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Potential utilization of purslane (*Portulaca oleracea* L.) as food ingredients and traditional medicine

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Abstract

Portulaca oleracea (PO) is a type of wild plant that has long been used as food and traditional medicine. This study aims to examine the use of PO as a food ingredient and traditional medicine and its bioactivity. The research method is a literature study on various online scientific sources from Google scholar using the keywords PO and uses PO. The information obtained is synthesized so that it can explain the use of PO in a comprehensive manner. Purslane is a nutritious vegetable with high antioxidant properties and has been recognized as the richest source of a-linolenic acid, omega-3 fatty acids, ascorbic acid, glutathione, a-tocopherol and b-carotene. Ethnobotanically PO is used for the treatment of various diseases such as skin diseases, fever, dysentery, diarrhea, hemorrhoids, kidney, liver and spleen disease. The bioactivities PO is analgesic, antibacterial, skeletal muscle relaxant, wound healing, anti-inflammatory and radical scavenger, anti-inflammatory, antioxidant, antibacterial, and antitumor. The compounds portulacerebroside B, portulacerebroside C, portulacerebroside D and portulaceramide A showed significant antibacterial effects on enteropathogenic bacteria in vitro. PO has the potential to be developed as a nutraceutical, especially to treat digestive tract disorders.

Keywords: *Portulaca oleracea*; Antibacterial; Nutraceutical; Portulacerebroside

1 Introduction

Sustainable food production through the integration of indigenous and local knowledge has an important meaning for fulfilling the UN-SDGs (sustainable development goals) [1]. Empirically, it can be seen that various types of food plants that are recognized and used by local communities, especially wild plants, have not been developed optimally, which has implications for the degradation of local knowledge [2]. Pawera et al [3] stated that wild plants are rich in nutrients that are very beneficial for humans, but information on their nutritional value is still limited which causes them to be underutilized by the community.

Purslane or with the scientific name *Portulaca oleracea* (PO) is a type of wild plant that has long been used as food and traditional medicine [4], but its use is only known by certain community groups. Purslane can be used as a nutritious vegetable with high antioxidant properties and rich in a-linolenic acid, omega-3 fatty acids, ascorbic acid, glutathione, a-tocopherol and b-carotene [5]. PO is a succulent, herbaceous, erect or decumbent plant that grows to a height of 30 cm with cylindrical stems with a diameter of 2-3 mm [6] and is easily found in various landscapes in Indonesia. Alam et al [5] stated the need to introduce PO as a new vegetable source of fatty acids. Purslane leaves at the flowering stage are a valuable source of fatty acids (especially a-linolenic acid) and antioxidants in the human diet [7].

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The use of PO as a food ingredient is related to its nutritional content. Besides being used as food, PO is also used as an ingredient in traditional medicine. Since ancient times PO is used for the treatment of various diseases such as skin diseases, fever, dysentery, diarrhea, bleeding hemorrhoids, kidney, liver, spleen disease [6]. In traditional Iranian medicine, PO is used to treat abnormal uterine bleeding [8]. The use of PO as a traditional medicine is related to its bioactivity as analgesic, antibacterial, skeletal muscle relaxant, wound healing, anti-inflammatory and radical scavenger [9], anti-inflammatory, antioxidant, antibacterial, and antitumor activity [10]. Dkhil et al [11] stated that PO is a promising natural product, which can be useful for the prevention of cardiovascular, neurodegenerative and chronic diseases caused by oxidative stress. PO seeds have prominent hypoglycemic, hypolipidemic and insulin resistance-reducing effects; probably due to the content of polyunsaturated fatty acids, flavonoids, and polysaccharides [12].

The use of PO as an ingredient of traditional medicine and its bioactivity is related to the content of its secondary metabolites. PO leaf extract contains total phenols (698.6 mg GAE 100 g-1 DW), flavonoids (46.9 mg QE 100 g-1 DW), a-linolenic acid (2.7 mg g-1 DW) and linoleic acid. (0.8 mg g-1 DW) [7]. However, the content of PO secondary metabolites is influenced by the processing process. Drying methods (hot air drying, microwave drying and freeze drying) caused a significant decrease in total phenolics, total flavonoids and antioxidant capacity of PO leaves [4] and antioxidant activity correlated with phenol content [7].

