

A Review On Nutritional Value, Functional Properties and Pharmacological Application of Perilla (*Perilla Frutescens* L.)

Akriti Dhyani¹, Rajni Chopra^{1*} and Meenakshi Garg²

¹Department of Foods and Nutrition, Institute of Home Economics, University of Delhi, F-4 Hauz Khas Enclave, New Delhi, 110016, India.

²Department of Food Technology, Bhaskaracharya College of Applied Sciences, University of Delhi, Dwarka, New Delhi, 110075, India.

*Corresponding author E-mail: rajn145ihe@gmail.com

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Perilla frutescens is an annual herb belonging to the mint family (Lamiaceae). It is majorly produced in countries like China, Japan, India, Thailand and Korea. Recently, Perilla plant is gaining more attention because of its medicinal benefits and phytochemical contents. The major phytochemical compounds reported in this species are phenolic compounds (Rosmarinic acid, caffeic acid, ferulic acid), flavonoids (luteolin, apigenin), Phytosterols, Tocopherols, Policosanols and Fatty acid. Perilla seed oil is also a rich source of essential fatty acid such as α -linolenic acid (54-64%) and linoleic acid (14%). Perilla seeds and its oils have been widely used in traditional nutritional and medicinal formulations. Biological analysis of Perilla seeds revealed that it showed anticancer, ant-diabetic, antiasthma, antimicrobial, anti-inflammatory, antioxidant and cardioprotective effect. The aim of this review is to provide an update on the nutritional composition, phytochemical profile and pharmacological research of Perilla seed.

Keywords: Perilla seed, antioxidant, bioactive compounds, fatty acid, linolenic acid.

Perilla frutescens L. belongs to the family Lamiaceae which consists of 236 genera and more than 7000 species. *P. frutescens* commonly known as Perilla is an annual herb found in China, Korea, Japan and the Himalayan region of India and Nepal. Now it is also being cultivated by some western countries like U.S.A, Russia, and Europe due to its growing economic importance¹. In Japan, it is found in Aomori, Akita, Iwate, Yamagata, Miyagi, Oshika, Fukushima, Ishikawa, Ibaraki, Gunma, and Nagano prefecture. In Korea, it is reported from Kangwan, Kyonggi, Kyongsangbuk, Kyongsangnam, Chungchongbuk, Chungchongnam, Chollabuk and Chollanam

province. In China, it is distributed in southeastern and southwestern parts mainly Gansu, Shaanxi, Jiangsu, Zhejiang, Jiangxi, Hunan, Xichuan, Yunnan, and Guangxi². In India, it is found in Uttarakhand, Kashmir, Himachal Pradesh, Sikkim, Manipur, Mizoram and Meghalaya state³. Perilla plant contains a number of important phytochemicals such as Rosmarinic acid, Luteolin, Chrysoeriol, Quercetin, Catechin, Caffeic acid and Ferulic acid^{4,5}. The presence of Phytosterols, Tocopherols, Squalene, and Polyunsaturated fatty acid has also been reported from Perilla seed⁶. Biological analysis of Perilla plant revealed that this plant showed anti-microbial, anti-allergic, anti-

cancer, anti-tumor, anti-depression, anti-viral, anti-asthmatic and antioxidant activities⁷⁻⁹. It is utilized as functional food in various parts of the world but in some parts, there is no organized cultivation of this crop and in spite of having numerous benefits and uses, it is still an underutilized crop¹⁰.

There are few review papers available on *Perilla frutescens*. Two review papers are available on the comprehensive information on phytochemical and pharmacological properties^{11,12}. Some scientists have reviewed various aspects of *Perilla* plant such as its bioactive components and its use as food as well as medicine^{13,14}. Another review¹⁵ focused on the health benefits of *Perilla* plants but there is no complete review with detailed information about the nutritional aspects of *Perilla*. The purpose of this review is to provide complete information on the botany, uses, Phytochemistry, nutritional and pharmacological research of *Perilla* with more emphasis on *Perilla* seed and *Perilla* seed oil. Moreover, this review would provide scientific gaps in current knowledge and offer a systematic basis for future research work on *Perilla*.

