Coriander (*Coriandrum sativum* L.)

A Nutritional, Aromatic and Medicinal Herb

Muhammad Yasir Naeem (PhD Candidate)
Dr. Tefide Kızıldeniz
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(The Licence Number of Publicator: 2014/31220)
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ISBN: 978-625-8423-86-0
January / 2022
Ankara / Turkey
Size = 16 x 24 cm

PREFACE

The current reference book is based on the nutritional and therapeutic value of 'coriander,' is one of most often used herbal ingredients for medicinal and therapeutic applications. Coriander is a key component in the creation of several Ayurvedic medicines. Coriander is a member of the Umbelliferae family and is technically known as *Coriandrum sativum* L. This plant is one of the ancient traditional remedies, used to treat a number of problems such as digestion related, worm infections, rheumatism, loss of appetite, convulsion, sleeplessness, anxiety, and joint pain.

This plant is well-known in traditional medicine for its carminative, spasmolytic, digestive, and galactagogue effects. The herb is cultivated all over the globe because of its seed, foliage, and essential oil. It is used as a flavouring additive in confections, drinks, and baked goods. Coriander is high in volatile oil, with linalool as a prominent ingredient, along with -pinene, borneol, citronellol, camphor, geraniol, coriandrin, dihydrocoriandrin, coriandrin A-E, coumarins, phthalides, flavonoids, and other phenolic acids and terpinene.

Essential oils are highly volatile and are made up of a variety of tiny molecules such as terpenes, hydrocarbons, and alcohols. These are soluble in the majority of organic solvents, includes ether, chloroform, and ethanol. These can be extracted using steam distillation or the expression technique. Steam distillation or hydro distillation is a common method for extracting most oils, but expression methods are utilized in a few circumstances, such as the extraction of citrus essential oils by cold pressing. Approximately 100 essential oils have been

identified for usage in medicinal and cosmetic applications to date. Aside from their medicinal properties, they are also used to flavour food and drinks, fragrances, soap, shampoos, and massage oils. Among the most prevalent health issues, such as stress, anxiety, depression, headaches, migraines, sleep, insomnia, inflammation, antifungal and antibacterial infections, can be treated in a variety of ways with essential oils. Essential oils are utilized in dentistry adhesives, floor cleaners, and insect repellents due to their antibacterial and disinfecting characteristics. This book named **"Coriander (*Coriandrum sativum* L.): A Nutritional, Aromatic and Medicinal Herb"** is made up of Ten chapters that cover all aspects of this significant plant. Its occurrence, taxonomy, traditional usage, phytochemistry, and pharmacological properties are thoroughly explained, with references.

The materials in this book will be useful to students, scientists, and academics, working in biological sciences, natural products, and other related fields. Its cultivation, processing, and commercial usage, primarily of its essential oil, are explained in simple terms with the ordinary man and agriculturist in mind.

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Since 2016 she has worked as a researcher at the University of Navarra, in the Department of Environmental Biology, Biological and Agricultural Chemistry Group (BACh). Her current line of research focuses on the reduction of nitrates in leafy plants, such as lettuce, spinach, Swiss chard, etc. We develop molecules capable of reducing nitrate as well as a new range of natural chelates of metal micronutrients. She also has experience in studies of fatty acids (ω-3 and ω-6) in vegetable oils and plants, as well as in the analysis of

phenolic and hormonal compounds under deficit irrigation conditions (vineyard and grape) under deficit irrigation conditions.

In addition, Dr. Movila is assistant professor at the University of Navarra, and University Foundation Iberoamericana (FUNIBER).

Dr. Movila has been contributor in projects at the local, national, and international levels, she has participated in numerous national and international meetings, also has published in specialized international journals.

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Chapter 1.
Introduction

The most inclusive and oldest apothecary of all times is the nature itself. The nature gifted vegetables and plants are the rich source of various precious constituents containing different kinds of secondary metabolites, phytochemicals along with the various phyto-medicines, which has been experienced against a number of various human health disorders in different classifications of folk remedies, including Unani-Tibb (Greco-Arab), Ayurveda and Chinese (Patwardhan et al., 2005; Gilani and Atta-ur-Rahman, 2005; Tapsell et al., 2006; Krishnaswamy, 2008). According to the world health organisation, nearly 80% population across the globe directly or indirectly relies on the traditional remedies (WHO, 2002).

A new horizon for the researcher has been unbolted due to the advancement of skills and exploration in area of nutritive value and medicines, while their functions against various health disorders. Consideration to this, different plant origin counting herbs are the vital source of various antioxidant actions and other natural products which are mainly different from each other in their structures, mechanism of action and also in their biological functions. This new field human health and nutrition has switched the main focus of scientists and researchers towards plant based natural spices and herbs, as an alternative for various synthetic medicines with no possible side effects. Food designer, product developers, food researchers and nutritionist have obligatory by the consumers due to the awareness of natural food

components and their possible health function against a series of diseases and named as functional food which may be define as “food with health promoting bioactive molecules along with the traditional functions”. In recent days around the globe there is a rapid increase in the functional food market (Jayasekera et al., 2011). These medicinal plants and herbs not only contributing vital function against protection of various illnesses but also playing a weighty task in country economies as well. In this case the coriander is an important herb spice with easily availability, low cost and high benefits values. Having enriched phytochemicals and health promoting components in their seeds and herbs, strongly suggested by researchers their consumption in our daily diet on required level with age limit (Sharma and Sharma, 2012; Laribi et al., 2015). The components coriander having significant potential against the life changing diseases like renal modulating, renal modulating, inflammations, hypolipidemic, digestive health and controller of diarrhea, mouth ulcers, small pox and anemia, many other serious disorders of human health. In view of the above-mentioned indications, the recent work is designed in order to explore and to extend the beneficial and relaxing job of regionally cultivated coriander varieties counter various severe problems.

1.1. Coriander (*Coriandrum sativum* L.)

A significant seasoning crop named coriander occupied leading place in flavouring ingredients. It’s an herbaceous plant belongs to carrot family Apiaceae. The term coriander is resultant from “Greek Koris”, which mean bed-bug, due to its unpleasant, bug like smell of its green

herb and un-ripened fruit. Fresh leaves of coriander are called "cilantro" while the dried fruit is known as coriander. The seeds, roots, stem and leaves have aromatic fragrance which is broadly helpful in flavouring. The young plant is mainly used in the making of sauces and chutneys (very famous especially in Asia). Its leaves are widely used for flavouring interior curry and soup. Broadly active fruits used as a dressing in making of pickling, curry powder, sausages and seasonings, likewise employed to flavoured pastries, buns, biscuits and cakes, particularly gin. *C. sativum* is recognized as one of the oldest and prehistoric herbs almost 3000 years (Ebbers papyrus of 1550 BC) using for both purposes medicinal and culinary actions. In the recent era, much has been investigated to explore health promoting and antioxidant activities of this herb and spice. Various common names around the world are mentioned in Table 1.

Table 1. Various common name across the globe

Name	**Country**
Dhanya	Pakistan
Kişniş	Turkey
Coriander, cullender, Chinese parsley	English
Kuzbara, kuzbura	Arab
Chamem	American
Coriandre, persil arabe	French
Geshnes	Persian

1.2. Botanical account

Coriander belongs to the Umbelliferae family and its botanical classification are as:

Division	Angiospermae
Class	Dicotyledonae
Sub-class	Calyciflorae
Order	Umbellales
Genus	Apiaceae
Species	Umbellifera

1.3. Origin and distribution

Coriander is domesticated from Mediterranean area and also widely cultivated across the globe. Coriander earliest record dates back to 5000 BC. Both Roman and Greek culture used it as spices. Its cultivation also mentioned in Bible where the manna colour is compared to that of the coriander. The Romans introduced the coriander in Britain. In south Asia coriander is known since the Vedic age (1500 – 500 BCE). In addition to Pakistan and Turkey, coriander is also growing in number of countries like Spain, France, Italy, the Netherlands, Myanmar, India, Mexico, Canada, Argentina and Australia and, to some degree, in United Kingdom and United States (Melo et al., 2005; Singh et al., 2006). In order to obtain the vital oil from coriander the 1st factory was established in 1885 in Russia at Voronezh district by the process of steam distillation (Eikani et al., 2007).

1.4. Plant elucidations

Purse glove et al., (1981) mentioned a complete botanical explanation, dividing them into two variant morphological plant types.

1. 1st one is straight, tall with a relatively tougher main shoot and smaller twigs,
2. 2nd is bushy and relatively weaker main and longer shoot with scattered divisions.

The entire plant of coriander (Figure 1) consists of roots, stem, leaves and fruits, while the root system is tap root system. The plant attains maximum height of 60 to 120 cm, its start flowering after 45 to 60 days of sowing, while it takes a period of 4 months to get fully ripe fruit. The lower leaves are broad and the upper ones are thin and splinted. Every branch along with focal shoot terminates in umbel compound containing 3 to 10 umbels, while every umbel bearing 10 to 50 pentamerous flowers. The flowers are protandrous, small and hard to use for controlled pollination. The level of cross pollination mentioned ranging from 50 to 60 percent (Dimri et al., 1977; Ramanujam et al., 1964). Fruit of coriander consists of the dry cremo-carp of *C. sativum* L. and is nearly round with a 1.5–5.0 mm diameter. The colour of the fruit is yellow brown when fully ripen. Oil of coriander is essential oil gotten by steam distillation (Kamat et al., 2003). For germination and initial growing of coriander the ideal temperature is 20°C to 25°C (Verghese, 2001).

Figure 1. Seeds, Leaf, Flower and Stem of Coriander.

Chapter 2.

Cultivation of Coriander

2.1. Climate and soils

C. sativum is a tropical crop, and needs low temperature and moderately dry free frost climatic conditions, mainly at seed and flowering development phases. High temperature and breeze speed all through anthesis and seed development lead to increase sterility rate and decrease production. At flowering period, cloudy weather rises the sum of aphids and diseases. There is wide range of soil for coriander growing from loamy to moderately heavy soils as an irrigated crop rich in organic substances and well drained system.

2.2. Field preparation

The field will be slightly irrigated prior to ploughing if the moisture level is down than the required level. Then the field will be bringing into fine tilth with the help of ploughing machine (discussion with farmers, Swabi, Pakistan).

2.3. Sowing time

The ideal temperature for coriander early growth and for sprouting is 20 ºC to 25 ºC. The foremost sowing time is from the last week of October till 2nd week of November. The germination process and early development are badly pretentious by high temperature. The prevalence

of viruses and pests will be increases and plant growth will be decreases when sowing delayed (discussion with farmers, Swabi, Pakistan).

