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Review Article

Medical Utilization of Coriander (Coriandrum sativum L.)-Products

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Abstract

Dried coriander fruit is an important ingredient in pickle making. It is sometimes used to mask odd flavors. Its fruits contain vegetable oil with a high concentration of monounsaturated fatty acids, especially of petroselinic acid. This oil can be extracted using various techniques; most commonly three different techniques are used: steam distillation, organic solvent extraction (soxhlet), supercritical fluid extraction. Moreover, coriander oil is used as an antimicrobial agent as it possesses broad spectrum antimicrobial activity. This oil can be encapsulated in alginates, chitosan etc. so as to enable isolation, protection, transport and release of its active components like vitamins, flavours, peptides, minerals, fatty acids, polyunsaturated fatty acids, antioxidants, enzymes and living cells. Coriander powder and its essential oil are considered as natural food preservatives including antibacterial, antifungal and antioxidant properties. The commercial value of its essential oil depends on its physical properties, chemical composition and aroma quality. C. sativum extract protects liver from oxidative stress induced by carbon-tetrachloride (CCl_4) and thus helps in evaluation of traditional claim on this plant. Its leaves may also be processed to form various products like purees and pastes which are tremendously used nowadays in fast food industries. After harvesting of fresh mature plant, degradation of its components starts. Coriander sauce gives an intense flavor and deep green color but is not spicy. In case of powder formation, freshly harvested leaves are blanched at 90°C for at least 2 min so as to inactivate peroxidase enzyme, dried and then ground to uniform size and preserved for further use. In contrast, water-blanching and extended steam-blanching even yielded increased levels compared to the unheated control, whereas short-time water-blanching resulted in higher values than prolonged heat treatment. Thus, short-time water-blanching was recommended as the initial unit in the processing of coriander leaves and fruits into novel pasty products. This essential oil due to its radical scavenging activity can be used as natural antioxidant to enhance the shelf stability of many foods. Its seed extract is used as a traditional medicine for diabetic patients. Incorporation of ground coriander seed extract in diet led to marked decline in blood glucose and rise in levels of insulin in diabetic rats. Besides peroxidative damage inhibition, addition of its seed extract reactivated antioxidant enzymes and antioxidant levels in diabetic rats. An aqueous extract of coriander (1 mg/ml) increased the 2-deoxyglucose transport by 1.6 folds, glucose oxidation by 1.4 folds and incorporation of glucose into glycogen of isolated murine abdominal muscle by 1.7 folds. Hyperlipidemia increases the risk for generation of lipid oxidation products, which accumulate in the subendothelial spaces of vasculature and bone. Atherogenic high-fat diets increase serum levels of oxidized lipids, which are known to attenuate osteogenesis in culture and to promote bone loss. Coriander has been used as folk medicine in Iran for treatment of insomnia. It was observed that the extract of 100 and 200 mg/kg produced anti-anxiety effects similar to diazepam. Coriander can be used as a natural cleansing agent as it has potential to remove toxic metals from body. Chemical compounds present in coriander attach to toxic metals and remove them from cells. This plant is very effective to remove inorganic (Hg^{2+}) and methyl mercury (CH_3Hg) from aqueous solutions. This effect was due to the binding effect of carboxylic group to mercury. These results clearly showed that sorbent can be used to remove inorganic and methyl mercury from contaminated water. Coriander led to marked decline in oxidative stress caused by lead nitrate. Many of its healing properties can be attributed to its exceptional phytonutrients and hence, it is often referred to as store house for bioactive compounds. It also has preventive action on gastric mucosal membranes due to many reasons like free radical scavenging activity or due to formation of protective layer. Its oil can also be used as anti-microbial agent. This oil is effective against both gram positive as well as gram negative bacteria and also against pathogenic fungus. Coriander oil also exhibits bactericidal activity with the exception of Bacillus cereus and Enterococcus faecalis. In Iranian traditional medicine, coriander has been indicated for a number of medical problems such as dyspeptic complaints, loss of appetite, convulsion and insomnia.

Key words: carbon-tetrachloride; petroselinic acid; sorbent; phyto-nutrients; soxhlet

Summary

Coriander (*Coriandrum sativa* L.) which belongs to the family Apiaceae (Umbelliferae) is mainly cultivated from its seeds throughout the year (Mhemdi *et al*., 2011). India is the biggest producer, consumer and exporter of coriander in the world with an annual production of around three lakh tonnes. It is an annual, herbaceous plant which originated from the Mediterranean and Middle Eastern regions and known as medicinal plants. It contains an essential oil (0.03 to 2.6%) (Nadeem *et al*., 2013). All parts of this herb are in use as flavoring agent and/or as traditional remedies for the treatment of different disorders in the folk medicine systems of different civilizations (Sahib et al., 2012). Coriander closely resembles flat leaf parsley. This resemblance makes many people confused between the two however, coriander has strong fragrance and parsley has mild fragrance. It grows best in dry climates however it can grow in any type of soil like light, well drained, moist, loamy soil, and light to heavy black soil (Verma *et al*., 2011). Its seeds are almost ovate, globular and have a mild, sweet, slight pungent like citrus flavor with a hint of sage. The most important constituents of its seeds are the essential oil and fatty oil. It is highly reputed ayurvedic medicinal plant commonly known as "Dhanya" in India. This plant is highly aromatic and has multiple uses in food and in other industries.

Plants have played a critical role in maintaining human health and civilizing the quality of human life for thousands of years. It is also used to flavor sausages. All parts of plant are edible, fresh leaves can be used for garnishing and are common ingredient in many foods like chutneys and salads. The green herb is also employed for the preparation of either steam-distilled essential oil or the solvent extracted oleoresin (Nadia and Kandi, 2012). Fresh juice of coriander is extremely advantageous in curing many deficiencies related to vitamins and iron. One to two teaspoons of its juice, added to refreshing buttermilk, is incredibly beneficial in curing many diseases. Fresh leaves can be eaten as such because of various health benefits however, if it is not harvested freshly seeds mature and ripen in late summer developing delicate aroma which are then used as dried spice. Moreover, this plant is used to cure diseases like digestive tract disorders, respiratory tract disorders, urinary tract infections. Coriander has been reported to possess many pharmacological activities like antioxidant (Darughe *et al*., 2012), anti-diabetic (Eidi *et al*., 2012), anti-mutagenic (Cortes et al., 2004), anti-lipidemic and anti-spasmodic (Sunil *et al*., 2012).

Dried coriander fruit is an important ingredient in pickle making. It is sometimes used to mask odd flavors (Parthasarathy *et al*., 2008). Its fruits contain vegetable oil with a high concentration of monounsaturated fatty acids, especially of petroselinic acid. This oil can be extracted using various techniques; most commonly three different techniques are used: steam distillation, organic solvent extraction (soxhlet), supercritical fluid extraction (Mhemdi *et al*., 2011). Moreover, coriander oil is used as an antimicrobial agent as it possesses broad spectrum antimicrobial activity (Silva *et al*., 2011). This oil can be encapsulated in alginates, chitosan etc. so as to enable isolation, protection, transport and release of its active components like vitamins, flavours, peptides, minerals, fatty acids, polyunsaturated fatty acids, antioxidants, enzymes and living cells (Cristian, 2013). Coriander powder and its essential oil are considered as natural food preservatives including antibacterial, antifungal and antioxidant properties (Politeo *et al*., 2007). The commercial value of its essential oil depends on its physical properties, chemical composition and aroma quality.

Coriander may sometimes be affected by certain diseases and pests like wilt (Fusarium oxysporum) and stem gall. The powdery mildew is effectively controlled byspraying sultaf (0.25%). There are no direct control measures for wilt. It is very difficult to control stem-fall (Verma *et al*., 2011). To check its quality, automatic quality assessment techniques have been developed in Indian spice industries. Quality analysis of its seed was done by image morphological operations (Rohit *et al*., 2011).

Harvesting is the primary process of collecting the crop and should be done at optimum time period to ensure production of plant material and the best quality of finished spice product (Douglas *et al*., 2005). In order to remove field heat and prolong shelf life after harvesting, it is necessary to pre-cool harvested coriander before transportation. This can be done by vacuum cooling. Vacuum cooling is achieved through boiling part of the moisture of the product under vacuum conditions. This cooling has a significant effect on amount of vitamin C and shelf life (Apichart *et al*., 2012).