METHODOLOGY

All the available information about the botany, uses, nutritional composition, phytochemistry and pharmacological properties (84 Research papers) on *Perilla* up to 2018 was collected via electronic search (using PubMed, Scopus, Web of Science, ScienceDirect, J-Gate, Google Scholar, and other web search engines, such as Google, Yahoo) and a library search for articles published in peer-reviewed journals, unpublished materials, theses, as well as some of the government survey reports. All obtained data from previously published literature are summarized in 5 tables (Botanical description, Proximate, Phytochemicals, Minerals and Fatty acid composition) and 2 figures. Reported bioactive constituents from this plant are presented in figure 1.

Plant description

Perilla is an annual herb that grows up to 150 cm height with shiny green or purple, downy-hair ovate to round leaves, square stem, small tubular purplish to white flowers 3-4 mm in length, Flower-stalks length are about 1.5 mm, Calyx is about 3 mm with brown seeds. *Perilla*

seeds are small and weigh about approximately 4g/1000 seeds. Its seeds are sown in the month of May and harvesting period is September – October, which varies and depending on geographic area. It is grown in mixed cropping; the crop requires moisture absorbent soil but not a very fertile soil. Useful parts of *Perilla* plant are its leaves and seeds^{1,3,16,17}. The plant, seeds and seed oil are shown in Fig. 1. Botanical descriptions of *Perilla* plant are presented in Table 1.

Vernacular names of *Perilla*

Perilla has different synonyms and vernacular names that vary from area to area. In China it is known as Zisu, Shiso in Japan⁵, Deulkkae or Tilkae in Korea^{18,19}, Silam in Nepal. In India, it has several names across the state, such as Bhanjeer or Banjiraa (Uttarakhand), Hanshi or thoiding (Manipur), chhawahchhi (Mizoram)¹⁶.

Traditional application of *Perilla*

Useful parts of *Perilla* plant are its leaves and seeds. *Perilla* leaves are used as vegetable and spice as well to impart color and flavor in many dishes. In Japan, *Perilla* oil is marketed as vegetable edible oil²⁰ and its leaves are mainly used in garnishing, tempura dish and to color plum pickles known as Umeboshi, its color is the result of the reaction of citric acid with anthocyanin present in *Perilla*^{21,22}. In Korea, *Perilla* seeds and leaves are added in various dishes to add flavor. Its seeds are available in two forms, powder, and oil, for salad dressings and seasonings. Oil of roasted *Perilla* seed is used as a condiment oil¹⁶. *Perilla* seed powder is added to soup to add thickness and flavor. In Korea and Japan, Rice porridge prepared using *Perilla* seed and ‘rayu’ (Pepper oil sauce), a traditional condiment prepared using *Perilla* seed oil^{23,24}. *Perilla* leaves herbal tea is also available in some Korean shops for cold and cough. *Perilla* rice porridge is also consumed in Vietnam in case of cold^{1,3}. In India, it is mainly cultivated in Uttarakhand, Uttar Pradesh, Himachal Pradesh and Kashmir states for its flavoring essential oil. *Perilla* seeds are roasted with onion and tomato to form chutney (sauce) and also used in the curry material¹⁰. In Northeast Asia, it is mainly used by tribal groups for its edible seeds as it is a less expensive source of fat and protein. Grounded roasted seeds are consumed in a salad called ‘Singju’ in Manipur. Its leaves can be used as a

vegetable and can be preserved by drying. Its flower buds are edible raw and young shoots are used in soup preparation^{25,26}.

