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A COMPREHENSIVE ASSESSMENT OF THE *PORTULACA OLERACEA* (PURSLANE): PLANT EXPLORING ITS NATURE AND BIOMEDICAL BENEFITS

Madhu Gudipati[*1], M.Dhanya Sri[2], G.J.V.S Sai Krishna[3], T. Annapurna[4], S. Pavan Kumar Reddy[5], S. Greeshma[6], P. Srinivasa Babu[7]

[*1,2,3,4,5,6,7]Department of Pharmaceutics, Vignan Pharmacy College, Vadlamudi- 522 231, Andhra Pradesh, India.

Corresponding Author:
Dr. Madhu Gudipati
Associate Professor
Department of Pharmaceutics
Vignan Pharmacy College, Vadlamudi-5222 213, Andhra Pradesh, India.

ABSTRACT:
Purslane (*Portulaca oleracea* L.) is a common weed that grows all over the world and is one of the most widespread weed species in summer crops. However, it has great potential to become a new crop since its identification as one of the best plant sources of 3- omega fatty acid, -linolenic acid, as well as some antioxidants (α-tocopherol, α-carotene, ascorbic acid, and glutathione). Several other features distinguish this species: high content of crude protein, water-soluble polysaccharides useful as gums, and good tolerance to salinity. This review summarizes purslane's origin, botanical, and physiological features while its nutritional and medical properties are reported in reference to several studies carried out on its chemical properties. Finally, its cultivation potential is discussed and future uses are proposed for this species, mainly as a component in ready-to-use vegetables (especially in mixed packaging) but also for other cultivation purposes.

Keywords: Purslane, antioxidant, prevent aging, skin care, formulation.

INTRODUCTION

Portulaca oleracea, a succulent plant belonging to the Portulacaceae family, is an annual herbaceous species that can grow up to 40 cm in height. Currently, there are around forty cultivated varieties known. Its distribution spans the Old World, ranging from North Africa across the Middle East and the Indian Subcontinent to Malaysia and Australia [1]. The presence of this species in the New World is not entirely clear: while generally regarded as an exotic weed, evidence suggests that it existed in Crawford Lake deposits (Ontario) between 1430 and 1989 AD, indicating its potential presence in North America before Columbus' arrival. The plant has also naturalized in various regions and is even considered invasive in some areas [2].

Characterized by smooth, reddish, mostly prostrate stems, Portulaca oleracea features alternate leaves that cluster at stem joints and tips. Its vibrant yellow flowers consist of five regular parts and can measure up to 6 mm in width. Depending on rainfall patterns, these flowers can bloom at any point during the year. They unfurl individually at the heart of leaf clusters, gracing sunny mornings for a brief few hour [3]. The plant produces seeds within petite pods that open upon seed maturation. Possessing a taproot accompanied by fibrous secondary roots, this plant demonstrates resilience by thriving in nutrient-poor, compacted soils, as well as enduring periods of drought [4].

Traditionally recognized for its anti-rheumatic and anti-fungal properties, Portulaca oleracea also garners attention in pharmacological studies for its diverse array of benefits. These include anti-fungal, antioxidant, anti-microbial, anti-inflammatory, anti-diabetic, diuretic, analgesic, and wound healing characteristics [5].

Figure 1: ***Portulaca oleracea***

Purslane emerges as an excellent reservoir of alpha-linolenic acid, an omega-3 fatty acid of paramount significance. This fatty acid plays a pivotal role in fostering human growth, development, and disease prevention [6]. Notably, the omega-3 content in purslane surpasses that of spinach by a factor of five. Omega-3 fatty acids, an essential subset of polyunsaturated fats, bear profound implications for human well-being, encompassing growth, cardiovascular ailment deterrence, and immune system maintenance. Since our bodies are incapable of endogenously synthesizing omega-3 fatty acids, their acquisition mandates dietary incorporation [7].

Vernacular Names	Botanical Study
Tamil: Koli-k-kirai	Kingdom: Plantae
Telugu: Peddapavilikura	Order: Caryophyllales
Malay: Koluppa	Family: Portulacacaceae
Manipuri: Leibak kundo	Genus: Portulaca
Hindi: Lunia	Species: P.oleracea
Kannada: Dudagorai	
Bengali: Nunia sag	

Characterized by a chain containing three or more double bonds and spanning 18 to 24 carbon atoms, omega-3 fatty acids underscore their vital role [8]. Primarily abundant in fish, these fatty acids command endorsement from health authorities, advocating frequent fish consumption to fulfill the body's omega-3 requisites, given the scarcity of alternative sources [9].

