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Review Article

The multi-therapeutic effects of Portulaca oleracea L., a global plant with a wealth of phytochemical and pharmacological potential: A review

Naglaa Bahr[a*], Amna H M Nour[a], Abd El-Kader M. Abd El-Kader[a], Maha A. El Demellawy[b,c], Doaa A. Ghareeb[b,d,e]

[a] Zoology department, Faculty of Science, Aswan University, 81582 Aswan, Egypt.
[b] Center of Excellence for Drug Preclinical Studies (CE-DPS), Pharmaceutical and Fermentation Industry Development Center, City of Scientific Research & Technological Applications (SRTA-city), New Borg El Arab, Alexandria, Egypt
[c] Medical Biotechnology Department, Genetic Engineering & Biotechnology research Institute (GEBRI), City of Scientific Research & Technological Applications (SRTA-City), Borg Al-Arab, Alexandria, Egypt.
[d] Bio-Screening and Preclinical Trial Lab, Biochemistry Department, Faculty of Science, Alexandria University, Alexandria, Egypt
[e] Research Projects unit, Pharos University in Alexandria; Canal El Mahmoudia Street, Beside Green Plaza Complex 21648 , Alexandria, Egypt

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Abstract:

"Purslane is a genus of succulent herbs that grows in warmer climates around the world. Two foreign species have naturalized in India, while four species are still found there. Purslane is the common name for the herbaceous weed *Portulaca oleracea*. It has been said in traditional systems to cure leprosy, ulcers, asthma, piles, diarrhea, dysentery, and to lessen inflammation and tiny tumors. The herb is said to have refrigerant, aperient, diuretic, vulnerary, and antiscorbutic properties. Among the strong pharmacological effects that have been shown are hepatoprotective, analgesic, anti-inflammatory, wound-healing, neuropharmacological, antidiabetic, antioxidant, antihypertensive, and biological characteristics. The chemical constituents of the plant have been identified and include steroids, vitamins, minerals, fatty acids, alkaloids, saponins, and more. In order to highlight and evaluate *Portulaca oleracea*'s potential as a pharmaceutical, this review attempts to gather the pharmacological and phytochemical researches on *Portulaca oleracea* and evaluate the plant's underappreciated medicinal potential.

Keywords: *Portulaca oleracea* , neuropharmacological, antidiabetic, alkaloids.

1- Introduction

The *Portulacaceae* Juss family includes purslane, or *Portulaca oleracea L.*, as a prominent member (**Ocampo and Columbus, 2012**). It comes from South America and Africa, but it grows primarily in tropical and subtropical climates worldwide.

Corresponding author*: E-mail address: aml.nour28@yahoo.com

The plant's milky liquid is referred to as "Portulaca," a phrase derived from the Latin words "lac," which means "milk," and "porto," which means "to carry" (**Uddin et al., 2020).** In the past, purslane was considered an anti-magic herb and was believed to provide protection from nightmares and evil spirits when placed about a bed (**Parham et al., 2020**). For hundreds of years, people have used it as a medicinal plant and in salads. The scorpion sting is treated with the stem and leaf juice. It is used as a cooling and moisturizing herb for fevers in Jamaica. Although the seeds are now proven to be inert, they were originally thought to have anthelmintic qualities and have been used as a cooling diuretic in North America. In Indo-China, fresh leaf juice is applied to abscesses and used as a collyrium; a decoction is used to treat liver and dysentery disorders (**Yimer et al., 2019**).

Egyptian writings from the era of the Pharaohs mention purslane, a nutrient-dense vegetable that humans can eat (**Mohamed and Hussein, 1994**). Purslane can be consumed as green vegetables, cooked as a soup sauce, or eaten raw in salads. According to **Sudhakar et al. (2010)**, *P. oleracea* is a plant that offers a wealth of nutritional advantages. As a traditional remedy, purslane has been utilized in various nations, serving as a vermifuge, febrifuge, antimicrobial, and other functions (**Lee et al., 2012**). It displays a variety of pharmacological effects, including bronchodilator (**Malek et al., 2004**), renoprotective (**Hozayen et al., 2011**), neuroprotective (**Wang et al., 2007**), hepatoprotective (**Eidi et al., 2015**), antiulcerogenic (**Kumar et al., 2010**), antioxidant (**Karimi et al., 2011**), antimicrobial (**Dan, 2006**), and hepatoprotective (**Eidi et al., 2015**).

