Eco. Env. & Cons. 30 (3) : 2024; pp. (1191-1205)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i03.035

Perilla frutescens (L.) Britton: A review on phytochemical profile, biological potential, traditional applications, and future prospects

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(Received 27 December, 2023; Accepted 20 February, 2024)

ABSTRACT

Perilla frutescens (L.) Britton an annual herb in the mint family (Lamiaceae), is predominantly cultivated in countries like China, Japan, India, Thailand, and Korea. The *Perilla* plant has recently garnered increased attention due to its medicinal benefits and rich phytochemical content. Key phytochemical compounds found in this species include phenolic compounds (such as rosmarinic acid, caffeic acid, and ferulic acid), flavonoids (including luteolin and apigenin), phytosterols, tocopherols, policosanols, and fatty acids. *Perilla* seed oil stands out as a notable source of essential fatty acids, particularly alpha-linolenic acid (54-64%) and linoleic acid (14%). Traditional nutritional and medicinal practices have widely incorporated *Perilla* seeds and oils. Biological analysis of *Perilla* seeds has demonstrated their potential in exhibiting anticancer, antidiabetic, antiasthma, antimicrobial, anti-inflammatory, antioxidant, and cardio-protective effects. This review aims to present an updated perspective on the nutritional composition, phytochemical profile, and pharmacological research associated with *Perilla* seed.*Perilla* plant, owing to its varied phyto-constituents. *Perilla* exhibits potential in addressing non-communicable diseases and can be employed as a key element in crafting various functional foods.

Key words: *Lamiaceae, Perilla seed, Phenolic acids, Flavonoids, Anthocyanins, and linolenic acid.*

Introduction

Bhangjeera,*Perilla frutescens* (L.) Britton, family Lamiaceae, is an annual herb native to Asian countries. The plant is used as medicinal and edible purposes mostly in eastern world countries (Kurowska *et al*., 2003; Axtell and Fairman, 1992). *Perilla* is less known in other parts of the world, and there is no appreciable acreage. *Perilla* is a annual herb that reaches a height of up to 150 cm, featuring glossy green or purple, softly hairy, ovate to round leaves, a square stem, and small tubular flowers that range from purplish to white in color, 3-4 mm in length, flower-stalks length are about 1.5 mm, calyx is about 3 mm with brown seeds (Bachheti *et al*., 2014).

As a significant crop for the economy, the growing of *Perilla* is more than 2000 years of history in China as well as other countries in Asia (Lee and Ohnishi, 2001, 2003; Lee and Kim, 2007). The seed of *P. frutescens* is the important source of *Perilla* oil and

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the fresh plant is a spicy vegetable in East Asia. According to traditional Chinese medicine, the plant is used to treat fish and crab sickness. People utilize *Perilla* to create pickles and package with roast meat in Japan and Korea, respectively, and use it as a representative flavor in Japanese cuisine (Yu *et al*., 2017).

Whole plant of *Perilla* especially seeds, stems, and leaves have 271 different phytochemical substances that have been identified and documented so far.Plants are rich in phytosterols, tocopherols, squalene, and polyunsaturated fatty acids (Ciftci *et al*., 2012). Some important phytochemicals are Rosmarinic acid, Luteolin, Chrysoeriol, Quercetin, Catechin, Caffeic acid and Ferulic acid (Peng *et al*., 2005; Meng *et al.,* 2009; Sargi *et al*., 2013; Zhang *et al*., 2012).

The leaves of *Perilla* are one of the most popular garnishes in Asian countries where they are also used in folk Medicine (Zhang *et al.,* 2012; Meng *et al*., 2009). A decoction of *Perilla* leaves were used against some ailments such as cold, cough, indigestion (Duke, 1985).Biological analysis of *Perilla* plant revealed that this plant showed anti-microbial, anti-allergic, anti-cancer, anti-tumor, anti-depression, anti-viral, anti-asthmatic, antioxidant activities and immune-modulatory action (Ueda *et al*., 1997; Zekonis *et al*., 2008). While it is used as functional food in many places of the world, it is still an under utilized crop in others where it has no organized system for cultivation despite its many uses and benefits (Chauhan *et al*., 2014).

After examining various reviews on *P. frutescens* literature, the present review was crafted with meticulous attention to enhancing its pharmacological content through the integration of insights derived from other reviews. The primary aim of this review is to provide an up-to-date summary of the *Perilla* phytochemical profile, therapeutic values, traditional applications and biological potential.