Coriander may sometimes be irradiated to reduce microbial load before consumption. Irradiation dose of 0.5 kGy of gamma radiations results in reducing aerobic mesophilic count to 99.9%, while the initial total coliform bacteria decreased from 871,000 cfu/g to less than 100(Cruz-Zaragoza *et al*., 2011). It was found that microwave-dried samples had higher chlorophyll content and the green color was preserved better than for the air-dried and freeze-dried samples (Alibas, 2006). This is because microwave drying of coriander is faster than other conventional drying methods which are gradual and slow to reach the final moisture content. Microwave drying is able to reduce the coriander moisture content to the 12% (wb) target within 21 to 22 min (Shaw *et al*., 2007). obtain essential oil. This oil is mainly obtained by steam distillation, super critical CO2 extraction etc. Oil extraction from its seeds was studied with carbon dioxide and propane as solvents, under sub and supercritical conditions. The ratio of solvent to seed (g/g) required to achieve a complete oil extraction was between 20 and 40 using CO_2 at pressures of 200 and 300 bar and temperature of 35°C. A complete oil recovery was attained with propane or propane-rich solvents at 25°C and 50, 80 and 100 bar. The solvating power of propane and propane-containing solvents was proved to be much higher than that of CO_2 (Illes *et al*., 2000).

Its oil has a characteristic odor of linalool and warm aromatic flavor. This oil is approved for food use by FDA (Food and Drug Administration), FEMA (Foreign Exchange Management Act) and Council of Europe (Silva *et al.*, 2011). In order to preserve the warm aromatic flavor and prevent nutrient loss upto end use, this oil is encapsulated mainly in alginates or chitosans.

The aqueous solution of sodium alginate is transformed in gel under the action of calcium ions which form the intermolecular cross-links with the carboxyl groups of guluronate, leading to the well-known "egg-box" structure providing best possible protection to coriander essential oils.

The coriander plant is mainly used for making sauces and salsas; on the other hand, the fruits are blended into powder for flavouring various products like meat, fish, sodas, pickles, bakery and curry recipes (Ravi *et al*., 2007).

Its leaves may also be processed to form various products like purees and pastes which are tremendously used nowadays in fast food industries. After harvesting of fresh mature plant, degradation of its components starts. Coriander sauce gives an intense flavor and deep green color but is not spicy. In case of powder formation, freshly harvested leaves are blanched at 90°C for at least 2 min so as to inactivate peroxidase enzyme, dried and then ground to uniform size and preserved for further use (Ahmed et al., 2003). In contrast, water-blanching and extended steam-blanching even yielded increased levels compared to the unheated control, whereas short-time water-blanching resulted in higher values than prolonged heat treatment. Thus, short-time water-blanching was recommended as the initial unit in the processing of coriander leaves and fruits into novel pasty products (Kaiser *et al*., 2013).

Its seeds contain upto 1.8% volatile oil according to origin. The distilled oil (coriander oil BP) contains 65 to 70% of (+)-linalool (coriandrol), depending on the source (Anju *et al*., 2011). It includes: Monoterpene hydrocarbons viz α- pinene, β-pinene, limonene, γ-terpinene, ρ-lymene, borneol, citronwllol, Xmphoe, Geraniol and Geranylacetate; Hetero-cyclic compounds viz – pyrazine, pyridine, thiazole, furan, tetrahydrofuran derivatives; Isocoumacin viz coriandrin,dihyrocoriandrin, coriandrones A-E, glazonoids; Phtha-lides viz -neochidilide, Z-digustilide; Phenolic acids and sterols, flavonoids (Wallis, 2005). Its leaves being good source of β-carotene serve as a precursor of vitamin A. In coriander, β-carotene content, 160 µg/100 g is present whereas total carotenoid content is 1010 µg/100 g (Kandlakunta *et al*., 2008). Its foliage is used in various types of foods especially in diets of people facing vitamin A deficiency. Green foliage contains anthocyanin (Omidbaigi, 2005). Anthocyanins are bioactive flavonoid compounds that prevent body fromvarious chronic diseases. Anthocyanin in foliage acts as antioxidants which are very useful in improvement of nutritional value as well as maintenance of health and wellbeing (Rahimi *et al*., 2013).

The various nutrients present in coriander leaf and seeds. The characteristic aromatic flavor of its seeds comes from many fatty acids and essential volatile oils. According to USDA (2013), cholesterol content of its seeds is nil. Its seeds are considered as an important source of vitamins, minerals and lipids.

Among minerals, potassium is present in high amount (1267 mg/100 g) followed by calcium (709 mg/100 g), phosphorus (409 mg/100 g), magnesium (330 mg /100g), sodium (35 mg/100 g), zinc (4.70 mg/100 g). The folate content in coriander seed is 200 µg/ 100 g (fresh weight) (Iwatani *et al*., 2003).

Coriander contains high number of essential oils that are very important for growth and for proper functioning of brain. The main essential fatty acids present in coriander include linoleic and linolenic acids. Linoleic acids belong to PUFA (polyunsaturated fatty acid) group. Dietary supplementation of coriander seed greatly affects the lipid composition of carcass by decreasing saturated fatty acid (SFA) contents (palmitic and stearic acids) and by increasing monounsaturated and polyunsaturated fatty acid (MUFA and PUFA) (Ertas *et al*., 2005).

This plant is a potential source of lipids (rich in petroselinic acid) and an essential oil (high in linalool) isolated from the seeds and the aerial parts (Sahib *et al*., 2012). The high content of fats and protein in the fruits make distillation residues suitable for animal feed. Coriander fruits yield 5 to 7% of ash, 13% resin, astrin-gent principle, malic acid and alkaloids. Coriander oil contains coriandrol, jireniol and vebriniol (Rao *et al*., 2012).

The functional properties of coriander cannot be under estimated. Besides nutritional benefits, it is well known for its health or medicinal benefits as well as for additional benefits like it acts as antimicrobial agent. The type of meat and temperature did not influence the antimicrobial activity of the oil; indicating the potential of coriander oil to serve as a natural antimicrobial compound against Campylobacter jejuni in food (Rattanachaikunsopon and Phumkhachorn, 2010).

Coriander is a good source of polyphenols and phyto-chemicals due to its high antioxidant activity. Reactive species of oxygen can cause oxidative stress and consequently, the damage of tissues and biomolecules (Barros *et al*., 2012). Both leaves and seeds of coriander contain antioxidants but leaves contain more amounts of antioxidants than seeds (Wangensteen *et al*., 2004). Its Antioxidant content is attributed to its high content of pigments particularly carotenoids. The carotenoids of its extract were found to show higher hydroxyl radicals scavenging potential thereby protecting cells from oxidative damage (Peethambaran *et al*., 2012). Among secondary metabolites, phenolic compounds are considered as one of the most important and largest group. Phenolic groups may be categorized into four main groups depending upon number of phenol rings and structural elements that bind these rings. These groups include: flavonoids (anthocyanins, flavones and isofla-vones) tannins, stilbenes and lignans (Balasundram *et al*., 2006).

In recent years, essential oils have been qualified as natural antioxidants. Coriander essential oils serve as potential antioxidants. Main components of its essential oil are: camphor (44.99%), cyclohexanol acetate (cis-2-tert. butyl-) (14.45%), limonene (7.17%), α-pinene (6.37%). This essential oil at percentage of 0.05, 0.10 and 0.15 is very much effective in inhabiting primary and secondary oxidation products. It was found that at the proportion of 0.02%, its effects were almost equal to BHA (butylated hydroxyanisole) (Darughe *et al*., 2012).

One of the major problems in high lipid product in food industry is rancidity resulting in undesirable flavor changes and decline in nutrients (vitamins) leading to change in their texture and appearance. Lipid peroxidation causes oxidative stress, resulting in the development of rancidity, unpleasant taste and odors as well as changes in color and losses related to nutritional value.Use of antioxidants reduces oxidative rancidity (Bhanger *et al*., 2007). Addition of coriander essential oil may greatly serve the purpose. Darughe et al. (2012) studied the antioxidant effects of CEO (coriander essential oils) in cake. It was found that antioxidant effect of CEO may be due to the presence of terpenoidcomponents (camphor, limonene, α-pinene and geraniol).

This essential oil due to its radical scavenging activity can be used as natural antioxidant to enhance the shelf stability of many foods (Ramadan *et al*., 2003). Its seed extract is used as a traditional medicine for diabetic patients. Incorporation of ground coriander seed extract in diet led to marked decline in blood glucose and rise in levels of insulin in diabetic rats. Besides peroxidative damage inhibition, addition of its seed extract reactivated antioxidant enzymes and antioxidant levels in diabetic rats (Deepa and Anuradha, 2011). An aqueous extract of coriander (1 mg/ml) increased the 2-deoxyglucose transport by 1.6 folds, glucose oxidation by 1.4 folds and incorporation of glucose into glycogen of isolated murine abdominal muscle by 1.7 folds.

