Annals of Phytomedicine 11(2): 82-91, 2022

DOI: http://dx.doi.org/10.54085/ap.2022.11.2.9

Annals of Phytomedicine: An International Journal
http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885

Review Article : Open Access

Nutraceutical benefits of Himalayan fern (*Diplazium esculentum* (Retz.) Sw.)

Arti Ghabru, Neerja Rana◆ and Shivani Chauhan*

College of Horticulture and Forestry, Dr.Yashwant Singh Parmar University of Horticulture and Forestry, NERI, Hamirpur-177001, H.P., India

**Department of Basic Sciences, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh, India*

Article Info

Article history
Received 13 July 2022
Revised 28 August 2022
Accepted 29 August 2022
Published Online 30 December-2022

Keywords
Diplazium esculentum (Retz.) Sw.
Phytochemicals
Antioxidants
Antimicrobial
Immunomodulatory
Antidiabetic

Abstract

Despite hundreds of floras being utilized worldwide in the direction to cure/prevent ailments; it is necessary to provide scientific evidence to increase utilization of therapeutic flora in current medication. One of the most common *Diplazium esculentum* (Retz.) Sw. is used to make vegetables, pickles, salad and remedial drives. This review focuses on the nutritional benefits of *D. esculentum*. It contained different phytochemicals such as carbohydrates, free fatty acids, phenols, flavonoids and alkaloids. The leafy fern also contained essential micronutrients such as beta-carotene, folic acid and possess antioxidants, antimicrobial, immunomodulatory and antidiabetic activity. The nutritional qualities of this plant will aid in locating a potential source of a remedy for the nutritional issue and aid in biodiversity preservation. Fern provides potential for usage in food or nutritional programmes because it is nutrient-rich.

1. Introduction

Due to severe weather circumstances, Himalayan flora are popularly acknowledged for producing variety of secondary metabolites. These flora, notably wild plants, important aspect in the socioeconomic advancement and food security of the himalayan area. High nutritional value and abundance of bioactive chemicals, these plants are also used locally as food, medicine and other resources (Das *et al*., 2010). Recent new discoveries have highlighted the value of wild plants as potential sources of functional ingredients (Wali *et al*., 2016; Das, 2019; Naik *et al*., 2021).

In fact, since the Green Revolution, we have participated in the extinction of a variety of local and indigenous cultivars (Khamparia *et al*., 2020). Factors like shelf-life, appearance, flavour, nutritional value, growing practises and environmental adaptation; there is an emphasis on high-yielding cultivars developed through modern breeding programmes, ensuring their acceptability and popularity throughout nations (Katoch, 2020).

Many uncultivated natural plant species are traded and consumed by the local population. They are commonly called as natural plant foods (Beluhan *et al*., 2010; Gupta *et al*., 2020; Singh and Singh, 2021). Numerous studies show that these plants can occasionally provide more nutrition than conventional plants (Das *et al*., 2010; Wali *et al*., 2016). Additionally, there is no negative effects of the pesticides and fertilisers that are frequently employed in modern vegetable gardens (Shukla *et al*., 2013; Chowdhury, 2015; Ansari and Ahmad, 2019).

One of the most prevalent and widely used ferns, *Diplazium esculentum* (Retz.) Sw., grows primarily around water ways and hills up to 2,300 metres wide (Manickam and Irudayaraj, 2003). All around the world, *D. esculentum* is found which include India, Cambodia, China, Japan, Indonesia, Bangladesh and Philippines. It is full of open wet vegetation and the leaves of this plant are slightly open and threatened to be eaten by locals like nutritious leafy vegetables (Devi, 2020). Typically, they can be found in subterranean areas, arctic-alpine regions, cold or hot rain forests and tropical rain forests (Pande and Pande, 2003; Sarkar *et al*., 2018).

2. Traditional uses

D. esculentum traditionally being utilized to cure different ailments such as dysentery, measels, constipation, headache, asthma, fever, diabetes, diarrhea, smallpox, hypertension, bone fractures, inflammation of the glands and dermatological diseases by various societies all over the world (Archana *et al*., 2012; Abe and Ohtani, 2013; Kadir *et al*., 2014; Lense, 2016; Essien *et al*., 2019). The Mishing community of Assam largely employed it in the religious ceremonial for the deceased (Kutum *et al*., 2011). For the locals who are destitute, this fern frows organically, and it is a well-liked source of revenue (Figure 1) and its leaves are used as a vegetable and pickles (Figure 2). A decoction of *D. esculentum* is utilized for treatment of cough, while the dried rootsare utilized as an insecticide (Sudha *et al*., 1999; Kaushik *et al*., 2012). Devi (2020) reported that unlike other beneficial plants taken from the wild, the natural population of *D. esculentum* has not decreased as a result of harvesting, this ferns in the forest has stayed unchanged, according to local vendors, which may be because they are not dug up like therapeutic herbs.

Corresponding author: Dr. Neerja Rana
Department of Basic Sciences, College of Forestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh, India.
E-mail: drneerjauhf24@yahoo.co.in
Tel.: +91-9418748100

Figure 1: Fresh leaves and fronds of *D. esculentum*.

(a) **(b)**

Figure 2: Vegetable preparation (a) and Pickle (b) of *D. esculentum*.

3. Chemical constituents

The proximate and mineral content of any food component can be used to determine its nutritional profile (Gupta *et al*., 2020). *D. esculentum* contained lipids, proteins, carbohydrates, vitamins, fiber, essential micro and macro compounds, *etc.* (Archana *et al*., 2012; Tongco *et al*., 2014; Koniyo *et al*., 2019). It is rich in micronutrients, especially iron, manganese and zinc. Among antioxidants, maximum vitamin C value was reported which was 46 mg/100 g (Zannah *et al*., 2017). Table 1 provide assessments of the proximate and mineral content of *D. esculentum.*

3.1 Bioactive compounds

Conventionally, plants have also been extensively exploited to cure different ailments because of occurrence of biological important phytoconstituents (Ghanbari *et al*., 2012; Mohammad *et al*., 2016). Over the past years, several studies have been undertaken with a focus on phytoconstituents and their biological characteristics in the plants. Consequently, a number of medications have been created, including emetin, quinine, belladonna and many more (Das *et al.*, 2013; Roy and Chaudhary, 2020). Earlier studies have recommended the association between the chemical structure of a phyto-constituents and their pharmaceutical activites (Akter *et al*., 2014; Naik *et al*., 2021).