Furthermore, studies of phytochemicals have shown that this plant contains flavonoids, alkaloids, terpenoid, organic acids, fatty acids, minerals, and vitamins (**Petropoulos et al., 2016**).

2-The Phytochemical characteristics of purslane:

Examining purslane's phytochemical constituents is crucial given its ethnobotanical significance. A phytochemical study of purslane has been attempted in a number of research (**Nemzer et al., 2020**). The phytoconstituents found in different sections of purslane have been studied using both qualitative and quantitative methods (**Negi, 2018**). It has numerous significant metabolites that are beneficial to health, according to studies of **Rahimi et al.(2019**). Purslane has been found to be a plentiful supply of vital amino acids, proteins, and carbohydrates (**Zhou et al., 2015**). Both the leaf and the stem have a significantly larger fat content, and the leaf has more fiber than the stem (**Ezeabara et al., 2014**).

The various purslane parts have been subjected to the measurement of a number of bioactive substances. It has been demonstrated that the water extract of purslane flowers has more phenolic compound than the stem and leaves, despite the fact that the leaves also have higher levels of total flavonoids and ascorbic acid (**Siriamornpun and Suttajit, 2010**). Additionally, the leaves have more β-carotene than the stem (**Liu et al., 2000**). Fatty acids with omega-3 can be found in very high concentrations in purslane (**Silva and Carvalho, 2014**). The omega-3-fatty acid content of purslane wild genotypes is approximately 188.48 ~ 6.35 mg/100 g (**Nemzer et al., 2020**) widely recognized by **Nemzer et al. (2020**). Quercetin, kaempferol, isorhamnetin, and naringenin are among the well-known flavonoids found in purslane. Several other phytoconstituents, such as eleven flavonoids and their derivatives, seven carbohydrates, fatty acyl/lipids, many terpenoids, steroids, lignan, purine nucleosides, and two glycosylated hydroxy-cinnamic acid derivatives were discovered (**Farag et al., 2021**).

3-The nutritional value

In China, purslane is known as a "longevity vegetable" due to its high nutritional content. Fresh purslane is primarily composed of water, accounting for 88.5% to 94.78% of its fresh weight (FW) (**Srivastava et al., 2023**). The protein concentration reaches 5.2% of its FW, whereas the ash and carbohydrate contents are 1.37%-11.18% of its FW and 3.39%-5.20% of its FW, respectively (**Srivastava et al., 2023**). The composition and nutritional roles of purslane's fatty acids (FAs), amino acids, carotenoids, vitamins, and minerals are thoroughly described in the section that follows.

3.1. Amino acids

A diverse range of amino acids can also be found in purslane. It has been discovered that cultivated purslane has more amino acids than wild purslane (**Nemzer et al., 2020**). Cultivated purslane has been found to contain essential amino acids such as leucine (1 463.00 ± 5.77 mg/100 g dry weight [DW]), valine (976.00 ± 9.85 mg/100 g DW), lysine (978.00 ± 13.50 mg/100 g DW), phenylalanine (853.00 ± 7.51 mg/100 g DW), isoleucine (801.00 ± 9.17 mg/100 g DW), threonine (759.00 ± 5.51 mg/100 g DW), hisidine (346.00 ± 3.21 mg/100 g DW), and methionine (316.00 ± 27.68 mg/100 g DW).

3.2. Vitamins

Vitamins are a type of micronutrient that is needed in trace amounts. Most people consider vitamins to be natural antioxidants. Vitamins like C, E, and K, as well as B-complex vitamins like pyridoxine, niacin, and riboflavin, are abundant in purslane. When **Nemzer et al. (2020)** evaluated the nutritious contents of wild and farmed purslane, they discovered that the former had more vitamins than the latter. In particular, vitamin C (152 mg/100 g DW) is the most abundant vitamin in farmed purslane, compared to wild purslane (140 mg/100 g DW). Vitamin E (11. 967 µg/100 g DW vs. 7. 793 µg/100 g DW) and vitamin K (1. 383 µg/100 g DW vs. 907 µg/100 g DW) are the next in line.

