

Morphological, Phytochemical and Pharmacological Properties of *Carum carvi* (Caraway) and *Bunium persicum* (Black Caraway) Seeds: A Review

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Abstract: *Carum carvi* and *Bunium persicum* belongs to Apiaceae family. Both the species are medicinally important and has been used as antimicrobial, antioxidant, anticarcinogenic, antidiabetic, to treat heart problems, spice, condiments and breath freshener or lotions industries etc. Due to morphological similarities, the adulterations are being observed, so it is essential to understand the morphological, phytochemical and pharmacological properties of both the seeds. The plants look similar with approximately similar flower colour. Most prominent difference is in root structure. The roots of *C. carvi* are fleshy, fusiform tap while that of *B. persicum* is tuberous. *C. carvi* seeds are larger than that of *B. persicum*, with comparatively lighter brown colour. The seeds of *C. carvi* are sickle shaped while the seeds of the *B. persicum* are cylindrical in shape. Chemical composition of essential oil is approximately similar with variation in the percentage content of various compounds. Both the seeds are used for food preparation with some variation in their utilization due to difference in their aroma.

Keywords: Spices; Condiments; Essential oil; Jeera; Aroma; Food.

1. Introduction

Bunium persicum Bioss. Fedtsch syn. *Carum bulbocastum* Koch (black caraway or Kala jeera) is an aromatic spice from Apiaceae family, is naturally found in northwest Himalaya, mainly in the alpine region of Uttarakhand, Kashmir and Himachal Pradesh states of India. It mostly grows in the area where snow fall occurs in winter season, as long chilling period is required for the seed germination. It is a perennial plant and is one of the economically and medicinally important plant species. It is used for the treatment of indigestion, pneumonia, and as carminative, appetizer, and galactagogue in different traditional systems [1,2]. Essential oil of black cumin is used in food sweetening, pharmaceutical, soft drink and hygiene industries. Fruits of ripe black cumin contain essential oil rich in aldehydes, monoterpene, p-mentha-1, 3-dien-7-al, Cuminaldehyde, and p-mentha-1, 4-dien-7-al; terpene hydrocarbons. Digestive, anticonvulsive, diuretic, and anthelmintic effects have been reported in Seeds and the essential oil of *Bunium persicum* [3,4]. Due to the wide scope of pharmacological effects, the plants and seeds were extensively collected and sold by the people. *Carum carvi*, belonging to Apiaceae family, is cultivated mainly in Asia, Europe and North Africa [5]. It is commonly used in liquors, desserts, casseroles, spice, rice dishes etc. *C. carvi* roots are also cooked as vegetable sometimes. Leaves of *Carum carvi* are also used as medicine. Seeds of both the plants are being used as condiments during food preparations. Due to some of the similar pharmacological, chemical and morphological properties among these two, *Carum carvi* (Caraway or Siah Zira) plant or seeds has been confused with the *Bunium persicum* or vice versa. The present paper is an effort to document the properties of their edible parts.

2. Morphological properties

The comparative analysis of both the plants is shown in Table 1. The flowers of *B. persicum* and *C. carvi* is having umbel inflorescence which is characteristics feature of Apiaceae family. The flower colour is white for both the *B. persicum* and *C. carvi*, although there is pink tinct in earlier one and red tinct in later one [6]. The *C. carvi* inflorescences have compound umbels, bracteates and bracts linear and are rigid in nature. Calyx in this case is unequal, having small teeth, subulate. White coloured petals are oblong or obovate, emarginated and are frequently unequal [7]. In case of *B. persicum*, small sepals, petals and stamens are readily symmetrical and each five in number [6]. The leaves of both the plants are also very much similar. The glabrous leaves of *C. carvi* are

rosette, cauline type and in part tri-pinnate [8]. Leaves of *Bunium persicum* are also tri-pinnate and are finely dissected and filiform [9]. The leaves are soft fern like (Agrahari & Singh, 2014) with partite at 3 sides [7].