Hyperlipidemia increases the risk for generation of lipid oxidation products, which accumulate in the subendothelial spaces of vasculature and bone. Atherogenic high-fat diets increase serum levels of oxidized lipids, which are known to attenuate osteogenesis in culture and to promote bone loss (Pirih et al., 2012). Lal et al. (2004) studied the hypolipidemic effect of coriander (*Coriandrum sativum* L.). Coriander was given at a dose of 1g/kg to triton induced hyperlipidemic rats. It was found that coriander decreases the uptake and enhances the breakdown of lipids. Results were compared with commercially available herbal drug for hypolipidemia. Its aqueous extract was also investigated for in vivo anthelmintic activity in sheep infected with H. contortus. Both extract types of coriander inhibited hatching of eggs completely at a concentration less than 0.5 mg/ml (Debella *et al*., 2007).

Coriander has been used as folk medicine in Iran for treatment of insomnia. Mahendra and Bisht (2011) studied anti-anxiety activity of hydro alcoholic extract of coriander in mice using diazepam as standard. It was observed that the extract of 100 and 200 mg/kg produced anti-anxiety effects similar to diazepam.

Coriander can be used as a natural cleansing agent as it has potential to remove toxic metals from body. Chemical compounds present in coriander attach to toxic metals and remove them from cells (Abidhusen, 2012). Arunasagar et al. (2005) observed that this plant is very effective to remove inorganic (Hg^{2+}) and methyl mercury ($CH_3Hg^)$ from aqueous solutions. This effect was due to the binding effect of carboxylic group to mercury. These results clearly showed that sorbent can be used to remove inorganic and methyl mercury from contaminated water. Kansal et al. (2011) found that coriander led to marked decline in oxidative stress caused by lead nitrate.

Many of its healing properties can be attributed to its exceptional phytonutrients and hence, it is often referred to as store house for bioactive compounds (Ullagaddi and Bondada, 2011). It also has preventive action on gastric mucosal membranes due to many reasons like free radical scavenging activity or due to formation of protective layer (Al-Mofleha, 2006). Its oil can also be used as anti-microbial agent. This oil is effective against both gram positive as well as gram negative bacteria and also against pathogenic fungus. Coriander oil also exhibits bactericidal activity with the exception of Bacillus cereus and Enterococcus faecalis (Silva, 2011).

In Iranian traditional medicine, coriander has been indicated for a number of medical problems such as dyspeptic complaints, loss of appetite, convulsion and insomnia. (Benjumea *et al*., 2005; Maghrani *et al*., 2005 and Duke, 2002)

Coriander (*Coriandrum sativum* L.) is an annual plant that belongs to the family Umbelliferae possessing spice, aromatic, nutritional as well as medicinal properties (Mc Ausland *et al*., 2020). The origin of coriander is uncertain, the area suggested by most authors being the near east. Some authors suggested central Asia and Mediterranean countries (Laribi *et al*., 2015). Balasubramanian et al. (2012) stated that coriander is native to southern Europe, North Africa and southwestern Asia. Major producers are India, Morocco, Canada, Pakistan, Romania, Ukrain, Russia (Priyadarshi *et al*., 2016), United States, Canada, Argentina and Mexico (Sharma *et al*., 2014).

Coriander is one of the important and earliest seed spices crop known to humankind (Meena *et al*., 2014), which can be dated back to the history of Queen of Sheba who visited king Solomon mentioned in the Holy Bible. The aromas and flavors have for many years attracted the attention of man is due to the presence of pleasant aromatic odor or essential oil rich in linalool found in the stem, leaves and fruits of coriander (Beyzie *et al*., 2017). It can be used directly or indirectly for diverse purposes. It can be used as a spice in culinary (Geremew *et al*., 2015), medicine (Singletary, 2016), food industry (Prachayasittikul *et al*., 2018), in perfumery, beverage and pharmaceuticals industries (Priyadarshi *et al*., 2016). Coriander is also a good melliferous plant and studies indicated that coriander could be used for honeybee production (Abou-Shaara, 2015).

The herb as young plants is used to prepare curry, soups, salads, and sauces, whereas the fruit is mainly used as a seasoning for pickles, cold meats, confectionery products and seasoning mixtures (Ravi *et al*., 2007). It is the most widely consumed popular ingredient in the world as a domestic spice, a traditional medicine, and a flavoring agent (Gupta, 2010). Coriander is available throughout the year providing a fragrant flavor that is reminiscent of both citrus peel and sage. It's essential oil is used in pharmaceutical recipes and as a fragrance in cosmetics (Al-Mofleh *et al*., 2006). In addition to culinary value, coriander is known for its wide range of healing properties. It is generally used in gastrointestinal complaints such as anorexia, dyspepsia, flatulence, diarrhea, griping pain and vomiting. Coriander fruit is also reputed as refrigerant, tonic, diuretic, and aphrodisiac, while, its essential oil is considered useful in flatulent colic, rheumatism, neuralgia, etc. Coriander is also used as antiedemic, anti-inflammatory, antiseptic, emmenagogue, antidiabetic, antihypertensive, lipolytic and myorelaxant, and possess nerve soothing property (Jabeen *et al*., 2009).

Its seeds contain up to 1.8% volatile oil according to origin. The distilled oil (coriander oil BP) contains 65 to 70% of (+)-linalool (coriandrol), depending on the source (Dhankar *et al*., 2011). The minor chemical constituent of coriander includes Monoterpene hydrocarbons viz α-pinene, β- pinene, limonene, γ-terpinene, ρ-lymene, borneol, citron wllol, Xmphoe, Geraniol and Geranylacetate; Heterocyclic compounds viz – pyrazine, pyridine, thiazole, furan, tetrahydrofuran derivatives; Isocoumacin viz coriandrin, dihyrocoriandrin, coriandrones A-e, glazonoids; Phthalides viz -neochidilide, Z-digustilide; Phenolic acids and sterols, flavonoids. Carotenoids are of ubiquitous occurrence in all plants with higher concentrations in reproductive organs. In green leafy vegetables, carotenoids, particularly β-carotene is deposited mainly in leaves (Wallis, 2005).

Carotenoids can also be processed and used as coloring agents as well as good source of antioxidants. Besides other roles, carotenoids chiefly function as scavengers of the free radicals produced by chlorophylls during photo-oxidation. Its leaves being good source of β-carotene serve as a precursor of vitamin A. In coriander, β-carotene content, 160 μg/100 g is present whereas total carotenoid content is 1010 μg/100 g (Kandlakunta *et al*., 2008). Its foliage is used in various types of foods especially in diets of people facing vitamin A deficiency. Green foliage contains anthocyanin (Omidbaigi, 2005). Anthocyanins are bioactive flavonoid compounds that prevent body from various chronic diseases. Anthocyanin in foliage acts as antioxidants, which are very useful in improvement of nutritional value as well as maintenance of health and wellbeing (Rahimi *et al*., 2013). The various nutrients present in coriander leaf and seeds. The characteristic aromatic flavor of its seeds comes from many fatty acids and essential volatile oils. According to Rahimi et al. (2013), cholesterol content of its seeds is nil. Its seeds are considered as an important source of vitamins, minerals and lipids. Among minerals, potassium is present in high amount (1267 mg/100 g) followed by calcium (709 mg/100 g), phosphorus (409 mg/100 g), magnesium (330 mg /100g), sodium (35 mg/100 g), zinc (4.70 mg/100 g). The folate content in coriander seed is 200 μg/ 100 g (fresh weight) (USDA National Nutrient Database for Standard Reference Release 26 Full Report (All Nutrients)

Nutrient data for 2003). Among the various constituents, vitamin C content is present in ample amount (21 mg/100 g).

