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# AN ANALYSIS OF PHARMACOLOGICAL ACTIVITIES OF *PORTULACA OLERACEA*

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***Keywords:***

*Portulaca oleracea*, Pharmacological activities, Anti-inflammatory, Anti-diabetic, Hepatoprotective

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**ABSTRACT:** *Portulaca oleracea* belonging to the family Portulacaceae has a wide occurrence throughout the World. It has numerous nutritional and medicinal benefits to humans because it is a good source of many minerals, vitamins, fatty acids, alkaloids, flavonoids, aspartic acid, coumarins, glutathione, *etc*. It is used in the traditional system of medicine in many countries like India, Nigeria, Palestine, China, Iran *etc*. for the treatment of various ailments like edema, ulcers, indigestion, repro-ductive system disorders, *etc*. The present review focuses on pharmacological activities of *P. oleracea* like anti-inflammatory, anti-diabetic, protective effect on the reproductive system, hepatoprotective, and antimicrobial effects. The analysis of recent researches on the above aspects will further, validate the use of *P. oleracea* as a medicinal plant.

**INTRODUCTION:** *Portulaca oleracea* is an annual succulent herbaceous plant that is distributed as turf grass weed or grown as a field crop in a wide range of geographical conditions throughout the World. It is also known as Purslane, Parsley, Redroot, Verdolaga, Ma-Chi-Xian, *etc*. It is a small plant, may reach 40 cm in height, and with mostly prostrate growth. It has a fleshy stem and leaves and bears small yellow flowers. Research has confirmed that *P. oleracea* has higher nutritional quality due to its higher levels of ascorbic acid, α-linolenic acid, and β-carotene [1, 2]. Due to its nutritional as well as antioxidant properties, *P. oleracea* is regarded as a unique food of future [3]. People nowadays show more preference for plants and their products in matters concerned with their health because they are of low cost, are easily available, and have less or no side effects.

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*P. oleracea* contains several types of minerals and vitamins, fatty acids, coumarins, glutamic acid, aspartic acid, alkaloids, anthocyanin, glutathione (GSH), tannins, terpenoids, flavonoids, and saponins [4, 5, 6, 7]. *P. oleracea* has a high resistance to drought, so its medicinal values are also available to people living in areas having low rainfall [8]. In folk medicine in different regions of the World including Mediterranean, Middle East, American, Asian and Central European countries, it is used for the treatment of different health problems like urinary disorders, headache, hemorrhoids, scurvy, wounds, sores and fever [9]. *P. oleracea* is used in Iranian folk medicine to treat diabetes [10]. It is used to treat hemorrhoids and to treat vermifuge in Brazil [11, 12].

In China, the plant is used for analgesic, wound healing, and anti-inflammatory activities [13]. Nigerian men and women use it to improve their fertility [14]. *P. oleracea* is the most common plant used by traditional healers of Palestine to treat renal failure [15]. It is known as Loni, Lonaa, Ghotikaa, and Ghoddhika in the Ayurvedic system of medicine, as Kulfaa and Khurfaa in the Unani system of medicine Paruppukirai and Pulli Keerai

in Siddha system of medicine [16]. In Ayurveda, leaves and tender twigs of *P. oleracea* are used to treat indigestion, ulcer, edema, eye diseases, and bronchial asthma. Tribal people of the Raigarh district of Chhatisgarh state of India use the plant as Ayurvedic vegetable [17]. The plant was cooked as a vegetable with curd to cure excessive mucus, cough, diarrhea, dysentery, and piles, as mentioned in Charaka Samhita, Sushruta Samhita, 1000 BC [18]. Due to such huge traditional importance of *P. oleracea* as a medicinal plant, the present study is undertaken to analyze the recent researches done to check various pharmacological activities of the plant so that its medicinal potential can be further validated.