3.3. Fatty acids (FAs)

Several fatty acids from different purslane plant sections have been discovered and extracted. According to studies, purslane contains more total fatty acids than popular vegetables including spinach, red leaf lettuce, mustard, and buttercrunch lettuce (**Simopoulos et al., 2005**). According to **Chugh et al. (2019),** purslane is known for its omega-3 (α-linolenic acid) and omega-6 (linoleic acid) fatty acids, which are vital for human health and a fantastic source of polyunsaturated fatty acids (PUFA). Purslane has been shown to have higher levels of α-linolenic acid than spinach (**Uddin et al., 2014**). Purslane's FAs profile varied according on the plant sections, growing circumstances, genotypes, and harvesting phases. The quantities of PUFAs in purslane leaves harvested at the 14-true-leaf stage were similar to those at the 6-true-leaf stage; however, the leaves picked at the 14-true-leaf stage had a higher omega-6/omega-3 ratio whereas. For the cardiovascular system to work properly, the human body must maintain a proper balance between these two FAs, which requires a low omega-6/omega-3 ratio (< 2) (**Noorbakhshnia and Karimi-Zandi, 2017**). According to **Nemzer** and colleagues, the leaves of wild purslane had the highest concentration of total FAs (332.49 mg/100 g, dry weight) (**Nemzer et al., 2020**). Additionally, **Liu et al. (2020)** discovered that the total FAs (linolenic acid and omega-3 acid) made up 9.6%–24.0% of the stems and 58.0%–62.5% of the leaves of purslane.

3.4. Carotenoids

Apart from the significant amount of FAs, purslane also contains other vital minerals including carotenoids. Carotenoids are colors found in plants, fungi, algae, microorganisms, and a range of animals (in feathers, beaks, exoskeletons, and fish skin). It serves as antioxidant defenses and participates in photosynthesis in addition to giving these organisms their color (**Pereira et al., 2020**). Numerous carotenoids, such as lutein (5.4 mg/100 g FW), zeaxanthin (0.19 mg/100 g FW), α-carotene (0.009 mg/100 g FW), and β-carotene (3.5 mg/100 g FW), have been found to be present in purslane (**Dias et al., 2009**). Neoxanthin and violaxanthin were also detected in purslane in another investigation, with corresponding contents of 0.73 and 11.47 mg/100 g DW (**Raju et al., 2007).**

4. Compounds with bioactive properties

Foods contain non-nutrient components called bioactive chemicals, which have the power to alter physiological functions and improve health (**Correia et al., 2012**). Because of their many therapeutic uses and their application across a wide range of economic sectors- including the food, cosmetic, and pharmaceutical industries- natural bioactive compounds are gaining increasing attention. Nevertheless, the purslane component index has not been established, and it is still unknown which component contributes most to the plant's health benefits. Thus, this section summarizes and discusses the main types of bioactive substances that were extracted from purslane, including polysaccharides, alkaloids, flavonoids, and other phytochemicals.

4.1. Alkaloids

One of the most significant classes of chemical compounds found in nature, alkaloids possess a variety of pharmacological uses in therapy (**Dey et al., 2020**). Numerous alkaloids including trollisine, oleracins, scopoletin, and oleraisoindole have been reported in purslane (**Ma et al., 2021**). According to **Yang et al. (2009)**, purslane contained three phenolic alkaloids with antioxidant qualities: oleracein A, oleracein B, and oleracein E**. Sun et al. (2017)** demonstrated the neuroprotective effects of oleracein E using both in vitro and in vivo models. Using the 1,1-diphenyl-2-picryl-hydrazyl (DPPH) radical scavenging experiment, **Xiu et al. (2019)** isolated alkaloid A from purslane for the first time and evaluated its antioxidant efficacy. **Xiu et al. (2019)** discovered oleraurea, a novel alkaloid from *Portulaca oleracea* , along with a number of other well-known chemicals. Its anticholinesterase activity is noteworthy, indicating that it acts as a cholinesterase inhibitor and plays a major role in Alzheimer's disease (**Xiu et al., 2019**).