Food plants which are also efficacious to overcome various diseases or known as nutraceuticals are one of the potential alternatives to improve human health. Until now, in-depth studies that discuss the relationship between utilization and bioactivity of PO are still limited. This study aims to explain the botany, benefits and bioactivity of PO as a food ingredient and traditional medicine.

2 Methods

The research was conducted with an online library review from Google Scholar. Some of the keywords used are PO, uses PO. The information obtained is synthesized so that it can explain the use of OP in a comprehensive manner.

3 Results and discussion

3.1 Botany of *Portulaca oleracea* L.

Portulacaceae consists of 30 genera and about 450 species, mainly characterized by the presence of two sepaloids, five rapidly wilting petaloids, and a fruit capsule usually consisting of three fused carpels [13]. PO is a species of Portulacaceae which has long been used as food and traditional medicine.

A B

Figure 1 *Portulaca oleracea* L. A. Habitus with succulent leaves. B. Flowers with yellow corolla

Description, PO is an annual herb, fresh, and ducking and can form up to 60 cm in diameter (Fig. 1A). Roots thick with secondary fibers. Stem glabrous, succulent, often reddish, primary and secondary branches may grow as long as or longer than the main trunk resulting in the appearance of radial rather than monopodial growth; up to a branching level of 8 was observed. Leaves alternate or sub-opposite, often clustered at branch tips, glabrous, thick, succulent, sessile, spatulate to obovate with smooth margins, 4-28 mm long, 2-13 mm wide. Flowers sessile, axillary and in terminal clusters, opening only on sunny mornings, 2 fleshy sepals about 4 mm long, 4-6 pale yellow petals slightly shorter than

the sepals, 6-12 stamens, 4-6 pistil, some more low (Figure 1B). Fruit shaped round, pointed capsule or pyxis, when immature difficult to distinguish from flower buds, 4-9 Can. The number of seeds is large; seeds are brownish black and shiny with a diameter of 0.5-0.8 mm [14].

3.2 Uses and Bioactivities

3.2.1 Foodstuffs

Plants that are used as food sources are plants that contain nutritional value. Various wild plants that contain nutritional value are food sources that can be utilized by humans, including PO. The use of PO as a food ingredient is due to its high nutritional value, especially the content of omega-3 fatty acids [1,15]. PO is an excellent source of alpha-linolenic acid (ALA) and gamma-linolenic acid (4mg/g fresh weight) compared to any green leafy vegetable [16] and contains the highest measured micro and macro-mineral content of K followed by N, Na, Ca, Mg, P, Fe, Zn, and Mn [1,17]. PO mineral concentrations vary such as potassium (494 mg/100 g), magnesium (68mg/100 g) and calcium (65mg/100 g) [16].

PO contains vitamins, minerals, and omega-3 essential fatty acids which are high because consuming it can help improve health [18]. When traced further, Potassium PO content is higher than green leafy vegetables and has four types of omega-3 fatty acids [1,16,17]. PO is a nutritious vegetable with high antioxidant properties and omega-3 fatty acids [1,16] the richest source of a-linolenic acid, and 6 essential, ascorbic acid, glutathione, a-tocopherol and b-carotene. Besides being rich in fat, PO is also rich in carbohydrates (3%) and protein (2%) and the water content is about 93% of its fresh weight [1]. Glucose and fructose were the main free sugars in stems and leaves, respectively, whereas stems contained higher amounts of total sugar (values ranged between 0.83 g and 1.28 g/100 g fw) [15].