Table 1: **Analysis of the phytonutrients in *D. esculentum* (Gupta *et al.*, 2020)**

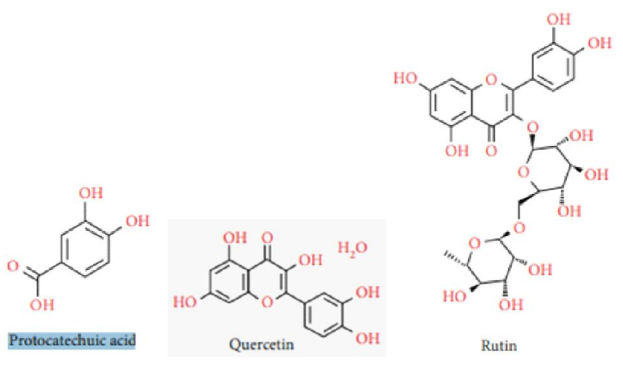
S.No.	Nutrient constituents	Mature fronds of *D. esculentum*
1.	Energy (kcal/100 g)	324.13
2.	Total protein (%)	52.31
3.	Carbohydrate (%)	28.15
4.	Vitamin C (mg/100 g)	46.0
5.	Total dietary fibre (%)	17.44
6.	Calcium (mg/100 g)	12.25
7.	Iron (mg/100 g)	10.71
8.	Sodium (mg/100 g)	1.18
9.	Total sugar (%)	0.86
10.	Total phenol (mg GAE /100 g FW)	0.56
11.	Total fat (%)	0.25
12.	Flavonoids (mg QE/100 g FW)	0.16
13.	Tannin (mg TAE/g FW)	0.12

Numerous solvents systems used to extract phytoconstituents from *D. esculentum* such as tannins, glycosides, oils, alkaloids, phenolics, terpenoids, carbohydrates, steroids, fats and flavonoids (Amoroso *et al.*, 2014; Chawla *et al.*, 2015; Amna and Mardin, 2019; Koniyo *et al.*, 2021). Any plant material's usage as an ingredient in food is the ultimate goal of nutritional depiction. Even while there are lot of research on the beneficial properties of palatable fronds, but very few studies that directly link the phytochemicals in edible ferns with biological activity of edible ferns.

3.2 Polyphenols and flavonoids

The presence of polyphenols or flavonoids in plants is thought to be responsible for many of the biological actions which includes antioxidant and anticancer (Srivastava *et al.*, 1981;Tongco *et al.*, 2014). Their redox characteristics, which are crucial in absorption and eliminating oxidative stress, accepting singlet and triplet oxygen, or breaking down oxidizing agents, supposed to be primary cause of this activity. Additionally, flavonoids have demonstrated to have chemopreventive, antibacterial, anticancer, antiviral, anti-inflammatory and antitumor action (Mandal *et al.*, 2010; Ghasemzadeh and Ghasemzadeh, 2011; Kadir *et al.*, 2014; Ali, 2020; Naik *et al.*, 2021).

Various scientists have reported that the *D. esculentum* contained phenolic and flavonoids (Tangco *et al.*, 2014; Sarkar and Dalal, 2016; Koniyo *et al.*, 2021). The aqueous isolates of *D. esculentum* possess 131.42 ± 3.7 mg/gm, whereas alcoholic isolate possesses 151.90 ± 5.01 mg/gm content of phenolic compound (Saika and Upadhyaya, 2011). The flavonoids were determined to be 64.02 ± 0.56 mg/gm in aqueous isolate and 67± 0.28 mg/gm in the ethanolic isolate of *D. esculentum*, according to Das *et al.* (2013). Akter *et al.* (2014) testified the occurrence of flavonoid constituents in the chloroform and methanolic extract of *D. esculentum*.



(a) (b) (c)

Figure 3: **Phytoconstituents a) Protocatechic acid b) Quercetin c) Rutin of *D.esculentum*.**

Furthermore, three ecdysteroids named amasterone A1, macisterone C and ponasterone A; and four phenolic composites such as trans cinnamic acid, (2R)-3-(42 -hydroxyphenyl) lactic acid, rutin and protocatechuic acid were attained from undeveloped fronds of *D. esculentum* (Figure 3). *D. esculentum* methanolic isolates were found to have 26 bioactive composites (Watanabe *et al.*, 2021; Naik *et al.*, 2021).

3.3 Alkaloids

Another major category of bioactive molecules presents in *D. esculentum* and have been shown to possess stimulatory activity on the neural synapses (Akter *et al.*, 2014; Koniyo *et al.*, 2021; Thomas and Bindu, 2021). Alkaloids revelations acetylcholinesterase inhibition, imrove memory in animals and may even be used to treat Alzheimer's disease (Hirasawa *et al.*, 2003; Ma and Gang, 2004). Thomas and Bindu (2021) reported the presence of alkaloid in chloroform and methanolic leaf extract of *D. esculentum*. Various scientists have reported the occurrence of petrosin B in *D. esculentum* (Pathania *et al.*, 2012; Wali *et al.*, 2016).Pterosin B is the most noticeable biologically active component in *D. esculentum* (Figure 4). Pterosin B concentrations in freeze and shade-dried *D. esculentum* samples ranged from 10.94 to 16.36 mg/kg (Gangwar, 2004).

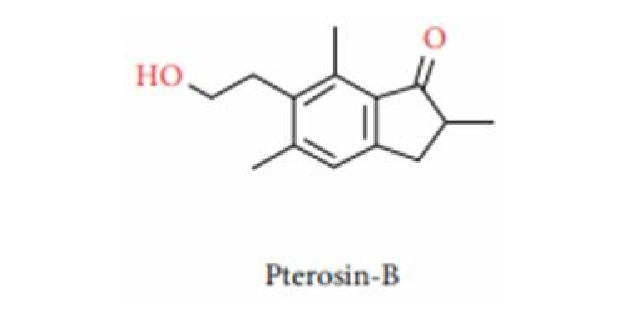
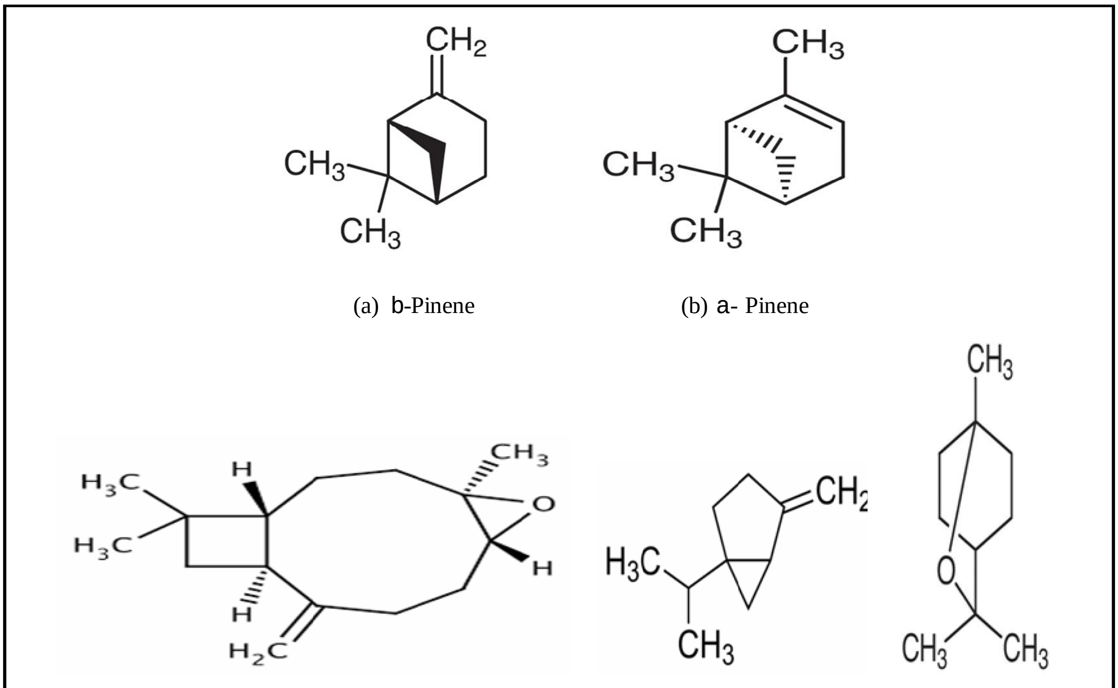


Figure 4: **Phytoconstituents alkaloid (Pterosin B) of *D. esculentum*.**

3.4 Essential oils

Essential oil is an intense aquaphobic liquid that is obtained from plants through mechanical processing, solvent extraction, steam distillation, or maceration. The term “essential” denotes that the oil has a unique scent that is characteristic of the plant (Roy and Chaudhary, 2020). Essential oils are frequently used in soaps, cosmetics, fragrances and other goods that are used to flavour food and beverages. Recently, utilization of essential oils in medicine takes consideration of numerous scientists (Wang *et al*., 2016; Amna and Mardin, 2019).