**Pharmacological Activities:**

**Anti-inflammatory Effect:** Inflammation is protective response of an organism's body to pathogens, damaged cells, and traumatic stimuli. After the stimuli agents are removed, there is need to restrict the inflammatory response for preventing un-controlled damage and the initiation of any autoimmune disorders like systemic lupus erythematosus, Crohn's disease, rheumatoid arthritis, multiple sclerosis, and psoritis arthritis [19, 20]. Nitric oxide (NO), cytokines, and chemokines are inflammatory mediators that are increased during inflammation [21, 22].

Interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), and interleukin-1β (IL-1β) are the main pro-inflammatory cytokines having an important role in an inflammatory response. Although in acute inflammatory conditions, the cytokines play a protective role, but their extra production in inflammatory and autoimmune diseases can produce harmful effects like tissue destruction [21, 23]. TNF-α over production can ultimately lead to DNA and cell damage [24]. The use of traditional herbs is a good choice to prevent the progression of inflammation. Hydroalcoholic extract of *P. oleracea* produced anti-inflammatory effects on human peripheral blood mononuclear cells (PBMCs) [25].

PBMCs were obtained from twelve normal volunteers and were then cultured. Treatment of *Escherichia coli* lipopolysaccharide (LPS) (100 pg/ml) was given to the cells. LPS, as a potent stimulator of pro-inflammatory cytokines, led to the production of TNF-α and IL-6. The production of TNF-α and IL-6 was downregulated in cells treated with *E. coli* LPS, together with *P. oleracea* extract (100 µg/ml). Macrophages are the main cells involved in cell-mediated innate immunity reactions. They possess the capability to start acute inflammatory response [26]. LPS stimulation of macrophages results in increased production of cytokines and NO [27]. *P. oleracea* anti-inflammatory effects on LPS-induced macrophage cells (RAW 264.7) were studied [28]. Macrophage RAW 264.7 cells were incubated for 24 h with 1 µg/ml LPS alone or along with different concentrations of *P. oleracea* aqueous extract (0.05, 0.1 and 0.2 mg/ml). LPS-induced NO production was inhibited in a dose-dependent manner by *P. oleracea* extract. The extract also inhibited the production of IL-6 and TNF-α in LPS-induced RAW 264.7 cells. The findings suggested that *P. oleracea* could regulate the stimulation of inflammation mediated by macrophages [28].

Carrageen, an induced paw oedema model to study the anti-inflammatory response of various drugs or plant extracts, has gained importance over the years. There are many reasons for it. It has been reported that carrageen induced paw oedema is inhibited by a majority of the non-steroidal and steroidal anti-inflammatory drugs. Histologically the lesions induced by carrageenan to a certain extent resemble those of rheumatoid arthritis in human beings. These facts justify the use of carrageen as the main oedemogen. Carrageen and induces its effect in phases. In the first phase, histamine and serotonin are released, and it is 0-3 hrs. At 3 h a kinin-like substance maintains the plateau phase. The late phase of inflammation which covers the time period from 4.5 to 5 h is attributed to release of prostaglandin [29].

It had been observed in rats that paw oedema induced by carrageen an administration was reduced by the administration of *P. oleracea* petroleum-ether extract to the rats. Presence of phytoconstituents like alkaloids, saponins, flavonoids, tannins, terpenoids were also detected in the extract [7]. Anti-inflammatory and analgesic activity of the above phytoconstituents is supported by a number of reports [30, 31, 32]. Anti-inflammatory activity of *P. oleracea* was determined by oral administration of its methanolic extract to chicks

having oedema in foot (induced by injecting carrageen an). The extract administration resulted in a dose dependent reduction in oedema and the effect was even more than the aspirin (reference drug) [33].

Anti-diabetic Effect: Diabetes mellitus is a metabolic disorder which is characterized by abnormal protein and lipid metabolism, hyperglycemia along with long term complications affecting the liver, nervous system, kidney and retina [10]. It is called a 'silent killer' because it causes many chronic complications and a large number of people are suffering from it. People affecting from diabetes are increasing day by day and according to International Diabetes Federation, they are expected to reach 592 million by 2035 [34].

