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Article *in* Plant Archives · April 2020

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Plant Archives Volume 20 No. 1, 2020 pp. 1624-1630 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

PURSLANE: A PERSPECTIVE PLANT SOURCE OF NUTRITION AND ANTIOXIDENT

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Abstract

Purslane (*Portulaca oleracea*) is a leafy vegetable that most likely originated in the Mediterranean region. It is a rich source of potassium, magnesium and possesses the potential to be used as vegetable source of omega-3 fatty acid and recently has been recognized as the richest source of a-linolenic acid, essential omega-3 and 6 fatty acids, ascorbic acid, glutathione, a-tocopherol and b-carotene. The stems and leaves also have high energy values which is 303.9 Kcal/100g dry weight. Mineral contents (mg/100gm DM) were K (14.71), Na (7.17), Ca (18.71), Fe (0.48) and Zn (3.02). *P. oleracea* has higher total phenolic and antioxidant content than plants at immature stages. The antioxidant content and nutritional value of purslane are important for human consumption. It revealed tremendous nutritional potential and has indicated the potential use of this herb for the future.

Introduction

Purslane (*Portulaca oleracea*) is one of the members from Family "portulacaceae (Hyam and Pankhurst, 1995) and the genus Portulaca. The 'weed' purslane (*Portulaca oleracea* L.) is a weed of open agricultural habitats, especially in turf grass and field crops areas (Uddin *et al*., 2009; Uddin *et al*., 2010). The antioxidant content and nutritional value of purslane are important for human consumption. It revealed tremendous nutritional potential and has indicated the potential use of this herb for the future Uddin *et al*., (2014). The plants are characterized by its taller upright growth habit and larger leaves and seeds Gorske *et al*., (1979). Purslane is a nutritious vegetable which can be consumed by human being and it was mentioned in Egyptian texts from the time of the Pharaohs (Mohamed and Hussein, 1994). *P. oleracea* can be eaten raw as a salad, eaten cooked as a sauce in soups or eat as green vegetables. *P. oleracea* provides a rich plant source of nutritional benefits (Sudhakar *et al*., 2010). According to Simopoulos and Salem, (1986), *P. oleracea* is one of the green plants which is rich in omega-3 fatty acids and alinolenic acid. Low incidence of cancer and heart disease were reported in the areas where *P. oleracea* is eaten, possibly due to *P. oleracea'* naturally occurring omega-3 fatty acids (Simopoulos, 1991). *P. oleracea* has been used as an antiseptic, antidiuretic, vermifuge in oral ulcer and urinary disorders. Recent research reported that *P. oleracea* shows a wide range of biological effects, including skeletal muscle relaxant effect (Parry *et al*., 1993), analgesic and anti-inflammatory effects (Chan *et al*., 2000), antifungal activity (Oh *et al*., 2000) and antifertility effect (Verma *et al*., 1982). Other than these, it also shows other beneficial effects such as anti-diabetic (Gong *et al*., 2009) and wound healing properties (Rashed *et al*., 2003). Besides that, *P. oleracea* may have a protective effect against oxidative stress caused by vitamin A deficiency (Arruda *et al*., 2004). In addition, *P. oleracea* consists of active molecules which can be used for the treatment of some parasitic infectious diseases such as leishmaniasis and trypanosomiasis (Costa *et al*., 2007). Skulski, (2010) reported that *P. oleracea* has freshy leaves with slightly sour taste, it is rich in iron content and has significant amount of Omega-3 fatty acids which is commonly found in seed. Hence, *P. oleracea* is used widely in Chinese medicine as an herb which is able to

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Fig. 1: Purslane plant with leaf, flower and seed.

clear heat toxin and antibiotic and antifungal effect increases uterine contraction and prevention and treatment of dysentery.