The vitamin content contained in PO is strongly influenced by the processing process. Lactic acid fermented PO juice markedly increased total antioxidant capacity, maintained inherent vitamin C, A, and E levels, and increased bioavailability of vitamin B2 and phenolic levels [19]. PO contained the highest amounts (22.2 mg and 130 mg per 100g fresh and dry weight, resp.) of α-tocopherol and ascorbic acid (26.6 mg and 506 mg per 100g fresh and dry weight, resp.). The oxalate content of purslane leaves is reported as fresh weight of 671-869 mg/100 g [16]. Total phenol (0.96 ± 0.04 to 9.12 ± 0.29 mg GAE/g DW), total flavonoids (0.13 ± 0.04 to 1.44 ± 0.08 mg RE/g DW) fan total carotenoids (0.52 ± 0.06 to 5.64 ± 0.09 mg) at PO [5].

Tocopherol and total tocopherol PO (values were in the range of 197–327 g/100 g fresh weight (fw) and 302–481 g/100 g fw, for -tocopherol and total tocopherol respectively [15]. Oxalic and organic acid content, respectively. The total was higher in the leaves, while the PO stem fatty acids were mainly palmitic (20.2-21.8%) and linoleic acid (23.02-27.11%), while the leaves were abundant in -linolenic acid (35.4-54, 92%). Oleracein A and C were the main oleracein derivatives in leaves (values were in the range of 8.2-103.0 mg and 21.2-143 mg/100 g dry weight (dw) for oleracein A and C, respectively. respectively).Early harvested (young) PO and separation of plant parts can increase the nutritional value of the final product through increasing the content of valuable compounds, such as omega-3 fatty acids, phenolic compounds and oleracein derivatives, while at the same time, the content of compounds anti-nutrients such as reduced oxalic acid [15].

3.3 Traditional Medicine and Bioactivity

3.3.1 Anti-Microbial

Antimicrobial compounds are compounds that are able to inhibit the growth or cause death of microorganisms such as bacteria, protozoa and fungi. PO has been used to treat bacillary dysentery for thousands of years in China [21]. P. oleracea also showed a significant antibacterial effect on enteropathogenic bacteria. The compounds portulacerebroside B, portulacerebroside C, portulacerebroside D and portulaceramide A showed significant antibacterial effects on enteropathogenic bacteria in vitro, which may have contributed to revealing the treatment of P. oleracea in cases of bacillary dysentery. [21].

Various diseases related to the digestive tract are caused by pathogenic bacteria. The flavonoid apigenin was isolated from the aerial part of the PO has antibacterial activity against pathogens such as *P. aeruginosa, S. typhimurium, P. mirabilis, K. pneumoniae and E. aerogenes*. Two active ingredients in PO mucus, linoleic and oleic acid, were identified from PO with synergistic antibacterial activity when combined with erythromycin against Methicillin-resistant *Staphylococcus aureus* (MRSA) and may act by inhibiting the efflux pump of bacterial cells [22].

3.3.2 Anti-hyperlipidemia and Anti-hyper cholesterol

Hyperlipidemia is a term used to express fat levels in the blood above normal so that it can interfere with the blood circulation system. Hyperlipidemia is directly or indirectly related to hypercholesterolemia. Hypercholesterolemia is a major risk factor for cardiovascular disease [23]. Cholesterol has three components, namely triglycerides, low density lipoprotein (LDL) and high-density lipoprotein (HDL). The HDL is also known as good cholesterol, so the higher the concentration in the blood, the better the condition. OP polysaccharides significantly increased high-density lipoprotein cholesterol (HDL) concentrations and serum insulin levels in diabetic rats [24]. Oral intake of *Portulaca oleracea* alcohol extract may play an important role in lowering cholesterol levels, similar to the use of atorvastatin [23]. PO significantly increases blood plasma HDL cholesterol and insulin levels [25].

The stem of PO have a hypolipidemic effect and contain polyphenols, flavonoids, alkaloids, tannins, saponins and mucilage. Administration of 10% PO stem extract in rats on a hyperlipidemic diet reduced high-density lipoprotein cholesterol (HDL-C) significantly compared to controls [26]. The reduction in cholesterol levels with the administration of PO extract is thought to have performance related to the high density of antioxidants and omega-3 found in this herb and the mechanism of inhibition of cholesterol synthesis [23].