4.2. Flavonoids

The root, stem, flower, and fruit of plants all contain plant flavonoids, a large class of naturally occurring phenylchromones (**Middleton and MD 1996**). Flavonoids have been found to have a wide range of biological effects in humans due to their anti-oxidative, anti-inflammatory, anticancer, antiviral, and antibacterial qualities **(Cushnie and Lamb, 2011).** Numerous flavonoids, such as apigenin, kaempferol, luteolin, quercetin, isorhamnetin, kaempferol-3-O-glucoside, and rutin, have been identified from purslane (**Sicari et al., 2018**). **Xiu et al. (2019)** used capillary electrophoresis in conjunction with electrochemical detection to identify five flavonoids: kaempferol, apigenin, myricetin, quercetin, and luteolin . Purslane-derived quercetin significantly improved mice's memory and learning, suggesting that it possesses neuroprotective qualities (**Lu et al., 2006**). Also, **Santiago-Saenz et al. (2018)** assessed the myricetin content of purslane.

4.3. Polysaccharides

Plant polysaccharides, an emerging class of natural product with high added value, have diverse biological processes, encompassing immunomodulatory, antibacterial, antidiabetic, and prebiotic properties, in addition to low toxicity (**Zhang et al., 2021**). Although difficulties occurred in figuring out the structure of bioactive polysaccharides, ginseng, and astragalus polysaccharides have been successfully used in clinical practice (**Xie et al., 2016**). According to reports, purslane has a carbohydrate content of roughly 5.20 percent FW. A significant active ingredient that was separated from purslane, polysaccharide, has been thoroughly investigated. Prior research has demonstrated that purslane polysaccharides (PPs) possess biological actions like anticancer, anti-diabetic, and antioxidant qualities, the first known PPs was a mucilage that was extracted from fresh purslane leaves (**Bai et al., 2016**).

5-pharmacological properties of purslane:

The pharmacological properties of purslane have been the subject of several studies over the past few decades. Numerous biological actions, including neuroprotective, antidiabetic, hepatoprotective, antioxidant, anti-inflammatory, anticancer, wound healing, and many more, have been described for *Portulaca oleracea*. Several researchers have conducted more pharmacological research on these activities, which are listed below:

5.1. Neuroprotective Activity:

Several studies have shown that different purslane extracts have neuroprotective activity. Because it may scavenge free radicals and reverse rotenone-induced neuronal apoptosis, dopamine depletion, and complex-I inhibition in the rat striatum, *portulaca oleracea* may be a promising neuroprotective candidate against Parkinson's disease (**Abdel Moneim, 2013**). By allegedly raising glycolysis and hypoxia inducible factor-1 expression levels, the extract of *Portulaca oleracea* (EP) shields nerve tissue and cells from hypoxic damage (**Wang et al., 2007**). Consequently, the alkaloidal extract of *Portulaca oleracea* showed a considerable inhibition of Acetylcholinesterase (AChE) activity at a final concentration of 100 μg/mL, with an IC50 value of 29.4 μg/mL. Purslane may be a helpful treatment and preventative measure for Alzheimer's disease (AD), as AChE inhibitors have demonstrated promise in treating AD (**Yang et al., 2012**). High concentrations of vitamins C and E, which are potent antioxidants that can stop lipid peroxidation in plasma and tissue and shield membranes, organelles, and proteins from oxidative damage, are found in purslane. It is also known to be high in omega-3 fatty acids; in fact, early research showed that giving pregnant rats omega-3 supplements stopped hypothyroidism-induced apoptosis in the developing rat cerebellum (**Sinha et al., 2009**). According to all of these findings, purslane may help shield the brain from oxidative stress-related neurodegenerative illnesses and damage.