Considering the serious side effects of hypo-glycaemic agents, more preference is given to the use of plants and their extracts for the treatment of diabetes. Streptozotocin (STZ) and alloxan are used to induce diabetes in the test animals. STZ with the help of low-affinity glucose protein-2 transporter enters the pancreatic β-cells and thus results into selective damage to insulin-producing islet β cells. In STZ treated rats both local and systemic oxidative stress is the cause of damage to pancreas and the progress of diabetes [35].

Diabetes was induced in male Wistar albino rats by a single intraperitoneal injection of STZ at a dose of 60 mg/kg. Significant alterations were produced in oxidative stress and inflammatory parameters in diabetic rat's serum four weeks after STZ injection like malonaldehyde (MDA), IL-6 and TNF-α increased and total antioxidant status (TAS) and GSH decreased. Above alterations were among the factors responsible for significant hyperglycemia observed in STZ induced rats in comparison to the control rats.

Administration of the aqueous extract of *P. oleracea* (400 mg/kg/d) to the STZ-induced rats, recovered decreased TAS and GSH as well as increased MDA; IL-6 and TNF-α level [35]. The protective effect of *P. oleracea* against diabetes in mice was studied. Mice were injected with a single dose of STZ (135 mg/kg) intraperitoneally. A decrease in the level of serum insulin and an increase in the level of blood glucose were observed after STZ administration.

Treatment with *P. oleracea* (100 and 200 mg/kg) significantly restored the normal glucose levels and also maintained it effectively. *P. oleracea* treatment also reduced the high concentrations of triglycerides, total cholesterol, alanine amino-transferase (ALT), aspartate aminotransferase (AST) and inflammatory cytokines (IL-6, IL-1β and TNF-α) caused by STZ administration. Pathologic liver changes were alleviated by *P. oleracea* in the diabetic mice. It was observed that the levels of Rho-Nuclear factor-kappa B (NFKB) signaling related proteins were restored as compared to those of diabetic mice. The suppression of Rho-NFKB pathway might have played a positive role in regulating STZ-induced liver injury [13]. Administration of ethanolic extract (50 and 100 mg/kg) prepared from the whole plant of *P. oleracea* regulated the blood glucose level and reduced inflammatory cells in pancreas islet in a dose-dependent manner in STZ induced diabetic rats [36].

Like STZ, alloxan also causes damage to the pancreatic β cells and results in a reduction in the secretion of endogenous insulin and consequently results in less utilization of glucose by the tissues. Antidiabetic effect of the seeds of *P. oleracea* in diabetic rats was checked [10]. Male rats were given an intraperitoneal injection of alloxan (90 mg/kg) to make them diabetic. The test group diabetic rats were administered intraperitoneally with hydro alcoholic extract of *P. oleracea* seeds for 14 days at doses of 50, 100, and 200 mg/kg. Control diabetic rats were given 0.5 ml saline for 14 days. Different biochemical analyses were done to evaluate serum profiles of the rats. In the control diabetic rats, the serum levels of uric acid, urea, triglyceride, glucose, low-density lipoprotein, and cholesterol were 94, 492, 220, 494, 163, 122 mg/dL, and alkaline phosphatase, AST; ALT were 1527, 3215 and 3394 UI/L.

The above parameters were reduced to 52, 36, 120, 165, 63, and 18 mg/dL and 1717, 1219, and 1229 UI/L, respectively, in the test groups. Total protein and high-density lipoproteins levels enhanced significantly, and histopathological damages in the liver tissue were attenuated in comparison to the control [10]. Oleracein E and oleracein L are the main isoquinoline alkaloids present in *P. oleracea* plants. Antioxidant and anti-diabetic efficacy of the above

alkaloids on β-TC-6 pancreatic cell line was investigated [37]. β-TC - 6 pancreatic cells were treated separately with the oleracein E and oleracein L at concentrations of 0, 50, 100, 200, and 400 µM and incubated for 24 h. Both the oleraceins at 100 µM considerably enhanced the antioxidant activity of enzymes: glutathione peroxidase (GSH-PX), superoxide dismutase (SOD) and catalase in comparison to the control. MDA, which is a side product of lipid peroxidation was decreased by oleracein E (100 µM) and oleracein L (50 and 100 µM). Dityrosine (DTY), product of protein oxidation, was also reduced by oleracein-E and L at 50 and 100 µM concentrations, relative to the control. 50, 100 and 200 µM concentrations of oleracein-E and L enhanced the secretion of insulin.