2.4. Seed rate

To attain optimal plant thickness in irrigated state, seed rate of 11 to 15 kilogram per hectare, dependent upon the size of seed, while for rain fed areas, a seed rate of 25 to 30 kilogram per hectare is suggested. Seed will be broken or crushed into 2 splits and treated with almost 1000 mg carbendazim per kg of seed or any other mercurial fungicide at the rate of 2.0 g/ kilogram of seed (discussion with farmers, Swabi, Pakistan).

2.5. Sowing method

Seeds should be crushed or broken (halves) as shown in Figure 2. Sowing can be carried out by random scattering of seeds in field or by sowing in lines. The lines distance should be 60 to 75 cm (for seed collection purpose) and plant to plant distance should be 30 to 45 cm. Sowing in line also helps in inter cultural processes in the standing crop. While, for salad or fresh consumptions the line distance should be 30 to 145 cm and plant to plant 15 to 30 cm. Moreover, in heavy soil row spacing should be increases to 110 cm. An ideal distance between plants in rows is 10 to 15 cm. Attention needed in each sowing method to ensure seed roofed with soil not more than 4 inches deeper (discussion with farmers, Swabi, Pakistan).

Figure 2. Full and broken halves of coriander seeds

Chapter 3.

Nutrient Composition

Coriander contains different amount of nutrients like protein, fats, carbohydrate fibres, minerals and vitamins. Till now, 81 components from leaf essential oil are recognized with 2- dimensional gas chromatography investigation (Eyres et al., 2007). The moisture content in coriander green leaves 87.9 %, 6.5 % carbohydrate, 3.3 % protein, 1.7 % mineral matter and 0.6 % fats. Dehydrated prepared coriander seeds consist of almost 6 to 8 percent moisture and essential oil 0.3 2.06 percent, fatty oil up to almost 18 percent, crude protein lies between 11 to 21 percent, fat ranging from about 17 to 19 percent, crude fibre and ash percentage was recorded as approximately 28 to 29 and 5 to 6 percent respectively (Coskuner and Karababa, 2006). It is also stated, about 60 to 70 percent linalool and almost 20 percent hydrocarbons were recorded in seed oil of coriander while the oil from the herbal portion totally varies from oil extracted from seeds (Coskuner et al., 2006; Eikani et al., 2007). While ingredients from the vital oil are recorded as: β-pinene, α-thujene, sabinene, camphor, limonene, myrcene, z-β-ocimene, y-terpenin, terpinolene, Cumin aldehyde and citronellal, trpinene-4-ol. (Coskuner et al., 2006; Eikani et al., 2007; Telci et al., 2006). Oil from coriander healthy in phyto-nutrients containing linalool along with other components like geraniol, carvone, borneol, limonene and camphor. The main mineral composition of coriander leaf and stem is mentioned in Table 2.

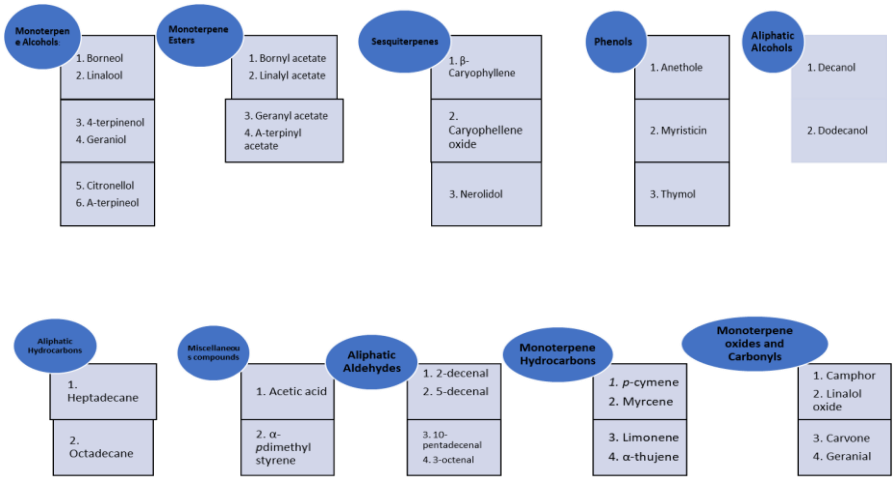
Table 2. Mineral composition of coriander leaf and stem per 100g

Composition	*USDA*
Water	7.3 g
Food energy (kcal)	279.00 g
Protein	21.83 g
Fat	4.76 g
Carbohydrates	52.10 g
Ash	14.02 g
Calcium	1.24 g
Phosphorus	481.00 (mg)
Sodium	211.00 (mg)
Potassium	4.466 (mg)
Iron	42.46 (mg)
Vit – C	566.7 (mg)

3.1. Compounds in essential oil of coriander

According to Parthasarathy et al. (2008) and Ramezani et al. (2009) essential oil from coriander consist of a series of components the details are mentioned as Figure 3.

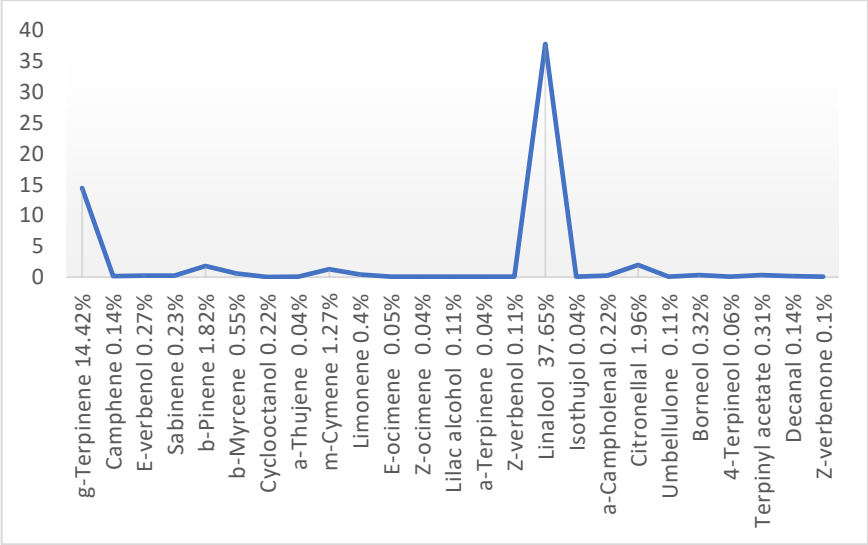
Figure 3. Essential oil components in coriander

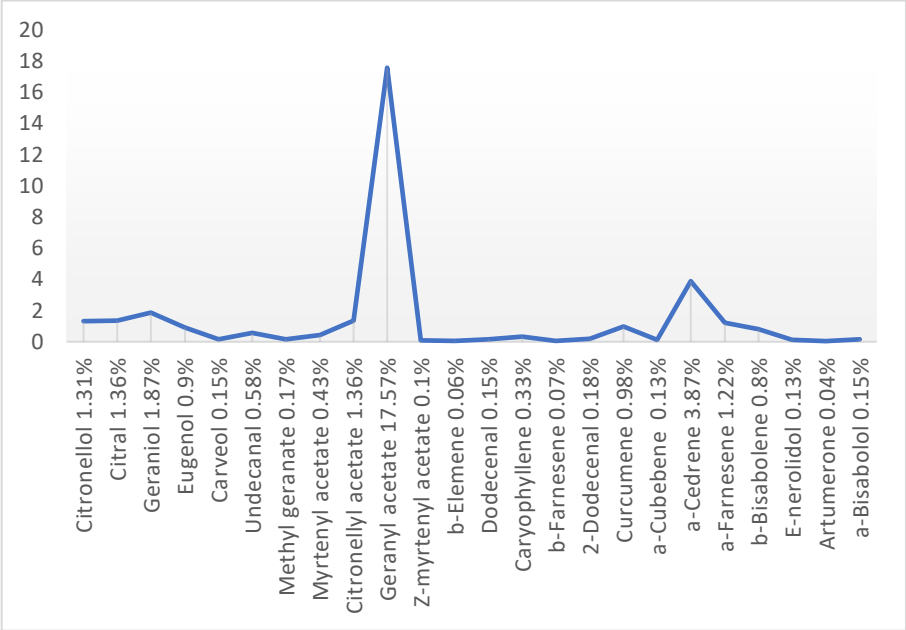


A variation has been found in the extracted essential oil from coriander seed changed geographical locations (Coleman and Lawrence, 1992;

Tashinen and Nykanen, 1975; Leung and Foster, 1996; Pino et al., 1996). For example, oil composition of Indian coriander changes from that of European one in relation of lower linalool and maximum linalyl acetate contents (Rao et al., 1925). According to the Nazrul et al. (2009) described that these differences detected between cultivars are not because of geographic deviation and ecological environments but are instead outcome of unlike chemotypes. Figure 4 shows the details essential oil composition of coriander seed.