3.3.3 Neuroprotective

Neuroprotective compounds are compound that function to protect the nervous system. The PO extract had a hypoxic neuroprotective effect and reduced brain inflammation in rats [27]. Mice treated with 1 g/day PO extract increased mRNA and protein expression in the rat cortex compared to the control group [27]. The bioactivity of PO as a neuroprotective agent is thought to be related to the content of oleraurea compounds, (E)-p-coumaramide, (E)-ferulamide, soyalkaloid A, -carboline-3-carboxylic acid, 2, 3, 4, 9-tetrahydro-1H-pyrido [3, 4-b]indole-3-carboxylic acid, (1S, 3S)-1-methyl-1, 2, 3, 4-tetrahydro- -carboline- 3-carboxylic acid showed anticholinesterase activity, from P. oleracea extract showed anticholinesterase activity [28].

3.3.4 Anti-Diabetes Mellitus

Diabetes Mellitus is a metabolic syndrome caused by multiple genetic disorders and environmental factors [29]. Type 2 diabetes is often associated with micro and macrovascular complications such as diabetes, vascular inflammation and endothelial dysfunction [25]. Macrovascular complications including atherosclerosis are a major cause of morbidity and mortality in patients with diabetes (DM) [30]. The OP polysaccharides significantly increased high-density lipoprotein cholesterol (HDL) concentrations and serum insulin levels in diabetic rats [24].

Polysaccharides extracted from PO can control blood glucose and modulate blood glucose and lipid metabolism in diabetic rats [24]. Treatment of polysaccharide OP (200, 400 mg/kg body weight) for 28 days resulted in a significant reduction in fasting blood glucose, total cholesterol and triglyceride concentrations in diabetic rats. OP polysaccharide at a dose of 400 mg/kg body weight (bw) showed optimal effect [24]. PO aqueous extract has anti-hyperglycemic activity in serum of streptozotocin-induced diabetic rats [31].

Oral administration of crude extract of polysaccharide PO (CPOP) significantly increased body weight and glucose tolerance in diabetic rats [24]. The db/db mice were treated with PO aqueous extract (300 mg/kg/day, p.o.) for 10 weeks significantly reduced blood glucose, plasma triglycerides, plasma LDL cholesterol levels, and systolic blood pressure in diabetic mice db/db [30]. CPOP can significantly reduce fasting blood glucose levels, and increase fasting serum insulin levels and insulin sensitivity index values in diabetic rats [24]. PO aqueous extract improved malondialdehyde, interleukin-6 (IL-6), tumor necrosis factor-a (TNF-a), glutathione, and levels of total antioxidant status in the diabetic group compared to the diabetic group untreated [31].

The Hb A1C, serum glucose levels, TNF-a and IL-6 were all significantly decreased in diabetic rats treated with PO. Histopathology demonstrated a marked increase in the destructive effect on pancreatic islet cells induced by alloxan [32]. PO prevents hyperglycemia by preventing oxidative stress and inflammation [31], whereas dry hydroalcoholic purslane extract showed the highest α-glucosidase inhibitory potential (IC50 value 45.05 g/ml) [33].

3.3.5 Hepatoprotective

Hepatoprotective compounds are chemical compounds that can protect liver injury. Exploration of natural substances to protect liver function continues, including PO [33]. The bioactivity of PO as hepatoprotective has been reported by Eidi et al [33], Qiao et al [34], El-Sayed [12] thus supporting the potential therapeutic use of purslane as an alternative for patients with liver disease [33].

In laboratory experiments, liver injury was induced by CCl_4 [34] and alcohol [35]. PO exerts a protective effect against CCl_4-induced damage in rat liver and supports the potential therapeutic use of purslane as an alternative for patients with liver disease [34]. PO extract can increase antioxidant capacity and alleviate ethanol-induced inflammatory injury of liver cells by reducing the expression of miR-122, acetyl coenzyme A carboxylase (ACC) 1 mRNA and protein and increasing the expression of lipoprotein lipase mRNA and protein in the liver [35].