According to Essien *et al.* (2019) research, main volatile components in the essential oil obtained after extractions of *D. esculentum* leaves, are a-pinene (10.5 per cent), b-pinene (17.2 per cent), sabinene (6.1 per cent), caryophyllene oxide (7.5 per cent), and 1,8-cineole (5.8 per cent) (Figure 5). Sesquiterpene hydrocarbons, nonterpene, monoterpene hydrocarbons, oxygenated monoterpenoids derivatives can all be found in *D. esculentum's* essential oil.



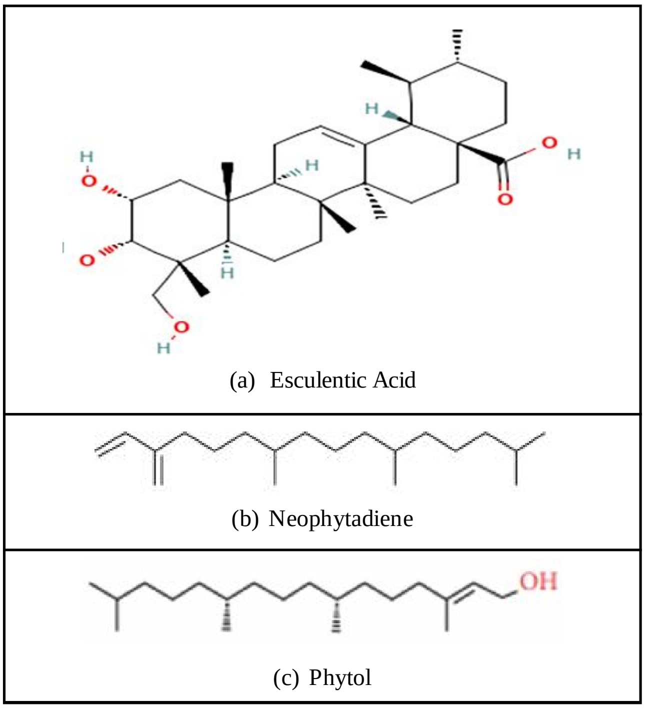
(a) b-Pinene (b) a- Pinene (c) Caryophyllene oxide (d) Sabinene (e) 1 ,8-Cineole

Figure 5: Essential oil constituents (a) b-pinene (b) a-pinene (c) Caryophyllene oxide (d) Sabinene (e) 1, 8-Cineole present in *D. esculentum*.

3.5 Terpene and carotenoids

Esculentic acid, ptaquiloside, phytol and lutein (Figure 6) are two significant putative bioactive components of *D. esculentum* that are being researched (Somvanshi *et al*., 2006; Arancibia *et al*., 2016; Semwal *et al*., 2021). Esculentic acid, a triterpene shown drastically decreased inflammation in rodents. The production of the anti - inflammatory peptides tumour necrosis factor-a and interleukin-6, as well as the inflammatory cytokines nitric oxide and PGE-2 by macrophages and the transcription of the COX-2 receptor in mice are supposed to be reduced by it (Niu *et al*., 2014). Lutein, a carotenoid that has undergone oxygenation, functions as protecting cells from damaging effects of free radicals and antioxidant (Jia *et al*., 2017).

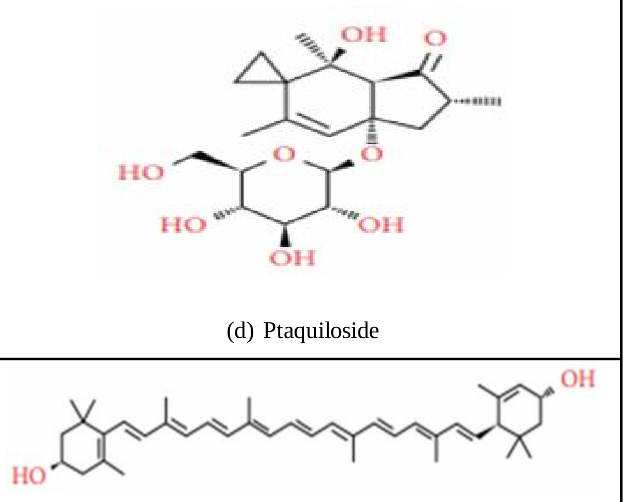
Somvanshi *et al*. (2006) has testified that the Northern India's high-altitude region of Harsil-Gangotri produced *D. esculentum*, which contained 19 mg/kg ptaquiloside. Smith *et al*. (1994) reported that the location of tumours in the rat ileum and the urine bladder of ruminants is thought to be related to the activation of ptaquiloside at alkaline pH. Phytol has cytotoxic, anxiolytic, antioxidant, signalling pathways, analgesic activity, immunomodulatory, pro-inflammation and antibacterial properties (Dash *et al*., 2017; Islam *et al*., 2018).



(a) Esculentic Acid

(b) Neophytadiene

(c) Phytol



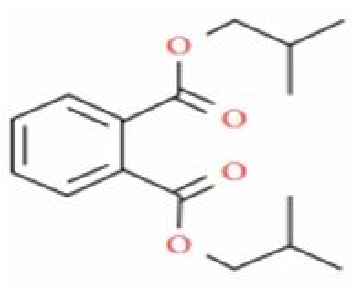
(d) Ptaquiloside

(e) Lutein

Figure 6: Structure of terpenes and carotenoids (a) Esculentic acid, (b) Neophytadiene, (c) Phytol, (d) Ptaquiloside, and (e) Lutein present in *D. esculentum*.

3.6 Phthalic acid

The another most significant bioactive phytoconstituent is pthalic acid (Figure 7). It has already been established that *D. esculentum* contains significant amounts of phthalic acid. Phthalates are phthalic acid diesters that have been shown to increase uterine weight and decrease ovarian weight in female mice (Koniyo *et al*., 2019). Pthalate exposure during pregnancy or lactation changes the expression of steroidogenic genes in the ovary, lowers oestrogen production, decreases ovarian weight and decreases ovulation. Low molecular weight phthalates may also act as hormones, resulting in male infertility, obesity, and diabetes (Lyche, 2017; Roy and Chaudhary, 2020).



Diisobutyl phthalate

Figure 7: Structure of diisobutyl phthalate present in *D. esculentum*.