Coriander contains high amount of essential oils that are very important for growth and for proper functioning of brain. The main essential fatty acids present in coriander include linoleic and linolenic acids. Linoleic acids belong to PUFA (polyunsaturated fatty acid) group. Dietary supplementation of coriander seed greatly affects the lipid composition of carcass by decreasing saturated fatty acid (SFA) contents (palmitic and stearic acids) and by increasing monounsaturated and polyunsaturated fatty acid (MUFA and PUFA) (Ertas *et al*., 2005). This plant is a potential source of lipids (rich in petroselinic acid) and an essential oil (high in linalool) isolated from the seeds and the aerial parts (Sahib *et al*., 2012). The high content of fats and protein in the fruits make distillation residues suitable for animal feed. Coriander fruits yield 5 to 7% of ash, 13% resin, astringent principle, malic acid and alkaloids. Coriander oil contains coriandrol, jireniol and vebriniol (Rao *et al*., 2012). The extraction of essential oil from coriander seeds and leaves was carried out through hydrodistillation (Shahwar *et al*., 2012). The yield of coriander seed essential oil varied from 0.03–2.6 %, depending on the species, growing region and climatic conditions. The accumulation and chemical composition of essential oil in plants were determined by different factors like environmental (Rakic and Johnson, 2002), genetic (Ebrahimi *et al*., 2010), ontogenetic (Mohammadi and Saharkhiz, 2011) as well as cultivation. The fresh coriander herb, containing essential oil (Telci and Hisil, 2008), fatty acids (Neffati *et al*., 2011), flavonoids (Raju *et al*., 2007), carotenoids as well as coumarin compounds (Bhuiyan *et al*., 2009). The aroma of the coriander fruit and herb is completely different, the aliphatic aldehydes (mainly C10–C16 aldehydes), having unpleasant odour, are the main components of the volatile oil from the fresh herb, linalool and other oxidized monoterpenes as well as monoterpene hydrocarbons predominate in the oil distilled from the fruit (Bhuiyan *et al*., 2009). The compounds present in seeds and leaves were found to vary significantly .The composition of coriander seed essential oil was found to vary with place of production. The chemical composition of coriander revealed that the linalool was72.3 and 77.7 %, while α-pinene was 5.9 and 4.4 %, γ-terpinene 4.7 and 5.6 %, camphor 4.6 and 2.4 %, limonene 2.0 and 0.9%, in Argentinean and European coriander, respectively (Gil *et al*., 2002).

All parts of this herb are in use as a flavoring agent (culinary purposes) and/or as traditional remedies for the treatment of different ailments in the folk medicine on different civilizations (Bhat *et al*., 2014) especially in digestive disorders. The fruits of this herb are very popular as spice in Mediterranean countries (Laribi *et al*., 2015). Hippocrates (460–377 BC) used coriander in ancient Greek Medicines. Decoction and tincture of powdered fruits of *C. sativum* alone or in combinations with other herbals are recommended for dyspeptic complaints, loss of appetite, convulsion, insomnia, and anxiety. Coriander essential oil has also a long history in traditional medicine. The essential oil was found to improve blood glucose control and promise as an antihyperglycemic (antidiabetic) agent (Mandal and Mandal, 2015). On the other hand, the aqueous extract of coriander fruits is used in traditional Moroccan medicine in the treatment of diabetes and dyslipidemia besides to treat a variety of disorders (Aissaoui *et al*., 2011) including Saudi Arabia and Jordan (Laribi *et al*., 2015). In addition, Moroccan and Palestinian pharmacopeias have been mentioned the usages of coriander as a traditional diuretic and treat urinary infections. The plant is also used to cure diseases like digestive tract disorders, respiratory tract disorders, urinary tract infections (Abdella *et al*., 2018). In Iranian traditional medicine, coriander fruits have a long history of use as an anxiolytic and a sedative in insomnia. The fruits were widely used internally as a carminative, digestive, spasmolytic, and galactagogic as usual. Moreover, it is also known as an anti-inflammatory agent in Iranian traditional medicine, still in herbal formulations, might be beneficial in human inflammatory bowel diseases (Heidari *et al*., 2016).

Coriander is highly reputed Ayurvedic medicinal plant commonly known as “Dhanya” in India (Abdella *et al*., 2018). Usage of coriander leaves is not clear on diabetes as suggested on Persian folklore medicine, but Ayurvedic medicine also recommends the regular use of a decoction of coriander fruits (seeds) and mentioned about effects in the treatment of arthritis and other inflammatory disorders (Laribi *et al*., 2015). Anyway, it is the main ingredient in curry powder in Indian food; the fresh green leaf is dominated in Thai and Vietnamese foods. Moreover, the roots of coriander have been used in Asian cuisine for intense flavor (Laribi *et al*., 2015). Moreover, in some regions of India, the plant has been used traditionally for its “antiinflammatory” principals; besides, the fruits are used to treat spermatorrhea, leucorrhea, and rheumatic fever (Rajeshwari and Andallu, 2011). In the United States, coriander has recently been studied for its cholesterol-lowering effects (Rajeshwari and Andallu, 2011). Moreover, in some parts of Europe, coriander has traditionally been referred to as an “antidiabetic” plant (Rajeshwari and Andallu, 2011 and Melnyk and Marcone, 2011). In Pakistan, the whole plant part is used for the treatment of flatulence, dysentery, diarrhea, cough, stomach complaints, jaundice, and vomiting. In Turkey, it is noted that the fruit infusions are useful in indigestion and as an appetizer (Laribi *et al*., 2015). However, in history, it is mentioned that coriander has an aphrodisiac effect as many other spices (Melnyk and Marcone, 2011). In traditional medicine, the usual dose of fruit powder is from 1-5 g, three times per day. This translates to a 43–71 mg/kg dose for a 70 kg individual (Abascal and Yarnell, 2012). Most of the traditional usages of the coriander have been supported by scientific data as mentioned in the text. This point is very important that the plant has been integrated between traditional and scientific usages.

Coriander fruits and its oil have been used for many diseases (Randall *et al*., 2013) such as for the treatment of rheumatism, gastrointestinal upsets, insomnia, flatulence, and joint pain in humans (Emamghoreishi *et al*., 2005). Moreover, coriander has a positive influence on lipid profile in plasma of rats (Ramadan and Mörsel, 2003). The fruits of the plant are famous for carminative, diuretic effects and used in the treatment of cold, fever, nausea, and stomach disorders (Rajeshwari and Andallu, 2011). The fruit extract has been found as a strong analgesic agent than dexamethasone (Taherian *et al*., 2012). Laribi et al. (2015) discussed with all aspects regarding the pharmacological effects of coriander in a review (Laribi *et al*., 2015). In this manner, the most frequent effects of coriander will be debated in an order.

The aqueous extract of coriander seed possesses diuretic and saluretic activity, thus, validating the use of coriander as a diuretic plant in Moroccan pharmacopoeia aqueous extract of coriander seed was administered by continuous intravenous infusion (120 min) at two doses (40 and 100 mg/kg) to anesthetized Wistar rats. Furosemide (10 mg/kg), a standard diuretic was used as the reference drug. Excretion of water and electrolytes (sodium, potassium and chloride) in urine was measured, and glomerular filtration rate (equal to creatinine clearance) was determined. The crude aqueous extract of coriander seeds increased diuresis, excretion of electrolytes, and glomerular filtration rate in a dose-dependent way; furosemide was more potent as a diuretic and saluretic. The mechanism of action of the plant extract appears to be similar to that of furosemide (Aissaoui Abderahim *et al*., 2008).

The biochemical effect of coriander fruits on lipid parameters in 1, 2-dimethylhydrazine induced colon cancer has been studied in rats. The concentrations of cholesterol and cholesterol to phospholipid ratio declined while the level of phospholipid increased significantly in 1, 2-dimethylhydrazine control group compared to the coriander administered group. Fecal dry weight, fecal neutral sterols, and bile acids showed a sharp increase in the coriander-fed group compared with the DMH-administered group. Thus, it seems that the coriander plays a protective role in the lipid metabolism of colon cancer (Chithra and Leelamma, 2000). Although there are not many studies on the anticancer effect of coriander, there are some studies based on antioxidant effect.

The antimicrobial activity of the coriander has been arisen from the essential oil content. The spice, C. sativum is one of the plants that are known to produce essential oils with antimicrobial activity (Burst, 2004). The coriander seed essential oil was screened for antibacterial activity against both Gram positive (Staphylococcus aureus, Bacillus spp.) and Gram negative (escherichia coli, Salomonella typhi, Klebsiella pneumonia, Proteus mirabilis, Pseudomonas aeruginosae) bacteria and a pathogenic fungi Candida albicans (Sabahat and Perween, 2007). The essential oil showed pronounced antibacterial activity against all of the microbes tested except for P. aeruginosae, B. cereus and enterococcus faecalis (Silva *et al*., 2011), which showed resistance. *C. sativum* showed a significant antibacterial activity against e. coli and B. megaterium bacterial species and two mycopathogenic ones responsible for cultivated diseases as determined with the agar diffusion method whereas F. vulgare var. showed a much reduced effect (Singh *et al*., 2006).