Phytochemical constituents

Whole plant of *Perilla* constitutes active phyto-constituents which can be categorized as hydrophilic (phenolic acids, flavonoids, and anthocyanins) or hydrophobic (lipophilic) depending on their chemical properties (volatile substances, triterpenes, phytosterols, fatty acids, tocopherols, and policosanols). The constituents of *Perilla* include apigenin, ascorbic acid, beta-carotene, caffeic acid, citral, dillapiol, elemicin, limonene, luteolin, myristicin, perillaldehyde, protocatechuic acid, quercetin, rosmarinic acid, *Perilla* ketone, elsholzia ketone, isoegomaketone, naginata ketone, and safrole. Rosefurane, found in *Perilla*, shows promise as a potentially more economical substitute for rose oil in perfume formulations.Minor constituents are linalool, β-caryophyllene, lmenthol, α-pinene, perillene (2-methyl-5-(3-oxolanyl)-2-pentene), and elemicin.

Perilla seeds contain a drying oil (40%) with high content of multiple unsaturated fatty acids (60% á-linolenic acid and 15% both linoleic and oleic acid); their medicinal valuable phenolic compounds are the natural bioactive molecules formed by the secondary metabolism of plants. They are responsible for pigmentation, astringency and also act as protective agents against UV light, besides protecting the plants against parasite and insects (Heleno *et al*., 2015). *Perilla* possesses pseudotannins and antioxidants characteristic of the mint family. The reddish-purple color of some cultivars is caused by an anthocyanin pigment called perillanin chloride. All phytochemical are listed in Table 1 to 9 and their structures are displayed.

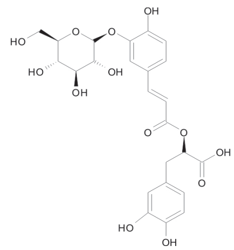
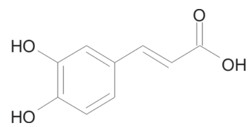
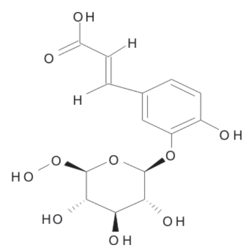
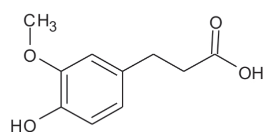
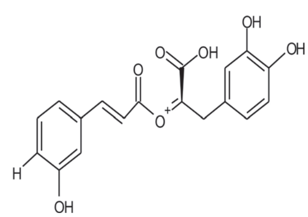
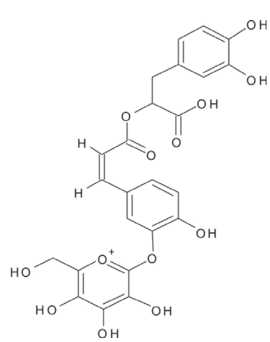
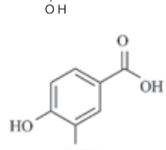
Phenolic compound

The seeds of *P. frutescens* contain various phenolic compounds, including rosmarinic acid, methyl rosmarinic acid, rosmarinic acid-3-O-glucoside, 32-dihydroxyl-rosmarinic acid-3-O-glucoside, caffeic acid, caffeic acid-3-O-glucoside, vanillic acid, ferulic acid, and cimidahurinine (Ha *et al*., 2015). In *P. frutescens* stems, caffeic acid and its derivatives are prevalent, particularly ethyl caffeate, methyl caffeate, vinyl caffeate, and protocatechuic aldehyde (Hou *et al*., 2022) (Table 1).

Flavonoids

Flavonoids are naturally occurring phenolic compounds exhibit a distinctive phenylbenzopyran chemical structure, featuring a general composition comprising a C15 (C 6-C, 3-C 6) skeleton connected to a chroman ring (benzopyran moiety). Based on the positioning of the aromatic ring relative to the benzopyran moiety, flavonoids can be categorized into four classes: major flavonoids (2-phenylbenzopyrans), isoflavonoids (3-benzopyrans), neoflavonoids (4-benzopyranes), and minor flavonoids. These compounds are ubiquitously present in plants across diverse species (Cotelle *et al*., 1996; Asif, 2012). Increasingly, flavonoids are recognized for various beneficial prop-