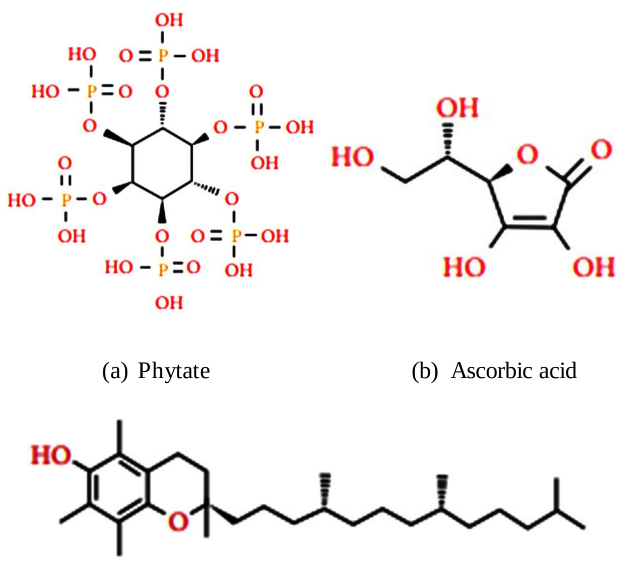
3.7 Saponins and tannins

In addition to these advantageous phytochemicals, *D. esculentum* also contains certain harmful substances, the most significant of which being saponins and tannins from a pharmacological standpoint (Akter *et al*., 2014; Wali *et al*., 2016). According to research, saponins possess remarkable property to coagulate and aggregate RBCs (Okwu, 2004). In methanolic leaf extract of *D. esculentum* contained steroid, saponin, carbohydrate and cardioglycosides. Various reports showed that *D. esculentum*, both raw and cooked, has hemolytic activity since they have the ability to damage cell membranes (Saikia and Upadhyaya, 2011; Das *et al*., 2013). Tannins, on the other hand, prevent the availability of proteins by denaturing them. Tannins are chemicals that can endure high temperatures during boiling because they are heat-resistant. Thus, tannins and other heat-resistant chemicals may be responsible for the harmful effects that *D. esculentum* (Roy *et al*., 2013b).

3.8 Other important constituents

Certain other composites like eriodictyol 5-O-methyl ether 7-O-beta-D-xylosigalactoside, ascorbic acid, a-tocopherol, phytate, tyrosine and hopan-triterpene lactone are also described to be occured in *D. esculentum* (Figure 8) (Hayati *et al*., 2002; Astuti *et al*., 2014; Miean and Mohammed, 2001; Pathania *et al*., 2012; Somvanshi *et al*., 2006; Tongco *et al*., 2014).

Higher intakes of the pentadecanoic acid and heptadecanoic acid which are odd-chain saturated fatty acids, are linked to lower mortality and lower risks of cardiometabolic illnesses (Venn-Watson *et al*., 2020). In contrast, the pharmacological activities of hexadecanoic acid methyl ester are extensive and include antifungal, antioxidant, antibacterial, hypocholesterolemic, nematicide and insecticide properties (Mustapha *et al*., 2016; Arora *et al*., 2017).



(a) Phytate

(b) Ascorbic acid

(c) Alpha-tocopherol

Figure 8: Structure of terpenes and carotenoids (a) Phytate, (b) Ascorbic acid, and (c) Alpha-tocopherol present in *D. esculentum*.

4. Biological applications

Various biological processes for example immunomodulatory, antibacterial, antioxidant, antidiabetic, pro-inflammation effects, may contribute to the therapeutic and preventive benefits of *D. esculentum* (Table 2).

Table 2: Biological activity of *D. esculentum*

1	2	3	4
Antimicrobial activity	**Antidiabetic activity**	**Immunomodulatory activity**	**Antianaphylactic activity**
- Effects on *R. stolonifer*, *C. albicans* and *A. niger* as an antifungal -Antibacterial actions against a variety of microorganisms, including *S. typhi*, *E. coil*, *S. aureus* and *S. arizonae*	-Normalised the serum marker enzymes and lipid profile -Decreased fasting blood glucose levels -Inhibitor action onglucosidase and amylase	-Immunosuppressive impact by lowering T1 and T2 cytokines concentrations -Hemolyticfunction by preventing splenocyte growth	-*In vivo* anaphylactic shock prevention -The prevention of mast cell degranulation
5	**6**	**7**	**8**
Antiinflammatory activity	**CNS stimulant activities**	**Antioxidant activities**	**Other activities**
- Analgesic efficacy in an *in vivo* model of writhing brought on by acetic acid - Inhibited progression of inflamed region -Protection against mast cell degranulation has a preventive effect against *in vivo* anaphylactic shock	-Cause stimulant effect on central nervous system of mice -Inhibiting NADH oxidase and anticholinesterase *in vitro*	- Scavenging activity for free radicals (H_2O_2, OH•, O_2 •–) - Tendency to chelate metals	- Acceleration of the coagulation process - *Pheretima posthuma* was resistant to an anthelmintic -Antitrypanosomal activity against the strain of *Trypanosoma brucei*

4.1 Antioxidant activity

Various researcher reported that *D. esculentum* showed maximum antioxidant activity in *in vitro* model assessed by different antioxidant methods (DPPH, ABTS, FRAP, *etc*.) because of occurrence of flavonoids and phenolic constituents (Roy *et al*., 2013a; Tongco *et al*., 2014; Choudhary *et al*., 2017; Amna and Mardin, 2019; Mamarasulov *et al*., 2020). As describe before, phenolics are significant biological components because of hydroxyl groups present which contribute to scavenging activity (Diplock, 1997). Methanolic isolates of *D. esculentum* holds scavenging activities in contrast to numerous reactive oxygen and nitrogen species (Roy *et al*., 2013a; Akter *et al*., 2014). Besides, *D. esculentum* isolates, also represented by way of lipid peroxidation inhibitors, an iron chelator and influenced reducing power (Cook and Samman, 1996; Sander *et al*., 2011; Roy *et al*., 2013a).

According to Akter *et al*. (2014), *D. esculentum* possess DPPH radical scavenging (IC_{50} = 146:51 mg/ml), hydroxyl radical (IC_{50}= 43:45 mg/ml), superoxide radical (IC_{50} =111:17 mg/ml) and reducing power (IC_{50} = 76:36 mg/ml) and therefore, have strong antioxidant properties. Antioxidant and antibacterial effect of *D. esculentum* is closely correlated with the presence of phenolic and flavonoid component (Kumar *et al*., 2015; Maqsood *et al*., 2014; Thomas and Bindu, 2021). DPPH and nitric oxide methods were employed to evaluate the antioxidant capacity of water-ethanol extracts of *D. esculentum*, the IC_{50} values were observed to be 138.8 and 151.9 mg/ml, respectively (Junejo *et al*., 2018; Nur *et al*., 2018).

4.2 Antimicrobial activities

Now a days, various infective microbes partake antibiotic confrontation therefore, using these antibiotics could have unfavourable impact on health (Sheriff, 2001). As a result, scientists are concentrating on creating herbal-based antibiotic replacements (Das *et al*., 2013; Semwal *et al*., 2021). Ethanolic isolate of *D. esculentum* was assessed for antimicrobial properties. The extract demonstrated significant minimum inhibitory concentration (MIC) values, ranged from 200-800 mg/ml for *Bacillus cereus*, 400 mg/ml for *Escherichia coli* and *Aspergillus ocracus*, and 800 mg/ml for *Bacillus megaterium*, whereas minimum bactericidal concentration from a range of 800 to >800 µg/ml for other bacteria (Mackeen *et al*., 1997; Akter *et al*., 2014).

D. esculentum isolates exhibited antimicrobial activity against *Cryptococcus neoformans, Aspergillus brasiliensis*, showed MIC ranges from 1.6 to 12.5 mg/ml values. *D. esculentum* extract showed antifungal activity using the agar propagation process (Zakaria *et al*., 2010). The methanolic extract showed significant resistance to *Aspergillus niger* and *Rhizopus stolonifera* (Roy and Chaudhari, 2015).