Botanical Description of *Portulaca oleracea*

P. oleracea is a succulent annual herb. Stems of *P. oleracea* are sometimes flushed red or purple, not articulated, prostrate or decumbent, less often erect, diffuse, much branched; leaf axils with a few inconspicuous stiff bristles (Fig. 1). The leaves are alternate or occasionally subopposite, with short petiole and flat leaf blade, obovate, 10-30 × 5-15 mm, base cuneate, apex obtuse, rounded and truncated. The flowers of *P. oleracea* are in clusters of three to five, 0.4-0.5 cm in diameter, surrounded by involucre of two to six bracts. Sepals are green, helmeted, ca. 4 mm, apex acute and keeled. Petals 5, yellow, obovate, 3-5 mm, slightly connate at base, apex retuse. Stamens 7-12, circa 12mm; anthers are yellow. The ovary is glabrous with four to six lobed stigma. Capsule ovoid, ca. 5 mm. Seeds are glossy black when mature, never iridescent, obliquely globose-reniform, 0.6-1.2 mm; testa cells stellate, usually with central peg like tubercle, sometimes without and then surface granular (Lu and Michael, 2003). Seed production of these plants is very high (one plant can introduce up to 10,000 seeds to the environment. It has a slightly sour and salty taste. The stems, leaves and flower buds are all edible (Wiersema and Leon, 1999).

Chemical Constituents of *Portulaca oleracea*

Aberoumand, (2009) reported that the leaves and stems of *P. oleracea* contained ashes (22.66%), crude protein (23.47%), lipid (5.26%) and fibers (40.67%). The stems and leaves also have high energy values which is 303.9 Kcal/100g dry weight. Mineral contents (mg/100gm DM) were K (14.71), Na (7.17), Ca (18.71), Fe (0.48) and Zn (3.02). According to Chowdhary *et al*., (2013), *P. oleracea* contains more omega-3 fatty acids, alpha-linolenic acid than other leafy vegetables plant available in the market. *P. oleracea* has 0.01mg/g of eicosapentaenoic acid (EPA) which is an Omega-3 fatty acids found mostly in fish, some algae and flax seeds. *P. oleracea* also contains vitamin as well as dietary minerals such as magnesium, calcium, potassium and iron. It also contains two types of betalain alkaloid pigments which are the reddish betacyanins visible in the coloration of stem and the yellow betaxanthis that can be seen from the flowers. These two pigments are potent antioxidants and have been found to have anti-mutagenic properties. Many types of chemical compound has been found present in *P. oleracea* including alkaloids, terpenoids, organic acids, coumarins, flavonoids, volatile oil and polysaccharides (Prashanth *et al*., 2005)

Anti-microbial Activity

Ramesh and Hanumantappa, (2011) had reported the phytochemical and anti-microbial activity in the aerial parts of chloroform and ethanolic extracts of *P. oleracea* by agar diffusion method. The antimicrobial activity in *P. oleracea* are used in against five bacteria for example *Bacillus cereus* and *Klebisilla pneumonia* and three fungi such as *Aspergillus fumigates* and *Nerospora crassa*. Ethanolic crude extract of *P. oleracea* showed maximum effect on organism such as *Staphylococcus aureus, Klebisilla pneumonia* and *Nerospora crassa*. Whereas chloroform extract of *P. oleracea* showed moderate effect on *Klebisilla pneumonia, Aspergillus niger* and *Nerospora crassa*. The result of this research supported the folklore usage of the studied plant and shows that the extract of this studied plant contains compounds which have anti-microbial agent in the form of drugs for the therapy of infectious diseases caused by pathogens. Based on the previous study of Bae, (2004), antimicrobial effect of *P. oleracea* extracts on food borne pathogens was assessed. His study had found that ethyl acetate extract was having highest antimicrobial activity against *Staphylococcus aureus* and *Shigella dysentrica* compared to petroleum ether, chloroform and methanol extracts. Strong antimicrobial activity was found from the ethyl acetate extract of *P. oleracea* to against *Staphylococcus aureus* at 4000 ppm concentration.