Recently, purslane has garnered recognition as the preeminent plant-based reservoir of alpha-linolenic acid, an indispensable omega-3 fatty acid [10]. The dearth of dietary avenues for omega-3 fatty acids has kindled heightened interest in introducing purslane as a novel cultivated vegetable [11, 12]. Thriving across diverse biogeographical settings globally, purslane demonstrates remarkable adaptability to adverse conditions, including drought, salinity, and nutrient deficiency [13].

CHARACTERISTICS

Chemical Constituents:

Purslane possesses an abundance of omega-3 fatty acids, with a particular emphasis on alpha-linolenic acid, surpassing all other leafy vegetable plants in this regard [14]. Notably, it contains 0.01 mg/g of eicosapentaenoic acid (EPA), an Omega-3 fatty acid primarily prevalent in fish, certain algae, and flax seeds. This EPA content is remarkably high for a land-based vegetable source [15].

Moreover, Purslane is rich in essential vitamins, prominently vitamin A, vitamin C, some vitamin B, and carotenoids. In addition to vitamins, it boasts an array of dietary minerals, including magnesium, calcium, potassium, and iron. The plant is also characterized by two distinct classes of betalain alkaloid pigments: reddish betacyanins, evident in stem coloration, and yellow betaxanthins, noticeable in flowers and lending a slight yellowish tint to the leaves [16]. Both these pigment categories exhibit potent antioxidant properties and have been discovered to possess anti-mutagenic attributes [17].

The composition of this plant extends to encompass a diverse array of chemical compounds. Among them are alkaloids, terpenoids, organic acids, coumarins, flavonoids, volatile oil, and polysaccharides.
Nutrition 100 Grams of fresh purslane leaves (about 1 cup) contain 300 to 400 mg of alphalinolenic acid7 cup of cooked leaves contains 90 mg of calcium, 561 mg of potassium, and more than 2,000 IUs of vitamin A [18]. A half-cup of purslane leaves contains as much as 910 mg of oxalate; a compound implicated in the formation of kidney stones however many common vegetables, such as spinach, also can contain high concentrations of oxalates [19].

Macroscopy:

The leaves range from 0.4 to 2.5 cm in length and are arranged alternately. They have a succulent texture and are shaped like a spatula, with a slightly truncated or retuse tip. The underside of the leaves is pale and glossy, appearing thick [20]. When crushed, they release a mucilaginous substance. The leaves have very short stems and usually lack noticeable stipular appendages [21]. They have a sour taste but no distinct odor. The petiole, which is the leaf stem, is short, measuring about 1-1.5 mm in length and 0.5 mm in thickness. Its upper surface is greenish, while the lower surface has a reddish tint [22].

The stem is also succulent and displays diffuse branching. When crushed, it feels very slippery due to the presence of mucilage [23]. The stem has a diameter of approximately 2 mm, and the spaces between the points where leaves attach (internodes) are between 1.5 and 3.5 cm in length. The nodal appendages, which are small structures at the nodes of the stem, are fewer in number compared to those of Portulaca quadrifida, and they are tiny and membranous [24].

Microscopy:

The microscopic structure of the leaf cross-section in both Portulaca oleracea and Portulaca quadrifida exhibits significant similarities [25]. The mesophyll is primarily composed of water-rich tissue, and the vascular bundles are encased by a layer of green palisade cells, resembling the arrangement seen in P. quadrifida [26]. Crystals of calcium oxalate, varying in size, appear in prismatic and rosette formations in both species. Notably, the leaf of Portulaca oleracea is amphistomatic, in contrast to P. quadrifida, which is epistomatic. The adaxial surface of the leaf contains a higher density of stomata compared to the abaxial surface [27].

A transverse section of the petiole reveals distinct features: the lower surface is prominently bulging, while the upper surface is slightly depressed [28]. The uniseriate epidermis consists of tubular parenchymatous cells with elongated tangential arrangements. The lower epidermal cells possess a curved anticlinal wall and contain some dark pigmentation [29]. The ground tissue, comprising 4-6 layers of thin-walled, rounded parenchymatous cells, is characterized by well-defined intercellular spaces [30].