4.3 Diabetes prevention measures

A chronic disorder of protein, lipid and carbohydrate metabolism known as diabetes mellitus causes an increase in blood glycemic levels as a result of impairment of insulin secretion (Irudayaraj *et al*., 2012). It has been claimed that *D. esculentum* exerts its antidiabetic effects *via* inhibiting the enzymes a-glucosidase and a-amylase (Tabianoand Deli, 2014; Ansari and Ahmad, 2019). The finding showed that *D. esculentum* extract had the best inhibitory activity for both a-glucosidase and a-amylase (70.01% and 92.09%, respectively).

Protecting impact of *D. esculentum* extract against streptozocin-(STZ-) induced diabetes were assessed (Junejo *et al*., 2018). The finding demonstrated that the plant isolates at concentration of 500 mg/kg significantly lowered the blood glycemic level in diabetic rats induced by STZ to 50.2 %. Also, a large decrease was observed in rats given plant extracts for lipid profile, serum marker enzyme, beta cells regeneration and necrosis (Junejo *et al*., 2015; Roy *et al*., 2017).

4.4 Immunomodulatory activity

In animal models, *D. esculentum* extracts have been tested for their hemolytic and immunosuppressive properties (Roy *et al*., 2013b). The body weight, relative spleen weight, hematopoietic antibody titrant level and the number of human monocytes all significantly decreased in response to the plant extracts. To put it another way, *D. esculentum* may have immunosuppressive effects (Roy and Chaudhari, 2015). The study's findings showed that when compared to the control, the plant isolate dramatically lowered the levels of Th1 and Th2 mediators. According to another study, boiled *D. esculentum* extract may modify the levels of the cytokines Th1 and Th2 to influence various innate and cell-mediated immune responses (Kumar, 2004).

4.5 Central nervous system stimulating activities

It has been assessed how *D. esculentum* affects cognitive status (You *et al*., 2020). 132 people in total were enrolled in this cross-sectional study. Anthropometric measurements, food history, meal frequency and cognitive performance were evaluated along with sociodemographic data. According to the findings, *D. esculentum* had a 62.9% protective impact against cognitive deterioration. *D. esculentum* methanolic isolate evaluated for its inhibitory effects on NADH oxidase and anticholinesterase activity (Roy *et al*., 2015). In current years, the majority of research have indicated that inhibiting anticholinesterase is an effective technique for treating neuro-degenerative diseases.The finding indicated that the *D. esculentum* methanolic isolate cause inhibition of NADH oxidase and acetyl-cholinesterase with IC_{50} values of 265.81 and 272.97 mg/ml, respectively, in dose dependant manner (Kaushik *et al*., 2012).

4.6 Toxicity effect of *D. esculentum*

D. esculentum methanol and chloroform isolates assessed for their toxic effects with brine shrimp lethal biomarkers. LC_{50} values were recorded 1.62 µg/ml for methanol, 1.87 µg/ml for chloroform and 0.66 µg/ml for vincristine sulphate (Akter *et al*., 2014). Ullah *et al*. (2013) demonstrated that the cytotoxic activity of ethanolic extract of *D. esculentum* in diverse cell lines including colon cancer, hepatocellular carcinoma and no cytotoxic effects were observed. *D. esculentum* systemic toxicity were evaluated and results showed that plant extracts significantly reduced growth, body weight, changes in blood glucose values, haemoglobin, total leukocyte count, including all neutrophils, lymphocyte counts, erythrocyte sedimentation rate on rabbits and guinea pigs (Kumar, 2004). Roy and Chaudhari, (2017) reported the harmful effect of *D. esculentum* on male reproductive system of swiss albino mice.

4.7 Antianaphylactic activity

On swiss albino mice and wistar rats, ethanolic and aqueous extracts of *D. esculentum* were assessed for anti-anaphylactic efficacy and mast cell stability. A noteworthy decrease in the degranulated mast cells was detected in the rats treated with plant extract. The percentage of intact mast cells was 72.83%, 76.67%, 69% and 71.67% for both extracts at dosages of 250 and 500 mg/kg. The plant extracts demonstrated defence against mast cell deterioration (Semwal *et al*., 2021). Additionally, Das *et al*. (2012) reported that plant extract alleviated mast cell membranes then reduced NO levels in serum and peritoneal fluid.

4.8 Acetylcholinesterase inhibitory activity

Acetylcholinesterase inhibition effect of *D. esculentum* is one of the utmost significant properties explored so far. This property describes about the neuroimmune role of the plant. One of the most basic species with a neurological system, the roundworm contains the neurotransmitter acetylcholine, which is widely distributed (Kosinski and Zaremba, 2007; Rakowski *et al*., 2013). The higher importance of acetylcholine is in comprehending the physiological activities of tested medications because any inflammatory implications of acetylcholine inhibitors might affect both the CNS and PNS (Pohanka, 2014). The cholinergic anti-inflammatory mechanism, which is predominately found in blood and mucosa, is closely linked to the cholinergic system. This mechanism serves as a control point between macrophages that express the a7 nicotinic acetylcholine receptor on cell surface and nerve terminations in blood (Pohanka, 2012). The cholinergic anti-inflammtory mechanism can continue to develop by inhibiting acetylcholine due to the presence of bioactive components such as phytol and lutein found in *D. esculentum* (Silva-Herdade and Saldanha, 2013).

4.9 Antiinflammatory activity

D. esculentum extracts was assessed for their ability to reduce inflammation (Zainol *et al*., 2017). In the treated group, *D. esculentum* ethanolic isolate showed anti-inflammatory activity against hind paw edema at concentrations of 125 mg/kg b.w. (71.72%) and 250 mg/kg b.w. (92.60%). Another investigation found that *D. esculentum* had significant analgesic activity when rats were subjected to acetic acid-induced writhing method (Chawla *et al*., 2015).

5. Conclusion

D. esculentum has endured since the Paleozoic era and has adapted to a far wider range of environmental changes. *D. esculentum* is therefore anticipated more beneficial chemical constituents as compare to the other plants. This review concludes that *D. esculentum* fronds are a great foundation of micronutrients like carbohydrates, proteins, lipids, flavonoids, alkaloids, minerals and saponins. Mature fronts may also contain other bioactive medicine with the best commercial potential for usage in healthcare products. We have a long history of utilizing regional plants with medicinal characteristics both in cuisine and for treating illnesses. Although, this wild edible fern is not available throughout the year, dried fronds of *D. esculentum* can be prepared and preserved for later use in the form of various foods like pickles, soups and other dishes. Further study on the prevention of this wild edible fern and appropriate agricultural practices, including its effective reproduction techniques, are required for its long-term use in ensuring the health security of rural and tribal communities. The results of nutraceutical analysis of the fronds are anticipated to spark interest in local traditional vegetables for dietary and health benefits.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

References

Abe, R. and Ohtani, K. (2013). An ethnobotanical study of medicinal plants and traditional therapies on Batan Island, the Philippines. Journal of Ethnopharmacology, **145**(2):554-565.

Akter, S.; Hossain, M. M.; Ara, I. and Akhtar, P. (2014). Investigation of in vitro antioxidant, antimicrobial and cytotoxic activity of *Diplazium esculentum* (Retz.) Sw. International Journal of Advances in Pharmacy, Biology and Chemistry, **3**:723-733.

Ali, A. (2020). Herbs that heal: The philanthropic behaviour of nature. Ann. Phtomed., **9**(1):7-17.

Amna, U. and Mardina, V. (2019). Antioxidant activity of methanol extract of *Diplazium esculentum* (Retz.) Sw. leaves collected from Aceh. In: IOP Conference Series: Materials Science and Engineering, **725**, 3rd Nommensen International Conference.