Table 1. List of important phenolic compounds found in *Perilla* plants

S. N.	Compounds	Chemical structure	Plant organ	References
1	Rosmarinic acid 3-O glucoside		Seeds	Zhou *et al*., 2014
2	Caffeic acid		Leaves, Seeds	Zhou *et al*., 2014; Meng *et al*., 2008; Peng *et al*., 2005; Kang *et al*., 2011
3	Caffeic acid 3-O glucoside		Seeds	Zhou *et al*., 2014; Ha *et al*., 2012
4	Ferulic acid		Leaves,Seeds	Peng *et al*., 2005
5.	Rosmarinic acid		Stem, Leaves, Seed	Zhou *et al*., 2014; Liu *et al*., 2013; Ha *et al*., 2012; Meng *et al*., 2008; Peng *et al*., 2005; Gu *et al*., 2009;Yamazaki *et al*., 2003;Kang *et al*., 2011
6	Rosmarinic acid 3-O glucoside		Seeds	Zhou *et al*., 2014; Ha *et al*., 2012
7	Vanillic acid		Seeds	Zhou *et al*., 2014

erties, encompassing anti-inflammatory, estrogenic, enzyme inhibition, antimicrobial, antiallergic, vascular, and cytotoxic antitumor activities, with antioxidant activity (AA) being the most extensively studied among them (Meng *et al*., 2009; Pereira *et al*., 2009; Aron and Kennedy, 2008). Some flavonoid classes with potent molecules are employed for treating pathologies unrelated to antioxidant activity. Isoflavones, with their established estrogen-like capacity, are utilized similarly to estrogen for conditions where an agonistic effect on estrogen receptors is beneficial, such as menopause (Dixon and Ferreirra, 2002). Flavonoids reported in *Perilla* plants are listed in Table 2.

Anthocyanins

Anthocyanins constitute a category of water-soluble flavonoids found abundantly in leaves and stem of *Perilla* plant formed through the phenylpropanoid pathway. The six predominant anthocyanidins are cyanidin, delphinidin, malvidin, peonidin, petunidin, and pelargonidin. The health benefits of anthocyanins are particularly in preventing diseases linked to oxidative stress, such as cardiovascular and neurodegenerative conditions, and an influence on gut microbiota modulation (Mattioli *et al.,* 2020; Liu *et al.,*2018 and Khoo *et al*., 2017). Important anthocyanins present in *Perilla* plants are listed in Table 3.

Terpenes

Terpenes and terpenoids in particular have a variety of biological properties, including anticancer, antibacterial, anti-inflammatory, antioxidant, and antiallergic (Masyita *et al*., 2022). Some of common terpenes and terpenoids present in *Perilla* plants are as follows in Table 4.

Phytosterol

Phytosterols are natural plant compounds,reduce blood cholesterol levels by interfering with the absorption of cholesterol from the gut (Klingberg *et al.*, 2008; Calpe-Berdiel *et al*., 2009; Jones, 1999; Hayes *et al*., 2004; Jia *et al*., 2007; Varady *et al.,* 2007; Jones *et al*., 1997, 1999; Marinangeli *et al*., 2006). In addition to decreasing cholesterol, growing data suggests that phytosterols have anti-cancer properties that protect against stomach cancer, lung cancer, and other types of cancer (Choi *et al*., 2007), ovary (McCann *et al*., 2003) and estrogen-dependent human breast cancer (Ju *et al.,* 2004). Some of the important phytosterols found in *Perilla* plant are listed in Table 5.

Fatty acid

Edible vegetable oils serve as the primary source of essential fatty acids in the human diet. *Perilla* seed oil stands out for its elevated levels of polyunsaturated fats compared to other cooking oils. Derived from the oil seed crop *Perilla,* it is particularly rich in omega-3 and omega-6 polyunsaturated fatty acids and minerals (Gwari *et al*., 2014). The fatty acid composition in the oils, determined through Gas Chromatography (GC), revealed three predominant fatty acids: α-linolenic acid (C18:3 n-3), linoleic acid (C18:2 n-6), and oleic acid (C18:0). These fatty acids exhibited varying ranges, with 51.2-63.3%, 12.2-18.6% and 11.9-23.8% of the total FA's, respectively (Table 6, 7). Gwari *et al*. (2014) represented that *Perilla* oil contains a higher amount of linoleic and linolenic acid as compared to linseed, sesame, mustard, soya and sunflower (Kiralan *et al*., 2010; Longvah and Deosthale, 1991; Nzikou *et al*., 2009). Earlier reports from Italy revealed the presence of α-linolenic acid, linoleic acid and palmitic acid which ranged from 52.0-55.0%, 11.5-12.1% and 8.5-9.7%, respectively (Peirett, 2011). It is widely acknowledged that both omega-3 and omega-6 fatty acids play a significant role in lowering cholesterol levels, reducing triglyceride content in the bloodstream, and are also utilized in the treatment of cancer.

Tocopherol

The primary lipid-soluble element of the cell's antioxidant defense mechanism, vitamin E (tocopherol), can only be found in food. Because of its antioxidant activity, it plays a variety of significant roles in the body and protect the body against diseases, including cancer, aging, arthritis, and cataracts. The alpha, beta, gamma, and delta classes of tocopherol and tocotrienol, which are produced by plants, are the eight naturally occurring forms of vitamin E (Chow, 1975).

