compounds isolated from the plant. This inhibition of acetylcholinesterase is a primary therapeutic strategy in the management of Alzheimer's disease [3]. Moreover, *P. oleracea* extracts have demonstrated protective effects against hypoxia-induced nerve damage. The proposed mechanisms include the enhancement of erythropoietin (EPO) expression in the cortex and the elevation of key glycolytic enzymes. This action leads to improved energy metabolism (higher ATP levels) in the brain, thereby protecting nerve cells from hypoxic damage and reducing associated inflammation [22].

Table 2. *In Vitro* Pharmacological Studies

Pharmacological Activity	Model / Assay	Finding	Reference(s)
Antitumor	HeLa (cervical cancer) cells	POL-P3b induced apoptosis via TLR4/NF-κB	[5]
Cytotoxicity	HepG2 (liver) & A-549 (lung) cells	Seed oil reduced cell viability dose-dependently	[12]
Anti-adipogenic	3T3-L1 preadipocytes	Homoisoflavonoids reduced fat accumulation	[10]
Antiviral	Influenza A (H1N1, H3N2) assay	Water extract (WEPO) inhibited viral binding	[2]
Antiviral	HCV NS3 Serine Protease assay	Extract showed >70% inhibition of the enzyme	[16]
Antifungal	Bioassay system	Extract showed strong activity against *Trichophyton* spp.	[13]
Antileishmanial	*Leishmania major* promastigotes	Extract significantly inhibited parasite growth	[19]
Antibacterial	Assay vs. dysentery pathogens	Portulacerebrosides showed significant activity	[7]
Skin Protection	Keratinocytes (HaCaT cells)	Extract reduced inflammation after AHA/UV damage	[8]
Anticholinesterase	Enzyme assay	Alkaloid (Olerauera) inhibited acetylcholinesterase	[3]

4.3. Antitumor and Immunomodulatory Activity

A significant body of research has focused on the oncological and immunomodulatory potential of *P. oleracea* constituents, particularly its complex polysaccharides.

4.4. Cytotoxic and Antitumor Mechanisms

A specific polysaccharide fraction, POL-P3b, has been shown to exert direct antitumor activity on HeLa cervical cancer cells by inducing apoptosis. This process was found to be mediated through the TLR4/NF-κB signaling pathway, a critical regulator of immune response and cell survival [5]. In addition to polysaccharides, the seed oil of *P. oleracea* has demonstrated cytotoxic effects against human liver cancer (HepG2) and human lung cancer (A-549) cell lines. The oil significantly reduced cell viability and induced morphological changes in a dose-dependent manner [12].

4.5. Immunomodulation

The immunomodulatory properties of *P. oleracea* are closely linked to its antitumor effects. The POL-P3b polysaccharide, for instance, not only targets cancer cells directly but also modulates the host immune response. It was found to protect intestinal dendritic cells from apoptosis in mouse models of cervical cancer [17]. Moreover, POL-P3b promotes the phenotypic and functional maturation of murine bone marrow-derived dendritic cells. It enhances the ability of these critical immune cells to stimulate an adaptive immune response by activating the TLR-4 receptor, suggesting its potential as a nutrient supplement or adjuvant for dendritic cell-based cancer vaccines [18].