Amoroso, V.B.; Lagumbay, A.J.; Mendez, R.A.; Dela Cruz, R.Y. and Villalobos, A.P. (2014). Bioactives in three Philippine edible ferns. Asia Life Sciences, **23**(2):445-454.

Ansari, M.H.R. and Ahmad, S. (2019). Herbs that heal: Natural remedies for health promotion and longevity. Ann Phytomed., **8**(1):7-18.

Arancibia, L.A.; Naspi, C.V.; Pucci, G.N.; Arce, M.E. and Colloca, C.B. (2016). Biological activity of 1-heneicosanol isolated from *Senecio coluhuapiensis*, an endemic species from Patagonia, Argentina. The Pharmaceutical and Chemical Journal, **3**(4):73-77.

Archana, G. N.; Pradeesh, S.; Chinmayee, M. D.; Mini, I. and Swapna, T. (2012). *Diplazium esculentum*: A wild nutrient-rich leafy vegetable from Western Ghats. In: Prospects in Bioscience: Addressing the Issues, Springer, pp:293-301.

Arora, S.; Kumar, G. and Meena, S. (2017). Screening and evaluation of bioactive components of *Cenchrus ciliaris* L. by GC-MS analysis. Int. Res. J. Pharm. **8**(6):69-76.

Astuti, M. D.; Kuntorini, E. M. and Wisuda, F. E. P. (2014). Isolasi dan identifikasi terpenoid darifraksi n-butanol herbalampasau (*Diplazium esculentum* Swartz). Jurnal Kimia Valensi, **4**:117-130.

Beluhan, S. and Ranogajec, A. (2010). Chemical composition and non-volatile components of Crotial wild edible mushrooms. Food Chem., **124**:1076-1082.

Chawla, S.; Chawla, S.; Ram, V.; Semwal, A. and Singh, R. (2015). Analgesic activity of medicinally important leaf of *Diplazium esculentum*. African Journal of Pharmacy and Pharmacology, **9**:628-632.

Choudhury, J., Majumdar, S., Roy, S. and Chakraborty, U.(2017). Antioxidant activity and phytochemical screening of two edible wetland pteridophytes *Diplazium esculentum* (Retz.) Sw. and *Marsilea minuta* L.: A comparative study World Journal of Pharmaceutical and Medical Research, **3**:195-203.

Chowdhury, A. (2015). Studies on the diversity and ethnic uses of wetland vascular plants in Terai and Duars of West Bengal, India. Ph. D. Thesis.

Cook, N.C. and Samman, S. (1996). Flavonoids: Chemistry, metabolism, cardioprotective effects, and dietary sources. Journal of Nutritional Biochemistry, **7**:66-76.

Das, A.P.; Ghosh, C.; Sarkar, A.; Biswas, R.; Biswas, K.; Chowdhury, D.; Lama, A. S; Baishakhi, S. and Chowdhury, A. (2010). Preliminary report on the medicinal plants from three MPCAs in Terai and Duars of West Bengal, India. Pleione, **4**(1):90-101.

Das, B.; Paul, T.; Apte, K.; Parab, P.; Chauhan, R. and Saxena, R. (2012). Antianaphylactic and mast cell stabilizing activity of *Diplazium esculentum*(Retz.) on sensitized wistar rats. Inventi Impact Ethnopharmacol, **3**:136-141.

Das, B.; Paul, T.; Apte, K.G.; Chauhan, R. and Saxena, R.C. (2013). Evaluation of antioxidant potential and quantification of polyphenols of *Diplazium esculentum* (Retz.) with emphasis on its HPTLC chromatography. Journal of Pharmacy Research, **6**:93-100.

Das, K. (2019). Authentic identification and new drug discovery from natural plant-based constituents through DNA bar-coding: A challenging task to the researchers. Ann. Phytomed., **8**(2):19-27.

Dash, G.K.; Khadidi, S.K.J. and Shamsuddin, A.F. (2017). Pharmacognostic studies on *Diplazium esculentum* (Retz.) Sw. Der Pharmacia Lettre, **9**(3):113-120.

Devi, T. (2020). Traditional use and role of wild edible fern *Diplazium esculentum* and *Pteridium aquilinum* in socio-economic development of District Mandi of Himachal Pradesh, North Western Himalaya. International Journal of Scientific Research in Biological Sciences,**7**(6):44-50, ISSN: 2347-7520 DOI: https://doi.org/10.26438/ijsrbs/v7i6.4450.

Diplock, A.T. (1997). Will the good fairies please prove to us that vitamin E lessens human degenerative disease? Free Radical Research, **27**:511-532.

Essien, E.; Ascrizzi, R., and Flamini, G. (2019). Characterization of volatile compounds of *Diplazium esculentum*. Chemistry of Natural Compounds, **55**(5):958-959.

Gangwar, N.K. (2004). Studies on the pathological effects of linguda (*Diplazium esculentum*, Retz.) in laboratory rats and guinea pigs. Indian Journal of Veterinary Pathology, **28**:149-50.

Ghanbari, R.; Anwar, F.; Alkharfy, K. M.; Gilani, A.H. and Saari, N. (2012). Valuable nutrients and functional bioactives in different parts of olive (*Olea europaea* L.): A review. International Journal of Molecular Sciences, **13**(3):3291-3340.

Ghasemzadeh, A. and Ghasemzadeh, N. (2011). Flavonoids and phenols: Role in biochemical activity in plants and human. J. Med. Plants Res., **5**:66-97-6703.

Gupta, S.M.; Ballabh, B.; Yadav, P.K.; Agarwal, A and Bala, M. (2020). Analysis of *Diplazium esculentum*: Underutilized Wild Wetland Pteridophytes Ensure Food and Nutritional Security. Acta Scientific Nutritional Health, **4**(11) (ISSN:2582-1423).

Hayati, I. N.; Aminah A.; Mamot S.; Aini, I. N. and Lida H. M. N. (2002). Physical characteristics of modified milkfat in highmelting fat preparation. International Journal of Food Sciences and Nutrition, **53** (1):43-54.

Hirasawa, Y.; Morita, H.; Shiro, M. and Kobayashi, J. (2003). Sieboldine A, a novel tetracyclic alkaloid from *Lycopodium sieboldii*, inhibiting acetylcholinesterase. Organic Lett, **5**:3991-3993.

Irudayaraj, S. S.; Sunil, C.; Duraipandiyan, V. and Ignacimuthu, S. (2012). Antidiabetic and antioxidant activities of *Toddalia asiatica* (L.) Lam. leaves in streptozotocin induced diabetic rats. Journal of Ethnopharmacology, **143**(2):515-523.

Islam, M.T. (2018). Phytol: A review of biomedical activities. Food Chem Toxicol, **121**:82-94.

Jia, Y.P.; Sun, L.; Yu, H.S.; Liang, L.P.; Li, W.; Ding, H.; Song, X.B. and Zhang, L.J. (2017). The pharmacological effects of Lutein and Zeaxanthin on visual disorders and cognition diseases. Molecules, **22**(4):610.

Junejo, J. A.; Ghoshal, A.; Mondal, P. (2015). *In vivo* toxicity evaluation and phytochemical, physicochemical analysis of *Diplazium esculentum* (Retz.) Sw. leaves a traditionally used North-Eastern Indian vegetable. Advances in Bioresearch, **6**(5):412-430.