Studies conducted by researchers on the composition of seed oil from *Perilla* in various countries revealed variation in percentage of different compounds (Table 9).

Biological Activities

Anti-Asthmatic Activity

In China, *Perilla* is a significant component in various traditional remedies employed for managing

Table 2. List of common flavonoid compound found in different plant parts with their chemical structure

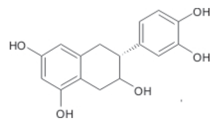
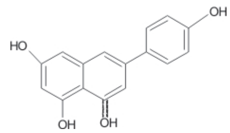
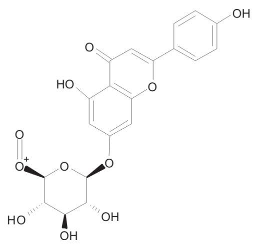
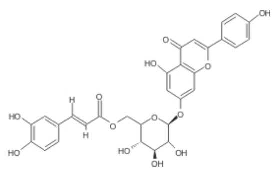
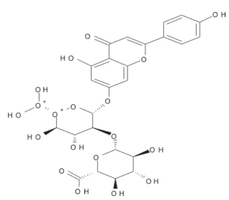
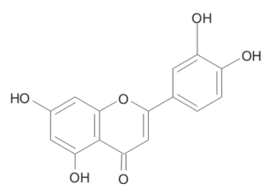
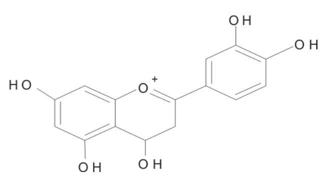
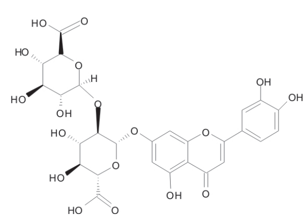
S. No	Compounds	Chemical structure	Plant organ	References
1	Catechin		Leaves, Seeds	Peng *et al*., 2005
2	Apigenin		Leaves, Seeds	Zhou *et al*., 2014; Ha *et al*., 2015; Peng *et al*., 2005; Gu *et al*., 2009
3	Apigenin 7-O glucuronide		Leaves	Yamazaki *et al*., 2003
4	Apigenin 7-O Caffeoylglucoside		Leaves	Meng *et al*., 2008; Yamazaki *et al*., 2003
5	Apigenin 7-O diglucuros		Leaves	Meng *et al*., 2008; Yamazaki *et al*., 2003
6	Chrysoerial		Seeds	Gu *et al*., 2009
7	Luteolin		Leaves, Seeds	Zhou *et al*., 2014; Ha *et al*., 2015; Peng *et al*., 2005; Gu *et al*., 2009
8	Luteolin 7-O diglucuronide		Leaves	Meng *et al*., 2008; Yamazaki *et al*., 2003

Table 2. *Continued ...*

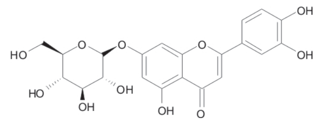
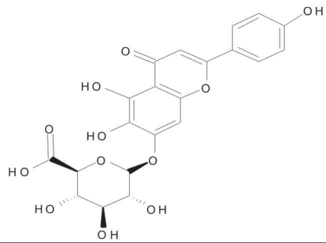
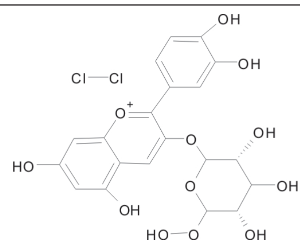
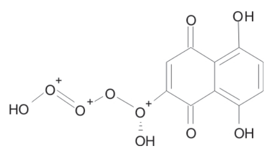
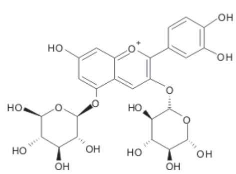
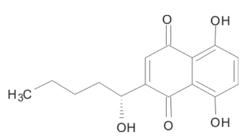
S. No	Compounds	Chemical structure	Plant organ	References
9	Luteolin 7-0-glucoside		Leaves	Yamazaki *et al*., 2003
10	Scutellarein		Leaves	Meng *et al*. (2008), Yamazaki *et al*. (2003)