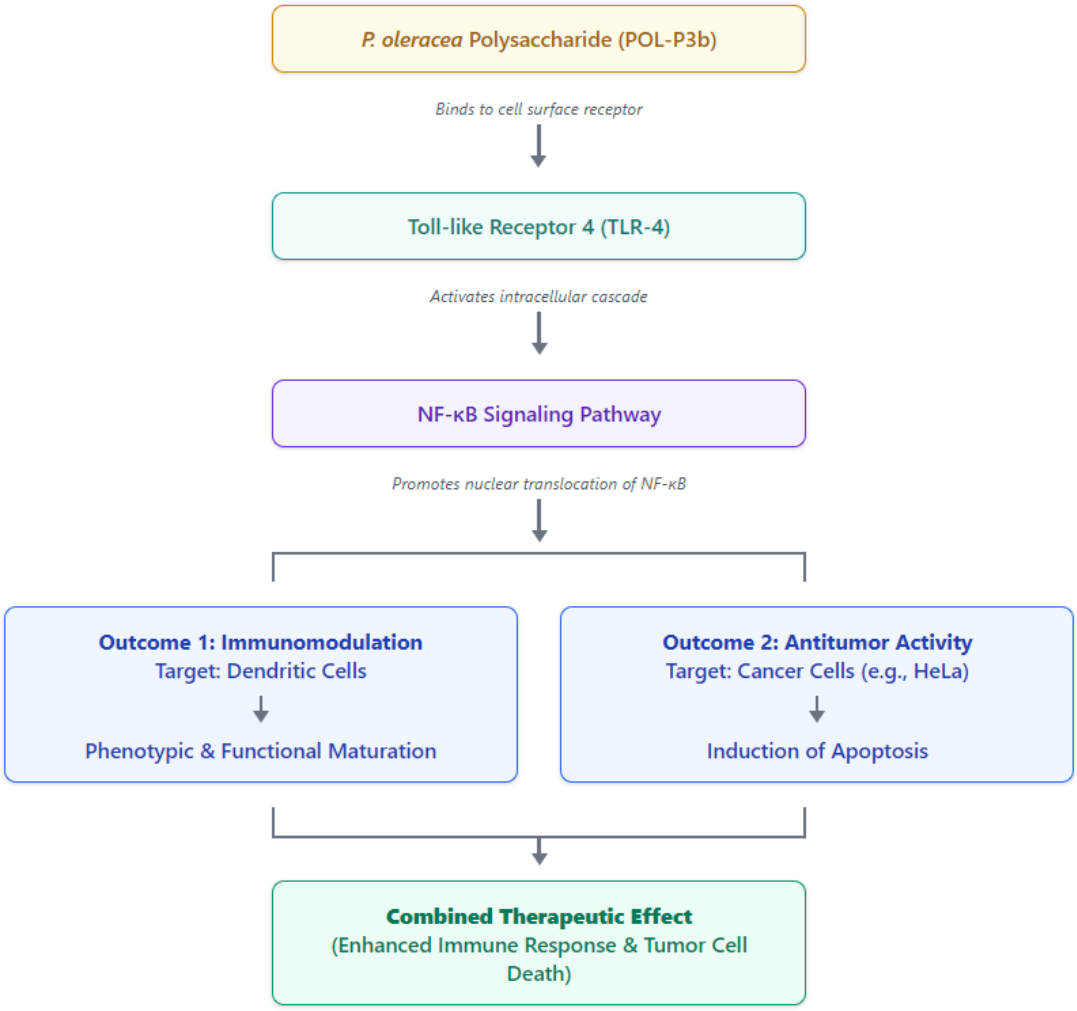

Figure 3. Mechanism of Antitumor and Immunomodulatory Effects of *P. oleracea* Polysaccharides (POL-P3b)

4.6. Antimicrobial and Antiviral Properties

The historical use of *P. oleracea* for treating infections is supported by its broad-spectrum antimicrobial activity.

4.7. Antibacterial Activity

The plant's traditional use against bacillary dysentery has been rationalized by the isolation of specific antibacterial compounds. Four new compounds, including portulacerebrosides B-D and portulaceramide A, demonstrated significant antibacterial action against bacteria responsible for dysentery. This finding provides a direct molecular basis for its ethnomedicinal application [7].

4.8. Antiviral Activity

P. oleracea extracts have shown promise against viral pathogens. A water extract of the plant (WEPO) exhibited potent activity against influenza A virus (IAV), including both H1N1 and H3N2 strains. The extract appears to act at the early stages of infection by inhibiting viral binding to host cells and possessing virucidal properties [2]. Its potential also extends to other significant viruses. Extracts have shown strong inhibitory activity (over 70%) against the Hepatitis C Virus (HCV) NS3 serine protease, an enzyme essential for HCV replication. This suggests *P. oleracea* could be a source for new anti-HCV therapeutics [16].