Figure 4. Represent the composition of essential oil of *C. sativum* L. seed



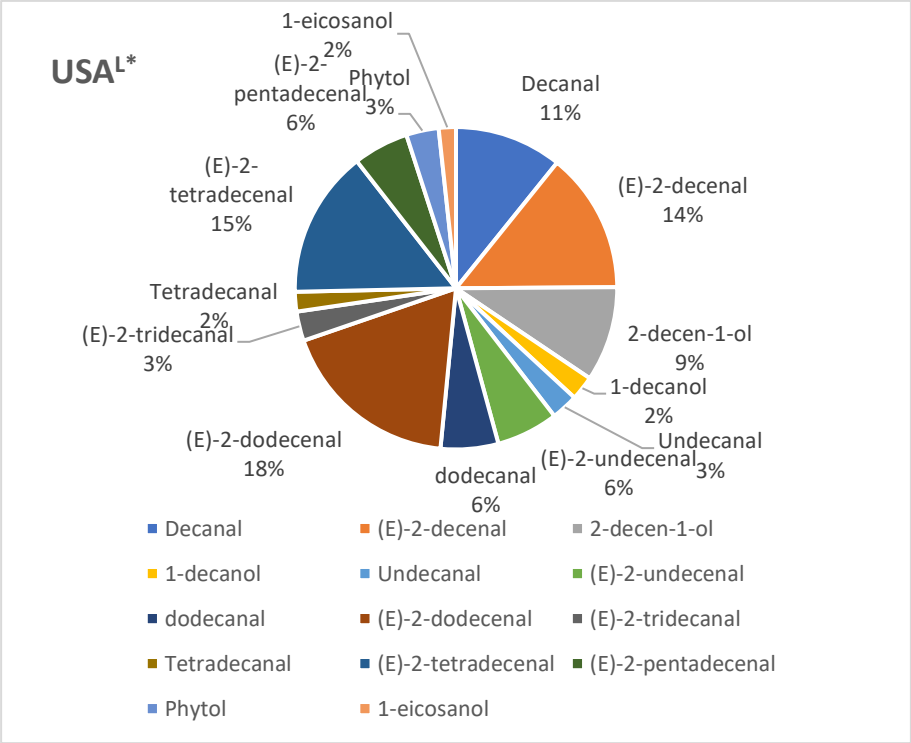


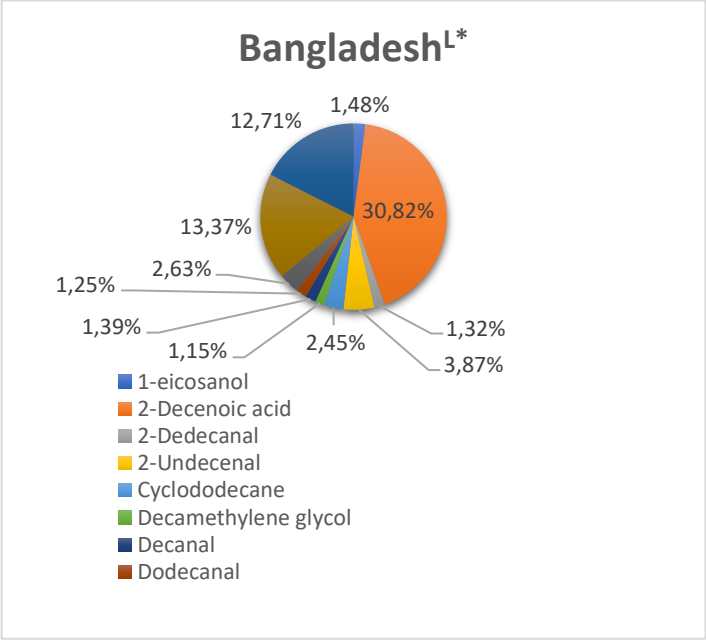
3.1. Aerial parts (leaves and stem)

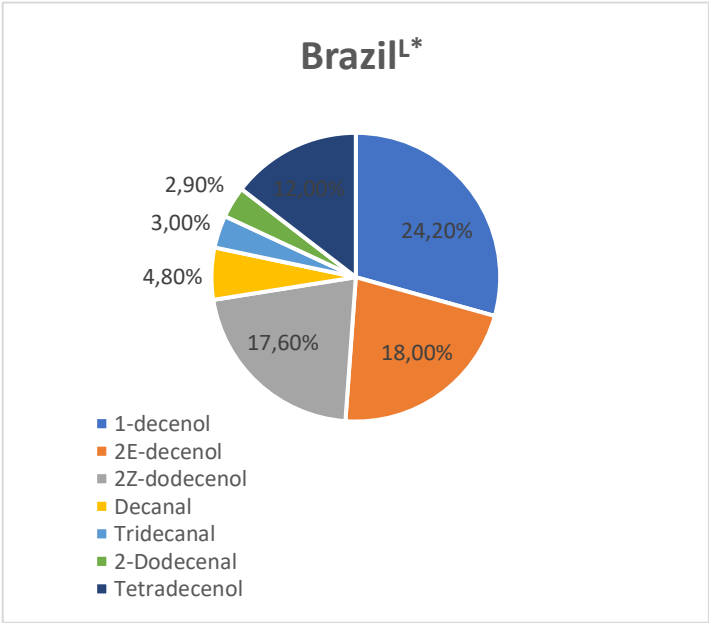
Coriander young green foliage's broadly employed as garnishes, additional basils, in chutneis and dressings. The foliage's of coriander are not finely investigated like its fruits. However, essential oils, flavonoid, phenolic contents and polyphenol are amongst the additional components find in their greeneries (Ceska et al., 1988; Matasyoh et al., 2009; Nambiar et al., 2010). Besides, aqueous, methanolic extract of stem, leaves of coriander evaluated aimed at total phenolic contents, stated like caffeic acid equal (Wong and Kitts, 2006). The coriander from Kenya having essential oils, typically comprise of alcohol and aldehydes with almost 46 % and 56 % respectively. The key ingredients of coriander leave essential oils Include: (2E- decanal almost 16 percent) (n-decanol almost 13 percent). Additional components like,

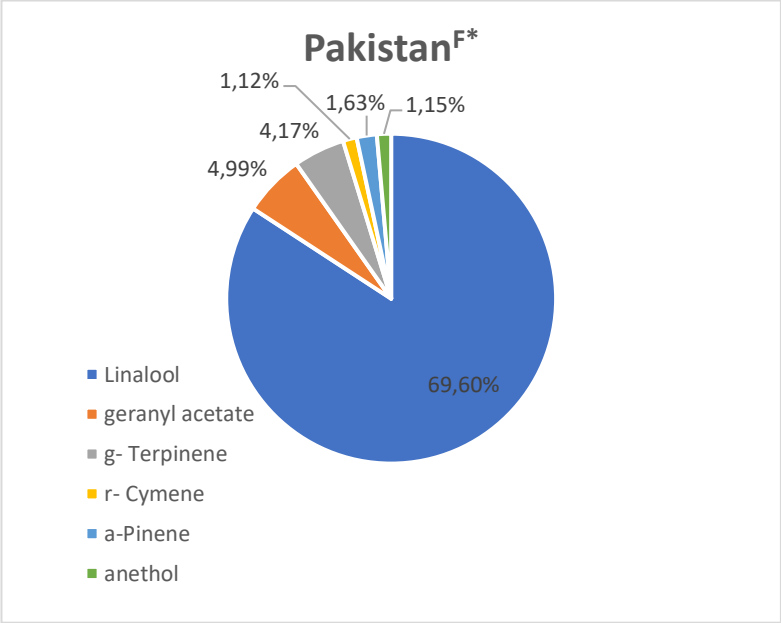
docdecanal, undecanol, 2Etridecen- 1-al, undecanal and 2E-dodecenal are also available. The essential oil composition as of Bangladesh coriander leaves influenced in (tridecanoic acids 5.5%), (undecanoic acids 7.1%), (E-11-tetradecenoic acids 13.4%), (2-decenoic acids 30.8%), (capric acids 12.7%) and (undecyl alcohols 6.4%) (Bhuiyan et al., 2009). The coriander leaves essential oil chemical configuration from various sources is mentioned in Figure 5. Altogether investigations look to authorise that key compounds from leave of coriander essential oils are the aldehydes and alcohols. The polyphenolic structure of leaves' shows: 3- O-mes quercetin, kaempferol, quercetin, vanillic acid, 4-O-mes quercetin and acacetin. p-coumaric acid, cis and trans-ferulic acids are the chief phenolic contents known (Nambiar et al., 2010). During 1988, 2 photo-active furioso-coumarins and di-hydrocoriandrin extracted from leaves of coriander (Ceska et al., 1988). *C. sativum* leave are frequently utilized aimed at their characteristic spicy odour. Eyres et al. (2005) recognised feature that effect odorant in leaves of coriander by means of GC-olfactometry and 2-dimensional GC-time-of-flight mass spectrophotometry. The furthermost significant odorant in coriander is Z-2-decenal, a co-eluting cluster (E-2-dodecenal, E-2-dodecen-1-ol and 1-dodecanol), b-ionone, eugenol and E-2-decenal. The main component from leaves of coriander is: E-2- Decen- 1-l paid slightly to odour action (0.39 percent).

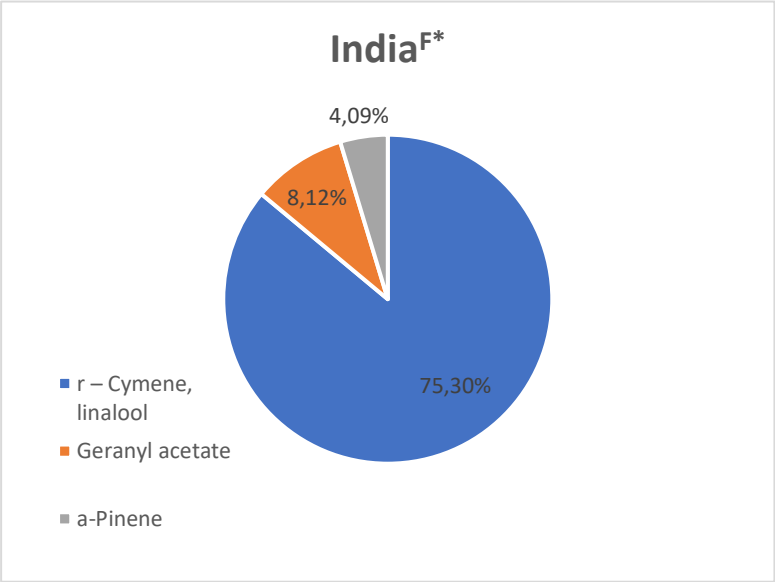
Figure 5. Chemical configuration of essential oils from coriander leaves and fruits from various areas across the globe (Potter, 1996; Bhuiyan et al., 2009; Begnami et al., 2010; Anwar et al., 2011; Singh et al., 2006; Delaquis et al., 2002; Grosso et al., 2008; Bhuiyan et al., 2009; Matasyoh et al., 2009).