3.3.6 Antioxidant

Antioxidant compounds are compounds that can inhibit free radicals. The antioxidant capacity of PO is influenced by the processing process. Drying with hot air at a temperature of 50 ºC and freeze drying has the effect of having a better antioxidant capacity than microwave drying [4]. Fresh hydroalcoholic purslane extract showed the highest radical scavenging potential in 2,2-Azinobis 3-ethyl benzothiazoline 6- sulfonic acid (ABTS) and 2,2- difenil-1-pikrilhidrazil (DPPH) assays (IC50 values 52.86 and 66.98 g/mL, respectively) [33].

Bioactivity as an antioxidant is positively correlated with the content of phenolics [4], oleracone [36] and oleracimine [37]. The crude extract of PO contains flavonoids in the form of chlorogenic, caffeic, p-coumaric, ferulic and rosmarinic acids are free phenolic acids, and quercetin and kaempferol [36] apigenin, kaempferol, luteolin, quercetin, isorhamnetin, kaempferol-3-O-glucoside and rutin while phenolic acid content in the form of caffeic acid, p-coumaric acid and ferulic acid [33]. The oleracone compound showed scavenging activity in DPPH with an IC50 value of 17.78 M [36]. The compound oleracimine PO strongly inhibits nitric oxide production reducing the secretion of interleukin 6, tumor necrosis factor, nitric oxide, and prostaglandin E2 in cell culture supernatants as well as cyclooxygenase-2 mRNA and inducible nitric oxide synthase [33].

3.3.7 Anti-inflammation

Various infections and injuries cause inflammation in the body, to overcome this, anti-inflammatory compounds are needed. Anti-inflammatory compounds are anti-inflammatory compounds that function to inhibit the release of prostaglandins into injured or infected tissues [9]. Oleracone is an alkaloid of PO which has a very anti-inflammatory effect, which is rapidly distributed in rats with a high bioavailability of 74.91 to 10.7% [39].

Alkaloids produced from the ethanolic and methanolic extracts of PO exhibited anti-inflammatory activity through inhibition of NO production in lipopolysaccharide-induced RAW 264.7 murine macrophage cells [40]. PO prevents vascular inflammatory processes through inhibition of intracellular reactive oxygen species (ROS) production and NF-B activation as well as reduced expression of adhesion molecules in TNF--induced HUVECs. PO may have a potential therapeutic effect by inhibiting vascular inflammatory processes in vascular diseases such as atherosclerosis [25]

3.3.8 Anti-cancer

Cancer is a disease caused by uncontrolled cell growth, therefore anti-cancer compounds are compounds that can inhibit cancer cell division but do not affect normal cells. Oleraciamide D is an alkaloid compound of PO which showed cytotoxicity to SH-SY5Y cells when the concentration was at 50 M by CCK-8 method [41]. The aqueous extract of PO significantly inhibited DNA damage in human lymphocytes, possibly due to the antioxidant constituents in the extract [42]. PO seed oil showed a significant decrease in the percentage of cell viability and changes in the cellular morphology of HepG2 and A-549 cells which were strongly influenced by concentration [12]. HepG2 and A-549 cell lines exposed to 250, 500, and 1000 g/ml PO seed oil lost their normal morphology, cell adhesion capacity, became spherical, and were found to be smaller in size [10].

4 Conclusion

Ethnobotanically *P. oleracea* is used for the treatment of various diseases such as skin diseases, fever, dysentery, diarrhea, hemorrhoids, kidney, liver and spleen disease. *Portulaca oleracea* bioactivities include: analgesic, antibacterial, skeletal muscle relaxant, wound healing, anti-inflammatory and radical scavenger, anti-inflammatory, antioxidant, antibacterial, and antitumor.

Compliance with ethical standards

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