The vascular bundles, numbering around 2-4, are collateral and closed. They are centrally positioned and arranged in an arch that opens towards the adaxial side. Vesicles with helical and scaliferous thickenings exhibit simple perforations, and fibers often display intrusive growth patterns [31].

Table 1: Purslane (Portulaca oleracea) (Nutritive value per 100 g) [5].

Principle	Nutrient value	Percentage of RDA **DA**
Energy	16 Kcal	1.5%
Carbohydrates	3.4 g	3%
Protein	1.30 g	2%
Total Fat	0.1 g	0.5%
Cholesterol	0 mg	0%
Vitamins		
Folates	12 µg	3%
Niacin	0.480 mg	3%
Pantothenic acid	0.036 mg	1%
Pyridoxine	0.073 mg	5.5%
Riboflavin	0.112 mg	8.5%
Thiamin	0.047 mg	4%
Vitamin A	1320 IU	44%
Vitamin C	21 mg	35%
Electrolytes		
Sodium	45 mg	3%
Potassium	494 mg	10.5%
Minerals		
Calcium	65 mg	6.5%
Copper	0.113 mg	12.5%
Iron	1.99 mg	25%
Magnesium	68 mg	17%

Table 2 Lipidic content and main fatty acid percentage contents in edible portions of purslane (only values higher than 1% are reported) (adapted from Guil *et al.* 1996).

Fatty acids	**Composition (%)**
Lipids (g kg^{-1} fm)	3.9
α-linolenic acid - 18:3ω3	32.60
Palmitoleic acid - 16:1ω7	20.96
Palmitic acid - 16:0	17.40
Linoleic acid - 18:2ω6	16.82
Oleic acid - 18:1ω9	5.89
Stearic acid - 18:0	3.46
Behenic acid - 22:0	3.33
Saturated acids/ω3	0.80
ω3/ω6	2.00

TABLE 3: Composition of selected fatty acids in purslane (*Portulaca oleracea*) (% of total FA)[a].

	Omara-Alwala et al., 1991 [22]			Simopoulos and Salem, 1986 [10]
Fatty acid	Leaf	Stem	Whole plant	Whole plant
18.3-omega-3	41.4–66.4	2.4–5.9	28.4–42.5	47.6
20.5-omega-3	0.8–12.6	18.6–35.5	6.4–21.5	0.1
22.3-omega-3	1.4–3.3	trace	1.0–3.0	—
22.6-omega-3	0.3–6.4	trace	0.6–5.6	—

[a]Results from Omara-Alwala et al., 1991 [22], and Simopoulos and Salem, 1986 [10], expressed as mg of FA per kg or g of net weight.

Traditional Uses

Burns and skin eruptions like boils and carbuncles can be treated with an effective concoction of the leaves. Extracts of Portulaca is effective in saving the skin from pollution and premature aging, which is why it is used in number of skin lotions [32].

PHARMACOLOGICAL ACTIVITIES

Anti-microbial activity:

Ramesh londankar and Hanumantappa (2011) had reported the phytochemical and anti-microbial activity in aerial parts of chloroform and ethanolic extracts of Portulaca oleracea by agar diffusion method against five bacteria and three fungi (bacteria like Staphylococcus aureus, Bacillus cereus, Klebisilla pneumonia and fungi like Aspergillus fumigates and Nerospora crassa). Ethanolic crude extract showed maximum effect on

organisms like Staphylococcus aureus, Klebisilla pneumonia and Nerospora crassa. Whereas chloroform extract showed moderate effect on Klebisilla pneumoniae, Aspergillus niger and Nerospora crassa. The results of this present study supported the folklore usage of the studied plant and suggest that, this plant extract possess compounds which is having antimicrobial properties and helps in developing antimicrobial agent in the form of drugs for the therapy of infectious diseases caused by pathogens [33].

Antioxidant Activity:

Kamal Uddin et al (2012) had reported the antioxidant activity of Portulaca oleracea over the different growth stages by using 1, 1-diphenyl-2-picrylhydrazyl (DPPH), ferric–reducing antioxidant power (FRAP) assays and ascorbic acid content [34]. There was a correlation between the results of total phenol content 174.5 ± 8.5 to 348.5 ± 7.9 mg GAE/100 g. and ascorbic acid equivalent antioxidant activity 60.5 ± 2.1 to 86.5 ± 3.9 mg/100 g and between DPPH scavenging IC50 (1.30 ± 0.04 to 1.71 ± 0.04 mg/mL) and ferric-reducing anti-oxidxant power assays (r2 > 0.9), The concentrations of Ca, Mg, K, Fe and Zn increased with plant maturity. Calcium (Ca) was negatively correlated with sodium (Na) and chloride (Cl), but positively correlated with magnesium (Mg), potassium (K), iron (Fe) and zinc (Zn). It was concluded that mature plants of Portulaca olerecea had higher total phenol content and antioxidant activities than plants at immature stages [35].