It has been conventionally used as a therapeutic food in many countries, mainly China and Japan. According to the Chinese ministry of health, it is recognized as food as well as medicine used to treat different infections²⁷. Leaves of Perilla are a major constituent of traditional Chinese herbal medicine ‘Banxia Houpu Decoction’ and SYJN which is used to treat depression^{7,28}. In Japan, dried leaves and stems of Perilla are used in the preparation of herbal medicine ‘saiboku-to’, which is used in the treatment of asthma and morning sickness^{29,30}. Also, its fresh leaves are cooked with seafood to prevent food poisoning. Perilla is also used in skin creams, soaps, and medicinal preparations because of its antioxidant and anti-allergic properties³¹. Perilla is also a major constituent of herb *Houttuynia cordata* Thunb (HC), which is used in the treatment of alopecia³². As a medicinal plant, Perilla is used as a treatment for cold, cough, vomiting, abdominal pain and constipation. Volatile oil from Perilla leaves used to prepare microcapsules, and these capsules are used as a food preservative agent³³. Perilla leaves are also used in the preparation of herbal tea for cold and fever²⁵. Juice from Perilla leaves applied to wounds and cuts because of its anti-bacterial properties³⁴. A chewable tablet is prepared by³⁵ using Perilla leaf powder and extract, a good source of vitamin and minerals especially calcium. It can also be used as a treatment for cold, cough, vomiting, abdominal pain and constipation³.

Composition and functional properties of Perilla seed and Perilla seed oil

The entire plant of Perilla is very useful and nutritious as it contains fat, protein, vitamins, minerals and phytochemicals. The crude protein, crude fat and moisture content of Perilla leaf

extract is 5.47%, 7.61% and 7.68% respectively³⁶. Similar to spinach leaves, Perilla leaves are also a rich source of carotenoids³⁷. The seed contain a nutty flavor, yellowish oil (40%), protein, amino acids (Valine, Leucine, Isoleucine, Lysine, Tryptophan, Threonine, Tyrosine, Phenylalanine, Cysteine, Methionine, Histidine, Aspartate, Serine, Glutamate, Proline), polyphenols The protein content of Perilla seed improved with hulling and roasting, as protein content of whole Perilla seed and Perilla kernel are 17.2% and 20.1% respectively³⁸. Proximate content of Perilla seed is summarized in table 2. Perilla seed also have been found to contain some essential mineral (Calcium, iron, zinc, magnesium and phosphorous). Mineral composition of Perilla seeds are summarized in table 3.

In a study Perilla seed oil was extracted with a mixture of chloroform and methanol solvent (2:1, v/v) and total lipid content was found to be 40%. Major fatty acids reported in Perilla oil were

linolenic acid, linoleic acid, palmitic acid, oleic acid and stearic acid (Table 4). Neutral lipids accounted for about 91.2- 93.9% followed by glycolipids (3.9-5.8%) and phospholipids (2-3%) respectively. The neutral lipids contain triacylglycerol (88.1-90%), sterol ester (4.1-6.2%) and hydrocarbon (1.9-2.7 %) and some amount of free fatty acid. The glycolipid fraction separated into four fractions by thin layer chromatography, the major GL were esterified steryl glycoside (48.9-53.2%) and steryl glycoside (22.1-25.4%). Monogalactosyldiacylglycerol and digalactosyldiacylglycerol were present in small quantities. Among the phospholipids, phosphatidylethanolamine (50.4-57.1%), phosphatidylcholine (17.6-20.6%) and phosphatidic

Table 1. Botanical description of Perilla plant

Kingdom -	Plantae
Subkingdom -	Tracheobionta
Division -	Spermatophyta
Superdivision -	Magnoliophyta
Class -	Magnoliopsida
Subclass -	Asteridae

Table 2. Proximate composition of Perilla seeds

Components	Perilla seed (%)
Moisture	6.02 ± 0.12
Ash	3.33 ± 0.02
Total lipids	42.27 ± 1.69
Crude protein	25.38 ± 0.10
Carbohydrate	23.00 ± 1.54

Values reported as means ± SD of three replicate analyses (n = 3).
Source- Sargi *et al.*, 2013 [39]

acid (13.6-19.9%) were the most abundant. Lysophosphatidyl choline, phosphatidylserine and phosphatidyl inositol were present in small quantities⁴⁰. In another study compressed fluids (CO₂ and LPG) were used under different conditions of pressure and temperature to extract Perilla seed oil and it was found that Perilla seed oil extracted with compressed LPG showed higher yield (42.20 %) and antioxidant activity⁴¹