Anti-oxidant Activity

In 2012, Uddin *et al.,* had reported the antioxidant activity of *P. oleracea* over different plant maturity stages by using 1,1-diphenyl-2-picrylhydrazyl (DPPH), ferric-reducing antioxidant power (FRAP) assays. Iodine titration was used in this study to determine the ascorbic acid content (AAC). From the study, he found that DPPH scavenging (IC_{50}) capacity ranged from 1.30±0.04 to 1.71±0.04 mg/mL. For ascorbic acid equivalent antioxidant activity (AEAC), the values were 229.5±7.9

to 319.3±8.7 mg AA/100g. It was found that the total phenolic content (TPC) in *P. oleracea* varied from 174.5±8.5 to 348.5±7.9 mg GAE/100g, ascorbic acid content (AAC) ranged from 60.5±2.1 to 86.5±3.9mg/100g and FRAP ranged from 1.8±0.1 to 4.3±0.1mg GAE/g. The study found that there was a good correlation between the results of TPC and AEAC and between IC50 and FRAP assays (r2>0.9). This study also reported the concentration of Ca, Mg, K, Fe and Zn increased with plant maturity. Calcium (Ca) showed negative relationship with sodium (Na), Chloride (Cl), but showed positive relationship with magnesium (Mg), potassium (K), iron (Fe) and Zinc (Zn). It was concluded that mature plants of *P. oleracea* has higher total phenolic content and antioxidant activities than plants at immature stages.

Anti-atherogenic and Immunomodulatory Activity

Rasha *et al.*, (2011) had reported the efficiency of *P. oleracea* (components of ω -3 and ω-6) on hyperlipidemia, kidneys function and as immunomodulators in rats which fed with high cholesterol diets. In this study, 40 male albino rats were divided into four groups which are control group, hypercholesterolemic rats, fed the balanced diet supplemented with cholesterol at a dose level of 2g/100g diet. The other two groups of rats were fed with the same as previous hypercholesterolemic diet supplemented with *P. oleracea* (ω -3 and ω -6). The study showed that there was a significant increase in total cholesterol, total lipids and triacylglycerol in both serum and liver caused by the 2% cholesterol administration. Serum phospholipids, LDL-C and atherogenic index (AI) also showed significantly increased compared to the control groups of rats. Cholesterol-enriched diet significantly increased serum urea, creatinine, sodium, potassium levels and also serum IgG and IgM compared to the control group. A significantly decrement in lipid parameters and significant improvement in IgG and IgM levels was found in the hypercholesterolemic rats fed with *P. oleracea*. This result showed that *P. oleracea* had anti-atherogenichypolipidemic and immunmodulator effects which were probably mediated by unsaturated fatty acids present in seed mixture.

Anti hyperlipidemic Activity

In the previous study of Sankara *et al*., (2012), anti-hyperlipidemic activity of ethanolic extract of leaves of *P. oleracea* were reported. Significant inhibition against dexamethasone induced hyperlipidemia in adult wistar rats were shown from the test extracts (200 and 400 mg/kg) treatment for 8 days. Biochemical parameters such as 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.

Anti-arthritic Activity

Jagan *et al.*, (2012) reported the anti-arthritic activity of Petroleum-ether extract of *P. oleracea* Linn by Fruends Adjuvant arthristis model in male wistar rats. The extracts of *P. oleracea* were at the dose of 100, 200 and 300 mg/kg/p.o and standard as Indomethacin at a dose of 100 mg/kg. Maximum of inhibition which is about 77.82% was observed on 21st day. This study revealed the anti-arthritic activity of aqueous extract of *P. oleracea*.