5.2. Anti-hyperglycemic Activity:

Diabetes mellitus (DM) is an disorder of carbohydrate metabolism that affects nearly every nation, age group, and economy worldwide. It is characterized by the body's decreased ability to produce or respond to insulin, resulting in an inability to maintain appropriate blood sugar (glucose) levels. DM is an emerging epidemic. One of the two types of diabetes that typically manifest in infancy is type 1 diabetes, also known as juvenile-onset diabetes mellitus or insulin-dependent diabetes mellitus (IDDM). Type II diabetes is formerly known as non-insulin-dependent diabetes mellitus or adult-onset diabetes mellitus, typically manifests after the age of 40 and becomes more prevalent with aging (**Chung et al., 2020**). Improvements in glucose tolerance and lipid metabolism were noted in rats with type II diabetes mellitus caused by injection of streptozotocin (25 mg/kg) and given high-calorie forage, indicating that *Portulaca oleracea* lowers insulin resistance. Additionally, it reduces body weight, serum free fatty acids, and hyperinsulinemia and improves impaired insulin sensitivity **(Lan and Fu-er, 2003).**

Additionally, the aqueous extract of *Portulaca oleracea* significantly reduces hyperglycemia, diabetic vascular inflammation, and diabetic endothelium damage in type 2 diabetic mice, suggesting a preventative activity against diabetes and related vascular issues (**Lee et al., 2012**). Additionally, the plant's crude polysaccharide extract lowers blood glucose and changes how glucose and blood lipids are metabolized in mice with alloxan-induced diabetes (**Gong et al., 2009**). In mice with type 2 diabetes, it lowers total cholesterol, triglycerides, and fasting blood glucose (**El-Sayed, 2011**).

Purslane seed research is already emerging, with a primary focus on its possible anti-hyperglycemic properties (**Hou et al., 2021**). It have been demonstrated to lower blood glucose levels along with possibly influencing phosphoinositide-3-kinase regulatory subunit 1, TNF, PPAR-γ, and other targets associated with insulin resistance and inflammation through the actions of multiple chemical components, including genistein, levodopa, and daidzein. Also, pure phytochemicals that were separated from purslane in addition to its extract demonstrated anti-hyperglycemic activity, offering a molecular foundation for the anti-hyperglycemic properties of purslane **(Park et al., 2009**).

5.3. Hepatoprotective Activity:

Intraperitoneal administration of carbon tetrachloride (CCl_4) in rats causes liver damage, significantly increasing the levels of hepatic marker enzyme in the blood, such as the enzymes glutamate pyruvate transaminase (GPT) and glutamate oxaloacetate transaminase (GOT), as well as total bilirubin levels. A 70% alcohol extract of purslane confirms its hepatoprotective activity by significantly reversing the increase in total bilirubin and hepatic marker enzyme levels (**Elkhayat et al., 2008).** Based on a prior study by **Prabhakaran et al. (2010)**, methanol and petroleum ether extracts of whole plant parts of purslane in carboxymethyl cellulose were tested for their hepatoprotective properties by inducing liver damage in Wister albino rats using D-galactosamine (400 mg/kg). Significant recovery of the changed biochemical markers was observed at dose levels of 200 and 400 mg/kg in comparison to groups treated with d-galactosamine and silymarin. Histology of albino rat liver sections further demonstrated that the cellular architecture of the liver cells has been retained considerably reduced the toxicity of d-galactosamine. These purslane extracts had strong hepatoprotective action, as demonstrated by biochemical and histological data**.**

5.4. Antioxidant Activity:

The components of purslane that give the plant its antioxidant qualities include gallotannins, omega-3 fatty acids, ascorbic acid, α-tocopherols, kaempferol, quercetin, and apigenin (**Yan et al., 2018**). While the ethanolic extract had little effect, the aqueous extract's antioxidant components might have played a significant role in reducing the oxidative DNA damage caused by hydrogen peroxide in human cells (**Behravan et al., 2011**).Through the suppression of p-PERK protein expression and FAS mRNA expression of the liver and spleen in mice, the increase of leptin/β-actin and liver PPAR a/β-actin, and the regulation of blood and liver antioxidant enzyme activities, the aqueous extract also reduces oxidative damage caused by a high-fat diet (**Chen et al., 2012**). Furthermore, in the mouse model of oxidative damage brought on by a high-fat diet, lipid peroxidation levels in the liver and blood sharply increased, whereas antioxidant enzyme activity fell when compared to normal control animals. Additionally, purslane's pure polysaccharide components (POP II and POP III) were evaluated for their antioxidant capacity. They were found to have strong antioxidant qualities in both cell-mediated radical production systems and systems that generated free radicals. With DPPH radical scavenging activities of 35.24% and 17.21% at 1.0 mg/mL, respectively, POP II and POP III both reduced lipid peroxidation in a dose-dependent manner with regard to cell-free radical generating systems. By inhibiting the generation of ROS caused by alloxan and protecting HIT-T15 cells from ROS stress brought on by alloxan, POP II and POP III, both helped to produce anti-cytotoxic effects in cell-mediated radical generating systems (**Li et al., 2014**).