Phytochemicals profile

Perilla plant has undergone various phytochemical studies and a range of different compounds has been isolated. Phytochemical estimation of Perilla seed showed the presence of phenols and flavonoids. Rosmarinic acid, Rosmarinic acid-3-O- glucoside, caffeic acid, ferulic acid and caffeic acid-3-O- glucoside were major phenolic compounds identified in Perilla seed whereas apigenin, luteolin and catechin were major flavonoids present in Perilla seed⁴. Polyunsaturated fatty acid, policosanol, sterols and tocopherols were also identified in Perilla seed^{5,36}. The total phenolic content (TPC) and total flavonoid content (TFC) of Perilla seed oil is 18.07 mg GAE/g oil extract and 0.15 mg RE/g oil extract respectively²⁰. Major Phytochemicals of Perilla seed are given in figure 1.

Pharmacological effects

Anti-asthmatic

In China Perilla is a major constituent in various folk medicines used for the treatment of Asthma, because of the flavone luteolin present in Perilla, which gives relaxant action to the smooth muscles of the trachea⁴³. Dietary treatment plays a key role in decreasing the Asthmatic allergies, serum OVA-specific immunoglobulin 1 level, and total immunoglobulin A antibodies, hence a diet with Perilla oil supplementation helps in treating Asthma⁴³. A clinical study on asthma patients showed that Perilla seed oil improves pulmonary function and also suppresses the leukotriene LB₄ and LC₄ release from leucocytes which are responsible for asthma. The effect of Perilla seed oil and Corn oil on Asthma patients was compared, and the results revealed that Perilla seed oil rich in α -linolenic acid (omega-3) inhibits the generation of leukotriene LB₄ and LC₄ more efficiently than corn oil rich in linoleic acid (omega-6)^{44,45}. In another study, the anti-asthmatic effect of Perilla seed oil was investigated both *in-vivo* and *in-vitro* in guinea pig induced by antigen and it was concluded that Perilla seed oil inhibited airway constriction and also improved lung function by

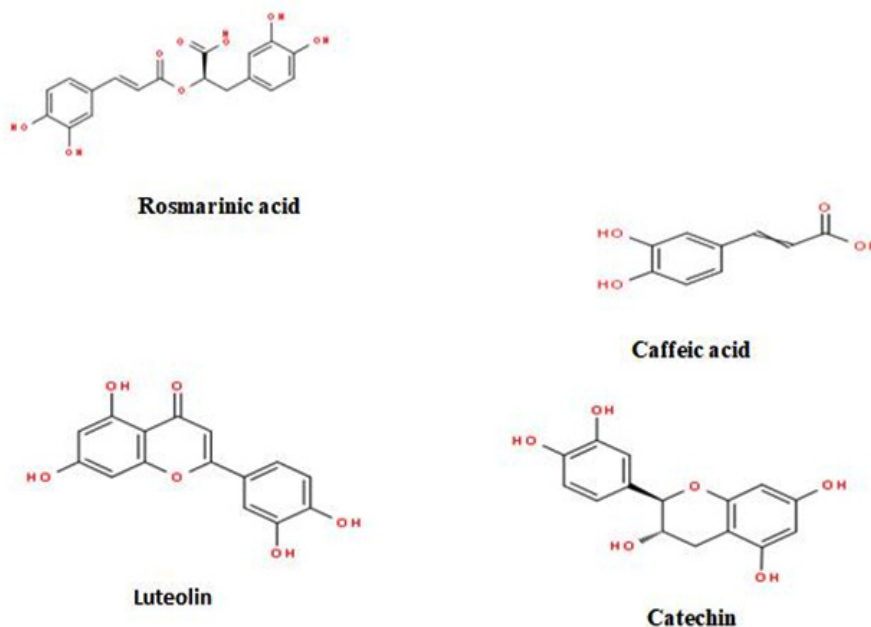


Fig. 1. Main active polyphenols in Perilla seed

decreasing lung resistance and increasing dynamic lung compliance⁴⁶.