Junejo, J. G.; Gogoi, G. and Islam, J. (2018). Exploration of antioxidant, antidiabetic and hepatoprotective activity of *Diplazium esculentum* : A wild edible plant from North Eastern India. Future Journal of Pharmaceutical Sciences, **4**(1):93-101.

Kadir, M. F.; Sayeed, M. S. B.; Setu, N. I.; Mostafa, A. and Mia, M. (2014). Ethnopharmacological survey of medicinal plants used by traditional health practitioners in Thanchi, Bandarban Hill Tracts, Bangladesh. Journal of Ethnopharmacology, **155**(1):495-508.

Katoch, R. (2020). Status of Research on Underutilized Crops for Food Security. In: Ricebean. Springer, Singapore. https://doi.org/10.1007/978-981-15-5293-9-2.

Kaushik, A.; Jijta, C.; Kaushik, J. J.; Zeray, R.; Ambesajir, A. and Beyene, L. (2012). FRAP (Ferric reducing ability of plasma) assay and effect of *Diplazium esculentum* (Retz) Sw. (a green vegetable of North India) on central nervous system. Indian Journal of Natural Products and Resources, **3:**228-231.

Khamparia, A.; Saini, G.; Gupta, D.; Khanna, A.; Tiwari, S. and de Albuquerque, V. H. C. (2020). Seasonal crops disease prediction and classification using deep convolutional encoder network. Circuits, Systems, and Signal Processing, **39**(2):818-836.

Koniyo, Y.; Lumenta, C.; Olii, A. H. and Mantiri, R. O. (2019). The characteristic and nutrients concentrated leaves of vegetable fern (*Diplazium esculentum* (Retz.) Swartz) live in different locations. Journal of Physics: Conference Series, **1387**, article 012003.

Koniyo, Y.; Lumenta, C.; Olii, A.; Mantiri, R. and Pasisingi, N. (2021). Nutrition of local wild edible fern (*Diplazium esculentum*) leaves. IOP Conference Series: Earth and Environmental Science, **637**, article 012008.

Kosinski, R.A. and Zaremba, M. (2007). Dynamics of the model of Caenorhabditis elegans neural network. Acta. Phys. Pol. B: 2201-2210

Kumar, G. N. (2004). Studies on pathological effects of linguda (*Diplazium esculentum*, Retz.) in laboratory rats and guinea pigs. Indian Journal of Veterinary Pathology, **28:**149.

Kumar, Y.; Yadav, D. N.; Ahmad, T. and Narsaiah, K. (2015). Recent trends in the use of natural antioxidants for meat and meat products. Comprehensive Reviews in Food Science and Food Safety, **14**(6):796-812.

Kutum, A.; Sarmah, R. and Hazarika, D. (2011). An ethnobotanical study of Mishing tribe living in fringe villages of Kaziranga National Park of Assam, India. Indian Journal of Fundamental and Applied Life Sciences, **1:**45-61.

Lense, O. (2016). Biological screening of selected traditional medicinal plants species utilized by local people of Manokwari, West Papua Province. Nusantara Bioscience, **3**(3):303-315.

Lyche, J. L. (2017). Phthalates. In: Reproductive and Developmental Toxicology (Second Edition), Academic Press, pp:829-856

Ma, X. and Gang, D.R. (2004). The Lycopodium alkaloids. Nat. Prod. Reports, **21:**752-772.

Mackeen, M.; Ali, A. and El-Sharkawy S. (1997). Antimicrobial and cytotoxic properties of some Malaysian traditional vegetables (ulam). International Journal of Pharmacognosy, **35**(3):174-178.

Mamarasulov, B.; Davranovu, K. and Jabborova, D. (2020). Phytochemical, pharmacological and biological properties of *Ajuga turkestanica* (Rgl.) Brig (Lamiaceae). Ann. Phytomed. **9**(1):44-57.

Mandal, S.M.; Chakraborty, D. and Dey, S. (2010). Phenolic acids act as signaling molecules in plant microbe symbioses. Plant Signal. Behav., **5**:359-368.

Manickam, V. and Irudyaraj, V. (2003). Pteridophytic flora of Nilgiris South India, Bishen Singh Mahendra Pal Singh, Dehradun.

Maqsood, S.; Benjakul, S.; Abushelaibi, A. and Alam, A. (2014). Phenolic compounds and plant phenolic extracts as natural antioxidants in prevention of lipid oxidation in seafood: A detailed review. Comprehensive Reviews in Food Science and Food Safety, **13**(6):1125-1140.

Miean, K. H. and Mohamed, S. (2001). Flavonoid (myricetin, quercetin, kaempferol, luteolin, and apigenin) content of edible tropical plants. Journal of Agricultural and Food Chemistry, **49 (**6):3106-3112.

Muhammad, G.; Hussain, M. A.; Jantan, I. and Bukhari, S. N. A. (2016). *Mimosa pudica* L., a high-value medicinal plant as a source of bioactives for pharmaceuticals. Comprehensive Reviews in Food Science and Food Safety, **15**(2):303-315.

Mustapha, N.; Abubakar, L. and Majinda, R.T. (2016). GC-MS analysis and preliminary antimicrobial activity of *Albizia adianthifolia* (Schumach) and *Pterocarpus angolensis* (DC). Medicine, **3**(3):111.

Naik, B.; Maurya, V. K.; Kumar, V.; Kumar, V.; Upadhyay, S. and Gupta, S. (2021). Phytochemical analysis of *Diplazium esculentum* reveals the presence of medically important components. Current Nutrition and Food Science, **17**(2):210-215.

Niu, X.; Mu, Q.; Li, W.; Yao, H.; Li, H.; Li, Y.; Hu, H. and Huang, H. (2014). Protective effects of esculentic acid against endotoxic shock in Kunming mice. International Immunopharmacology, **23**(1):229-235.

Nur, A.; Khairul, F.; Nuradibah, M. and Noor, S. (2018). Optimization of *Diplazium esculentum* extract using pressurized hot water extractor by Box-Behnken design of experiments and its antioxidative behaviour. IOP Conference Series: Materials Science and Engineering, **429**, article 012064.

Okwu, D.E. (2004). Phytochemical and vitamin content of indigenous spices of South Eastern Nigeria. J. Sustain. Agric. Environ., **6**:30-34.

Pande, P.C and Pande, H.C. (2003). An illustrated Fern Flora of Kumaon Himalaya, Vol. I. xvi, 372 p, plates, ISBN: 8121103711.

Pathania, S.; Kumar, P. and Singh, S. (2012). Detection of ptaquiloside and quercetin in certain Indian ferns. Current Science, **102 (**12):1683-1691.

Pohanka, M. (2012). Alpha7 nicotinic acetylcholine receptor is a target in pharmacology and toxicology. Int. J. Mol. Sci., **13:**2219-2238.

Pohanka, M. (2014). Inhibitors of acetylcholinesterase and butyrylcholinesterase meet immunity. Int. J. Mol. Sci., **15:**9809-9825.

Rakowski, F.; Srinivasan, J.; Sternberg, P.W. and Karbowski, Jra. (2013). Synaptic polarity of the interneuron circuit controlling *C. elegans* locomotion. Front. Comput. Neurosci., **7**:128.

Roy, S. and Chaudhuri, T. K. (2017). Toxicological assessment of Diplazium esculentum on the reproductive functions of male Swiss albino mouse. Drug and Chemical Toxicology, **40**(2):171-182.

Roy, S. and Chaudhuri, T. K. (2020). A comprehensive review on the pharmacological properties of *Diplazium esculentum*, an edible fern. J. Pharmaceutics and Pharmacology Research, **3**(1); DOI: 10.31579/2693-7247/014.