Anti-diabetic Activity

The effects of crude polysaccharide from *P. oleracea* on blood glucose, body weight, total cholesterol, high density lipoprotein cholesterol, triglyceride and serum insulin levels in diabetes mellitus mice were reported by Gong *et al*., (2009). A significant decrease in the concentrations of fasting blood glucose, cholesterol and triglyceride in mice were found from the treatment with crude polysaccharide from *P. oleracea* (200, 400 mg/kg bw) for 28 days. The concentration of HDL-c, body weight and serum insulin level in the mice were significantly increased by this polysaccharides. Besides that, it did not produce any physical or behavioral signs of toxicity. The data demonstrated best effects at the dose of 400 mg/kg bw. These results shows that crude polysaccharide from *P. oleracea* can be used to control blood glucose and modulate the metabolism of glucose and blood lipids in diabetes mellitus mice.A study was done by Gao *et al*., (2010) revealing the effects of polysaccharide from *P. oleracea* on alloxan-induced diabetic rats and its mechanisms. The polysaccharide treatment shows significant decreases in fasting blood glucose, total cholesterol and triglycerides. Polysaccharide also showed a tendency of improvement body weight gain on diabetic rats. In addition, the diabetic control group had low serum insulin level comparing with that of normal control group, at the same time, the insulin levels were dose-dependently raised in the polysaccharide treated groups than that of diabetic control group. According to the result get from single cell gel electrophoresis and LD51 analysis, polysaccharide was proved to be nontoxic to the animals. The result shows that polysaccharide would alleviate the blood glucose and lipid rising associated with diabetes. It also improved the abnormal glucose metabolism and increase insulin secretion by restoring the impaired pancreas cells in alloxan-induced diabetic rats, which suggest that polysaccharide has the hypoglycemic potential and could be useful on the diabetes therapy.

Hepatoprotective Activity

Based on the previous study of Prabhakaran *et al.,* (2010), the suspensions of methanol and petroleum ether extracts of whole plant parts of *P. oleracea* in carboxy methyl cellulose were evaluated for hepatoprotective activity in Wister albino rats by inducing hepatic injury with D-galactosamine (400 mg/kg). At the dose levels of 200 and 400 mg/kg, altered biochemical parameters were significantly restored when compared to d-galactosamine and Silymarin treated groups. Histology of the liver sections of albino rats also showed to significantly prevent the d-galactosamine toxicity as revealed by the hepatic cells with well-preserved cellular architecture. Both biochemical and histological data had confirmed significant hepatoprotective activity of these extracts from *P. oleracea.*

Nephro-protective Activity

Karimi *et al.,* (2010) reported the aqueous and ethanolic extract of *P. oleracea* against cisplatin induced acute renal toxicity in rats. Treatment with aqueous and ethanolic extracts in the highest dose (0.8 and 2 g/ kg), 6 and 12 hour before cisplatin injection reduced blood urea nitrogen and serum creatinine. Tubular necrotic damage was also not observed. Meanwhile in another group rats treated with aqueous and ethanolic extract, 6 and 12 hours after cisplatin injection also had blood urea nitrogen and serum creatinine levels significantly lower compared to those receiving cisplatin alone but mild to moderate cell injury was observed.

Neuronal Activity

The neuronal activities of aqueous extract of stem and leaves of *P. oleracea* with a dose of 1.5ml/kg in adult rats for 12 days were reported by Abdel *et al*., (2012). This study showed significant decrease in the Ca^{2+} level in cerebral cortex by about -25.2% at $p<0.05$. There was significantly decrease in dopamine content in spinal cord but significantly increase in dopamine content in cerebellum, cerebral cortex, thalamus and hypothalamus of rats. This study concluded that *P. oleracea* has the potential as neurotransmitters, which plays an integral part of many neurodegenerative disorders.

Neuroprotective Activity

In 2005, Li *et al.,* had reported the effect of flavones extracted from *P. oleracea* on ability of hypoxia tolerance in mice. The survival time of mice in hypoxic conditions in flavones-treated group was found to be significantly longer compared to the untreated group. The RBC, Hb concentration, HCT, plasma EPO level and the relative values of EPO mRNA in renal tissue and pallium of mice were significantly higher in the flavones treated group compared to the untreated group.

Anti-inflammatory Activity

According to Chan *et al.,* (2000), *P. oleracea* sub sp. sativa was evaluated for further work because of its abundant availability from reliable sources. The 10% ethanolic extract of the aerial parts showed significant anti-inflammatory activity in the carrageenan-induced hind paw oedema and the cotton pellet-induced granuloma models in rats. Besides that, significant analgesic activity were also found in the hot-plate and tail flick models (in mice and rats, respectively) after intraperitoneal administration.