Table 3. List of anthocyanins present in *Perilla* plant

S.N.	Compounds	Chemical structure	Plant organs	References
1	Chrysontenin		Leaves	Kang *et al*. (2011)
2	cis-shisonin		Leaves	Meng *et al*. (2008)
3	Cyanin		Leaves, stem	Kang *et al*. (2011)
4	Shikonin		Leaves	Meng *et al*. (2018); Yamazaki *et al*. (2003)

asthma due to the presence of the flavone luteolin, which imparts a relaxant effect on the smooth muscles of the trachea (Ko *et al*., 2005). Dietary interventions play a crucial role in reducing allergic responses associated with asthma, including the levels of serum OVA-specific immunoglobulin1 and total immunoglobulin-A antibodies. A clinical investigation involving asthma patients demonstrated that *Perilla* seed oil enhances pulmonary function and suppresses the release of leukotriene LB4 and LC4 from leucocytes, which are implicated in asthma (Ko *et al*., 2005 and Okamoto *et al*., 2000).

Anti-Diabetic activity

A study carried out on the anti-diabetic effect of *Perilla* seed sprouts in type 2 diabetes mice model revealed that the supplementation of *Perilla* seed (100,300, and 1,000 mg/kg of body weight) sprouts

Table 4. Important terpenes reported in *Perilla* Plant

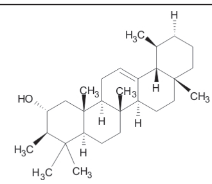
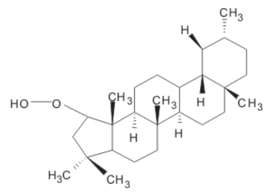
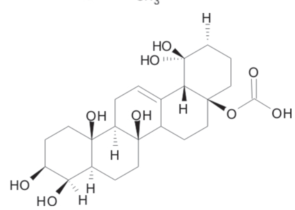
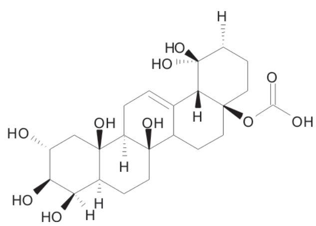
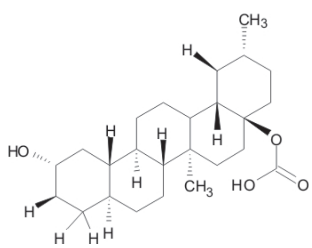
S.N.	Compounds	Chemical Structure	Plant Organs	References
1	Corosolic acid		Leaves	Banno *et al.*, 2004
2	Hyptadiemic acid		Leaves	Banno *et al.*, 2004
3	Pomolic acid		Leaves	Banno *et al.*, 2004
4	Tormentic acid		Leaves	Chen *et al.*, 2020; Banno *et al.*, 2004
5	Ursolic acid		Leaves	Chen *et al.*, 2020; Banno *et al.*, 2004

Table 5. List of important phytosterols reported in *Perilla* plants

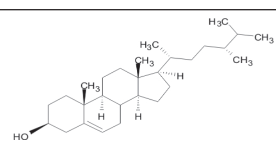
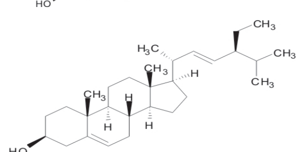
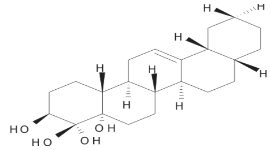
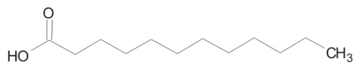
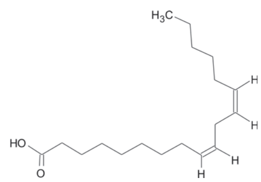
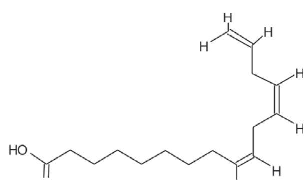
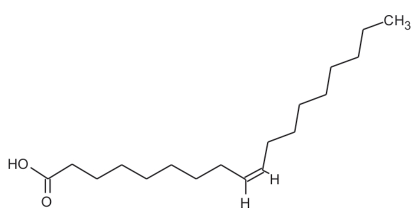
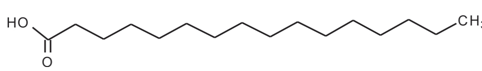
S.N.	Compounds	Chemical Structure	Plant Organs	References
1	Campesterol		Seeds	Kim *et al.*, 2012
2	Stigmasterol		Leaves	Kim *et al.*, 2012
3	β-Amyrin		Seeds	Kim *et al.*, 2012

Table 6. Fatty acid composition of *Perilla frutescens* seed oil compared to other seed oils