The height of both the plant is almost same. The height of *C. carvi* it varies from 30- 100 cm [10] while that of *B. persicum* it varies from 30 to 80 cm [9]. *C. carvi* is biennial in nature (i.e complete its life cycle in two years) [11] and *B. persicum* is perennial in nature (completes life cycle in several years) [12]. The *B. persicum* plant once planted, it forms rhizomes and in winter it become dormant and in next spring seasons plant again sprout from these rhizomes. The roots of *C. carvi* are fleshy, fusiform tap root [11] while *B. persicum* is having tuberous roots which are of hypocotyl or root origin [9]. Tubers become dormant in winter season and during spring, plants again originated from them. These two plants can be easily differentiated from this behaviour of plants.

In case of *Carum carvi*, stem is erect, angular, grooved, filled with latex, glabrous and branched from the ground up [10] for *B. persicum*, stem is often hollow in the internodal region with secretory canals containing ethereal oils and resins height [9]. The seeds of both the plant are shizocarpic type with two mericarps. In *C. carvi* the seeds are 3-6mm long with 5 lighter, angular main ribs [8]. The shape and colour of the *C. carvi* seed is distinct and helpful in differentiating both the plants. The seeds of *C. carvi* are sickle shaped and light brown in colour [8] (Fig.1 B) while the seeds of the *B. persicum* are cylindrical in shape and dark brown in colour [6] (Fig.1B). The size of the *B. persicum* seeds is also smaller than *C. carvi* seeds but the pungency is more in case of *B. persicum* seeds. The mericarps are often attached to an entire or deeply forked central stalk (carpophore) with lobular or elongated oil canals (vittae) [9].

Table1. Different characters between *Carum carvi* and *Bunium persicum*

Characters	<i>Carum carvi</i>	<i>Bunium persicum</i>
Plant type	Biennial [11]	Perennial [12]
Fragrance	Aromatic	Aromatic
Flowers	Flowers are white, pink or red in colour [13] with compound umbels, bracteates and bracts linear, rigid in nature, Calyx is unequal, having small teeth, subulate. It has oblong or obovate, emarginated, frequently unequal, white colored petals [7]	Pink and White (Readily symmetrical small sepals, petals and stamens (Each five in number) [6]
Inflorescence	Umbel [8]	Umbel [6]
Leaves	Rosette, cauline leaves are glabrous and in part tri-pinnate [13]	Freely, pinnate (2-3), finely dissected and filiform (Sofi <i>et al.</i> , 2009). It has soft fern like 2-3 leaves with partite at 3 sides [7]
Plant height	30 to 100 cm high plant [10]	30-80 cm height [9]
Stem	Erect, angular, grooved, filled with latex, glabrous and branched from the ground up [10]	Often hollow in the internodal region with secretory canals containing ethereal oils and resins height [9]
Fruit	Shizocarpic fruit with 2 mericarps that are 3 to 6 mm long, sickle-shaped, with 5 lighter, angular main ribs and light brownish in colour [8]	Shizocarpic with 2 mericarps that are often attached to an entire or deeply forked central stalk (carpophore) with lobular or elongated oil canals (vittae) [9], Slenderical in shape and dark brown in colour (Gani <i>et al.</i> , 2020).
Roots & Tubers	Fleshy, fusiform tap root [10]	tubers present which are of hypocotyls or root origin [9]
Bioactive constituents	α -Pinene, Camphene, β -Pinene, β -Myrcene, Limonene, γ -Terpinene, (E)- β -Ocimene, <i>p</i> -Cymene, Carvone, Terpinolene, myristicine, carvyl and dihydrocarvyl acetate, dihydrocarvone, terpinine-4-ol, 1,2dihydrocaveol and perillyl alcohol [14]	Cuminaldehyde, carvacrol, anisole, o-Cymene, γ -Terpinene, α -Propylbenzyl alcohol, β -Pinene, D-Limonene [15]
Chromosome number	2N= 20 (Iovene <i>et al.</i> , 2008)	2N=14 [9]
Medicinal properties	For relieving gastrointestinal cramps and feelings of fullness, as well as nervous cardiac-gastric complaints, in spasmodic gastrointestinal complaints, flatulence, irritable stomach, indigestion, lack of appetite, dyspepsia in adults, and in relieving flatulent colic of infants [8]	As stimulants, carminatives, and are useful in diarrhoea and dyspepsia, have hypoglycemic activity and can prevent diabetes and obesity, culinary purposes and for flavoring food and beverages [9]