Skeletal Muscle Relaxant Activity

Parry *et al*., (1993) had reported the skeletal muscle relaxant activity of aqueous extract of the stems and leaves of *P. oleracea*. It was found that the extract of *P. oleracea* able to stop the twitch contraction of the directly stimulated rat hemidiaphragm preparation. The effect of the extract mimic qualitatively the action of potassium oxalate which is one of the known constituent of *P. oleracea* on the diaphragm was also reported. Removal of potassium ions from the methanol extract by passing it through a cation exchange resin reduced the inhibitory effect of the extract. A positive relationship between the concentration of potassium ions in the extract and the effects of potassium chloride of similar molarity were reported. Hence, it can be concluded the relaxant effect observed on the isolated rat diaphragm is because of the potassium ion content of *P. oleracea.*

Plant Derived Antioxidant Compounds

Phytochemical are biologically active and naturally occurring chemical compounds found in plants. It provides health benefits for humans further than those attributed to macronutrients and micronutrients (Hasler and Blumberg, 1999). Recently, phytochemical was reported to have roles in protection of human health when their dietary consumption is significant. Dietary phytochemicals can be found in fruits, vegetables, legumes, whole grains, nuts, herbs and also spices. Costa *et al.,* (1999) had reported that the phytochemical will accumulate in different parts of the plants including stems, roots, leaves, flowers, fruits or even seeds. These compounds are known as secondary plant metabolites which have biological properties such as antioxidant activity, antimicrobial effect, modulation of detoxification enzymes, stimulation of immune system, decrease of platelet aggregation and modulation of hormone metabolism and anticancer property. Recently, researches had reported that many phytochemicals can used to protect human against diseases (Narasinga, 2003). Phytochemicals can be classified as primary or secondary constituents based on their role in plant metabolism. The examples of primary constituents are common sugars, amino acids, proteins, purines and pyrimidines of nuclei acids, chlorophyll and others. Secondary constituents are the remaining plant chemicals including alkaloids, terpenes, flavonoids, lignans, plant steroids, curcumines, saponins, phenolic and glucosides (Hahn, 1998). Literature surveys show that phenolics are the most numerous and structurally diverse plant phytocontituents.

Phenolic Compound

Phenolic phytochemicals which are widely distributed in plant kingdom are the largest category of phytochemicals. Flavonoids, phenolic acids and polyphenols are the three most important groups of dietary phenolics. Phenolic are hydroxyl group (-OH) containing class of chemical compounds where the (-OH) bonded directly to an aromatic hydrocarbon group. Phenol (C_6H_5OH) is considered the simplest class of this group of natural compounds. Phenolic compounds are a large and complex group of chemical constituents found in plants (Walton *et al*., 2003). They are plant secondary metabolites which play an important role as defence compounds. Phenolics exhibit several properties that bring benefits to human beings. Its antioxidant properties are important as protecting agents against free radical-mediated disease processes. Flavonoids are the largest group of plant phenols and the most studied (Dai and Mumper, 2010). Phenolic acids form a diverse group that includes the widely distributed hydroxybenzoic and hydroxycinnamic acids. Phenolic polymers, commonly known as tannins, are compounds of high molecular weight that are divided into two classes which are hydrolyzable and condensed tannins. Based on the previous study by Uddin *et al*., (2012ab), total phenolic content (TPC) of the edible aerial parts of *P. oleracea* at different growth stage was reported. The shoots were collected from 15, 30, 45 and 60 days old plants. The result shows that the TPC value for 15 days old plant was significantly lower compared to 30, 45 and 60 days old plants. The TPC of 60 days mature plant was slightly lower than those plants under developing stage. It can be concluded that TPC content was higher when the plant was under developing stage. Purslane is a nutritious vegetable with high antioxidant properties and recently has been recognized as the richest source of a-linolenic acid, essential omega-3 and 6 fatty acids, ascorbic acid, glutathione, a-tocopherol and b-carotene (Alam et al, 2014a). The TPC, TFC and TCC ranged from 0.96 ± 0.04 to 9.12 ± 0.29 mg GAE/g DW, 0.13 ± 0.04 to 1.44 ± 0.08 mg RE/g DW and 0.52 ± 0.06 to 5.64 ± 0.09 mg (β-carotene equivalent) BCE/g DW, respectively (Alam *et al.*, 2014b).