Components	Perilla	Linseed	Sesame	Sesame	Soya	Sunflower
C16:0 Palmitic	6.0-11.0	5.5-7.0	8.6-9.7	2.9-4.51	9.8-14.04	6.52-7.8
C18:0 Stearic	2.1-5.5	3.5-4.0	2.4-5.5	0.9-2.78	2.4-4.07	1.98-2.1
C18:1 Oleic	11.9-23.8	15.0-22.1	28.9-38.9	8.9-38.21	23.27-28.9	17.7-45.39
C18:2 Linoleic	12.2-18.6	18.0-20.5	46.2-50.7	18.1-25.31	50.7-52.18	46.02-78.5
C18:3 Linolenic	51.2-63.3	47.5-56.0	1.0-6.5	11.30-14.5	5.63-6.5	-

Table 7. Important fatty acids reported in *Perilla* plant with its structure

S.N.	Fatty Acids	Structure of fatty acids	Parts of Plants	References
1	Lauric acid		Seeds	Liu *et al.*, 2012
2	Linoleic acid		Seeds	Asif *et al.*, 2011; Liu *et al.*, 2012; Kim *et al.*, 2012 Longvah *et al.*, 2009; Kim *et al.*, 2007; Schantz *et al.*, 2013
3	Linolenic acid		Seeds, leaves	Ding *et al.*, 2012; Schantz *et al.*, 2013
4	Oleic acid		`Seeds	Liu *et al.*, 2012; Kim *et al.*, 2012; Kim *et al.*, 2007; Schantz *et al.*, 2013; Longvah *et al.*, 2000
5	Palmitic acid		Seeds, leaves	Asif *et al.*, 2011; Huang *et al*,, 2011; Liu *et al.*, 2012; Kim *et al.*, 2012; Longvah *et al.*, 2000; Kim *et al.*, 2007; Schantz *et al.*, 2013

decreased body weight and serum triacylglyceride level; improved hyperglycemia, glucose tolerance and insulin resistance; induced AMP-activated protein kinase (AMPK) activation and regulated gluconeogenesis. In another study, chlorogenic acid and rosmarinic acid are identified as Aldose reductase enzyme inhibitor in an ethyl acetate soluble fraction of methanol extract of *Perilla*, which reduces the diabetic complications. Additionally the effect of *Perilla* oil supplementation on gut microbiota was studied in diabetic KKAy mice for 12 weeks. It was found that *Perilla* oil supplementation significantly reduced the microflora blautia, which is a gram positive its anaerobic bacterium and responsible for glucose metabolism disturbances and increased the microflora *Lactobacillus*, which considered to be a beneficial bacteria as it converts sugars to lactic acid. Wang *et al*. (2018) conducted a study on the in vivo hypoglycemic effects of *P. frutescens* leaf, a plant traditionally recognized as both a medicine and food. Additionally, the ethyl acetate fraction exhibited notable inhibition against acetylcholinesterase and tyrosinase.

Anti-depressant activity

Perilla is a crucial component in various antidepressant drugs such as Hange-kouboku-to, Saiboku-to, SYJN, and Banxia Houpu (Ito *et al*., 2011). Additionally, some studies have identified bioactive constituents in *Perilla frutescens*, such as rosmarinic acid and apigenin, which possess antidepressant properties (Nakazawa *et al*., 2003; Yi *et al*., 2013; Ji *et al*., 2014; Ito *et al*., 2011). PAE also possesses the capability to inhibit and regulate nucleotide-binding domain-like leucine-rich receptor protein 3 (NLRP3), thereby mitigating depressive-like behaviors induced by chronic unpredictable mild stress (Chen *et al*., 2020; Song *et al*., 2018; Fan *et al*., 2020, Qu *et al*., 2019, and Tian *et al*., 2017; Uemura *et al*., 2018).

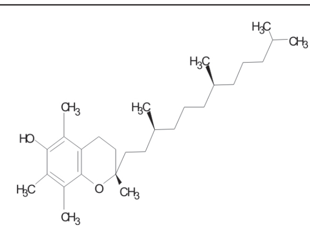
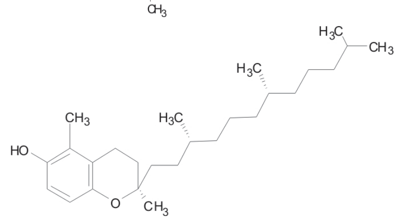
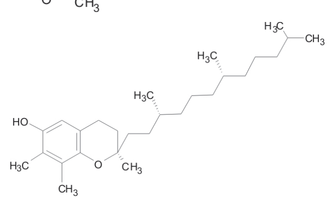
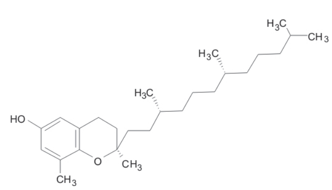
Anti-Cancer activity