Coriandrum sativum L. has been recommended for relief of insomnia in Iranian traditional medicine. To determine sedative & hypnotic activity Aqeuous and hydroalcoholic extract & essential oil administer to rat. The results of experiment shows that aqueous extract prolonged pentobarbital-induced sleeping time at 200, 400 and 600 mg/kg. Hydro-alcoholic extract at doses of 400 and 600 mg/kg increased pentobarbital- induced sleeping time compared to saline-treated group. The essential oil increased pentobarbital induced sleeping time only at 600 mg/kg. The extracts and essential oil of coriander seeds possess sedative-hypnotic activity (Emamghoreishi, and Heidari-Hamedani, 2006). It was a potent natural antioxidant and inhibited unwanted oxidation processes. The coriander leaves showed stronger antioxidant activity than the seeds (Wangensteen *et al*., 2004). It was reported that the aqueous extracts of seeds exhibited antioxidant activity both in vitro and in vivo (Satyanarayana *et al*., 2004). Time and dose dependent in vivo antioxidant activity of fresh coriander juice was evaluated by various methods (Panjwani *et al*., 2010). This spice reduced lipid peroxidation by 300-600 %, increased the antioxidant enzyme activities (catalase by 57-75 %, superoxide dismutase by 57-62 %, and glutathione peroxidase by 80-83 %) and reduced liver damage (Verma *et al*., 2011). Naveen and Farhath (2010) observed that coriander seed extract minimized the drug induced oxidative stress and protected the system against its toxicity. The antioxidant property of coriander seed was related to the large amounts of tocopherols, carotenoids and phospholipids, which acted through different mechanisms (Ramadan and Morsel, 2004).Coriander oil, could be used as free radical scavenger, preventing oxidative deterioration in foods. It showed greater activity against the radical generating activity of 1,1-diphenyl-2-picrylhydrazyl in several essential oils (Ramadan and Morsel, 2006). The carotenoids extract of coriander showed a high antioxidant activity with IC50 value of 14.29±1.68 µg/mL, scavenging hydroxyl radicals and reducing higher protection to DNA than by the standard gallic acid (IC50 value of 357.21±4.29 µg/mL) (Divya *et al*., 2012). Antioxidant effects of this essential oil may be due to its terpene and terpenoid components.

The coriander seeds also showed scavenging activity against superoxides and hydroxyl radicals in a concentration-dependent manner. Maximum free radical-scavenging action and free radical reducing power of coriander seed extract was observed at a concentration of 50 µg GAe (gallic acid equivalent). Increased dietary intake of coriander seeds decreased the oxidative burden in Diabetes mellitus (Deepa and Anuradha, 2011). A comparative study of lipophilic and hydrophilic antioxidants was undertaken in vivo and in vitro grown C. sativum by radical scavenging reducing power and lipid peroxidation inhibition (Dias *et al*., 2011). The invivo sample showed the highest antioxidant activity mainly due to its highest levels of hydrophilic compounds.

In another study, a single dose of coriander fruit-extract or glibenclamide suppressed hyperglycemia in obese–hyperglycemic–hyperlipidemic Meriones shawi rats. After administration, the insulin resistance significantly decreased in the rats. Interestingly, the hypoglycemic effect was lower in normal rats, its mean; the test substances reduced plasma glucose, insulin and insulin resistance, cholesterol, LDL-cholesterol, and triglyceride (Aissaoui *et al*., 2011). Moreover, it was observed that a dose of coriander fruit decrease and regulate blood sugar and dyslipidemia at typical traditional doses in the patients who have noninsulin dependent diabetes mellitus. In a study of 40 volunteers, 20 subjects took 2.5 g of ground coriander fruit twice daily for 60 days and 20 volunteers served as controls. The treatment group had a significant declining in fasting blood-sugar levels; a significant reduction in lipid peroxidation in red blood cells; and rises in serum β-carotene, vitamin A, vitamin C, vitamin e, and glutathione levels. In this frame, coriander, especially the fruits of the plant found in the receipts can be also acceptable for the treatment of hepatic fibrosis and chronic liver diseases (Wijayagunawardanea *et al*., 2015). In vitro anthelmintic activities of crude aqueous and hydro-alcoholic extracts of the seeds of *Coriandrum sativum* (Apiaceae) were investigated on the egg and adult nematode parasite Haemonchus contortus. The aqueous extract of *Coriandrum sativum* was also investigated for in vivo anthelmintic activity in sheep infected with Haemonchus contortus. Both extract types of *Coriandrum sativum* inhibited hatching of eggs completely at a concentration less than 0.5 mg/ml. e D(50) of aqueous extract of *Coriandrum sativum* was 0.12 mg/ml while that of hydro-alcoholic extract was 0.18 mg/ml. There was no statistically significant difference between aqueous and hydroalcoholic extracts. The hydro-alcoholic extract showed better in vitro activity against adult parasites than the aqueous one.

Coriander can be used as a natural cleansing agent as it has potential to remove toxic metals from body. Chemical compounds present in coriander attach to toxic metals and remove them from cells (Abidhusen *et al*., 2012). Arunasagar et al. (2005) Observed that this plant is very effective to remove inorganic (Hg^{2+}) and methyl mercury (CH_3Hg^+) from aqueous solutions. This effect was due to the binding effect of carboxylic group to mercury. These results clearly showed that sorbent can be used to remove inorganic and methyl mercury from contaminated water. Kansal et al. (2011) found that coriander led to marked decline in oxidative stress caused by lead nitrate.

The hydro-methanolic extract of coriander fruits has been found ardioprotective potential. This effect should be attributable to its high polyphenol content in the fruits likewise. The preventive effect of coriander on cardiac damage has been investigated by isoproterenol induced cardiotoxicity model in male Wistar rats and found that the methanolic extract of the fruits prevent myocardial infarction by inhibiting myofibrillar damage on rats (Patel *et al*., 2012). The coriander fruits caused a significant decrease in all cholesterol-associated lipids, while the extract reduced high-density lipoprotein (HDL) cholesterol; the extract also improved the cardioprotective indices. Coriander fruits also reduced dyslipidemia in rabbits. All blood-fat values improved significantly with the coriander diet. It means that the extracts have beneficial profits on cardio protective effect (Abascal and Yarnell, 2012).The long chain fatty acids are potentially beneficial in antiaging products for local use, helping to restore barrier properties of the epidermis and prevent moisture loss. Therefore, the long chain fatty acids can be considered as potential antiaging agents. Coriander fruit oil is very rich in these types of the fatty acids. The studies done as a topical treatment for a variety of skin conditions with coriander-fruit oil and as a component of herbal sunscreens seem very impressive (Abascal and Yarnell, 2012). The oil may contain ceramides of petroselinic acid as well. The extract also functions mas an anti-irritant and helps to maintain skin texture and tone. A specially prepared extract from coriander fruits such as Umbelliferin® (INCI: Coriandrum sativum (coriander) extract is a trademarked product containing petroselinic acid triglycerides obtained as a nonlauric fraction from coriander fruit oil) helps in supporting skin barrier functions (Majeed and Prakash, 2015). Preparations using coriander/oil as single form or in combination with the other plants can be developed in the future and may become famous as one of the secrets of staying young for a long time.

C. sativum extract protects liver from oxidative stress induced by carbon-tetrachloride (CCl_4) and thus helps in evaluation of traditional claim on this plant. Pretreatment of rats with different doses of plant extract (100 and 200mg/kg) significantly lowered serum glutamate oxaloacetate transaminase (SGOT), serum glutamate pyruvate transaminase (SGPT), and TBARS levels against CCl_4 treated rats. Hepatic enzymes like superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) were significantly increased by treatment with plant extract, against CCl_4 treated rats. Oral administration of the leaf extract at a dose of 200mg/kg significantly reduced the toxic effects of CCl_4. The activity of leaf extract at this dose was comparable to the standard drug, silymarin (Sreelatha *et al*., 2009).

The anti-convulsant effects of aqueous and ethanolic extracts of coriander sativum seeds were studied in order to evaluate the fokloric use of this plant. two anticonvlusant evaluation test, namely the pentylenetetrazole (PTZ) and the maximal electroshock test, were used for assessing antiseizure effect in the pentylenetetrazole test, aqueous and ethenolix extracts prolonged onset of clonic convulsions and anti-convulsant activity of high dose (5mg/kg) were similar to that of phenobarbital at a dose of 20mg/kg in the PTZ test. Both extracts in high doses decreased the duration of tonic seizures and showed a statistically significant anticonvulsant activity in the maximal electroshock test (Hosseinzadeh and Mohammad, 2005).

Coriander fruits at a dose of 750 mg/kg caused no mortality in rats, and LD50 (lethal dose that kills 50% of test subjects) for the oil was found 4.13 g/kg. However, high doses of coriander fruits (500 mg/kg) inhibited implantation in female rats significantly and had a small abortifacient (but no teratogenic) effect on the rats. In the Ames test, a dried leaf extract produced a mutagenic effect (Abascal *et al*., 2012). By the way, coriander juice extracts were neither toxic nor mutagenic in the range of concentrations tested (50–1000 μL/coincubation flask); the chlorophyll content in whole juice extracts was 0.0325 μg/mL (Cortés-eslava *et al*., 2004).