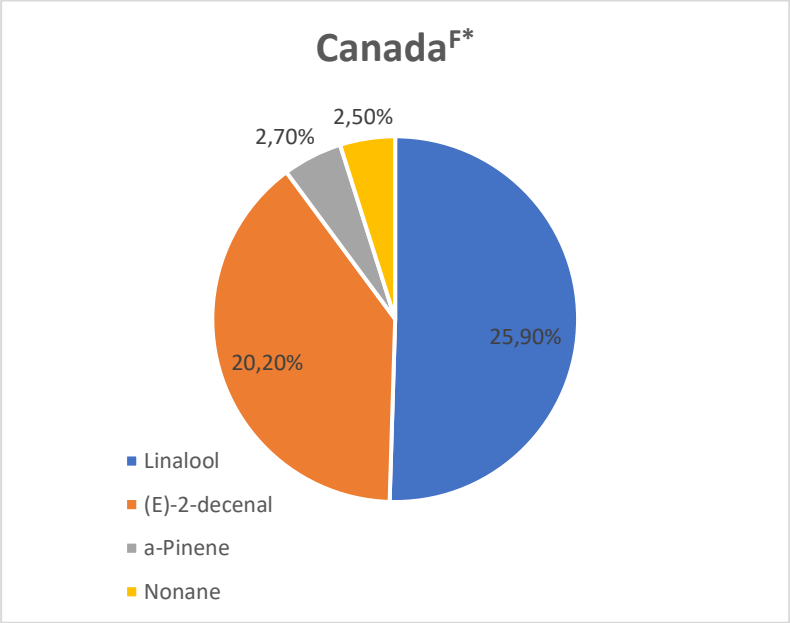


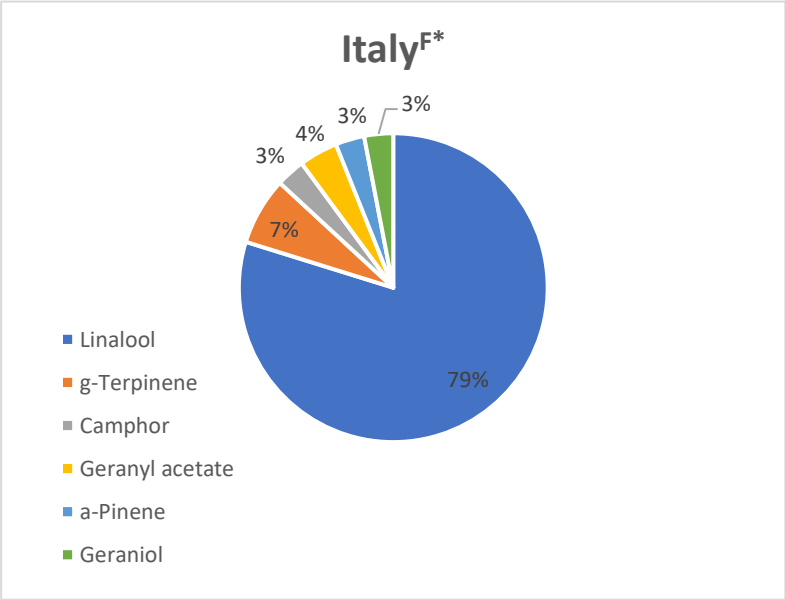

Bangladesh[L*]
1,48%
12,71%
30,82%
13,37%
2,63%
1,25%
1,39%
1,15%
2,45%
1,32%
3,87%
1-eicosanol
2-Decenoic acid
2-Dedecanal
2-Undecenal
Cyclododecane
Decamethylene glycol
Decanal
Dodecanal


Brazil[L*]
2,90%
12,00%
3,00%
24,20%
4,80%
17,60%
18,00%
1-decenol
2E-decenol
2Z-dodecenol
Decanal
Tridecanal
2-Dodecenal
Tetradecenol


Pakistan F*
1,12%
1,63%
1,15%
4,17%
4,99%
69,60%
Linalool
geranyl acetate
g- Terpinene
r- Cymene
a-Pinene
anethol


India F*
4,09%
8,12%
75,30%
r – Cymene, linalool
Geranyl acetate
a-Pinene


Canada F*
2,50%
2,70%
25,90%
20,20%
Linalool
(E)-2-decenal
a-Pinene
Nonane


Italy F*
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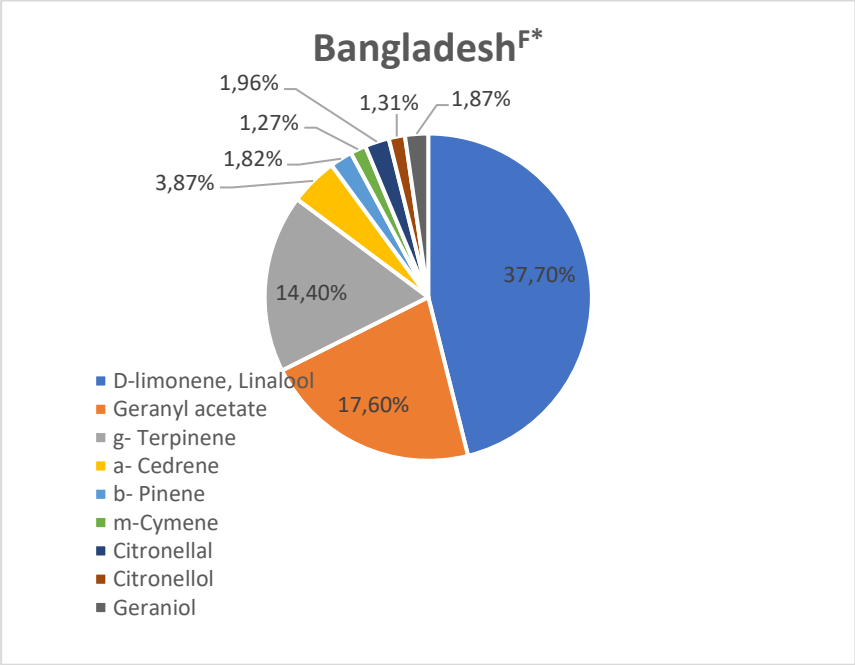
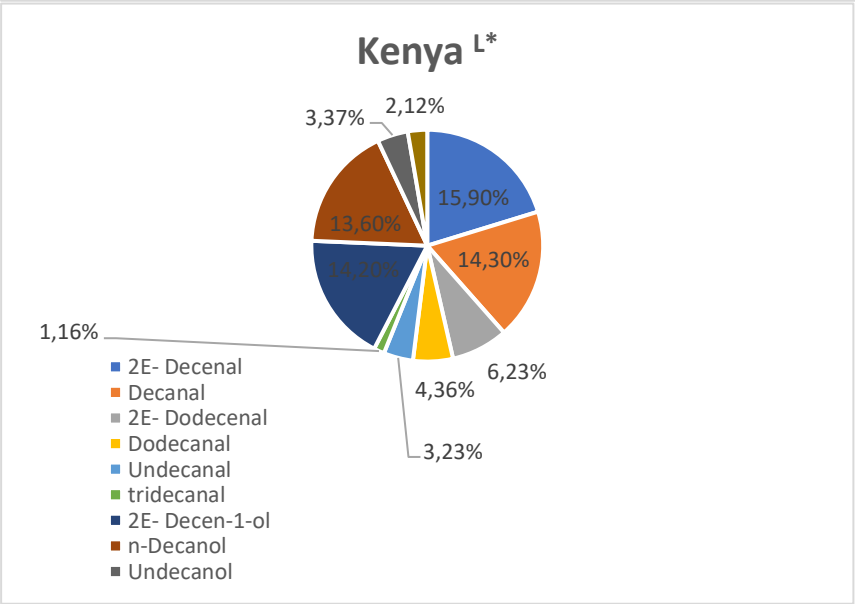
3%
4%
3%
7%
79%
Linalool
g-Terpinene
Camphor
Geranyl acetate
a-Pinene
Geraniol





***F: Fruit, L: Leaves**

3.2 Seeds

The seeds of coriander (Figure 3) are mutual, also broadly usable part, having vital components as vital oils and f. oils (fixed oil). The percentage of essential oil is usually less than fatty oil in coriander seeds 1 percent and 25 percent respectively.

The configuration of the essential oils appears like to be mostly reliant on geographical and biological inconsistency. A gas chromatography mass spectroscopy (GC-MS) method was employed by Bhuiyan et al. (2009) in order to carry out a detail investigation on essential oil from seeds with an origin from Bangladesh. Fifty-three various compounds were known with the key one (linalool 37 percent), (geranyl -acetate17 percent), (g-terpinine 14 percent). Additional components found with their percentage are about: citronellol (1.3 percent), m-cymene (1.2 percent), citral (1.3 percent), citronellal (1.9 percent), a-cedrene (3.8 percent), b-pinene (1.8 percent), citronellyl acetate (1.3 percent), a-farnesence (1.2 percent) and geraniol (1.8 percent). Another study carried out by Anwar and his co-workers during 2011, studied the physicochemical function of *C. sativum* seeds vital oils from Pakistan. Oils analysed via GC-flame Ionization Detector and more confirmed through gas chromatography mass spectroscopy that primarily composed of linalool with involvement of almost 70 %, other vital ingredients recognised were round about (p-cymene 1.12 %), (anethol 1.15 %), (geranyl acetate 5 %), (g-terpinine 4.17 %) and (a-pinene 1.63 %). Structures of some important the most common compounds derived

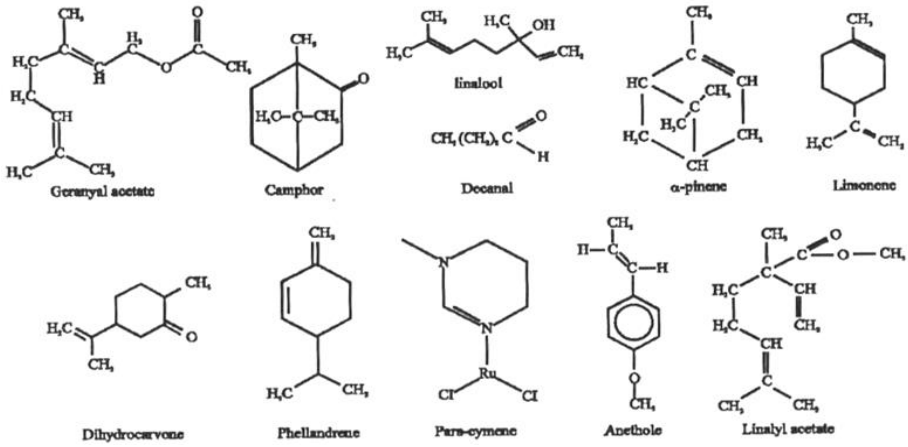
from coriander oil their basic structures are demonstrated in Figure 4. The coriander seeds essential oil's components are differed from each other that are cultivated in other countries summarised in Table 3.