Glucose uptake was increased by oleracein-E and L at 100, 200, and 400 µM concentrations. An increase in the antioxidant enzymes' activity results in more scavenging of free radicals and might be the cause of the decreased lipid peroxidation and protein oxidation. A decrease in oxidative stress means less damage to pancreatic islet β-cell mass, and they can function more effectively in insulin secretion, which results in a reduction in glucose levels [37].

**Protecting and Improving the Function of Reproductive System:** Traditional medical practitioners have been using *P. oleracea* plants for the management of infertility in women. In the Niger Delta region, located in the southern part of Nigeria, women take *P. oleracea* leaves by including them in yam or cocoyam porridge to enhance their fertility. For the same purpose males and females of eastern part of Nigeria extract juice of *P. oleracea* aerial parts and take it with or without raw egg [14]. 250 mg/kg of chloroform (lipophilic) and methanol (hydrophilic) extracts of *P. oleracea* leaves improved sperm count in male albino rats [14].

The efficacy of *P. oleracea* in treating the abnormal uterine bleeding was tested [38]. 30 women with abnormal uterine bleeding and of age group 18-45 years were allocated. Capsules of roasted powder of *P. oleracea* were given a day thrice for two consecutive cycles. During treatment, follow up was done before and after each menstrual cycle and also once in a month after treatment for two consecutive cycles. Out of 30 patients, menstrual regulation was achieved in 26 women (86.7 %). So, it was concluded that *P. oleracea* is an effective alternative medicine for the treatment of abnormal uterine bleeding. Also, no side effects of the treatment were observed [38]. Morphological and functional deterioration of biological systems is called aging [39]. It is produced by the accumulation of endogenous oxygen radicals [40]. It has been observed that in aging female mice, the ovary is the first major organ which weakens [41].

Effects of ethanolic extract of *P. oleracea* were checked on the reproductive system of aging female mice [42]. Effects were checked on naturally aging mice as well as mice induced with D-galactose (D-gal). D-gal is known to induce aging alterations that resemble the normal aging processes [43]. In D-gal treated and aging animals, the levels of follicle-stimulating hormone and luteinizing hormone reduced significantly, whereas the levels of progesterone and estrogen were significantly enhanced in comparison to the control group. In the uterus and ovaries of D-gal and aging groups, a significant increase was found in the MDA content. The activities of antioxidant enzymes like catalase and SOD were reduced significantly in both groups (D-gal and aging).

Atrophy was observed on the uterine wall, and endometrial glands and ovarian follicles degenerated in both the groups. The above alterations in the levels of hormones, the content of MDA, and activities of antioxidant enzymes were reversed significantly by the administration of *P. oleracea* ethanolic extract. There was an improvement in histological changes by *P. oleracea* treatment [42]. Flavonoids such as quercetin and myricetin found in *P. oleracea* have anti-aging and rejuvenating effects [44, 45, 46].

**Hepatoprotective Activity:** Acute or chronic alcohol consumption leads to many metabolic disorders in the liver, which falls under alcoholic liver disease. It is the second-largest liver disorder after viral hepatitis. Work was done to know the effectiveness of *P. oleracea* in treating the acute alcoholic liver injury in rats [47]. Flavonoids like hesperidin, myricetin, rutin and quercetin were detected in *P. oleracea* extract with the help of high

performance liquid chromatography. Alcoholic liver injury was induced in rats by administration of 50 % ethanol (8 mL/Kg) repeatedly after 6 hrs for 7 days. Pretreatment with *P. oleracea* extract lowered down the ethanol-elevated serum levels of ALP, ALT, AST, and triglyceride. The activities of enzymes like GSH-PX and SOD were elevated, while the content of MDA and NO were reduced followed by the administration of *P. oleracea* extract. IL-6 and TNF-α content in the liver were also reduced by *P. oleracea* treatment.