References

1. Abascal, K. and Yarnell, E., (2012). Cilantro - Culinary herb or miracle medicinal plant? *Alternative and Complementary Therapies*, 18(5):259-264.
2. Abdella, A., Chandravanshi, B.S. and WYohannes, W., (2018). Levels of selected metals in coriander (*Coriandrum sativum* L.) leaves cultivated in four different areas of Ethiopia. *Chemistry International*, 4(3): 189-197.
3. Abidhusen, H.M., Sawapnil, S.A. and Amit, V.G. (2012). *Coriandrum sativum*: Review of advances in psychopharmacology. *Int. J. Res. Pharm. Sci.*, 3(5):1233-1239.
4. Abou-Shaara, H.F., 2015. Potential Honey bee plants of egypt. *Cercetări Agronomice în Moldova.,* 3(2): 99-108.
5. Ahmed, J., Shivhare, U.S. and Singh, P. (2003). Colour kinetics and rheology of coriander leaf puree and Storage characteristics of paste. *Food Chem.*, 84:605-611.
6. Aissaoui Abderahim, Jaouad el-Hilaly, Zafar H Israili and Badi Lyoussi, (2008). Acute diuretic effect of continuous intravenous infusion of an aqueous extract of *Coriandrum sativum* L. in anesthetized rats. *Journal ofethnopharmacology*, 115: 89-95.
7. Aissaoui, A., Zizi, S., Israili, Z.H. and Lyoussi, B., (2011). Hypoglycemic and hypolipidemic effects of Coriandrum sativum L. in Meriones shawi rats. *Journal of Ethnopharmacology*, 137: 652-661.
8. Al-Mofleh, I.A., Alhaider, A.A., Mossa, J.S., Al-Sohaibani, M.O., Rafatullah, S. and Qureshi, S., (2006). Protection of gastric mucosal damage by Coriandrum sativum L. pretreatment in wistar albino rats. *Environ. Toxicol. Pharmacol.*, 22:64–69.
9. Apichart, S., Danai, B. and Pichaya, B. (2012). Effect of vacuum cooling on physicochemical properties of organic coriander. *As. J. Food Ag-Ind.*, 5(02):96-103.
10. Arunasagar, D., Balarama, K.M.V., Rao, S.V. and Arunachalam, J. (2005). Removal and pre concentration of inorganic and methyl mercury from aqueous media using a sorbent prepared from plant coriander sativum. *J. Hazard Mat.*, 118:133-39.
11. Balasubramanian, S., Singh, K.K., Kumar, R., (2012). Physical properties of coriander seeds at different moisture content. *Int. Agrophys.*, 26: 419-422.
12. Balasundram, N, Sundram, K. and Samman, S. (2006). Phenolic compounds in plants and agri-industrial by-productsAntioxidant activity, occurrence, and potential and uses. *Food Chem.*, 99:191-203.
13. Barros, L., Duenas, M., Dias, M.I., Sousa, M.J. and Santos-Buelga, C. (2012). Phenolic profile of in vivo and invitro grown *coriander sativum* L. *Food Chem.*, 132(2):841-848.
14. Benjumea, D., Abdala, S., Hernandez-Luis, F., P´erez-Paz, P. and Martin-Herrera, D. (2005). Diuretic activity of Artemisia thuscula, an endemic canary species. *J. Ethnopharmaco* , 100:205-209.
15. Beyzie, Karamanb K., Gunesc, A. and Beyzid, S.B., (2017). Change in some biochemical and bioactive properties and

essential oil composition of coriander seed (*Coriandrum sativum* L.) varieties from Turkey. *Ind. Cro.Prod.*, 109: 74-78.

16. Bhanger, M.I., Iqbal, S., Anwar, F., Imran, M., Akhtar, M. and Zia-ul-Haq, M. (2007). Antioxidant potential of rice bran extracts and its effects on stabilization of cookies under ambient storage. *Int. J. Food Sci. Technol.*, 43(5):779-786.
17. Bhat, S., Kaushal, P., Kaur, M. and Sharma, H.K., (2014). Coriander (*Coriandrum sativum* L.): Processing, nutritional and functional aspects. *African Journal of Plant Science,* 8(1):25-33.
18. Bhuiyan, M.N.I., Begum, J. and Sultana, M., (2009). Chemical composition of leaf and seed essential oil of Coriandrum sativum L. from Bangladesh. *J. Pharmacol.*, 4:150-153.
19. Burst, S., 2004. Essential oils: Their antibacterial properties and potential application in foods- A review, *Int. J Food Microbiol.*, 94: 223-253.
20. Chithra, V. and Leelamma, S., (2000). *Coriandrum sativum* – effect on lipid metabolism in 1, 2-dimethyl hydrazine induced colon cancer. *Journal of ethnopharmacology,*71:457-463.
21. Cortés-eslava J, Gómez-Arroyo S, Villalobos-Pietrini R, espinosa-Aguirre JJ. (2004). Antimutagenicity of coriander (*Coriandrum sativum*) juice on the mutagenesis producedby plant metabolites of aromatic amines. Toxicology Letters; 153: 283-292
22. Cortes-Eslava, J., Gomez-Arroyo, S. and Villalobos-Pietrini, R., (2004). Antimutagenicity of coriander (*Coriandrum sativum*) juice on the mutagenesis produced by plant metabolites of aromatic amines. *J.Toxicol. Lett.*, 153:283-292.
23. Cristian D, Liliana G, Petru A, Stefan D (2013). Encapsulation of coriander essential oil in alginate and alginate/chitosan microspheres by emulsification of external gelation method. Inside food symposium, pp.9-12.
24. Cruz-Zaragozaa, E., Ruiz- Gurrolab. B., Wacher, C., Flores Espinosac, T. and Barboza Floresd, M., (2011). Gamma radiation effects in coriander (Coriandrum sativum L) for consumption in Mexico. *J. Revista Mexicana de Fisica S.*, 57(1):80-86
25. Darughe, F., Barzegar, M. and Sahari, M.A. (2012). Antioxidant and antifungal activity of Coriander (*Coriandrum sativum* L.) essential oil in cake. *Int. Food Res. J.*, 19(3):1253-1260.
26. Debella, A., Feleke, A., Makonnen, E., Tilahun, G. and Eguale, T. (2007). In vitro and in vivo anthelmintic activity of crude extracts of *Coriandrum sativum* against Haemonchus contortus. *J. Ethnopharmacol.*, 110:428-433.
27. Deepa, B. and Anuradha, C.V. (2011). Antioxidant potential of *coriander sativum* L seed extract. *J. Exp. Biol.*, 49:30-38.
28. Dhankar, S., Kaur, R., Ruhil, S., Balhara, M., Dhankhar, S. and Chhillar, A.K., (2011). A review on Justicia adhatodaA potential source of natural medicine. *Afr. J. Plant Sci.*, 5(11):620-627.
29. Dias, M.I., Barros, L., Sousa, M.J. and Ferreira, I.C.F.R., (2011). Comparative study of lipophilic and hydrophilic antioxidants from in vivo and in vitro grown *Coriandrum sativum*. *Plant Food Hum. Nutr.*, 66:181-186.
30. Divya, P., Puthusseri, B. and Neelwarne, B., (2012). Carotenoid content, its stability during drying and the antioxidant activity of commercial coriander (*Coriandrum sativum* L.) varieties. *Food Res. Int.*, 45:342-350.
31. Douglas, M., Heyes, J. and Small field, B. (2005). Herbs, spices and essential oils post-harvest operations in developing countries. *NZ Institute for Crop and Food Research Ltd., New Zealand.*
32. Duke, J.A., (2002). Handbook of Medicinal Herbs, second ed., CRC Press LLC, Boca Raton, Florida, USA, 222-23
33. Ebrahimi, S.N., Hadian, J. and Ranjbar, H., (2010). Essential oil compositions of different accessions of Coriandrum sativum L. from Iran. *Nat. Prod. Res.*, 24:1287-1294.
34. Eidi, M., Eid, A., Saeidi, A., Molanaei, S., Sadeghipour, A., Bahar, M. and Bahar, K. 2012. Effect of coriander seed (Coriandrum sativum L) ethanol extract on insulin release from pancreatic beta cells in streptozotocin-induced diabetic rats. *J. Phytother. Res.*, 23(3):404-406.
35. Emamghoreishi, M. and Heidari-Hamedani, G., (2006). Sedative-Hypnotic Activity of extracts and essential Oil of Coriander Seeds. *Iran J. Med. Sci.*, 31(1): 22-27.
36. Emamghoreishi, M., Khasaki, M. and Aazam, M.F., (2005). Coriandrum sativum: evaluation of its anxiolytic effect in the elevated plus-maze. *Journal of Ethnopharmacology,* 96:365-370.
37. Ertas, O.N., Guler, I.T., Ciftcvi Dalkilicand, M.B. and Yilmaz, O. (2005). The Effect of a Dietary Supplement coriander seeds on the fatty acid composition of breast muscle in Japanese quail. *J. Revuede Med.Vet.*, 156(10):514-518.
38. Geremew, A., Mekbib, F. and Ayana, A., (2015). Variability, heritability and genetic advance for some yield and yield related traits and oil content in Ethiopian coriander (*Coriandrum sativum* L.) genotypes. *Int. J. Plant Breed. Genet.*, 9:116-125.
39. Gil, A., Fuentee, B.D.L., Lenardis Ae, Lopez Pereira M., Suarez, S.A. and Bandoni, A., (2002). Coriander essential oil composition from two genotypes grown in different environmental conditions. *J. Agric. Food Chem.*, 50:2870-2877.
40. Gupta, M., (2010). Pharmacological properties and traditional therapeutic uses of important Indian spices: *A review, Int. J. Food Prop.*, 13:1092–1116.
41. Heidari, B., Sajjadi, S.E. and Minaiyan, M., (2016). Effect of *Coriandrum sativium* hydroalcoholic extract and its essential oil on acetic acid-induced acute colitis in rats. *Avicenna Journal of Phytomedicine,* 6(2):205-214.
42. Hosseinzadeh Hossein and Mohammad Madanifard, (2005). Anticonvulsant effect of coriander sativum L. seed extracts in Mice. *Iranian journal of Pharmacy,* 3: 1-4.
43. Illes, V., Daood, H.G., Perneczki, S., Szokonya, L. and Then, M., (2000). Extraction of coriander seed oil by CO_2 and propane at super- and subcritical conditions. *J. Supercritical Fluids,* 17:177-186.
44. Iwatani, Y., Arcot, J. and Shreshtha, A.K. (2003). Determination of folate contents in some Australian vegetables. *J. Food Compos. Anal.*, 16:37-48.