4.9. Antifungal and Antileishmanial Activity

The plant's antimicrobial spectrum also includes fungi and parasites. Extracts have demonstrated potent antifungal activity, particularly against *Trichophyton* species, which are dermatophytes responsible for various skin infections [13]. Additionally, an in-vitro study on the effects of purslane extract against *Leishmania major* parasites, the causative agent of cutaneous leishmaniasis, found that the extract significantly inhibited parasite growth, albeit less potently than the standard drug glucantime [19].

4.10. Metabolic and Endocrine Effects

Traditional medicine systems often employ *P. oleracea* for conditions related to metabolic imbalance.

4.10.1. Anti-diabetic Properties

Preclinical studies have validated its use in diabetes-related complications. In rats with streptozotocin (STZ)-induced type 1 diabetes, *P. oleracea* extract demonstrated a protective effect against associated reproductive system dysfunction. The extract improved sperm count, modulated hormone levels, and, crucially, reduced the underlying inflammation and oxidative stress associated with the diabetic state [9].

4.10.2. Anti-adipogenic Activity

The plant's constituents also show potential for addressing obesity. Specific homoisoflavonoids isolated from *P. oleracea* were evaluated for their anti-adipogenic properties. These compounds effectively reduced fat accumulation and glucose consumption in 3T3-L1 preadipocytes. The mechanism involves the suppression of key genes integral to the process of fat formation, highlighting a potential application in obesity management [10].

4.11. Dermatological and Protective Effects

P. oleracea is a common ingredient in traditional dermatological remedies, and its protective effects are now being scientifically explored.

4.12. Wound Healing Activity

The topical application of a crude extract of *P. oleracea* was studied on wounds in mice. The extract was found to significantly accelerate the healing process, evidenced by a faster rate of wound contraction and increased tensile strength of the healed tissue [14].

4.13. Skin Protection

In a more specialized application, the extract was found to relieve skin barrier damage associated with increased photosensitivity following alpha-hydroxy acid (AHA) peeling treatments. In-vitro tests showed that UV exposure combined with AHA damaged the skin barrier and triggered inflammation, but the *P. oleracea* extract was able to reduce this damage, supporting its use in soothing and protective cosmetic formulations [8].

Table 3. *In Vivo* Pharmacological Studies

Pharmacological Activity	Animal Model	Finding	Reference(s)
Anti-inflammatory	Rat model (pharmacokinetics)	Alkaloid (Oleracone) showed high bioavailability (74.91%)	[15]
Analgesic / Anti-inflammatory	Mouse models	Extract efficacy was comparable to diclofenac sodium	[20]
Neuroprotective	Mouse hypoxia model	Extract increased EPO expression and brain ATP levels	[22]
Anti-diabetic	STZ-induced diabetic rats	Extract improved sperm count and reduced inflammation	[9]
Anti-ulcerative colitis	DSS-induced colitis mice	Polysaccharides (POP) regulated gut microbiota and reduced inflammation	[11]
Antitumor / Immunomodulatory	Cervical cancer mouse model	POL-P3b protected intestinal dendritic cells from apoptosis	[17]
Wound Healing	Mouse excision wound model	Topical extract accelerated wound contraction and increased tensile strength	[14]
Muscle Relaxant	*In vitro* muscle	Effect was due to high K+ ion concentration, not organic compounds	[21]

4.14. Other Pharmacological Activities

The other applications of *P. oleracea* extend to gastrointestinal health, muscle relaxation, and potential geroprotective (anti-aging) effects.

4.14.1. Gastrointestinal Protection

P. oleracea polysaccharides (POP) have been shown to be effective in animal models of ulcerative colitis. The polysaccharides helped alleviate colitis symptoms by reducing inflammation, improving gut health, and favorably regulating the gut microbiota [11].