3. Chemical composition

The *C. carvi* seed contain different types of secondary metabolites including terpenes, flavonoids, coumarins, and other types of phenolic compounds. These metabolites are the major cause of its antioxidant activity. Seeds contain approx. 5–7.5 % essential oil and terpenes are the major constituents of this. The oil contains many components including α -Thujene, β -Pinene, o-Cymene, β -Phellandrene, γ -Terpinene, 3-Carene, Linalool, 2-(1-Cyclohexenyl)cyclohexanone, Thymol, Trimethylene dichloride, δ -carvone and it also contains fixed oil, which consists of oleic, petroselinic linoleic, and palmitic acid. The flavour and odour of *C. carvi* seeds are mainly due to the presence of carvone and limonene [16]. The stabilizing effect of *C. carvi* seeds on food, especially meat products, is considered to be due to the presence of a high content of phenolic substances. The phenolic functional group is known to have antimicrobial properties and to be capable of retarding the oxidation of active substances. The phenolic compounds identified in *C. carvi* seed are flavonoids, glycosides, derivatives of quinic acid, proteids and tannins. The constituents responsible for the antioxidant properties of *C. carvi* seed are attributed to carvacrol.



Fig. 1. *Bunium persicum* and *Carum carvi* (Both plant seeds were collected from the Lahul, Himachal Pradesh, India).

The *B. persicum* seeds consist of approximately 2-9% essential oil and contain Carvone, Cuminaldehyde, γ -terpinene, α -terpinen-7-al, γ -terpinen-7-al, p-cymene, Limonene, α -pinene, β -pinene, Anisole, Apiole, Carvacrol, Caryophyllene, Cuminal alcohol, Germacrene, DTrans-Dihydrocarvone, α -methylbenzenemethanol. Out of these, major constituents include γ -terpinene, cuminaldehyde and γ -terpinen-7-al. The presence of terpene hydrocarbon such as p-cymene, β -pinene, limonene, γ -terpinene degrades its quality. Additionally, many other minor components such as bornyl acetate [17], 1,8-Cineole [18], delta-3-Carene [19], sabinene, cineole, menthone, myrcene, terpinolene, eugenol, α -thujene, safrole, cumyl acetate, camphene, pinocarvyl acetate and caranone, [20, 21] were also reported (generally < 5 percent). The percentage and the amount of these components in both plants may also vary from place to place [1].

4. Ethnomedicinal and therapeutic usage

C. carvi seeds are digestive in nature and being used as tea which is prepared by boiling seed with milk and then further addition of honey and it is suitable during menstrual pain. Seed powder mixed with butter oil is taken orally for 5 days for removing impurities from the uterus [22]. Its herbal tea is reported to be useful for stomachic, gastric trouble, gastric ulcer and abdominal pain. It is helpful in treatment of common cold, dyspepsia, diarrhoea, inflammations of mouth and pharynx, catarrh, cough, bronchitis, fever, liver and gall bladder complaints, loss of appetite [23]; abdominal irritation due to worms, hoarseness of voice [7]; painful womb swelling, leukoderma, abdominal tumors, malaria, piles [24]. It is also helpful in relieving gastrointestinal cramps and feelings of fullness, spasmodic gastrointestinal complaints, reduces nervous cardiac complaints, flatulence, indigestion, irritable

stomach, and relieves flatulent colic of infants [8]. Different herbal composition of *C. carvi* seeds with other seeds and herbs such as chamomile, peppermint, anise, thyme, fennel and coriander in different proportions are being used as carminatives and for digestive purposes. Different formulations of *C. carvi* seeds such as seed as such, seed water concentrate, seed powder, seed essential oil are being used for various purposes.

B. persicum is being used in various traditional medicinal systems, worldwide. In Unani system, it has been used for the treatment of bronchitis, asthma, rheumatism, cough, and other inflammatory diseases. It is also carminative, antiseptic, stomachic, and lactagogue. In Indian folk medicine, flower heads are used as carminative and plant leaves are used to cure abdominal pain. *B. persicum* seed decoction is found useful in case of Flatulence, headache, Spasm, Menstrual pains, cold, joint pain, stomachache, fever, tuberculosis, etc. Due to the presence of high levels of oxygenated monoterpenes, especially γ -Terpinene, cuminaldehyde, p -cymene and limonene in its essential oil, it is having antimicrobial and antioxidant properties. Due to the fact that *Bunium persicum* is widely used in people's diet as a flavoring agent, there is no major concern about the toxic effects of this plant [25].