45. Jabeen, Q., Bashir, S., Lyoussi, B. and Gilani, H., (2009). Coriander fruit exhibits gut modulatory, blood pressure lowering and diuretic activities. *J. Ethnopharmacol.,* 122:123-130.
46. Kaiser, A., Kammerer, D.R. and Carle, R., (2013). Impact of blanching on polyphenol stability and antioxidant capacity of innovative coriander (*Coriandrum sativum* L.) pastes. *Food Chem.,* 140(1-2):332-339.
47. Kandlakunta, B., Rajendran, A. and Thingnganing, L. (2008). Carotene content of some common (cereals, pulses, vegetables, spices and condiments) and unconventional sources of plant origin. *Food Chem.*, 106:85-89.
48. Kansal, L., Sharma, V., Sharma, A., Lodi, S. and Sharma, H., (2011). Protective role of Coriandrum sativum (coriander) extracts against lead nitrate induced oxidative stress and tissue damage in the liver and kidney in male mice. *Int. J. Appl. Pharmaceut. Technol.,* 2(3):65-83.
49. Lal, A.A., Kumar, T., Murthy, P.B. and Pillai, K.S. (2004). Hypolipidemic effect of *Coriandrum sativum* in triton-induced hyperlipidemic rats. *J. Exp. Biol.,* 42(9):909-912.
50. Laribi, B., Kouki, K., Hamdi, M. and Bettaieb, T., (2015). Coriander (Coriandrum sativum L.) and its bioactive constituents. *Fitoterapia,* 103: 9-26.
51. Maghrani, M., Zeggwagh, N., Haloui, M. and Eddouks, M. (2005). Acute diuretic effect of aqueous extract of Retamaraetam in normal rats. *J. Ethnopharmacol,* 99: 31-35.
52. Mahendra, P. and Bisht, S. (2011). Anti-anxiety activity of Coriandrum sativum assessed using different experimental anxiety models. *J. Pharmacol.,* 43 (5):574-577.
53. Majeed, M. and Prakash, L., (2015). Novel natural approaches to anti-aging skin care. In: Cosmetics and Toiletries Manufacture Worldwide. New Jersey, USA: *Sabinsa Corporation,* pp. 11-15.
54. Mandal, S. and Mandal, M., (2015). Coriander (*Coriandrum sativum* L.) essential oil: Chemistry and biological activity. *Asian Pacific Journal of Tropical Biomedicine*, 5(6):421-428.
55. Mc Ausland, L., Lim, M.T., Morris De, Smith-Herman H.L., Mohammed. U., Hayes-Gill, B.R. et al., (2020). Growth Spectrum Complexity Dictates Aromatic Intensity in Coriander (*Coriandrum sativum* L.). *Front. Plant Sci.,* 11: 462.
56. Meena, S.K., Jat, N.L., Sharma, B. and Meena, V.S., (2014). Effect of plant growth regulators and sulphur on productivity of coriander (*Coriandrum sativum* L.) in Rajasthan. *J. Environ. Sci. Int.,* 6:69-73.
57. Melnyk, J.P. and Marcone, M.F., (2011). Aphrodisiacs from plant and animal sources - A review of the current scientific literature. *Food Research International,* 44:840-850.
58. Mhemdi, H., Rodier, E., Kechaou, N. and Fages, J. (2011). A supercritical tuneable process for the selective extraction of fats and essential oil from coriander seeds. *J. Food Engg.,* 105(4):609-616.
59. Mohammadi, S. and Saharkhiz, M.J., (2011). Changes in essential oil content and composition of catnip (Nepeta cataria L.) during different developmental stages. *J. Essent. Oil Bear. P.l.,* 14: 396-400.
60. Nadeem, M., Anjum, F.M., Khan, M.I., Tehseen, S., El-Ghorab, A. and Sultan, J.I. (2013). Nutritional and medicinal aspects of coriander (*Coriandrum sativum* L.) A review. *Brit. Food J.,* 115(5):743-755.
61. Nadia, G. and Hala, K. (2012) Influence of cobalt nutrition on coriander (*Cariandrum sativum* L.) Herbs yield quantity and quality. *J. Appl. Sci Res.,* 8(10):5184-5189.
62. Naveen, S. and Farhath, K., (2010). Antioxidant potential of coriander seed extract and its amelioration of liver antioxidant enzymes by CCl_4 induced toxicity in rats. *Int. J. Pharm. Biol.,* 1:121.
63. Neffati, M., Sriti, J., Hamdaoui, G., Kchouk, Me. and Marzouk, B., (2011). Salinity impact on fruit yield, essential oil composition and antioxidant activities of *Coriandrum sativum* fruit extracts. *Food Chem.,* 124:221-225.
64. Omidbaigi, R. (2005). Production and processing of medicinal plants. 2, Tehran. *Astan Quds Publication, Tehran*, .397.
65. Panjwani, D., Mishra, B. and Banji, D., (2010). Dose dependent antioxidant activity of fresh juice of leaves of *Coriandrum sativum*. *J. Pharm. Res.,* 3:947-949.
66. Parthasarathy, V.A., Chempakam, B. and Zachariah, T.J. (2008). Coriander: Chemistry of Spices. *CAB International*, 190–206.doi:10.1079/9781845934057.0190 13
67. Patel, D.K., Desai, S.N., Gandhi, H.P., Devkar, R.V. and Ramachandran, A.V., 2012. Cardioprotective effect of Coriandrum sativum L. on isoproterenol induced myocardial necrosis in rats. *Food and Chemical Toxicology,* 50: 3120-3125.
68. Peethambaran, D., Bijesh, P. and Bhagyalakshmi, N. (2012). Carotenoid content, its stability during drying and the antioxidant activity of commercial coriander (*Coriandrum sativum* L.) varieties. *Int. J. Food Res.,* 45(1):342-350.
69. Pirih, F., Lu, J., Ye, F., Bezouglaia, O., Atti, E., Ascenzi, M.G., Tetradis, S., Demer, L,, Aghaloo, T. and Tintut, Y. 2012. Adverse effects of hyperlipidemia on bone regeneration and strength. *J. Bone Miner. Res.,* 27(2):309-318.
70. Politeo, O., Jukic, M. and Milos, M. (2007). Chemical composition and antioxidant capacity of free volatile aglycones from basil (*Ocimum basilicum* L.) compared with its essential oil. *Food Chem.,* 101:379-385.
71. Prachayasittikul, V., Prachayasittikul, S., Ruchirawat, S. and Prachayasittikul, V., (2018.) Coriander (*Coriandrum sativum*): a promising functional food toward the wellbeing. *Food Res. Int.,* 105: 305-323.
72. Priyadarshi, S., Khanum, H., Ravi, R., Borse, B.B. and Naidu, M.M., (2016). Flavour characterization and free radical scavenging activity of coriander (*Coriandrum sativum* L.) foliage. *J. Food Sci. Technol.,* 53(3): 1670-1678.
73. Rahimi, A.R., Babaei, S., Kambiz, M., Asad, R. and Sheno, A. (2013). Anthocyanin content of coriander leaves as affected by salicylic acid and nutrients application. *Int. J. Biosci.,* 3(2):141-145.
74. Rajeshwari, U. and Andallu, B., (2011). Medicinal benefits of coriander (*Coriandrum sativum* L). Kişnişin (*Coriandrum sativum* L.) Tıbbi Faydaları. *Spatula D.D.,* 1(1):51-58.