Figure 6. Seeds of coriander

Table 3. Showing variation in compounds from different countries

Country	Compounds
Pakistan	48
Algeria	17
Tunisia	41– 48
India	52

Figure 7. Structures of the major compounds identified in the essential oil of coriander



while, the product yield of fatty and essential oils by various portions of coriander's herb belonging to various areas is recorded in Table 4. Fixed oils having a characteristic smell with light yellow colour. The oil of the seed is inimitable that it comprises of high quantity of petroselinic acids. In fatty acid position of un-saturation is at t 6,7 location, that is occasional amongst octa-deconoic acids and hence may yield exclusive by-products which cannot be accomplished with additional seeds oil (Placek, 1963). The configuration of coriander oils was glowing investigated. Comparatively maximum contents of total glycolipid (GL) were observed at coriander seeds oil, along with some ratios of glucocerebroside, acylatedsterylglucoside and steryl glucoside. The petroselinic and linoleic acid are the most important F.A fluctuating from 65.7% to 76.6% and 13.0 to 16.7% respectively, followed by linoleic acid accounting for other fatty acid contain oleic acids and palmitic acids. The range of neutral lipids configuration lies

between 93 to 95 percent of the total lipid and is largely consist of triacylglycerol's. The key triacylglycerol's (TAG) are tri-petroselinic and di-petrose-linoyloleoyl glycerol's. The left neutral lipids (NL) are glycolipids (4.1 percent), trailed by phospholipid (PL) (1.5 percent). Total sterols calculated be in the lies between almost 0.036 to 0.051 g/ kg. Main indicators of sterols remain: stigma-sterol, b-sitosterol, Δ5-arenasterol, 24-stigmastadienol and camp sterol. The oil from seed source also comprises tocotrienols, where g-tocotrienol, a-tocotrienol and d-tocotrienol with the amount of 238.40, 24.9 and 12.57 mg per gram. The glucose is the only sugar found in the coriander seed (Sriti et al., 2010a; Ramadan and Morsel, 2003; Sriti et al., 2009a; Sriti et al., 2009b; Horvath et al., 2006).

From last few years, essential oil attracted researchers in the act of great increased popularity as a foundation of bioactive compounds, with numerous health potentials and aids (Burt, 2004). Investigators around the globe have various endeavours have been made by the scientists all over the world to investigate chemical composition of vital oils from seed source of *C. sativum* by means of diverse methodologies. The essential oil pleased of essential oil is almost 1% where the main element described in oils is linalool, ranging between 30 to 80 percent of total seed oils (Zoubiri and Baaliouamer, 2010; Singh et al., 2006; Sriti et al., 2009a; Bhuiyan et al., 2009).

Table 4. Showing fatty acids from different origin across the world.

Origin	Fatty acids	g/100g	References
Germany	C 16:0	3.96	Ramadan and Morsel, 2002
	C16: 1n-7	0.41	
	C18:0	2.91	
	C18:1n-12	65.7	
	C18:1n-9	7.85	
	C18: 2n-6	16.7	
	C18:3n-6	1.22	
	C20:0	0.25	
	C18:3n-3	0.20	
	C20:1n-9	0.30	
	C22:1n-9	0.16	
	C22:6n-3	0.34	
Tunisia	C14:0	0.08	Sriti et al., 2009a
	C16:0	3.48	
	C16:1n-7	0.23	
	C18:0	0.77	
	C18:1n-12	76.37	
	C18:1n-9	5.45	
	C18:2n-6	13.05	
	C20:0	0.15	
	C18:3n-3	0.15	
Austria	C16:0	4.4	Reiter et al., 1998
	C18:0	1.1	
	C18:1n-12	67.2	
	C18:2	18.5	

Chapter 4.

Traditional and Local Usage

C. sativum is sound famous aimed at their practise as a vigorous component of folk medications to cure numerous dysfunctions and its importance in culinary formulations (Bhat et al., 2014). Amongst innumerable spices and herbs on earth, coriander has a separate asset that it's all fragments (seeds, stem and leaves) are edible and having exclusive flavour and prime position (Gil et al., 2002). Nevertheless, in south Asia it is grinded in to fine powder and uses in curry. Their seed employment like a well-known flavour in areas of Mediterranean. Additionally, its foliage's too display a pleasing odour and flavour. The fresh foliage's are being mainly used in Vietnamese and Thai cookeries (Verma et al., 2011).

Likewise, the leafy part of the coriander has slight aroma and flavour than its roots. The root part is generally utilized in variety of Asian food and cooking. Nonetheless, coriander stalk is frequently used in making of casserole and broth in sliced form (Khan and Khatoon, 2008). Laterally with superb smell and taste, *C. sativum* is glowingly recognised as therapeutic herb owed their healing perceptions. Due to this reason, *C. sativum* broadly hired in preparation of abundant homegrown curative preparation to improve gastric complaints. Traditionally, in the north region of Pakistan, entire coriander herb mainly employed in traditional therapeutic intrusions for cure of illnesses like dysentery, coughing, diarrhea, jaundice, vomiting and

stomach worries (Ugulu et al., 2009). Medications from India, coriander is utilized to treat respirational, gastrointestinal, diaphoretic, urinary system with diuretic, stimulating and carminative actions. In Turkey, steeped seeds of coriander mainly employed as carminatives and gastral agent and to increase hunger (Platel and Srinivasan, 2004). The coriander greeneries mainly utilized for anti-spasmodic, grouchy, apetizer and too cure stomach uneasiness. Greeneries arrangements too functional for outwardly to cure cough, chest pain and bladder grumbles (Bruneton, 1995). In local Chinese treatment, seeds of coriander are employed to cure dyspepsia, digestive pain, flu with no perspiring, not good smell and disagreeable odours from genitalia parts (Leung and Foster, 1996), while, in Germany, its seed generally used as therapeutic drinks and ingredients. The key utilization is to cure grouchy problems, reduce hunger, stomach worries and intestinal disappointments (Wichtl and Bisset, 1994). Coriander fruits are utilized in the Europe pharmacopoeia and utilized as gastrointestinal relief, against worm, to cure rheumatic disorders. While in Iran, corianders have an extended antiquity of its homoeopathic utilization for treatment of spasms, sleeplessness and reduce hunger. In Saudi Arab, most people till now practises brew of corianders seed as an antidiabetic agent (Al Rowais, 2002), and seed extracts employed to reduce productiveness (Al Said et al., 1987). Coriander plant vital oils similarly has been conventionally practiced to inspire gastric fluids, to cure mouth contaminations and ulcers in the Asia regions (Leung and Foster, 1996; Kapoor, 1990). In USA, corianders have been currently investigated for their lowering effect of cholesterol (Rajeshwari et al., 2011). In countries alike Saudi

Arabia, Jordan and Morocco it has been traditionally used to enhance the glucose level (Otoom et al., 2006; Jelodar et al., 2007). Ayurvedic literatures has exposed that unremitting usage of coriander seed efficiently drops the serum lipid activity. This disclosed that newly herb-based remedies might be prepare in near upcoming liable on the data got from ethno-botanical investigations (Pavli'c et al., 2015).

2.6. Other uses

Numerous therapeutic activities of coriander plant (stem, root, leaves and seeds) were discoursed above. The volatile oil and seeds are rich in useful phyto-nutrients with, geraniol, limonene, borneol, carvone, and linalool. The flavonoids existing in *C. sativum* are quercetin, kaempferol, rhamnetin and apigenin. It consists of active phenolic components along with chlorogenic and caffeic acid. Coriander is also rich spring of nutritional fibre and virtuous basis for Fe, Mg and Mn. Coriander leaves also constitute one of the richest bases of vitamin C (250 mg per 100 gram) and Retinol (1.56 mg per100 gram). The juice of coriander is thus enormously useful in treating deficits of vitamins A, B1, B2, ascorbic acid and iron. Coriander is a valued component in perfumes, cosmetics, soaps, detergents and other toiletries (Smith et al., 1997). It's lenient, pleasing, somewhat peppery memo blends into aromas of oriental character. The juice from its leaf juice can also be employed as a cosmetic agent, and the essential oil can be used in aromatherapy.

Chapter 5.

Phytochemistry of Coriander

The coriander seeds also owing plentiful bio-active compounds as: tocols, fatty acids sterols, and unstable constituents.

5.1. Polyphenolics

According to one study shows that a Syrian coriander variety (1.09 mg GAE/gram) consist of high sum of total phenolic contents which is followed by coriander from Tunisia, Egypt (1.00 and 0.94 mg GAE/g, dry weight) variety respectively (Neffati et al., 2011). Despite to this another study, shows very different results that a Canadian variety contain 15.16 (mg GAE/g Dry Weight) of the total phenolic content (Sriti et al., 2011; Wangensteen et al., 2004). Nevertheless, a Norwegian variety of coriander shows almost 2.00 g GAE per 100 gram of extract in ethyl-acetate extracts (Barros et al., 2012). According to Barros et al. (2012) they stated substantial differences in degree of total phenolic content of similar extracts by changing polarity of solvents. Additionally, the coriander phenolic composition is not still clear and fully understood.

In literatures, the total tannin and flavonoid content was measured as mg CE per g DW. Formerly, total tannin and total flavonoid was calculated in methanol extractions of coriander seed, fluctuated between 0.09–0.17 and 2.03-2.51 mg CE/g DW respectively. It was

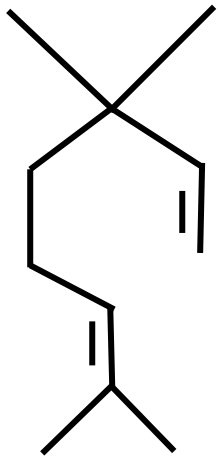
observed, Syrian variety for the total flavonoid and tannin showed extreme values (Neffati et al., 2011).

5.2. Essential oils

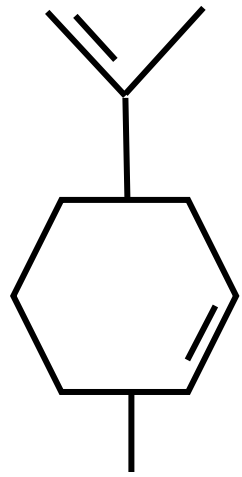
The coriander bearing the most significant essential oil in their flowers, leaves, stalks, seeds, roots, and bark; while, its chemical configuration vagaries during ontogenesis, which also disturbs scent. Immature leaves and fruits consist of disagreeable odour named “stink bug smell” because of the availability of a compound called trans-tridecane in oil (Mandal et al., 2015). While the perfume like smell in matured fruits nicely alike to citrus peel and sage (Mandal et al., 2015; Rajeshwari et al., 2011).

In coriander fixed and essential oils recorded as about 0.2–1.5% and 13–20% respectively. Moreover, some varieties contain high amount of essential oil 2.6 % (Bhat et al., 2014; Nadeem et al., 2013). Additional investigations also disclosed that coriander fruit have 1% essential oil where the major component was recorded monoterpenoid linalool (>50 percent) limonene, and geraniol (Figure 5) existing in weighty amount (Pavli’ et al., 2015).