Perilla leaves and seed oil have been identified for their anti-cancer properties. In a research study, female F3344 rats were fed a 12 percent fat diet containing *Perilla* and safflower oil in different ratios (1:3, 1:1), as well as *Perilla* oil alone. The results showed protection against MNU-induced colon cancers compared to safflower oil alone (Dhyani *et al*., 2019). Additionally, combining *Perilla* oil with olive oil and beta-carotene reduced colonic aberrant crypt foci induced by azoxymethane in male F344 rats, indicating a synergistic effect in preventing colon cancer. Research also highlights rosmarinic acid, the primary active polyphenol in *Perilla* seeds, preventing apoptosis in H9C2 cardiac muscle cells triggered by the drug adriamycin. In comparisons with other perillyl alcohol analogues like (-)-PAE, (-)-limonene 1, 2-epoxide, and (-)-8-hydroxycarvotanacetone, studies on (-)-8,9-PAE epoxide revealed the highest cytotoxic activity against human cancer cell lines HCT 116, OVCAR-8, and SF-295 (Andrade *et al*., 2015; Keesen *et al*., 2019; Souto *et al*., 2020).

Antimicrobial activity

In a research investigation, the ethyl acetate extract derived from *Perilla* seeds, along with polyphenols

Table 8. List of important Tocopherols reported in *Perilla* Plant

1	α Tocopherol		Seeds	Kim *et al*., 2012
2	β Tocopherol		Seeds	Kim *et al*., 2012
3	γ Tocopherol		Seeds	Kim *et al*., 2012
4	θ Tocopherol		Seeds	Kim *et al*., 2012

such as luteolin obtained from this extract, exhibited notable efficacy against oral pathogenic bacteria, specifically strains of oral Streptococci and *Porphyromonas gingivalis*. Furthermore, the combination of *Perilla* seed oil with Nisin demonstrated bactericidal properties targeting *L. monocytogenes* and *S. aureus*. Conversely, the ethanolic extract of defatted *Perilla* seed displayed a modest inhibitory effect on the growth of the oral pathogenic bacterial strain. Highlighting the significance of specific polyphenols, luteolin and quercetin, these compounds demonstrated substantial antibacterial activity against the tested oral bacteria. These findings provide additional support in another study, where polyphenols extracted from *Perilla* seeds exhibited anti-dental caries and antiperiodontal disease effects.

Anti-Oxidative activity

Gu *et al*. (2009) were the first to isolate four antioxidant compounds from the fruit of *P. frutescens* var acuta, including rosmarinic acid, luteolin, apigenin, and chrysoeriol. The antioxidant activity of these compounds was assessed using the 1,1-diphenyl-2-picryl-hydrazyl radical (DPPH). Epidemiological, clinical, and dietary research supports the idea that consuming "functional foods" and nutraceuticals may be linked to a decreased risk of cancer, cardiovascular diseases, and metabolic disorders (Lee *et al*., 2013). These benefits are often attributed to the heightened antioxidant capacity of the substances, particularly the presence of phenolic acids, flavonoids, and carotenoids.

The antioxidant capabilities of *Perilla* seed, leaf, and stalk extracts were evaluated using DPPH, superoxide radical scavenging activity, reducing power, and metal chelating capacity. The 50% methanol leaf extract was identified as a potential new functional food. *Perilla* seeds exhibited stronger antioxidant activity compared to chia seeds and flax seeds, as determined by the ABTS, DPPH, and FRAP assays. *Perilla* seed also boasts a higher average tocopherol content (152.1 mg/kg) compared to other seed oil crops like linseed (83.0 mg/kg), mustard (69.0 mg/kg), and sesame (100.0 mg/kg). The isolated antioxidant chemicals from *Perilla* extract include rosmarinic acid, luteolin, apigenin, and chrysoeriol (Lee *et al*., 2013).

Therapeutic Uses

In Asian traditional medicine, *Perilla* is recommended by herbalists for various purposes, includ-

Table 9. Comparison of chemical composition of seed oil from *Perilla frutscens* L. in various countries of the world