The results showed that *P. oleracea* enhanced the antioxidant potential and relieved the liver cells from inflammatory injury which was induced by ethanol. *P. oleracea* extract treatment also decreased the expression of miR-122 [47]. MiR-122 is micro RNA. Its specific and high expression in the liver is correlated with various liver diseases. In alcoholic and inflammatory diseases of the liver, miR-122 is a promising blood-based biomarker [48, 49].

It has been reported that inhibition of miR-122 regulates the expression of genes involved in the synthesis and oxidation of lipids, resulting in a reduction in the levels of triglyceride and cholesterol and a significant improvement in liver steatosis [50, 51]. Acetyl coenzyme A carboxylase 1 (ACC1) mRNA expression decreased, and lipoprotein lipase (LPL) mRNA expression increased when pretreatment of *P. oleracea* extract was given to the rats with acute alcoholic liver injury [47]. MiR - 122 silencing inhibit the genes that influence lipid metabolism and transport of lipids, which are synthesized in the adipose tissue. LPL major function is to hydrolyze triglyceride in triglyceride-rich lipoproteins, which lower down the levels of plasma triglyceride [52, 53, 54].

Antihepatotoxic effect of *P. oleracea* against hepatotoxicity in rats induced by carbon tetrachloride ($CCl_4$) was investigated [55]. $CCl_4$ administration to rats resulted in a significant enhancement in serum enzymes like ALT, ALP, and AST and serum bilirubin in comparison to normal control rats. The above biochemical parameters were reversed significantly towards normal after treatment with different extracts (aqueous, alcoholic, and petroleum ether) of *P. oleracea*. Hepatoprotection exhibited was almost equivalent to silymarin (100 mg/kg/day).

Transformation of $CCl_4$ (inactive metabolite) to a free radical by microsomal cytochrome P-450, dependent enzyme, causes the activation of $CCl_4$ and produces toxicity. The antihepatotoxic activity of a drug includes the capacity of its constituents to inhibit the aromatase activity of cytochrome P-450 [55]. Flavonoids found in *P. oleracea* could be a factor responsible for the inhibition of aromatase activity of cytochrome P-450 and contributing to its antihepatotoxic capacity [56].

**Antimicrobial Activity:** The World is facing a serious problem of antibiotic resistance of pathogenic bacteria. In fact, they are becoming increasingly resistant to multiple antibiotics and are called superbugs or multidrug-resistant. Evolutionary pressure has led to the development of multidrug-resistant varieties [57]. Misuse and overuse of antibiotics is a major reason for the emergence of resistant bacteria. In addition to this problem, some side effects like hypersensitivity to allergic reactions and immune suppression are also caused by the antibiotics [58]. New and effective therapeutic agents are needed in the wake of the alarming rate of antibiotic resistance in pathogenic bacteria. To circumvent the problem of antibiotic resistance in bacteria and also the undesirable side effects of synthetic antibiotics, there is a need to develop alternative antimicrobial drugs from medicinal plants for the treatment of infectious diseases. Medicinal plants are preferred because they are effective against a wide range of antibiotic-resistant bacteria and are safe to use. Secondary metabolites produced in plants like phenolic compounds, alkaloids, etc., have antimicrobial properties. The investigation was carried out to evaluate *P. oleracea* antibacterial activity against multiple drug-resistant bacteria which were isolated from clinical specimens [59].