Anti-atherogenic, renal protective and immuno modulatory activity:

Rasha Hamed mahmoud et al (2011) had reported the efficiency of purslane (components of ω-3 and ω-6) on hyperlipidemia, kidney function and as immunomodulators in rats fed high cholesterol diets. 40 male albino rats were divided into four groups: control group, hypercholesterolemic rats, fed the balanced diet supplemented with cholesterol at a dose level of 2 g/100 g diet; the other two groups of animals fed the same previous hypercholesterolemic diet supplemented with purslane (ω-3 and ω-6). The present study showed that 2% cholesterol administration caused a significant increase in total cholesterol, total lipids, and triacylglycerol in both serum and liver. Serum phospholipids, LDL-C, and atherogenic index (AI) also significantly increased compared to control group [36]. Cholesterol-enriched diet significantly increased serum urea, creatinine, sodium and potassium levels as well as significantly increased serum IgG and IgM compared to healthy control. Consumption of purslane by hypercholesterolemic rats resulted in a significantly decrement in lipid parameters and significant improvement in IgG and IgM levels as compared with hypercholesterolemic rats. This result suggests that purslane had anti-atherogenic hypolipidemic and immunmodulator effects which were probably mediated by unsaturated fatty acids (including alpha linolenic acid) present in seed mixture [37].

Anti hyperlipidemic activity:

Sankar sastry pragda et al (2011) reported the anti-hyperlipidemic activity of ethanolic extract of leaves of Portulaca oleracea. Test extracts (200 and 400mg/kg) treatment has showed significant inhibition against dexamethasone induced hyperlipidemia in adult wistar rats for 8 days [38] Biochemical parameters like total cholesterol, total triglycerides, phospholipids, high density lipoproteins (HDL), low density lipoproteins (LDL) cholesterol, very low-density lipoprotein (VLDL) cholesterol, atherogenic index levels were measured and compared with standard gemfibrozil. The ethanolic extract showed a significant decrease in triglycerides [39].

Anti-arthritic activity:

Jagan et al had (2011) reported the anti-arthritic activity of Petroleum-ether extract of Portulaca oleracea Linn by Fruends Adjuvant arthritis model in male wistar rats. The test extracts were at the dose of 100, 200 and 300 mg/kg/p.o. and standard as Indomethacin at a dose of 100mg/kg. A maximum of 77.82 % inhibition was observed on 21st day. In a similar fashion treatment with petroleum-ether extract also attenuated the increase in paw diameter due to Fruends adjuant administration, this was more pronounced at 300 mg/kg of petroleum ether extract of Portulaca oleracea. A maximum of 75.69% inhibition was observed on 21st day. This study revealed the anti-arthritic activity of aqueous extract of Portulaca oleracea [40].

Anti-diabetic activity:

Dae Gill Kang et al (2011) had reported the anti-diabetic activity in aqueous extract of Portulaca oleracea in rosiglitazone induced diabetics. Portulaca oleracea is an edible plant used as a folk medicine, on diabetic vascular complications. The diabetic mice were treated with P. oleracea (300mg/kg/day, p.o) for ten weeks, and P. oleracea treatment markedly lowered blood glucose, plasma triglyceride, plasma level of LDL – cholesterol and systolic blood pressure in diabetic mice. Furthermore, Portulaca oleracea significantly increased plasma level of HDL-cholesterol and insulin level [41]. The impairment of ACh- and SNP-induced vascular relaxation of aortic rings were ameliorated by P. oleracea treatment in diabetic db/db mice and it also showed that over expression of VCAM-1, ICAM-1, E-selectin, MMP-2 and ET-1 were observed in aortic tissues of untreated db/db mice, which were significantly suppressed by treatment with P. oleracea. In this study it was found that the immune reactivity of the pancreatic islets remarkably increased in treated diabetic mice compared with untreated diabetic mice. Thus, they concluded that P. oleracea suppresses the hyperglycemia and diabetic vascular inflammation, and prevents the development of diabetic endothelial dysfunction for the development of diabetes and its vascular complications [42].