S. No.	Country/ state	Compounds (% Composition)										References
		Myristic acid	Palmitic acid	Stearic acid	Oleic acid	Linoleic Acid	α-linolenic acid	Arachidic acid	Cis-11-eicosenoic acid'	Hwxad ecenoic (16:1)	Lithal	
1	Present study (Dehradun)	-	12.76	2.62	0.16	15.40	66.58	0.18	-	-	0.15	Joshi *et al*., 2015
2	India	-	9.9	2.33	0.10	14.5	68.6	0.10	-	0.11	-	Saklani *et al*.,2011
3	China	0.37	7.23	2.89	20.77	10.54	52.58	-	0.16	-	-	Ding *et al*., 2012
4	Japan	-	7.7	3.8	10.2	17.9	60.4-	-	-	-	-	Bhandari *et al*., 2011
5	Korea	-	7.4	3.6	9.5	16.5	63.0	-	-	-	-	Bgandari *et al* 2011
6	Thailand	-	4.62	0.37	7.0	13.9	40.8	-	-	-	-	Kanchanamayoon and Chiang, 2007

ing alleviating coughs and respiratory issues, preventing influenza, calming a restless its foetus during pregnancy, addressing seafood poisoning, and restoring energy balance in the body (Brenner, 1993). Studies of *Perilla* volatile oil have revealed that distinct chemo types of *Perilla* have dramatically different biological effects. The *Perilla* aldehyde chemo type is the source of Japanese "ao-shiso" a medicine with an agreeable fragrance (Brenner, 1993).

It has also been demonstrated that it is a potential source of food rich in protein and omega 3 and 6 poly unsaturated fatty acids, which can be considered nutritious food for humans and animals. Due to the variety of antimicrobial properties in its oil, the plant has a specific smell that the essential oil components affect its nutrition and fill with medicinal properties. Its oil is a matter of limited scrutiny, which is reported as a rich source of roses, which also makes delicious spices and perfumes. Omega 3 and Omega 6 is found in abundance which is a better alternative to cod liver oil. Research scientists claim that if the government and the drug companies take initiative in this direction, better employment opportunities canbe created by commercial cultivation of Bhangjeera.

Traditional Application of *Perilla*

Perilla plant parts, particularly its leaves and seeds, serve as both a vegetable and spice, adding color and flavor to various dishes. In Japan, *Perilla* oil is promoted as a vegetable edible oil, with the leaves commonly used in garnishing, tempura, and to impart color to Umeboshi (plum pickles). The color comes from the reaction of citric acid with anthocyanin in *Perilla*. In Korea, *Perilla* seeds and leaves enhance the flavor of different dishes, available in powder and oil forms for salad dressings and seasonings. Roasted *Perilla* seed oil is used as a condiment, while *Perilla* seed powder adds thickness and flavor to soups. Rice porridge with *Perilla* seed and 'rayu' (Pepper oil sauce) is popular in Korea and Japan. *Perilla* leaves herbal tea is also found in Korean shops for treating colds and coughs. *Perilla* rice porridge is consumed in Vietnam during colds. In India, it is cultivated in states like Uttarakhand, Uttar Pradesh, Himachal Pradesh, and Kashmir for its essential oil used in flavoring. *Perilla* seeds are roasted with onion and tomato for chutney and curry. In Northeast Asia, tribal groups use it for its edible seeds in salads like 'Singju,' and its flower buds and young shoots are consumed in various forms.

As a medicinal plant, *Perilla* is employed to treat colds, coughs, vomiting, abdominal pain, and constipation. The volatile oil from *Perilla* leaves is used in microcapsules, acting as a food preservative. Juice from *Perilla* leaves, possessing antibacterial properties, is applied to wounds. Chewable tablets, made from *Perilla* leaf powder and extract, provide vitamins and minerals, particularly calcium. Conventional use of *Perilla* extends to therapeutic food, notably in China and Japan. The Chinese Ministry of Health recognizes it as both food and medicine for treating infections. *Perilla* leaves are a significant component in traditional Chinese Herbal medicine like 'Banxia Houpu Decoction' and SYJN, used for depression treatment. In Japan, dried leaves and stems are used in the herbal medicine 'saiboku-to' for asthma and morning sickness. *Perilla* is also a key element in the herb *Houttuynia cordata* Thunb (HC), used to address alopecia.

Future Prospects

The examination of existing literature highlights the diverse nutritional components found in the *Perilla* plant, owing to its varied phyto-constituents. *Perilla* exhibits potential in addressing non-communicable diseases and can be employed as a key element in crafting various functional foods. As a result, this plant emerges as a prospective candidate for further exploration to substantiate its suitability in product development, utilizing its leaves, seeds, and oil. Although the results are promising in preclinical studies (in vitro and in vivo), clinical studies are insufficient, therefore, further study needs to be done to validate its therapeutic effects and to ensure its safety and efficacy.

Acknowledgements

Authors are grateful to Prof. (Dr.) Arun Kumar Dean, School of Basic and Applied Sciences, Shri Guru Ram Rai University, Patel Nagar, Dehradun for his kind support and suggestions.

Conflict of interest

Authors have declared that no competing interests exist.

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