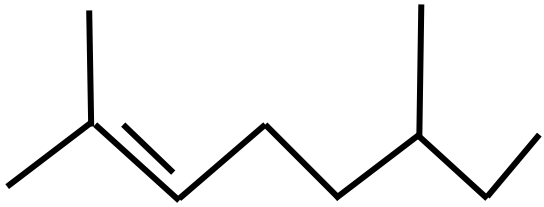
Figure 8. Chemical structure of linalool, limonene, and geraniol



Linalool



Limonene



Geraniol

Essential oil got from the Tunisian variety and Algerian variety Algerian variety was mainly composed of linalool which was recorded to be about 87.54%, 73.1%, respectively. While Tunisian variety also contain cis-dihydrocarvone 2.36%, whereas the Algerian variety contain bioactive molecule: p-mentha-1,4-dien-7-ol, neryl acetate, and α-pinene present in the concentration of round about 7 percent, 3 percent, and 3 percent accordingly (De Figueiredo et al., 2004; Ghani

2003). Moreover, Iranian coriander contain bioactive molecules as linalool, neryl acetate, γ-terpinine, and α-pinene, with the concentration round about 41to80 percent, 2 to 14 percent, 0.1 to 13 percent, and 1 to 7 percent accordingly (Bhuiyan et al., 2009), whereas, the oil from Bangladesh source, almost 37 percent of linalool trailed by geranyl acetate 17 percent and γ- terpinene 14 percent were recorded (Anwar et al., 2011). The Pakistani origin coriander seed consist of essential oil with the major component linalool almost 70 %, while additional compounds were geranyl acetate 4.99%, α- Pinene 1.63%, γ-terpinene 4.17%, anethole 1.15%, and p-cymene 1.12% were observed in significant amounts as (Zoubiri et al., 2010). The two Turkish varieties vulgare and microcarpum contain linalool content 42.1 to 52.7% and 63.5–71.0% respectively, whereas the other components were identified as geraniol, geranyl acetate, (Z)-isoapiole dillapiole, γ-terpinene, and p-cymene (Bandoni et al., 1998).

The essential oils from seeds of coriander are extremely sensitive in addition perishable to hard storing settings. Alteration mostly occurs in vital oils of seed is due oxidation of terpenes in sunlight. Such changes in chemical activity of vital oils can affect organoleptic features of oils, and may also damage the flavour and aroma of oils component's that can lead to series of illness in our body (Khan and Khatoon, 2008).

5.3. Extraction yield

Extraction yield can be stated as the authentic quantity of product (essential oils) gotten from the compounds (seed) afterwards employment of numerous extraction techniques. Usually, extraction vintage is stated in percent. Typically, volatile oil extractions from seeds of coriander are taken out with the help of steam and hydro distillation process. Various literatures have proposed that amount and yield of essential oil from corianders fluctuate with numerous factors such as cultivar origin, conditions of climate, and terrestrial position of growing area (not uniform around the world). In this consideration, it was stated that the vital oils yield obtained from seeds of coriander of Irian origin was almost 0.1–0.36 percent (Bhuiyan et al., 2009). Similarly, different studies show that the essential oils content from Tunisian and from India were almost 0.36 % and 0.19–0.38 % respectively (Msaada et al., 2009; Nejad et al., 2010). Research was carried out on two Turkish coriander varieties (microcarpum and vulgare) and the essential oil content was found 0.31–0.43% in microcarpum and vulgare yield was 0.15–0.25% (Bandoni et al., 1998). Moreover, another scientific research conducted in wet and cool conditions of Canada shows from 0.8% to 2.2%. Furthermore, an essential oil content in coriander seeds on fresh weight basis from Bangladesh was around 0.42% (Anwar et al., 2011).

5.4. Water soluble moieties

Water soluble components from corianders seed are not fine stated as essential oil, while a few researchers studied these constituents and mentioned that nearby thirty-three various components occur in water soluble portion of methanolic extracts, that contain 4 different mono-terpenoid glycosides, 2 mono-terpenoid glucoside sulfates, and 2 novel aromatic compound glycosides (Sriti et al., 2009a).

5.5. Lipids

5.5.1 Fatty acids

Numerous current scientific studies have well explained the compositional studies coriander seeds fatty acid profile. The oil content from French origin comprises of high quantity of mono-unsaturated fatty acids about (1.8%) and mainly petroselinic acid (73%) (Uitterhaegen et al., 2016). The oil content of Tunisian and German and varieties of coriander seeds were 28.4% and 19.24% on dry weight basis (Sriti et al., 2010a; Matasyoh et al., 2009). The plant is documented as a latent foundation of lipid (healthy in petroselinic acids) and essential oil extracted from the aerial Portions of fruits (Mandal and Mandal, 2015). The availability of petroselinic acids made *C. sativum* most valuable and fascinating. That is reason, due to the availability of petroselinic acid in coriander essential oils of fruit known as triglyceride oil. The prime fatty acid documented in maximum lipid class was petroselinic acid (66 to 81 percent) followed by linoleic acid (13 to 17 percent). Further, highlighted fatty acid documented as oleic,

palmitic, and stearic acids. Moreover, in minor amounts recognised compounds are arachidic 0.10–0.25%, palmitoleic 0.4–1.1% and α-linolenic 0.15–0.50% (Neffati and Marzouk, 2008).

In an investigation, variations in fatty acids through maturing of coriander fruit grown in the North-East of Tunisia (Charfine) were investigated. At maturity, key fatty acids were petroselinic acid 80%, tailed by linoleic acid 13.6 %, palmitic acid3.6 %, and stearic acid 0.7 %. Throughout ripening process of coriander fruit, mono-unsaturated fatty acids increase while saturated and polyunsaturated fatty acids decrease significantly (Bandoni et al., 1998).

It is essential to highlight that coriander fruits at the last 5 phases are with economic importance and industrial applications and the 1st 4 phases of maturity have a strong nutritional value and the last 5 phases are with financial importance and industrial considerations (Msaada et al., 2009).

Moreover, polar lipids were principal complement of key phospholipid subclass round about concentration are: phosphatidylcholine 36 percent followed by phosphatidylethanolamine 34 percent and phosphatidylinositol 15 percent. Though, phosphatidic acid and phosphatidylglycerol remained noticed in smaller quantities, while the maximum galactolipid detected were digalactosyldiacylglycerol 62.32% followed by monogalactosyldiacylglycerol 37.68% (Sriti et al., 2010b).

5.5.2. Tocols

Coriander seeds has almost 327.47 μg/g of tocols which shows that it is an enhanced source of tocols. The main tocopherols are γ-tocopherol and δ-tocopherol and α-tocopherol with a shown concentration of 26.40, 3.50 and 11.70 μg per gram respectively (Sriti et al., 2010a).

5.5.3 Sterols

Coriander seeds oils been documented a vital spring of sterols, conferring to prior literatures, the total of sterol content lies between 36.93–51.86 mg/g of the oil, preventing absorption of cholesterol which helps in cholesterol-lowering. In coriander seeds the most highlighted and well-known strolls are stigmasterol and β-sitosterol with the known concentrations of 36.93–51.86 and 24.8–36.8 mg/g oil. While the other sterols identified smaller concentrations are campesterol, Δ7-stigmasterol, stigma-stadienol and Δ5-avenasterol (Sriti et al., 2009a); (Ramadan and Mörsel, 2002).

5.6. Coriander herb

The vegetal moiety of coriander plant is not well sound investigated as other like fruit and part. However, the main and key factors like flavonoids phenolic contents, essential oil and polyphenols are found in the leaf section (Nambiar et al., 2010; Matasyoh et al., 2009).

5.6.1. Polyphenols

Polyphenols are significant secondary metabolites in coriander leaves and fruits having solid biological activities. Usually, tannins, flavones and anthraquinones have been nominated as a coriander fruits phenolic component (Barros et al., 2012).

Earlier, around twenty-one phenolic compounds were documented in the green portion of coriander plant, they were mostly composed of phenol carboxylic acid, flavonoids, and coumarins. The compounds like vicenin, hesperidin, gallic acid, dicoumarin, apigenin, hyperoside, ferulic acid, luteolin, diosmin, orientine, chrysoeriol, dihydroquercetin, tartaric acid and salicylic acid (Oganesyan et al., 2007).

The green part of the coriander has been studied for total phenolic and flavonoid contents conclusions displayed about 1.01395 and 5.25952 g per kg. The polyphenol outline of coriander green part involves quercetin-3-O-rutinoside, quercetin-3-O-glucuronide, dimethoxycinnamoyl hexoxide, quercetin-3-O-glucoside, and kaempferol-3-Orutinoside present at about 3.29, 1.23, 0.40, 0.41, and 0.32 g per kg correspondingly.

Amongst the flavonoids, p-coumaroylquinic acid, 3-O-caffeoylquinic acid, ferulic acid glucoside, and caffeoylquinic acid were spotted in the quantity of 0.30, 0.17, 0.12 and 0.07 g per kg respectively (Barros et al., 2012).

The coriander leaves also own anthocyanins. The anthocyanin biosynthesis is augmented by salicylic acid and microelements (Rahimi et al., 2013). The outcomes of a detail study of Barros et al. (2012) shows that the in vitro culture method may be explored in order to open novel research and investigation prospects in medicine, and pharmaceuticals along with the anthocyanins, flavones and flavanols, like secondary metabolites (Barros et al., 2012).

5.6.2. Essential oil

An outcome of the research showed that leaves of coriander own lesser quantity of essential oil as related to seeds (Kasmaei et al., 2016). the Tunisian coriander variety air dried leaves contain 0.12 percent of vital oils, while the essential oils in root portion was about 0.06% at the vegetative phase (Neffati and Marzouk, 2008).

5.6.3. Lipids

For the first time coriander green portion fatty acid profile was elaborated by (Neffati and Marzouk, 2008), study outcomes showed, the leaves near to the base of the coriander has high number of fatty acids 0.061 g per kg on dry weight basis, although the leaves from the upper portion contain 0.041 g per kg on dry weight basis.

Additionally, it was mentioned that main fatty acids found in leaves of coriander plant were polyunsaturated fatty acids. Furthermore, it is suggested also that α-linolenic were found richest fatty acid in together upper and basal leaves almost 39.4%, and 41.1% correspondingly,

trailed by linoleic, palmitic, and heptadecenoic acids. However, the insignificant amounts in both (upper and basal) leaves were cis-palmitoleic, stearidonic, trans-palmitoleic, oleic and stearic acids, assembling round about 4.7 percent upper leaves and 9.6 percent basal leaves (Neffati and Marzouk, 2008).