Agar well diffusion method was used for the purpose. Out of the five extracts prepared from the plant leaves and analyzed (acetone, petroleum ether, methanol, n-hexane, and ethanol), methanol extract was found to have maximum antibacterial efficacy. The maximum zone of inhibition of methanolic extract was found against *E. coli* followed by *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Klebsiella pneumoniae*, and *Salmonella typhi*. Phytochemical analysis showed the presence of tannins, flavonoids, alkaloids,

steroids, glycosides, saponins, phenolic substances in the metabolic extract. The above bioactive compounds might be responsible for the antimicrobial activity of *P. oleracea* [59]. Flavonoids have antioxidative and radical scavenging properties and play a role in a number of pharmacological and biochemical actions [60]. A flavonoid, apigenin, was isolated and purified from *P. oleracea*, and its antibacterial effects were checked [61]. Apigenin was found to be more significantly effective against the growth of *Proteus mirabilis* and *Salmonella typhimurium* and moderately effective against *Enterobacter aerogenes*, *Pseudomonas aeruginosa*, and *K. pneumoniae*. So, the flavonoid was effective against both the gram-negative and gram-positive bacteria. The minimum inhibition concentration for the apigenin was >4mg/mL for all the tested bacterial strains [61]. *P. oleracea* flavonoid extract (POFE) induced the death of *S. aureus* by apoptosis-like pathway [62].

Activation of the apoptotic pathway is the main mechanism involved in the action of antibacterial drugs. Various apoptotic markers were displayed by POFE treated *S. aureus* cells. Fluorescence intensity increase in POFE treated bacterial cells relative to the untreated cells indicated that POFE induced ROS accumulation. TUNEL assay demonstrated fragmentation of DNA of *S. aureus* upon POFE treatment. POFE treatment also led to the depolarization of the bacterial cell membrane. So, POFE, which entered into the bacterial cell cytoplasm through membrane pores led to the above changes and caused the death of bacteria [62]. Excess ROS attack the lipids in the bacterial cell membrane and disrupt their function [63]. The antimicrobial activity of oil extracted from *P. oleracea* seeds was tested against bacteria using agar diffusion method [64].

Inhibitory effect of *P. oleracea* fixed oil on the growth of gram-positive bacteria was less as compared to gram-negative bacteria. In the study, *E. coli* was the highly affected bacterial strain. Transmission electron microscopy analysis revealed that *P. oleracea* fixed oil disrupted the bacterial cell membrane releasing the internal cell contents. Fatty acid profile of the plant seeds tested by gas chromatography-mass spectrometry revealed that *P. oleracea* is a source of many fatty acids, including a high content of alpha-linolenic acid, an omega-3 fatty acid [64]. Omega-3 fatty acids are polyunsaturated fatty acids that play an important role in the growth and development of humans. They maintain a healthy immune system, thus preventing diseases [65]. Incorporation of Omega-3 fatty acids in the outer cell membrane of bacteria increases its permeability, which in turn dissipates the concentration gradient required between the organism and its environment and causes the death of the organism [66].

Antioxidant and antibacterial activities of methanolic extract of leaves of *P. oleracea* growing wildly were investigated [67]. The leaf extract showed high free radical scavenging activity. The plant extract showed antibacterial activities against *Pseudomonas syringae* pv. tomato, *Yersinia pseudotuberculosis*, *Bacillus subtilis* and *Vibrio cholerae* [67]. The methanolic extract of aerial parts of *P. oleracea* was also screened for its antibacterial properties [33]. Antimicrobial activity was checked by the agar well diffusion method. The extract was effective against all the bacteria checked *i.e., P. aeruginosa*, *E coli*, *Streptococcus pyogenes*, and *S. aureus* [33]. It was shown that methanol extract of *P. oleracea* was more effective than n-hexane and dichloromethane extract in its antibacterial potential against *E. coli*, *S. aureus*, and *P. aeruginosa* [68].

Antifungal and antiviral effects of *P. oleracea* have also been reported. Experiments have revealed that methanolic extract of *P. oleracea* was effective against fungus *Candida albicans* [33, 69]. A specific and marked activity was shown by ethyl acetate extract of *P. oleracea* against dermatophytes of the genera *Trichophyton* [70].