Anti-Diabetic

A study carried out on the anti-diabetic effect of Perilla seed sprouts in type 2 diabetes mice model. The supplementation of Perilla seed (100, 300, and 1,000 mg/kg of body weight) sprouts decreased body weight and serum triacylglyceride level; improved hyperglycemia, glucose tolerance and insulin resistance; induced AMP-activated protein kinase (AMPK) activation and regulated gluconeogenesis⁴⁷. 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 complications⁴⁸. 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 microfora *blautia*, which is a gram positive anaerobe bacterium and responsible for glucose metabolism disturbances and increased the microfora *Lactobacillus*, which considered to be a beneficial bacteria as it converts sugars to lactic acid⁴⁹.

Anti-depressant

Perilla is an important constituent of anti-depression medicines such as Hange-kouboku-to, Saiboku-to, SYJN and Banxia Houpu^{7,28,29}. In literature, some researchers reported that the bioactive constituent of Perilla frutescence such as rosmarinic acid and apigenin has an anti-depression effect. The intraperitoneal administration of Rosmarinic acid (2 mg/kg.) and caffeic acid (4

Table 3. Mineral composition of Perilla seeds (per 100g).

Minerals	Perilla seed
Calcium (mg)	249.9
Magnesium (mg)	261.7
Phosphorous (mg)	677.2
Iron(mg)	9.54
Manganese(mg)	4.93
Zinc (mg)	4.22
Chromium (µg)	17.6
Copper (mg)	0.20

Source – Longvah & Deosthale (1991) [26].

mg/kg) each significantly reduced the duration of immobility in the forced swimming test in mice^{50,51}. Similarly, intraperitoneal doses of Apigenin at 12.5 and 25 mg/kg significantly lessened the duration of immobility in the forced swimming test in mice⁵².

Anti-cancer

Perilla leaves and its seed oil showed anti-cancerous properties. In an experiment it was reported that a treatment of 12% fat diet with Perilla and safflower oil in the proportion of 1:3, 1:1 and Perilla oil alone, showed protection against MNU- induced colon tumors as compared with safflower oil alone in female F344 rats⁵³. Further synergistic effect of Perilla oil with β -carotene in the prevention of colon cancer was also proved, the supplementation of Perilla oil with olive oil and β carotene reduced colonic aberrant crypt foci induced by azoxymethane in F344 male rats⁵⁴. The Perilla seed main active polyphenol rosmarinic acid, is reported to inhibit apoptosis in H9C2 cardiac muscle cells induced by Adriamycin (ADR) by inhibiting reactive oxygen species and the activations of c-Jun N-terminal kinase and extracellular signal-regulated kinase⁵⁵

Antimicrobial

In a study it was found that the ethyl acetate extract of Perilla seeds and polyphenols isolated from ethyl acetate extract (luteolin) was effective

Table 4. Analysis of fatty acid (as a percentage of total oil).

Compound	Perilla Seed Oil
C16:0 Palmitic	5.94 ± 0.12
C18:0 Stearic	2.20 ± 0.14
C20:0 Arachidic	0.20 ± 0.01
C22:0 Behenic	0.03 ± 0.01
C24:0 Lignoceric	0.01 ± 0.00
C16:1 Palmitolic	0.12 ± 0.02
C18:1 oleic acid	16.21 ± 0.07
C18:2 linoleic acid	14.72 ± 0.08
C18:3 linolenic acid	60.93 ± 0.10
C20:1	0.17 ± 0.02
C20:2	0.05 ± 0.01
SFA	7.58 ± 0.05
MUFA	16.57 ± 0.11
PUFA	75.85 ± 0.17
Ration of n-6/n-3	0.22
Lipid %	40.0 ± 1.6

Source - Ciftci *et al.*, 2012 [6]