75. Raju, M., Kumar, S.V., Narayana, R.L., Kantha, T.P.K. and Baskaran, V.,2007. Carotenoid composition and vitamin A activity of medicinally important green leafy vegetables. *Food Chem.*, 101:1598-1605.
76. Rakic, Z. and Johnson, C.H.B., (2002). Influence of environmental factors (including UV-B radiation) on the composition of the essential oil of *Ocimum basilicum*-sweet basil. *J. Herbs Spice Med. Plants,* 9:157-162.
77. Ramadan, M.F. and Mörsel, J.T., (2003). Analysis of glycolipids from black cumin (*Nigella sativa* L.), coriander (*Coriandrum sativum* L.) and Niger (*Guizotia abyssinica* Cass.) oilseeds. *Food Chemistry,* 80:197-204.
78. Ramadan, M.F. and Morsel, J.T., (2004). Oxidative stability of black cumin (*Nigella sativa* L.), coriander (*Coriandrum sativum* L.) and niger (*Guizotia abyssinica* Cass.) upon stripping. Eur. *J. Lipid Sci. Technol.*, 106:35-43.
79. Ramadan, M.F. and Morsel, J.T., (2006). Screening of the antiradical action of vegetable oils. *J. Food Comp. Anal.,* 19:838-842.
80. Ramadan, M.F., Kroh, L.W. and Mo Rsel, J.T. (2003). Radical scavenging activity of black cumin (*Nigella sativa* L.), coriander (*Coriandrum sativum* L.), and niger (*Guizotia abyssinica* Cass.) crude seed oils and oil fractions. *J. Agric. Food Chem.,* 51:6961-6969.
81. Randall, K.M., Drew, M.D., Øverland, M., Østbye, T.K., Bjerke, M., Vogt, G. and Ruyter, B., 2013. Effects of dietary supplementation of coriander oil, in canola oil diets, on the metabolism of [1-14C] 18:3n-3 and [1-14C] 18:2n-6 in rainbow trout hepatocytes. *Comparative Biochemistry and Physiology,* Part B.2013; 166:65-72.
82. Rao, A.S., Ahmed, M.F. and Ibrahim, M. (2012). Hepatoprotective activity of Melia azed arach leaf extract against simvastatin induced Hepatotoxicity in rats. *J Appl. Pharm. Sci.,* 02 (07):144-148.
83. Rattanachaikunsopon, P. and Phumkhachorn, P. (2010). Potential of coriander (Coriandrum sativum) oil as a natural antimicrobial compound in controlling Campylobacter jejuni in raw meat. *J. Biosci. Biotechnol. Biochem.,* 74(1):31-35.
84. Ravi, R., Prakash, M. and Bhat, K.K. (2007). Aroma characterization of coriander (*Coriandrum Sativum* L) oil samples. *Eur. J. Food Res. Technol.,* 225(3-4):367-374.
85. Rohit, R.P., Kavindra, R.J. and Chintan, K.M. (2011). Image morphological operation-based quality analysis of coriander Seed (*Coriandrum sativum* L.) *Emerging Trends in Networks and Computer Communications (ETNCC), International Conference* on 22-24 Aprilpp.482-486.
86. Sabahat, S. and Perween, T., (2007). Antimicrobial activities of emblica officinalis and *Coriandrum sativum* against gram-positive bacteria and Candida albicans, *Pak. J. Bot.,* 39:913-917.
87. Sahib, N.G., Anwar, F., Gilani, A.H., Hamid, A.A., Saari, A. and Alkharfy, K.M. (2012). Coriander (*Coriandrum sativum* L.): A potential source of high-value components for functional foods and nutraceuticals- A Review. *J. Phytother. Res.,* 27(9),
88. Satyanarayana, S., Sushruta, K., Sharma, G.S., Srinivas, N. and Raju, G.VS., (2004). Antioxidant activity of the aqueous extracts of spicy food additives evaluation and comparison with ascorbic acid in vitro systems. *J. Herb Pharmacother,* 2, 1-10.
89. Shahwar, M.K., el-Ghorab, A.H., Anjum, F.M., Butt, M.S., Hussain, S. and Nadeem, M., (2012). Characterization of coriander (*Coriandrum sativum* L.) seeds and leaves: Volatile and nonvolatile extracts. *Int. J. Food Prop.,* 15:736-747.
90. Sharma, R.P., Singh, R.S., Verma, T.P., Tailor, B.L., Sharma, S.S. and Singh, S.K., (2014). Coriander the taste of vegetables: present and future prospectus for coriander seed production in southeast Rajasthan. *Economic Affairs,* 59(3): 345-354.
91. Silva, F., Ferreira, S., Queiroz, J.A. and Fernanda, C.D. (2011). Coriander (*Coriandrum sativum* L.) essential oil its antibacterial activity and mode of action evaluated by flow cytometry. *J. Med. Microbiol.,* 60:1479-1486.
92. Singh, G., Maurya, S., Lampasona, M.P.D. and Catalan, C.A.N., (2006). Studies on the essential oils, part 41: Chemical composition, antifungal, antioxidant and sprout suppressant activities of coriander (*Coriandrum sativum*) essential oil and its oleoresin. *Flav. Frag. J.,* 21:472-479.
93. Singletary, K., (2016). Coriander: overview of potential health benefits. *Nutr. Today.,* 51(3): 151–161.
94. Sreelatha, S., Padma, P.R. and Umadevi, M., (2009). Protective effects of Coriandrum sativum extracts on carbon tetrachloride-induced hepatotoxicity in rats. *Food Chem. Toxicol.,* 47(4):702-708.
95. Sunil, C., Agastian, P., Kumarappan, C. and Ignacimuthu, S. (2012). In vitro antioxidant, antidiabetic and antilipidemic activities of Symplocos cochinchinensis (Lour.) S. Moore bark. *J. Food Chem. Toxicol.,* 50 (5):1547-1553.
96. Taherian, A.A., Vafaei, A.A. and Ameri, J., (2012). Opiate system mediates the antinociceptive effects of Coriandrum sativum in mice. *Iranian Journal of Pharmaceutical Research,* 11(2):679-688.
97. Telci, I. and Hisil, Y., (2008). Biomass yield and herb essential oil characters at different harvest stages of spring and autumn sown *Coriandrum sativum* L. *Eur. J. Hortic Sci.,* 73:267-272.
98. Ullagaddi, R. and Bondada, A. (2011). Medicinal benefits of coriander (*Coriandrum sativum* L). *J. Spatula D.D.,* 1(1):51-58.
99. USDA National Nutrient Database for Standard Reference Release 26 Full Report (All Nutrients) Nutrient data for 2013, Spices, coriander seed.
100. Verma, A., Pandeya, S.N., Sanjay, K.Y. and Styawan, S. (2011). A Review on Coriandrum *sativum* (Linn.) An Ayurvedic Medicinal Herb of Happiness. *J. Adv. Pharm. Healthcare Res.,* 1(3):28-48.
101. Wallis, T.E. (2005). Textbook of Pharmacognosy; 5th edn, S. K. Jain for *CBS publishers and distibuters; New Delhi (India)*. pp. 125-126, 246-248.
102. Wangensteen, H., Samuelsen, A.B. and Malterud, K.E. (2004). Antioxidant activity in extracts from coriander. *Food Chem.*, 88:293-297.

103. Wijayagunawardanea, M.P.B., Wijerathnea, C.U.B. and Herath, C.B., (2015). Indigenous herbal recipes for treatment of liver cirrhosis. *Procedia Chemistry,* 14:270-276.

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