5.7. Carotenoids

Commercial varieties of coriander varieties are also the virtuous basis of (β-carotene) carotenoids (precursor of vitamin-A). β-carotene contents were noted maximum in leaves at a matured phase the leaves contain higher β-carotene contents than in seeds and seedlings. At the pre-flowering phase it was mentioned that carotenoids (217.50 mg/100 g DW) and β-carotene (73.64 mg/100 g DW) (Divya et al., 2012; Barbosa et al., 2005).

5.8. Isocoumarins

At present no current research articles concerning the isocoumarins from coriander plant. The dihydrocoriandrin and coriandrin together with isocoumarins, extracted from the upper parts of coriander plant (Baba et al., 1991).

Chapter 6.

Extraction Techniques

Besides employment of coriander as a cooking component across the world, it has also main use in health portion to cure different illness since ancient times. The chemical examines of seed and leave of this plant has exposed its main antioxidant components of seed is linalool which is an oxygenated mono-terpene, while the leaves major ingredients are quercetin. These bioactive compounds own high antioxidant actions and associated healing activities. Numerous techniques utilized for the removal and segregation of such vital bioactive ingredients from its seed and leaf source, e.g, hydro-distillation and Soxhlet extraction technique usage of standard organic solvent like ethanol, hexane and methanol together with some advanced methods like Ultrasonic extraction, microwave assisted extraction methods (Laribi et al., 2015).

Usually, hydro-distillation and Soxhlet procedures have been extensively hired for extraction of bioactive compounds from numerous plants including coriander and its various plant parts, however it is recommended by several research investigations that conservative methods consist of some negative influences on the life and environment of human. Additionally, shortcomings of conservative methods comprise need of big amount of energy that may harm heat sensitive compounds required more time for processing, uneconomic and organic solvents want to be wasted appropriately. Still, downsides

of conventional methods can be overwhelmed by application of novel green or modern methods such as subcritical water extraction (SWE) and supercritical fluid extraction technique (SFE) (Pourmortazavi and Hajimirsadeghi, (2007). The various extraction techniques in detail are mentioned in Table 5.

Table 5. Different extraction techniques from various parts of coriander with their solvent and time required

Sr. No	Coriander Component	Bioactive Components/ Antioxidant Assays	Time/ Pressure	Technique	Solvent	Concentration	References
1	Leaves	TPC	01 hour	Solvent extraction	Aqueous methanol	49.2 -3.4–126.0 T mmol GAE/ kg DM	Kaiser et al., 2013
2	Leaves	TPC	01 hour	Solvent extraction	Aqueous methanol	109.6 T 14.1 mmol TE/kg DM	Kaiser et al., 2013
3	Leaves	TEAC	01 hour	Solvent extraction	Aqueous methanol	19.0 T 0.8 TE/kg DM	Kaiser et al., 2013
4	Leaves	FRAP	01 hour	Soxhlet extraction	Ethyl acetate	5.5 g GAEper100 gram extract	Wangensteen et al., 2004
5	Fruits	FRAP and TPC	01 hour	Solvent extraction	Aqueous methanol	51.2 T 2.6 mmol TE/kg DM 55.4 T 0.9 mmol GAE/kg DM	Kaiser et al., 2013
6	Seeds	Linalool	01 hour	Soxhlet extraction	Lipid extract	785.05 mg/100 g	Pavlic et al., 2015
7	Seeds	TPC	01 hour	Soxhlet extraction	Ethyl acetate	1.9 g GAE/100 g extract	Wangensteen et al., 2004
8	Seeds	TPC	01 hour	Soxhlet extraction	Ethyl acetate	5.5 g GAE/100 g extract	Wangensteen et al., 2004
9	Seeds	Linalool	100 bars per 55 $^{\circ}C$	SFE	CO_2	717 mg/g	Zekovic et al., 2016
10	Seeds	Linalool	12 hours	Soxhlet extraction	Hexane	73.62%	Kaiser et al., 2013
11	Seeds	Linalool	03 hours	Hydro distillation	Steam	77.97%	Kaiser et al., 2013

12	Seeds	Essential oil/lipid extracts	30 bar/200 °C	Subcritical water extraction	CO_2	2.22 T 0.26%	Pavlic et al., 2015
13	Essential oil	Linalool	-	Subcritical water extraction	Water	82.91%	Eikani et al., 2007
14	Essential oil	Linalool	-	Soxhlet extraction	Water	82.91%	Eikani et al., 2007
15	Essential oil	Linalool	-	Hydro distillation	Steam	77.98%	Eikani et al., 2007

Chapter 7.

Antioxidant Capability of Bioactive Compounds

Antioxidant activity of coriander plant because of the occurrence of numerous active compounds such as secondary metabolites and phenolic ingredients. Such components involve of a multifaceted and widespread display of phytochemicals revealing antioxidant actions and human health increasing biological result. These constituents measured as naturally occurring antioxidant because of its health increasing features and plentiful existence in varied array of vegetables, herb, and fruits. Additionally, vegetables and fruits which holds such bioactive moieties are usually identified as functional food (McDonald et al., 2001).

Lately, the three different varieties of coriander from three different countries (Tunisian, and Egyptian) were associated by using methanolic extracts for its antioxidant activities. The analysis showed variant results for total phenloics ranges from0.94 - 1.09 mg GAE/g Dry weight while for flavonoids: 2.03-2.51 mg EC per g Dry Weight (Msaada et al., 2017).

Additionally, DPPH scavenging action of methanol extract and vital oils were carried out of coriander seeds, it was stated that methanolic extracts of Tunisian and Canadian coriander varieties, unveiled DPPH scavenging activity of about 36 and 32 µg per mL of extracts. While, essential oils unveiled very little DPPH scavenging action (60 mg per mL) of essential oil. Nonetheless, ethanolic extract results from Norway

coriander seeds revealed a DPPH scavenging activity of almost 510 μg per mL (Sriti et al., 2011; El-Massry et al., 2002).

In the other research analysis, the ferric reducing power of coriander extract exhibited that Canadian variety displayed higher measurements as compared to Tunisian one 0.78 and 0.70 mg per mL, correspondingly (Sriti et al., 2011). Moreover, Kaiser et al. (2013) conducted FRAP assay in order to project the antioxidant potential of coriander, and detected that foilages of coriander blanched at 100 ^{o}C in water for one minute revealed extreme FRAP activity of 109.6 mmol TE per kg DM, whereas, fruits blanched at the same temperature displayed FRAP activity of 51.2 mmol TE per kg DM.

Chapter 8.

Health Potentials

8.1. Antibacterial Properties

The plant coriander consists of solid antibacterial action against *Staphylococcus aureus*, *Salmonella typhi* and *Escherichia coli* (Al-Jedah et al., 2000). According to investigation of Delaquis et al. (2002) exhibited that coriander oil exhibited slight results against gram-negative bacterial stains (*Pseudomonas fragi*, *E. coli*, *S. typhi*) while, having strong effects against gram-positive bacterial stains such as (*S. aureus and Listeria monocytogenes*).

The antibacterial component in coriander called “dodecanal”, which is two times effective than the usually used antibiotic medicine “gentamicin” in killing *Salmonella* (Kubo et al., 2004). Count to dodecanal, 8 additional different anti-biotic components extracted from fresh corianders, which provide a new horizon to the food scientists to industrialize a new product of food additive to thwart foodborne illness. Water and methanolic extracts of coriander greeneries were analysed for anti-microbial action against *B. subtilis* and *E. coli* by defining cell injury. Results from the investigations shows that the growth and development of such bacteria is highly inhibited (Wong and Kitts, 2006). Though, few studies showed that corianders do not have potential against the urinary pathogens (Chaudry and Tariq, 2006; Saeed and Tariq, 2007).

8.2. Anti-diabetic actions

The anti-diabetic properties of corianders are mentioned in several articles. But in detail, coriander occurred inveterate as an anti-diabetic medicine. Research established anti-hyperglycaemic result of corianders in streptozotocin-diabetic rats. The way of act of anti-hyperglycaemic act of the aqueous extracts of the coriander fruit linked with encouragement of insulin excretion, improvement of glucose acceptance and absorption by muscles. In over-all, action made by one or more compounds were in extracts (Gray and Flatt, 1999).

Furthermore, it is detected that a dosage of coriander's fruit lessening and normalise the blood-sugar and dyslipidaemia at distinctive conventional dosages in patients who have non-insulin dependent diabetes mellitus. In an investigation of forty volunteers, twenty volunteers consumed 2.5 grams of crushed coriander fruits two times every day for 2 months and 20 volunteers helped as control. The results displayed dominant decreasing in fasting blood sugar levels, and dominant lessening in lipid peroxidation in red blood cells and increases in serum Carotenoids, retinol, ascorbic acid, vitamin E, and glutathione levels (Abascal et al., 2012). Moreover, Coriander plant, particularly the plant fruits initiate in takings may also suitable for handling of hepatic fibrosis and chronic liver illnesses (Wijayagunawardanea et al., 2015).

Earlier, it was stated that management of drink and diet enhanced with coriander to encouraged diabetic rats meaningfully dropped

hyperglycaemia (about 33%) in a 20 days experimental test (Gray and Flatt, 1999).

8.3. Antianxiety actions

The aqueous quotation of corianders has an antianxiety action and own opiate and muscles tranquilizer properties dosage vulnerably in rats. The result of coriander at a dosage of 0.10 g per kilogram effect in rats observed nearly correspondent to that of 0.03 g per kilogram diazepam on the plus maze analysis. For an average adult man, a potent recommended dose 07.5 g of dry coriander fruits extract was suggested (Emamghoreishi et al., 2005).

8.4. Cardioprotective activity

The fruits of coriander (hydro-methanolic extract) have been observed cardio-protective activity. This consequence would be owed to maximum polyphenolic contents in fruit. A study was carried out on mice (male Wistar) by isoproterenol induced cardio-toxicity model. The results demonstrate that methanolic quotation of coriander fruits avert myocardial barricade by preventing myofibrillar damage on rats (Patel et al., 2012). The coriander fruits produced a momentous reduction in all cholesterol associated lipids, whereas, extracts compact high-density lipoprotein (HDL) cholesterol. Fruits coriander abridged dyslipidaemia in rabbits likewise. It shows that coriander extracts have valuable proceeds on cardio-protective consequences (Abascal et al., 2012).