5.5. Anti-inflammatory Activity:

After pretreatment with the aqueous extract of *Portulaca oleracea*, human umbilical vein endothelial cells (HUVECs) exhibit dose-dependent overexpression of intercellular adhesion molecule-1, vascular cell adhesion molecule-1, and E-selectin mediated by tumor necrosis factor-(TNF-) α. Additionally, TNF-induced NF-B binding, inhibitor molecule (IκB) degradation, and nuclear factor κB (NF-κB) p65 translocation to the nucleus are all inhibited by this extract. Furthermore, it is demonstrated that the mRNA expression of monocyte chemo-attractant protein (MCP-) 1 and interleukin (IL- 8) is inhibition of HL-60 cells' adhesion to TNF-induced HUVECs. Additionally, the aqueous extract of purslane may have a crucial part in stopping the inflammatory process that leads to atherosclerosis in the arteries (**Lee et al., 2012).**

5.6. Anticancer Activity:

Purslane polysaccharides clearly impact immune responses and scavenge the buildup of free radicals in rats with ovarian cancer **(Chen et al., 2009**). HeLa and HepG2 cell growth is inhibited in vitro by sulfated derivatives of the water-soluble polysaccharide POP, which was extracted from *Portulaca oleracea*. According to **Chen et al. (2010),** who suggests that POP's sulfation increases its cytotoxicity in tumor cells. Alkaloids, flavonoids, and cerebrosides are among the other bioactive substances that, in addition to polysaccharides, have deadly effects on human cancer cell lines in vitro. According to **Zheng et al. (2014)**, portulacerebroside A causes the p38 MAPK and JNK-triggered mitochondrial death pathway, which in turn causes apoptosis in human liver cancer HCCLM3 cells.

5.7. Immunomodulatory effects

In order to maintain homeostasis in our bodies, the immune system is essential in responding to a variety of pathogens, such as parasites, germs, viruses, allergies, and other inflammatory triggers (**Gleeson, 2007**). Because of the immune system's significance and complexity, an immune system imbalance will inevitably lead to the development of a number of illnesses, such as infectious, autoimmune, and cancerous conditions. Therefore, it's crucial to look for a drug to control the improper immune response. Different purslane extract doses improved Th1/Th2 and Treg/Th2 balances in isolated human lymphocytes, according to an in vitro evaluation study (**Askari et al., 2016).** In addition, purslane extract had immunomodulatory properties that helped to avoid inflammatory bowel illness. The pathophysiology of colitis caused by acetic acid (AA) was revealed to be significantly influenced by immune dysregulation, however, by lowering the immune response and lessening the severity of colitis, purslane extract treatment reduced intestinal inflammation (**Alfwuaires et al., 2021**). Also, *in vitro* evaluation investigation found that different dosages of purslane extract improved Treg/Th2 and Th1/Th2 balances in isolated human cells (**Askari et al., 2016).** Purslane extract also shown immunomodulatory qualities that prevented inflammatory bowel disease. Immune dysregulation was found to have a major impact on the pathophysiology of acetic acid (AA)-induced colitis, whereas purslane extracts administration decreased the severity of colitis and decreased colonic inflammation by reducing the immune response (**Alfwuaires et al., 2021**).