Table 5. Tocopherols content, Sterol and Policosanols composition of Perilla oils

No.	Compounds	Perilla seed oil (mg/kg oil)
1	Tocopherols	
	α -tocopherol	43.81 \pm 0.38
	β -tocopherol	-
	γ -tocopherol	344.56 \pm 0.05
2	Sterols	
	Campesterol	321.16 \pm 5.16
	Stigmasterol	177.50 \pm 2.65
	β -sitosterol	2773.85 \pm 12.04
3	Policosanols	
	C21-OH	4.51 \pm 0.12
	C22-OH	-
	C23-OH	7.75 \pm 0.14
	C24-OH	4.08 \pm 0.11
	C25-OH	24.64 \pm 0.72
	C26-OH	5.19 \pm 0.09
	C27-OH	48.51 \pm 0.87
	C28-OH	11.28 \pm 0.25
	C29-OH	148.53 \pm 0.04
	C30-OH	15.13 \pm 0.88
	C31-OH	32.78 \pm 4.14
C32-OH	-	

Values reported as means \pm SD of three replicate analyses (n = 3).

Source- Jung *et al.*, 2012 [42]

against oral pathogenic bacteria (Oral Streptococci and strains of *Porphyromonas gingivalis*)⁵⁶. Similarly, Perilla seed oil in combination with Nisin acts as bactericidal against *L. monocytogenes* and *S. aureus*⁵⁷.

Anti-oxidant

The antioxidant properties of Perilla seed, leaf and stalk extract investigated by DPPH, superoxide radical scavenging activity, reducing power and metal chelating ability and reported that 50% of methanol leaf extract could be used as a new functional food⁵⁸. Perilla seeds reported to have the higher antioxidant activity than chia seeds and flax seeds, measured using ABTS, DPPH and FRAP assays, shown in Figure 2.³⁹. The average tocopherol content in Perilla seed (152.1 mg/kg) is higher than that in various other seed oil crops, such as linseed (83.0 mg/kg), mustard (69.0 mg/kg) and sesame (100.0 mg/kg)⁵⁹. Four antioxidant compounds isolated from Perilla extract and identified as rosmarinic acid, luteolin, apigenin and chrysoeriol⁶⁰. Due to the antioxidant activity of rosmarinic acid, it protects MES23.5 cells from 6 hydroxydopamine induced neurotoxicity⁶¹. Also Luteolin isolated from methanol extract of Perilla seed reduced the hydrogen peroxide induced cytotoxicity in primary neurons from newborn rat cortex⁶². In a more recent study, two antioxidant peptides were isolated from enzymes hydrolysates of defatted Perilla seed protein and identified as Tyr-Leu (YL) and Phe-Tyr (FY). It was found that