A pectic polysaccharide isolated from aerial parts of *P. oleracea* showed a moderate inhibitory effect on the penetration of herpes simplex virus type 2 (HSV-2) in time- and dose-dependent manners [71]. *P. oleracea* extract is effective in early stages of virus infection was also demonstrated in case of influenza A virus. Water extract of the plant inhibited influenza A virus binding to cells and good virucidal activity was exhibited, significantly reducing viral load within 10 min [72]. Various pharmacological activities of *P. oleracea* are enlisted in **Table 1**.

**TABLE 1: PHARMACOLOGICAL ACTIVITIES OF *P. OLERACEA***

| S. no. | Pharmacological Activity | Plant Part used | Extract/powder/Plant Part Administered as Such/isolated Compound | Reference |
|---|---|---|---|---|
| 1. | Anti-inflammatory effect | Aerial parts | Ethanolic extract | 73 |
| | | Aerial parts | Aqueous extract | 35 |
| | | Stem and leaves | Hydroalcoholic extract | 25 |
| | | Leaves | Hydro-ethanolic extract | 74 |
| | | Aerial parts | Juice | 75 |
| | | Aerial parts | Hydroalcoholic extract | 76 |
| | | Leaves | Hydroalcoholic extract | 77 |
| 2. | Anti-diabetic effect | Aerial parts | Crude water-soluble polysaccharide | 78 |
| | | Seeds | Seeds consumed as such | 79 |
| | | Seeds | Hydro-ethanolic extract | 10 |
| | | Aerial parts | Aqueous | 80 |
| | | Leaves | Methanolic extract | 81 |
| 3. | Protecting and improving the function of reproductive system | Stem and leaves | Ethanolic extract | 42 |
| | | Seeds | Aqueous extract | 82 |
| | | Seeds | Roasted powder in the form of capsules | 38 |
| | | Leaves | Chloroform and methanol extracts | 14 |
| 4. | Hepatoprotective activity | Leaves | Aqueous, alcoholic, and petroleum ether extracts | 55 |
| | | Seeds | Seeds consumed as such | 83 |
| | | Seeds | Ethanolic extract | 84 |
| | | Stem and leaves | Aqueous extract | 85 |
| | | Leaves | Ethanolic extract | 86 |
| 5. | Antimicrobial activity | | | |
| | Antibacterial activity against: *Serratia marcescens, Proteus mirabilis, Staphylococcus saprophyticus, Staphylococcus aureus, Acinetobacter baumannii, Enterococcus faecalis, Streptococcus pyogenes, Streptococcus pneumonia and Hafnia alvei* | Leaves and seeds | Hydroalcoholic extract | 87 |
| | *Escherichia coli* | Seeds | Omega-3 fatty acids and esters | 64 |
| | *Acinetobacter baumannii, Klebsiella pneumonia, Listeria monocytogenes, Staphylococcus aureusPseudomonas aeruginosa and Escherichia col,* | Aerial parts | Hydroalcoholic extract | 88 |
| | *Pseudomonas aeruginosa, Escherichia coli, Klebsiella pneumonia, Shigella boydii and Staphylococcus aureus* | Leaves | Methanolic extract | 68 |
| | *Antifungal activity against:* | | | |
| | *Trichophyton sp.* | Whole plant | Ethyl acetate extract | 70 |
| | *Fusarium sp.* | Aerial parts | Aqueous and hexane extracts | 89 |
| | *Rhizopus artocarpi* | Aerial parts | Ethanol and chloroform extracts | |
| | *Candida albicans* | Aerial parts | Hydro-ethanolic extract | 90 |

**CONCLUSION:** *P. oleracea* is a source of diverse phytochemicals like alkaloids, flavonoids, tannins, coumarins, saponins, glutamic acid, aspartic acid, GSH, omega-3-fatty acids, *etc*. The phytochemicals provide *P. oleracea* various pharmacological functions like protective effect on the reproductive system, hepatoprotective, anti-inflammatory, anti-diabetic, and antimicrobial effects. *P. oleracea* has been traditionally used to cure many human ailments, and the present work by analyzing the

recent researches done on the plant validates its pharmacological potential.

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**CONFLICTS OF INTEREST:** Nil

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