4.14.2. Muscle Relaxant Properties

While *P. oleracea* is traditionally noted for muscle relaxant properties, scientific investigation into its extracts provided a non-pharmacological explanation. The observed muscle-paralyzing effect was attributed not to specific organic compounds but to the exceptionally high concentration of potassium ions present in the extracts. Removal of this potassium eliminated the effect, indicating a purely ionic, non-ligand-based mechanism [21].

4.14.3. Geroprotective Effects

Preliminary research suggests *P. oleracea* may possess anti-aging, or geroprotective, properties. Studies have indicated that its components may contribute to increased lifespan by activating telomerase and lengthening telomeres, in addition to its established antioxidant, anti-inflammatory, and neuroprotective activities. These combined effects may contribute to a reduced risk of age-related diseases [23].

5. Conclusion

Portulaca oleracea L. has transitioned from a ubiquitous weed and traditional potherb to an object of significant scientific investigation. Its rich history in ethnomedicine is now substantially supported by preclinical evidence, which confirms its potent pharmacological activities. The plant's complex phytochemical profile, particularly its unique alkaloids, homoisoflavonoids, and multifunctional polysaccharides, provides a clear basis for its observed anti-inflammatory, neuroprotective, antitumor, antimicrobial, and metabolic benefits. The convergence of its nutritional value, especially its high omega-3 fatty acid content, with its therapeutic properties makes it a prime candidate for development as both a functional food and a source of novel pharmaceutical leads. While the *in vitro* and *in vivo* data are compelling, a notable gap exists in human clinical trials. Research must prioritize well-designed clinical studies to establish efficacy, safety, and optimal dosing in humans. Moreover, standardization of extracts and a deeper investigation into the synergistic interactions between its many bioactive compounds are necessary to fully translate the therapeutic potential of this remarkable plant into clinical practice.

References

[1] Yao J, Wang L, Liu P, Song M, Tian J, He F, et al. A new alkaloid from *Portulaca oleracea* L. with its anti-inflammatory activity. Z Naturforsch C J Biosci. 2023;78(11-12):409-13.

[2] Li YH, Lai CY, Su MC, Cheng JC, Chang YS. Antiviral activity of *Portulaca oleracea* L. against influenza A viruses. J Ethnopharmacol. 2019;241:112013.

[3] Xiu F, Li X, Zhang W, He F, Ying X, Stien D. A new alkaloid from *Portulaca oleracea* L. and its antiacetylcholinesterase activity. Nat Prod Res. 2019;33(18):2583-90.

[4] Yang X, Ying Z, Liu H, Ying X, Yang G. A new homoisoflavone from *Portulaca oleracea* L. and its antioxidant activity. Nat Prod Res. 2019;33(24):3500-6.

[5] Zhao R, Zhang T, Ma B, Li X. Antitumor Activity of *Portulaca oleracea* L. Polysaccharide on HeLa Cells Through Inducing TLR4/NF-κB Signaling. Nutr Cancer. 2017;69(1):131-9.

[6] Jalali J, Ghasemzadeh Rahbardar M. Ameliorative effects of *Portulaca oleracea* L. (purslane) and its active constituents on nervous system disorders: A review. Iran J Basic Med Sci. 2023;26(1):2-12.

[7] Lei X, Li J, Liu B, Zhang N, Liu H. Separation and Identification of Four New Compounds with Antibacterial Activity from *Portulaca oleracea* L. Molecules. 2015;20(9):16375-87.

[8] Wei J, Quan Q, Wang P, Wang Y, Huo T, An Q. *Portulaca oleracea* extract relieves skin barrier damage induced by increased photosensitivity after GA peeling. Cutan Ocul Toxicol. 2022;41(3):257-63.

[9] Rakhshandeh H, Rajabi Khasevan H, Saviano A, Mahdinezhad MR, Baradaran Rahimi V, Ehtiati S, et al. Protective Effect of *Portulaca oleracea* on Streptozotocin-Induced Type I Diabetes-Associated Reproductive System Dysfunction and Inflammation. Molecules. 2022;27(18):6075.