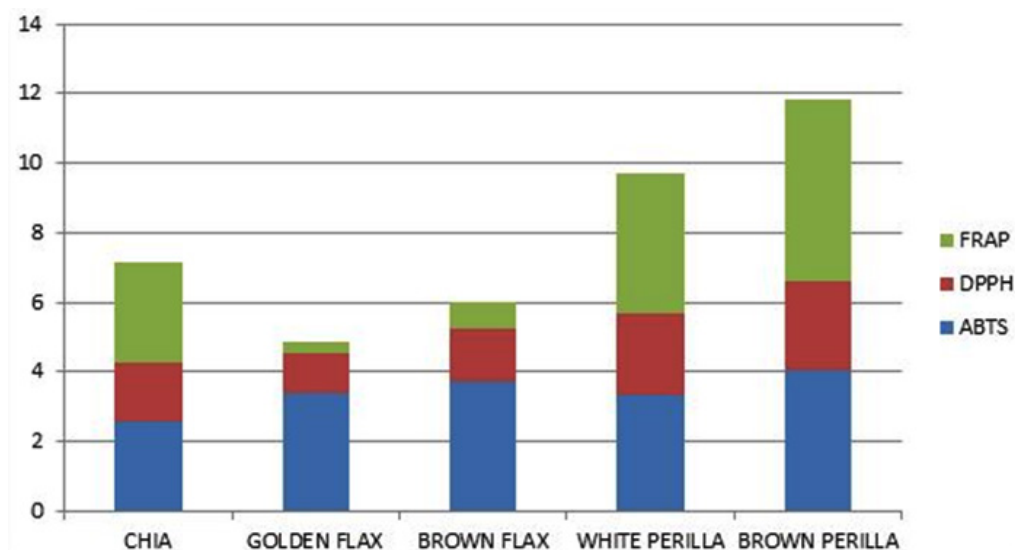


Fig. 2. Comparison of antioxidant activity of Perilla seeds with flax and chia seeds by FRAP, DPPH and ABTS assay

these peptides inhibited the lipid peroxidation in the rat liver and protect against hydrogen peroxide induced damage in HepG-2 cells⁶³.

Cardioprotective

Recently, the effect of Perilla seeds oil or palm oil were studied on serum cholesterol, hepatic lipid accumulation and hepatic expression of proteins regulating lipid metabolism in high fat diet (HFD) fed mice for 90 days. Additionally, Perilla oil treatment produced a significantly reduction in serum cholesterol and hepatic triglyceride levels compared with palm oil treatment in HFD-fed mice, also Perilla seed oil treatment decreased lipid accumulation in the thoracic aorta and liver compared with palm oil treatment⁶⁴. Another study was designed to compare the effect of feeding Safflower and Perilla oil on lipid metabolism in young and adult rats and concluded that α -linolenic acid present in Perilla oil regulates serum cholesterol, as α -linolenic acid reduces the expression of mRNA for HMG-CoA reductase, an enzyme essential for cholesterol biosynthesis⁶⁵. Perilla seed oil when fed to the mice for the period of eight weeks showed cardioprotective effect, as it increases the plasma concentration of docosapentaenoic acid and eicosapentaenoic acid⁶⁶. Furthermore, Replacement of Soybean with Perilla oil in cooking for 10 months resulted in increased serum level of n-3 fatty acid in elderly subjects, which showed cardioprotective activity without causing any side effect⁶⁷. In another investigation, Apigenin isolated from Perilla seed shows the anti-obesity effect by increasing pro-opiomelanocortin (POMC) and "cocaine and amphetamine-related transcript (CART) anorexigenic neuropeptides in neuronal cells which further reduced food intake in mice^{68,69}. The effect of Perilla oil on platelet aggregation and thrombosis were studied *in vitro* in rabbits and *in vivo* in rats respectively. Perilla oil incubated rabbit platelet showed reduction in aggregation induced by collagen (2.5 μ g/ml) and thrombin (0.1U/ml), also Perilla oil treatment (0.5, 1 or 2ml/kg) delayed the arterial occlusion induced by 35% FeCl₃ solution in rats⁷⁰. 10% Perilla seed oil supplementation in wister rats diet for 18 months significantly reduced the serum cholesterol and triglyceride level⁷¹. Additionally, the use of Perilla seed oil in emulsified form in the preparation of rice

porridge showed significant reduction in plasma triglycerides in human as well as in animal subject and also showed high score in sensory evaluation⁷².

Effect on gastrointestinal system

Gastrointestinal discomfort is caused because of ileum contraction and its risk factors are daily stress, food sensitivity and allergies, infections and genetic preposition. The effect of Perilla seed oil on gastrointestinal motility was investigated and it was found that Perilla seed oil supplementation (5ml/kg, 7.5ml/kg and 10ml/kg) increased the motility and produced a laxative effect in constipated albino rats, constipation in rats was induced by loperamide⁷³. Similarly, the intraperitoneal administration of Perilla seed oil (1, 2 and 3ml/kg) in wister strain albino rats provide significant protection against reflux esophagitis by inhibiting esophagitis index, reducing the volume of gastric juice and increasing gastric pH⁷⁴.