6. Other Activities:

Parry et al. demonstrated in 1993 that an aqueous extract of *Portulaca oleracea* stems and leaves have skeletal muscle relaxant properties. The twitch contraction of the directly induced rat hemidiaphragm preparation was demonstrated to be decreased by the *Portulaca oleracea* extract. The extract's effects on the diaphragm were also seen to be qualitatively comparable to those of potassium oxalate, a known *Portulaca oleracea* component. Additionally, the methanol extract was passed through a cation exchange resin to remove potassium ions, which reduced the extract's inhibitory activity. An assessment of *Portulaca oleracea's* ability to treat Mus musculus JVI-1 found that a unique crude extract dramatically speeds up the healing process by inducing wound contraction and downregulating the excision wound's surface area (**Rashed et al., 2003**). Additionally, illnesses like Keshan and Kashin-Beck that are associated with a selenium shortage can be avoided by using *Portulaca oleracea*, which can absorb selenium in as little as 42 days (**Prabha et al., 2015**).

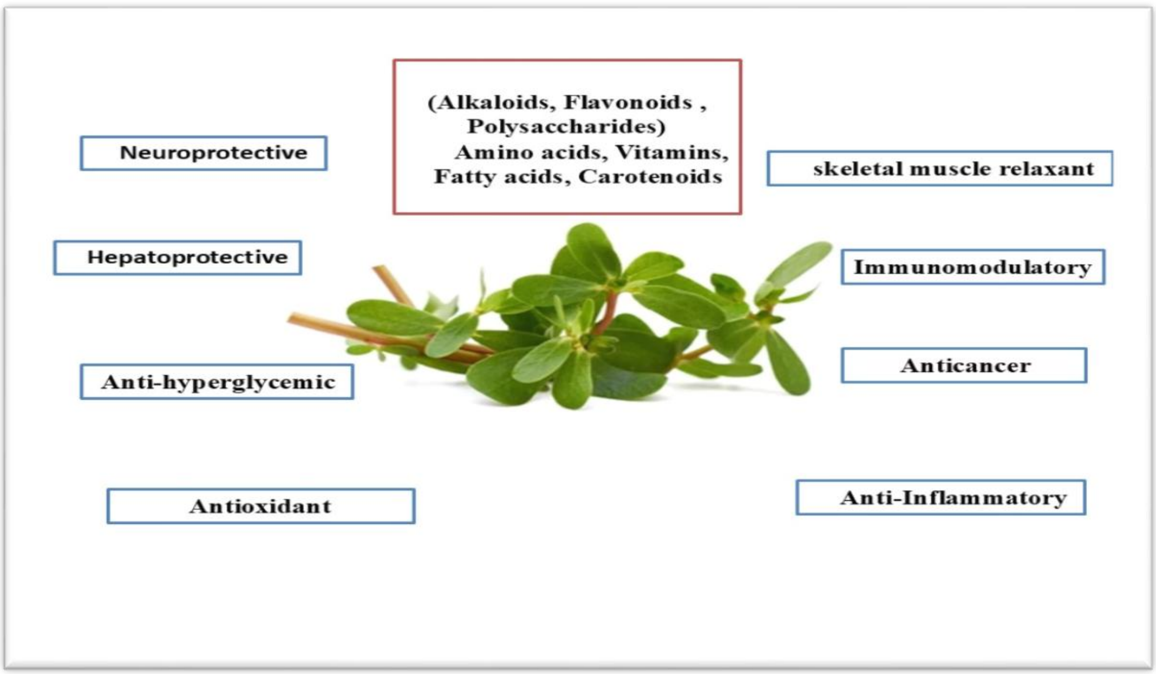

Fig.1. Showed the different phytochemical and pharmacological properties of purslane

7. Conclusion

A prominent medicinal plant, *Portulaca oleracea* has a wide spectrum of pharmacological effects. Because it is rich in minerals, especially antioxidants (vitamins A and C, á-tocopherol, â-carotene, and glutathione), it has been used historically as a topical treatment for inflammatory diseases and is neuroprotective and hepatoprotective. Because purslane's reported advantages are mostly attributed to its fresh juice or decoction, it would be most suited to employ water extractives. More study is required to explore the uncharted territories and their practical therapeutic uses that can be implemented for the good of humanity.

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