Roy, S. and Choudhuri, T.K.(2013b). Toxicological assessment of *Diplazium esculentum* on the reproductive functions of male Swiss albino mouse. Dr. Chem. Toxicol., **40**(2):171-182.

Roy, S.; Dutta, S. and Chaudhuri, T. K. (2015). *In vitro* assessment of anticholinesterase and NADH oxidase inhibitory activities of an edible fern, *Diplazium esculentum*. Journal of Basic and Clinical Physiology and Pharmacology, **26**(4):395-401.

Roy, S.; Tamang, S.; Dey, P. and Chaudhuri, T. K. (2013a). Assessment of the immunosuppressive and hemolytic activities of an edible fern, *Diplazium esculentum*. Immunopharmacology and Immunotoxicology, **35**(3):365-372.

Saikia, L.R. and Upadhyaya, S. (2011). Antioxidant activity, phenol and flavonoid content of some less known medicinal plants of Assam. Int. J. Pharmacol. Bio. Sci., **2**:383-388.

Sandhar, H.K.; Kumar, B.; Prasher, S.; Tiwari, P.; Salhan, M. and Sharma, P. (2011).A review of phytochemistry and pharmacology of flavonoids. Internationale Pharmaceutica Sciencia. **1**:25-41.

Sarkar, B.; Basak, M.; Chowdhury, M. and Das, A. (2018). Importance of *Diplazium esculentum* (Retz.) Sw. (Athyriaceae) on the lives of local ethnic communities in Terai and Duars of West Bengal-A report. Plant Archives, **18**:439-442.

Sarkar, P. and Dalal, A. (2016). Evaluation of antioxidant activity of *Diplazium esculentum* and *Enhydra fluctuans* of West Bengal. IOSR Journal of Pharmacy and Biological Sciences, **11**(6):45-50. DOI: 10.9790/3008-1106014550.

Semwal, A.S. (2012). MF *In vitro* anthelmintic activity of *Diplazium esculentum* (Retz.) Swiss rhizome extract. Journal of Pharmacognosy and Phytochemistry, **1**:84-87.

Semwal, P.; Painuli, S.; Kartik, M.; Painuli; Antika, G.; Tumer, T.B.; Thapliyal, A.; Setzer,W.N.; Martorell, M.; Alshehri, M. M.; Taheri, Y.; Da°tan, S.D.; Petkoska, A.T.; Sharifi-Rad, J and William, C.C. (2021). *Diplazium esculentum* (Retz.) Sw.: Ethnomedicinal, phytochemical, and pharmacological overview of the Himalayan Ferns. Oxidative Medicine and Cellular Longevity, **15**https://doi.org/10.1155/2021/1917890

Sheriff, Z. (2001). Modern Herbal Therapy for Common Ailments. In: Nature Pharmacy Series Vol. 1. Spectrum Book Limited, Ibadan, Nigeria in Association with Safari Books (Export) Limited, UK: 9-84.

Shukla, G.; Biswas, R.; Das, A.P. and Chakravarty, S. (2013). Visual qualitative description of a humid tropical foothill forest in Indian eastern Himalayas. Biodiversity, **14**(3):133-146.

Silva Herdade, A.S. and Saldanha, C. (2013). Effects of acetylcholine on an animal mode of inflammation. Clin. Hemorheol. Microcirc., **53**:209-216.

Singh, D. and Singh, S. (2021). Phytomedicine: Alternative safe vehicles on the pathway of diabetes mellitus. Ann. Phytomed., **10**(1):114-122.

Somvanshi, R.; Lauren, D. and Smith, B. (2006). Estimation of the fern toxin, ptaquiloside, in certain Indian ferns other than bracken. Current Science, **102**(12):1547-1552.

Srivastava, S.; Srivastava, S.; Saksena, V. and Nigam, S. (1981). A flavanone glycoside from *Diplazium esculentum*. Phytochemistry, **20**(4):862.

Sudha, P.; Awasthi, C.P. and Singh, A.B. (1999). Biochemical composition of Lungru (*Diplazium esculentum*) of Palam Valley of Himachal Pradesh. Vegetable Sci., **26**(2):183-185.

Tabiano, J. and Deliman, Y. (2014). *In vitro* inhibitory activity of *Atuna racemosa*, *Euphorbia hirta* and *Diplazium esculentum* juices against a-amylase and a-glucosidase. International Seminar on Science and Technology, pp:89.

Tangco J. V. V.; Villaber, R. A. P.; Aguda, R. M. and Razal, R. A. (2014). Nutritional and phytochemical screening, and total phenolic and flavonoid content of Diplazium esculentum (Retz.) Sw. from Philippines. Journal of Chemical and Pharmaceutical Research, **6**:238-242.

Thomas, A. and Bindu, P. K. (2021). Assessment of nutritional relevance of *diplazium esculentum* by qualitative phytochemical and overall protein profiling. Plant Archives, **21**(2):137-142.

Ullah, M. O.; Haque, M. and Urmi, K. F. (2013). Antibacterial activity and brine shrimp lethality bioassay of methanolic extracts of fourteen different edible vegetables from Bangladesh. Asian Pacific Journal of Tropical Biomedicine, **3**(1):1-7.

Venn-Watson, S.; Lumpkin, R. and Dennis, E.A. (2020). Efficacy of dietary odd-chain saturated fatty acid pentadecanoic acid parallels broad associated health benefits in humans: Could it be essential? Scientific Reports. **10**:8161.

Wali, A.; Sharma, S. and Walia, M. (2016). Two edible ferns of Western Himalaya: A comparative *in vitro* nutritional assessment, antioxidant capacity and quantification of lutein by UPLC-DAD. International Journal of Food and Nutritional Sciences, **5**:9.

Watanabe, M.; Miyashita, T. and Devkota, H. P. (2021). Phenolic compounds and ecdysteroids of *Diplazium esculentum* (Retz.) Sw. (Athyriaceae) from Japan and their chemotaxonomic significance. Biochemical Systematics and Ecology, **94**, article 104211.

You, Y. X.; Shahar, S.; Haron, H.; Yahya, H. M. and Din, N. C. (2020). Relationship between traditional Malaysian vegetables (Ulam) intake and cognitive status among middle-aged adults from lowcost residential areas. Jurnal Sains Kesihatan Malaysia (Malaysian Journal of Health Sciences), **17**.

Zainol, N.A.; Aziz, H.A and Lutpi, N.A. (2017). *Diplazium esculentum* leaf extract as coagulant aid in leachate treatment. Proceedings of AIP Conference Proceedings, **1835**(1): article 020034.

Zakaria, Z.; Sanduran, S. and Sreenivasan S. (2010). Antifungal activity of the edible ferns: Application for public health. 14 Oxidative Medicine and Cellular Longevity International Journal of the Humanities, **8** (8):113-118.

Zannah, F.; Amin, M.; Suwono, H and Lukiati, B. (2017). Phytochemical screening of Diplazium esculentum as medicinal plant from Central Kalimantan, Indonesia. 2017, AIP Conference Proceedings, **1844:** article 050001.

Citation **Arti Ghabru, Neerja Rana and Shivani Chauhan (2022). Nutraceutical benefits of Himalayan Fern (*Diplazium esculentum* (Retz.) Sw.). Ann. Phytomed., 11(2):82-91. http://dx.doi.org/10.54085/ap.2022.11.2.9.**