Hepatoprotective activity:

Anusha et al (2010) has reported the hepatoprotective activity of aqueous extract of the aerial parts of Portulaca oleracea in combination with lycopene against carbon tetrachloride induced hepatotoxicity in male wistar rats by intraperitoneal injection of carbon tetrachloride (0.1 ml/kg for 14 days). The aqueous extract of P. oleracea in combination with lycopene (50mg/kg) was administered to the experimental animals at two selected doses for 14 days [43]. The hepatoprotective activity of the combination was evaluated by the liver function marker enzymes in the serum aspartase transaminases (AST), alanine transaminases (ALT), alkaline phosphatases (ALK.P), total bilirubin (T.B), total protein (T.P), total cholesterol (T.C), pentobarbitone induced sleeping time (PST) and histopathological studies of the liver. These studies concluded that both the treatment groups showed hepatoprotective activity against carbon tetrachloride induced hepatotoxicity by significantly restoring the levels serum enzymes to normal when compared with silymarin group and also concluded that oral administration of Portulaca oleracea in combination with lycopene significantly ameliorates carbon tetrachloride hepatotoxicity in rats [44].

Nephro-protective activity:

Gholamreza Karimi et al (2012) reported the nephroprotective effect of aqueous and ethanolic extract of Portulaca oleracea against cisplatin-induced renal toxicity in rats. Single intraperitoneal injection of 4 mg/kg cisplatin was administrated to rats and determined the blood urea nitrogen and serum creatinine (SCR). After 5 days of investigation of the possible protective effect, Portulaca oleracea was administered as highest dose (0.8 and 2g/kg) for 6 to 12 h before cisplatin injection and had BUN and SCR levels significantly lower than those receiving cisplatin alone. The study concluded that the aqueous extract of Portulaca oleracea possess marked nephroprotective activity and could have a promising role in the treatment of acute renal injury induced by nephrotoxins, especially cisplatin [45].

Neuronal activity:

Abdel Moneim et al (2011) had reported the neuronal activities of aqueous extract of Purslane (stems and leaves) with a dose of 1.5ml/kg in adult rats for 12 days. There was significant increase in dopamine content in cerebellum, cerebral cortex, thalamus and hypothalamus of rats. Animals were adapted to a normobaric low oxygen environment (10% oxygenand 90% nitrogen) for different times and was sacrificed [46]. The mouse cortices were used for histological analysis by heamtoxylin and eosin (H-E) staining. The activities of pyruvate kinase (PK), phosphofructokinase (PFK) lactic acid (LD) and the level of lactate dehydrogena and ATP were detected, and the mRNA and protein levels of EPO in the cortices were analysis. The results concluded that the degrees of brain inflammation were reduced due to administration of Portulaca oleracea extracts and also enhanced the increment of PFK, PK, and LDH and lessened the decrement of ATP [47].

Anti nociceptive and Anti-inflammatory activity:

Jagan Rao et al (2012) had reported the anti-nociceptive and the anti-inflammatory activities of the petroleum ether extract of Portulaca oleracea. The petroleum-ether extract of Portulaca oleracea was subjected to a preliminary phytochemical screening study was carried out in Swiss albino rats with well-established models like acetic acid induced writhing, formalin test and the tail immersion method in mice. Acute anti-inflammatory effect was studied by the Carrageenan induced hind paw oedema method in rats. The acute toxicity studies showed that the extract was non-toxic up to a maximum dose of 2000 mg/kg body weight. The petroleum-ether extract exhibited significant inhibition of the acetic acid induced writhing, it reduced the paw-licking response time significantly in the formalin test and it increased the withdrawal latency time in the tail immersion test. The Carrageenan induced hind paw oedema was significantly reduced in rats. By this study they concluded that the petroleum-ether extract of Portulaca oleracea had potential anti-nociceptive and anti-inflammatory activities [48].

CONCLUSION

This review makes it clear that Portulaca oleracea (purslane) possesses numerous phytoconstituents that highlight its potential for diverse cosmetic applications. The abundance of antioxidants like vitamins A and C, alpha-tocopherol, and beta-carotene, along with omega-3 fatty acids, coupled with its ability to promote wound healing and act as an antimicrobial agent, in addition to its established traditional use for treating topical inflammatory issues, collectively indicate that purslane holds strong promise as a valuable ingredient in cosmetics and pharmaceuticals.

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