[10] Lee JI, Oh JH, Kong CS, Seo Y. Evaluation of anti-adipogenic active homoisoflavonoids from *Portulaca oleracea*. Z Naturforsch C J Biosci. 2019;74(9-10):265-73.

[11] Ning K, Shi C, Chi YY, Zhou YF, Zheng W, Duan Y, et al. *Portulaca oleracea* L. polysaccharide alleviates dextran sulfate sodium-induced ulcerative colitis by regulating intestinal homeostasis. Int J Biol Macromol. 2024;256(Pt 2):128375.

[12] Al-Sheddi ES, Farshori NN, Al-Oqail MM, Musarrat J, Al-Khedhairy AA, Siddiqui MA. *Portulaca oleracea* Seed Oil Exerts Cytotoxic Effects on Human Liver Cancer (HepG2) and Human Lung Cancer (A-549) Cell Lines. Asian Pac J Cancer Prev. 2015;16(8):3383-7.

[13] Oh KB, Chang IM, Hwang KJ, Mar W. Detection of antifungal activity in *Portulaca oleracea* by a single-cell bioassay system. Phytother Res. 2000;14(5):329-32.

[14] Rashed AN, Afifi FU, Disi AM. Simple evaluation of the wound healing activity of a crude extract of *Portulaca oleracea* L. (growing in Jordan) in Mus musculus JVI-1. J Ethnopharmacol. 2003;88(2-3):131-6.

[15] Meng Y, Ying Z, Xiang Z, Hao D, Zhang W, Zheng Y, et al. The anti-inflammation and pharmacokinetics of a novel alkaloid from *Portulaca oleracea* L. J Pharm Pharmacol. 2016;68(3):397-405.

[16] Noreen S, Hussain I, Tariq MI, Ijaz B, Iqbal S, Qamar-ul-Zaman, et al. *Portulaca oleracea* L. as a Prospective Candidate Inhibitor of Hepatitis C Virus NS3 Serine Protease. Viral Immunol. 2015;28(5):282-9.

[17] Zhao R, Shao X, Jia G, Huang Y, Liu Z, Song B, et al. Anti-cervical carcinoma effect of *Portulaca oleracea* L. polysaccharides by oral administration on intestinal dendritic cells. BMC Complement Altern Med. 2019;19(1):161.

[18] Zhao R, Zhang T, Zhao H, Cai Y. Effects of *Portulaca oleracea* L. Polysaccharides on Phenotypic and Functional Maturation of Murine Bone Marrow Derived Dendritic Cells. Nutr Cancer. 2015;67(6):987-93.

[19] Eskandari EG, Doudi M, Abedi S. An in vitro study of antileishmanial effect of *Portulaca oleracea* extract. J Vector Borne Dis. 2016;53(4):362-9.

[20] Chan K, Islam MW, Kamil M, Radhakrishnan R, Zakaria MN, Habibullah M, et al. The analgesic and anti-inflammatory effects of *Portulaca oleracea* L. subsp. Sativa (Haw.) Celak. J Ethnopharmacol. 2000;73(3):445-51.

[21] Habtemariam S, Harvey AL, Waterman PG. The muscle relaxant properties of *Portulaca oleracea* are associated with high concentrations of potassium ions. J Ethnopharmacol. 1993;40(3):195-200.

[22] Wang W, Gu L, Dong L, Wang X, Ling C, Li M. Protective effect of *Portulaca oleracea* extracts on hypoxic nerve tissue and its mechanism. Asia Pac J Clin Nutr. 2007;16(Suppl 1):227-33.

[23] Berezutsky MA, Durnova NA, Sheremetyewa AS, Matvienko UA, Kurchatova MN. [Experimental studies of geroprotective and anti-aging effects of chemical compounds of *Portulaca oleracea* L. (review).]. Adv Gerontol. 2021;34(5):715-20.