5. Pharmacological activity

Essential oil of *C. carvi* has shown good antimicrobial activity against gram positive and gram-negative bacteria (*Staphylococcus aureus*, *Salmonella typhi*, *Candida albicans*, *Aspergillus niger* and *Listeria innocua* etc) along with *Vibrio* strains due to the presence of limonene in good proportions. The antimicrobial activities are not reduced even after the treatment with γ -Irradiation as the related compounds are not affected by the radiations [26]. Antibacterial activities are also shown by the phenolic compounds present in the defatted seed powder. *C. carvi* essential oil has shown antifungal activity. Cuminaldehyde, γ -terpinene, p -cymene and c -terpinene-7-al, present in it, has shown the inhibition of aflatoxins produced by *Aspergillus parasiticus* [27]. It has also shown antifungal activity against *Candida albicans*, *C. glabrata*, *C. parapsilosis*, and *C. krusei*. γ -terpinene, present in *C. carvi*, has capacity to work as antioxidant and is also able to inhibit lipid peroxidation. Carvacrol, dihydrocarvecol and dihydroderivatives of main terpenes-dihydrocarbon present in *C. carvi* seeds are found responsible for its antioxidant activity. Some of the flavonoids such as isoquercitrine (Quercetin 3- β -D-glucoside), quercetin 3-glucuronide, kaempferol-3-glucoside and quercetin-3-O-Caffeoyl-glucoside have shown the capacity to activate enzymes which can detoxify cancer causing substances and metabolites present in the cells [2].

The coumarins and furocoumarins present in *C. carvi* seeds, have shown antibacterial properties and can also work as photosensitizers in presence of UV light. Coumarins are known to be used for the treatment of psoriasis and can be utilized in sunscreen lotions [28]. *C. carvi* seeds have the capacity to reduce tumor cells proliferations. Its essential oil can work against the inflammatory diseases such as Inflammatory bowel disease (IBD) and irritable bowel syndrome (IBS). Consumption of *C. carvi* seeds by breast-feeding women and bovines favours milk secretion and enhances lactation. It also has positive effect on digestive system of baby, consuming that milk due to antigripping properties. *C. carvi* seed extracts and oil have shown antidiabetic, diuretic, anti-inflammatory, anti-glycemic, anticonvulsant, antifatulent, antispasmodic, antihistaminic and hypolipidemic activities [29]. It also shows Diuretic, antifertility activities [30]. The aqueous extract of *C. carvi* seed have shown antifertility effect by increasing estrogen level, and be reducing progesterone and FSH level at proestrus phase [28]. The essential oil of *C. carvi* seeds have shown neuropharmacological properties due to which it helps in the preventing neurodegenerative diseases, including Parkinson's disease, Alzheimer's disease, and epilepsy. It also works as hepatoprotective by decreasing or normalizing the liver function enzyme activities such as activity of alkaline phosphatase, alanine aminotransferase, glutamic oxaloacetate transaminase, aspartate aminotransferase, and glutamic-pyruvic transaminase.

Aqueous extract of *B. persicum* seeds have shown Anticonvulsant [31], Anti-ulcerative and anti-diarrheal [32], anti-breast Cancer [33], antidiabetic [34], bronchodilatory and anticholinergic [35]. Oral administration of *B. persicum* seed oil can reduce oxidative stress in diabetes mellitus. Due to the presence of thymoquinone, the seeds can be helpful for Triple-negative breast cancer [33]. *B. persicum* seed extracts had shown anti-oxidant and antitoxic activities and have shown ha ability to prevent reactive oxygen species (ROS) induced hematotoxicity in leukemic blood rats. The extracts had shown the ability to inhibit glycosidase hydrolase activity due to which it has shown anti-obesity, hypoglycaemic, and antidiabetic effects.