Flavonoid Compound

Flavonoids are polyphenolic compounds that are ubiquitous in nature. More than 4,000 flavonoids have been found in many vegetables, fruits and beverages like tea, coffee and fruit drinks (Pridham, 1960). The flavonoids have played a major role in successful medical treatments of ancient times until today. Flavonoids are ubiquitous among vascular plants and occur as aglycones, glucosides and methylated derivatives. According to Harborne and Baxter, (1999), more than 4000 flavonoids have been found within the parts of plants normally eaten by humans and approximately 650 flavones and 1030 flavanols are known. Small amount of aglycones are frequently present and occasionally represent a considerably important proportion of the total flavonoid compounds in the plant. Milan *et al*., (2011) reported the total phenolic content, flavonoid concentrations and antioxidant activity of the whole plant and plant parts extract from *Teucrium montanum* L. var. montanum, *F. supinum* (L.) Reichenb. The study shows that the highest flavonoid content was found in acetone extract from the leaves of *T. montanum* (88.31 mg RU/g), followed by the leaf ethyl acetate extract with 58.48 mg RU/g. The lowest flavonoid concentration was measured in water and petroleum ether extracts. The concentration of flavonoids in various parts of the plant differed greatly from the value obtained for the whole plant. This can be concluded that flavonoids were present in different plant part with different concentration.

Proximate Composition

Proximate composition is the term usually used in the field of feed or food and means the 6 components of moisture, crude protein, ether extract, crude fibre, crude ash and nitrogen free extract, which are expressed as the content (%) in feed, respectively (Jagdish and Neeraj, 2008).

Animal feedstuff

Purslane also contains high levels of vitamin E, C and Beta-carotene (Simopoulos, 1991) as well as essential macro and micronutrients (Mohamed and Hussein, 1994).

Table 1: Proximate composition of purslane leaves.

Proximate composition	Concentration
Crude protein (%)	22.90
Crude fibre (%)	2.17
Ash (%)	27.00
Total lipid (%)	6.90
Pectin (%)	19.60
Vitamin C (ppm)	68.30
Vitamin E (mg/100g)	17.90
Beta-carotene (IU kg^{-1})	53,842.30
Source: Ezekwe *et al*., 2011	

The abundance of these essential nutrients in purslane allow it to become a new source of nutritious food for both human and livestock. Additional investigation showed that in spite of its genetic diversity, purslane remained one of the most abundant vegetable source of omega 3 fatty acids and other essential nutrients potentially beneficial for human and animal health (Ezekwe *et al*., 1999). The use of purslane as a feed supplement in poultry has been reported by several workers. Aydin and Dogan, (2010) working with laying hens suggested that supplementing diets with dried purslane increased egg production and egg weight. Zhao *et al*., (2013) reported that supplementing 0.2% purslane extract to broiler feed improved weight gain and feed conversion ratio (FCR), increased the population of *Lactobacillus* sp. and *Bifidobacterium* sp. and decreased the population of Escherichia coli in the gastrointestinal tract. Purslane was also reported used in pig and rabbits feeding (Leung and Foster, 1996). In addition *P. oleracea* was reported to reduce serum and egg cholesterol (DalleZotte *et al*., 2005). It was reported that the use of purslane powder up to 3.0% in quails diets has a positive effect on their performance (Zeinali *et al*., 2012). Purslane supplementation significantly altered the fecal bacterial community without affecting the intestinal pH (Zhao *et al*., 2013) and that broiler diets using purslane grains up to 7.5% improved their performance and health. Continuous field capacity condition produced purslane with longest leaf (26.3 mm), widest leaf (14 mm), highest total flavonoid content (1.35 mg QE/g) (Uddin *et al*., 2017.)

As a significant source of omega-3 oils, *P. oleracea* could yield considerable health benefits to vegetarian. Presence of high content of antioxidants (vitamins A and C, alphatocopherol, beta-carotene and glutathione) and omega-3 fatty acids and its wound healing and antimicrobial effects as well as its traditional use in the topical treatment. The nutritional value of purslane and antioxidant content are essential for human consumption.

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