Neuroprotective

The active component of Perilla seed containing certain fatty acid (α -linolenic acid) showed anti-apoptosis and anti-inflammatory effect in the brain cells of mice during atherogenic diet, thus showed neuroprotective effect⁷⁵. Perilla seed oil rich source of α -linolenic acid, could offer a novel substitute to fish oil for neuroprotective and mitochondrial functions in the brain⁷⁶. More recently the safety and feasibility of Perilla seed oil as an antioxidative therapy has been proved in patients with mild to moderate dementia⁷⁷. Cold pressed seed oil of Perilla showed protective effect against beta-amyloid induced neurotoxicity in PC12 rat pheochromocytoma cells and could be used as a functional food in Alzheimer disease⁷⁸. In a six month randomized, placebo-controlled trial, supplementation of Perilla seed oil with brain training in elderly with mild cognitive impairment, improved plasma and erythrocyte plasma membrane α -linolenic acid levels; enhanced cognitive function measured by Frontal Assessment Battery (FAB) score⁷⁹. Luteolin and apigenin isolated from ethanolic extract of Perilla seed possess monoamine transporter activator action in monoamine-transporter transgenic Chinese hamster ovary cell or wild dopaminergic cell lines for improvement of hypermonoaminergic neuropsychological disorders⁸⁰. Further, long term administration of luteolin in rats improved spatial cognition deficits

and neuronal damage induced by chronic cerebral hypoperfusion⁸¹.

Other Pharmacological activity

Hepatoprotective activity of the major phenolic components (rosmarinic acid and caffeic acid) present in cold-pressed *Perilla frutescens* seed flour (CP-PFSF) after oil extraction was investigated *in vivo* and *in vitro*. *In vitro*, treatment with RA-rich extract reduced H₂O₂-induced cytotoxicity and in *In vivo*, oral administration of RA-rich extract significantly reduced the levels of aspartate aminotransferase and alanine aminotransferase, and hepatocyte degeneration and neutrophilic infiltration induced by tert-butyl hydroperoxide⁸². It has proved that *Perilla* oil exerts same properties as fish oil in reduction of hepatic level of proinflammatory cytokines, the levels of IL-15, TNF- α , and IL-6 found significantly lower in fish oil and *Perilla* oil supplemented to high fat diet mice, also *Perilla* oil and fish oil supplementation showed reduction in Gram-negative *Prevotella*, which might be considered as a cause in the development of non-alcoholic fatty liver disease⁸³. *Perilla frutescens* increases cytokine LIF (leukemia inhibitory factor) which regulates endometrial receptivity. Proper implantation of the embryo depends upon the enhancement of endometrial receptivity, thus *Perilla* can be beneficial for women suffering from faulty implantation⁸⁴.

CONCLUSION

The present review paper reports extensive information about the traditional uses, nutritional, phytochemistry and Pharmacological analysis *Perilla* seeds and its oil. It is found that leaves, seeds and its oil are used in various regions of the world like China, Japan, Korea and India in the preparations of spices, condiments, sauces, tea, leafy vegetables and herbal medicines. In Japan and China, this plant is also used as a major constituent of anti-depressant and anti-asthmatic herbs such as SYJN, Banxia Houpu, Hange-kouboku-to, and Saiboku-to. Components of this plant are potential in curing diseases like food poisoning, asthma, diabetes, cancer and heart diseases. Medicinal investigation showed that the plant has potential antiviral, antioxidant, anti-inflammatory, anti-allergic, anti-aging and

anti-tumor activities. The major phytochemical compounds reported in this species are phenols, flavonoids, phytosterols, tocopherols, Policosanols and fatty acid. *Perilla* seed oil is also a rich source of essential fatty acids. Despite its numerous benefits and uses, this plant is still unknown to the common population.

There are very few toxicological researches on *Perilla* plant. Although, there are some studies that proved that its consumption is safe at a low dosage for a short period of time. Once the safe dosages of *Perilla* plant are established, its different parts could be used as an active constituent in the formulation of various functional foods. Hence, further researches are required to validate its use in product development by using seed and seed oil.

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