B. persicum seed essential oil contains phenolic compounds namely cuminaldehyde, p -cymene, and γ -terpinene which help it to work against gram positive bacteria. It has also shown antibacterial activity against food borne pathogens namely *Bacillus subtilis*, *Bacillus cereus*, *Klebsiella pneumonia*, *Escherichia coli* O157:H7, *Proteus vulgaris*, *Listeria monocytogenes*, *Salmonella enteritidis*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. It has also shown antifungal activity against *Alternaria mali*, *Aspergillus* spp., *Botrytis cinerea*, *Candida albicans*, *Colletotrichum lindemuthianum*, *Fusarium oxysporum*, *Penicillium chrysogenum*, *Saccharomyces cerevisiae*, and *Verticillium dahliae* [12]. p -cymene and Cuminaldehyde are believed to be responsible for antifungal activity of *B. persicum* essential oil. Essential oil of *B. persicum* have also shown antiparasitic activity and its nano-liposomes

are found efficient to kill a flagellated protozoan parasite *Trichomonas vaginalis*, which causes sexually transmitted diseases [12].

6. Difference at molecular level

At the molecular level both the plant was found different in some reported studies. *Carum carvi* contain 20 diploid chromosomes [36] and *Bunium persicum* contain only 14 diploid chromosomes [9]. In a study by Zehra et al. (2018) these two species from Apiaceae family showed on an average 81% genetic distance, when studied using the 23 RAPD primers [37]. Bansal et al. (2018) reported the use of DNA marker to detect the adulteration of safed zeera (*Cuminum cyminum*) in kala zeera (*Bunium persicum*) [25]. They have used ITS2, *psbA-trnH* marker out of which *psbA-trnH* produces amplicon of different size specific to safed zeera (322bp) as well as kala zeera (257bp). So, adulteration may be identified by just resolving the amplified product on agarose gel. These markers may also be used for identifying the *C. carvi* and *B. persicum* or other specific marker should also be developed for identification of these plants or seeds in future.

7. Use in food

The seed of *Caram carvi* have a distinct warm, sharp, pleasant aroma and slightly sweet. It is mostly used as a whole and sold in both national and international market. It possesses a good storage life due to its inherited preserving qualities. The seeds are mainly used as a common spice both at household or commercial levels [2]. It is used in breads, baked foods, sauces, meat dishes, stews, cakes and chesses, etc. According to Farrell, 1999, it is used in the preparation of canapés, onion bread, cheese spreads, omelettes, coleslaw, cooked pastas, rye bread, soups, salad dressings, sauces, rice, boiled seafoods, cabbage and potato soups, sauerkraut, cucumber salad, poultry dressings, stews, homemade sausage and vegetables such as beets, carrots, cabbage, cucumbers, onions, turnips, green beans, potatoes, cauliflower and zucchini, etc. In bakery industry, it is used as sprinkle on the dough before baking to create aroma [2]. In Denmark, it is used in different kinds of alcoholic beverages. It is also used to make a green tea.

The seeds are mostly used as a spices or flavouring agent [25]. It has astringent and bitter flavour and used to enhance the flavour [38]. It is used in bread, rice, yoghurt, cheese, confectionery products, and cosmetics industry for its aroma [9,38,39]. Besides its use as natural flavour, the seed essential oil can also contribute to good health and can be used as a preservative against microbial contamination in foods like masticatories, fish, edible oils, Gouda cheese, Iranian white cheese, etc [40-43].

8. Conclusion

Seeds of both the plants *C. carvi* and *B. persicum* looks similar, so the problem of adultration is being observed, but if these are studied in details then some of the difference may be identified. The most prominent character for their identification is through shape, size, colour and smell of the seeds, i.e., the *C. carvi* seeds have distinct sickle shape, larger in size, light brown in colour and are less pungent but in case of *B. persicum* the seeds are slenderical in shape, smaller in size, dark brown in colour and are more pungent than former plant. At molecular level about 81% genetic distance has been reported in two plants and one can also use the DNA marker to distinguish the two plants and seeds thereof. There are some differences in chemical and pharmacological properties also, due to unique set of compounds in each type of seeds. So, the comparative studies are required at chemical and pharmacological level between both the seeds.

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9. References

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