8.5. Antiulcer action

Coriander is an important plant to defend human body against fascination of heavy metals and additional dietetic toxin materials. Additionally, it also contributes a vital part in inhibition of development of gastric ulcers by *Helicobacter pylori.* In an analysis, the antigastric ulcer and antisecretory mode of action of this plant have been established and decided that consequence may be accompanying to antioxidant properties of various elements existing in this plant, it is readily intricate in scavenging activities of the reactive oxygen species on the superficial of gastric mucosa, may to form a defensive coating by hydrophobic exchanges. That is why, it keeps the cells from gastric damage (Chithra et al., 2000). In a fresh study, the animal work exhibited that coriander fruits (0.25 g per kg) defended the animals against the ulcerogenic effects of salt, sodium hydroxide, ethanol, indomethacin, and pylorus ligation dose-dependently (Abascal et al., 2012).

8.6. Anticancer activity

The biological outcome of this plant fruit on lipid parameters in 1,2-dimethylhydrazine encouraged colon cancer was investigated in rats. Absorptions of cholesterol and cholesterol to phospholipid ratios weakened while the level of phospholipid improved meaningfully in 1,2-dimethylhydrazine control group related to the coriander managed group. Fecal dry weight, fecal neutral sterols, and bile acids showed a piercing rise in the coriander fed group compared with the 1,2-dimethylhydrazine employed group. Therefore, it looks that the

coriander plays a defensive part in the lipid metabolism of colon cancer (Sahib et al., 2012). While there are not numerous researches on the anti-cancer outcome of coriander available.

8.7. Anthelmintic effect

The *C. sativum* seed (crude aqueous and hydro-alcoholic extract) totally withdrawn shading of nematode eggs at concentration lower than 0.005 g per mL with no statistically significant difference between both (crude aqueous and hydro-alcoholic) extracts. Though, the hydro-alcoholic extracts presented well *in vitro* action against fully-grown parasites as compared aqueous one. Effectiveness of anthelmintic action in vivo was verified by faecal egg count reduction (FECR) and total worm count reduction (TWCR) in sheep's artificially diseased with *Haemonchus contortus.* Suggestively FECR was spotted on day 2nd after action with 900 mg per kg of crude aqueous extracts of the herb. On the 7th and 14th days, FECR was also noticed at 450 mg per kg amount of crude aqueous extracts. A significant TWCR was only detected with 900 mg per kg dose of crude aqueous extracts (Eguale et al., 2007).

8.8. Antidiuretic activity

The coriander extracts (aqueous) improved dieresis and urinary flow of sodium, potassium, chloride and glomerular purification rate at doses of 0.04 and 0.10 g per kilogram employed by arterial distillation in an esthetised Wistar rats. The action of diuretic activity of coriander seemed alike to that of furosemide (Aissaoui et al., 2008). Rodents

served with *C. sativum* crude extracts, a slight upsurge in the urine production was detected at the dose of 0.3 g per kilogram, whereas a significant diuretic conclusion ($p < 0.01$) was produced by the amount of 0.10 m per kilogram. An upsurge in the urine volume was manifest within 01 hour of employment of furosemide, while the onset of diuretic effect was 03 to 04 hours with *C. sativum* crude extract (Jabeen et al., 2009).

8.9. Antiaging activity

The long chain fatty acids are possibly helpful in anti-aging goods for limited practise. Hence, the long chain fatty acids can be measured as latent anti-aging representatives. The fruits oils are very ironic in such types of the fatty acids. Research carried out as a current treatment for a diversity of skin situations with fruit oil of coriander and as a constituent of herbal sun-screens appear very inspiring (Abascal et al., 2012). The oil comprises ceramides of petroselinic acid. A specifically prepared extracts from coriander fruits like Umbelliferon *Coriandrum sativum* extracts is a trademarked product comprising of petroselinic acid triglycerides obtained as a nonlauric segment from coriander fruit oil assistances in supportive skin barrier purposes (Majeed et al., 2015). Preparations using coriander oil as single formula or in mixture with the additional floras can be industrialised in the future and may develop well-known as one of the confidences of remaining young for a long time.

8.10. Additional health assistances

Coriander also owns numerous additional health profits which comprise control of swellings, diarrhea, mouth ulcers, anemia, menstrual disorders, small pox, eye care, conjunctivitis, skin disorders etc (organicfacts.net, n.d.).

8.10.1. Swellings

Cineole and linoleic acid are the important constituents, existing in coriander, keep antirheumatic and antiarthritic functions and are actual helpful to cure swelling triggered because of improper function of kidneys or anemia some of elements helps in excretion of spare water from the body.

8.10.2. Mouth ulcers

A component (citronelol) in coriander vital oil of coriander is an outstanding anti-septic. Moreover, additional elements have antimicrobial and remedial properties which do not let wounds and ulcers in the mouth go worse. They help in curing up of ulcers and also freshen up the breath.

8.10.3. Gastral health and control of diarrhea

As the coriander has rich aroma because of its essential oils. Besides, from being a brilliant appetizer, also benefits in appropriate excretion of enzymes and digestive juices in stomach, increase ingestion process and peristaltic motion. Some of the constituent like borneol and linalool

in coriander essential oils, help in digestion, suitable working of liver and bonding of bowels and aid to treat diarrhea.

8.10.4. Small pox

The coriander essential oils are ironic in anti-oxidants, anti-microbial, anti-infectious and detoxifying compounds. Existence of iron and ascorbic acid strengthens the immune system as well. These functions assistance, to avoid and to treat small pox. They also help to decrease the discomfort and comforting result on pox patients.

8.10.5. Menstrual complaints

Actuality exciting in nature and serving appropriate excretion from endocrine glands, it also aids right excretion of hormones and thus encouraging appropriate menstrual cycles and decreasing troubles throughout periods.

8.10.6. Eye care

Coriander is the rich source of Vit- A and C and also contain a lot of antioxidants and mineral (phosphorus) in coriander of essential oils which help to avert aging of eye, macular disintegration and soothes eyes against stresses.

8.10.7. Skin ailments

The anti-septic, cleansing, anti-fungal and anti-oxidant functions of this herb are perfect for treatment skin complaints like dehydration and fungal contaminations. It also aids to treat ulcer, inflammation, spasm

and perform as a medicine, defends and calms liver. Coriander is known to be a natural aphrodisiac and earlier it was widely practiced in certain measures, mutual with other herbs (Kumar et al., 1977). The essential oil from coriander induced a marked painkilling actions in rats in research led by Afifi et al. (1994).

Table 6. The various chemical constituents in the coriander plant and their action against various diseases

Chemical constituents	Antioxidant	Antidiabetic	Anti-inflammatory	Antiaging	Antitumor	Anticancer	Antimicrobial	Antiulcer
Acetic acid (seeds)							■	
α-Pinene			■			■	■	
α-Phellandrene							■	
α-Terpineol							■	
α-Terpinene							■	
Apigenin	■		■	■	■	■	■	
Ascorbic acid (leaf)		■	■	■	■	■	■	■
Angelicin							■	
β-Pinene (seeds)			■					
β-Carotene	■			■	■	■		■
β-Sitosterol			■		■	■	■	
Bornyl acetate							■	
Borneol			■				■	
Camphene	■							
Caffeic acid	■				■	■	■	
Copper		■	■					
Carvone						■		
Chromium		■		■				
Chlorogenic acid		■			■	■	■	■
Citronellol							■	
cis-Ocimene							■	
Caryophyllene			■		■		■	■
Dipentene							■	
Elemol								■
Fructose		■						

Fiber								
Geranial								
γ-Terpinene								
Isoquercitrin								
Linalool								
Linoleic acid								
Limone								
Myristicin								
Magnesium								
Myristicin								
Myristic acid								
Nerolidol								
Nerol								
Niacin								
Oleic acid								
p-Hydroxy benzoic acid								
p-Cymene								
Psoralen								
Palmitic acid								
Protocatechuic acid								
Pectin								
Quercetin								

*Green colour in this table indicates the presence of these anti agents and white colour shows their absence.

Chapter 9.

Coriander in Traditional Medicine

All portions of the *C. sativum* plants can be employed as a flavouring agent (cooking drives) and folk medicines for cure of various disorders in traditional remedy in various cultures on the earth particularly in gastrointestinal complaints (Bhat et al., 2014; Sahib et al., 2012). Hippocrates (460–377 BC) practised coriander in antique Greek medicines. Decoction and tincture of fruit ground of coriander single or in mixtures with additional herbal suggested for dyspeptic disorders, loss of hunger, shaking, anxiety and insomnia. Essential oils from coriander have also very antiquity in folk medication (Mandal and Mandal, 2015). The aqueous extracts of coriander fruits are used in folk Moroccan remedy in the healing of diabetes and dyslipidaemia also to cure series of illnesses (Aissaoui et al., 2015) including Saudi Arabia and Jordan (Laribi et al., 2015). Moreover, Moroccan and Palestinian pharmacopeia's have been stated the practices of coriander as a traditional diuretic and to cure urinary infections (Bhat et al., 2014).

In Iranian folk medicines, coriander fruit have a long history of usage as an anxiolytic and a sedative in insomnia. The fruits were extensively consumed internally as a carminative, digestive, spasmolytic, and galactagogic as normal. Furthermore, it is also famous for anti-inflammatory representative in Iranian folk medicines (Heidari et al., 2016).

Coriander is highly believed traditional medicinal herb normally known as “Dhanya” in Pakistan. Folk medicines also acclaim the consistent use of a decoction of coriander fruits (seeds) and stated about properties in the treatment of arthritis and other inflammatory complaints (Laribi et al., 2015; Abascal et al., 2012). Nevertheless, coriander is the key component in curry powder in Pakistani foods. Furthermore, the coriander roots have been employed in Asian cooking for powerful flavour (Laribi et al., 2015). The entire plant portion across the Pakistan is used for the treatment of flatulence, dysentery, diarrhea, cough, stomach complaints, jaundice and vomiting.

In USA, coriander freshly investigated for its cholesterol lowering properties. While, in some countries of Europe, coriander has conventionally been referred to as an “antidiabetic” herb (Rajeshwari et al., 2011; Melnyk et al., 2011).

In Turkey, it is distinguished that fruits fermentations are valuable in dyspepsia and as an appetizer (Laribi et al., 2015).

In folk medicines, the normal dosage of fruit powder is from 1 to 5 gram, 3 times/day (Abascal et al., 2012). Maximum common practises of the coriander have been supported by technical data as specified in the manuscript. This point is very significant that the plant has been integrated between traditional and scientific usages.

Chapter 10.

Coriander Based Food

Connotation of and health and nutrition has improved opportunity for food-based remedy against numerous lifestyles linked ailments amongst public. Today, call for natural occurring constituents are ever-increasing daily because of people consciousness related nutrition associated health difficulties (Pernice et al., 2009). Flavour and herbs like coriander plant and their seeds are capable basis of health encouraging complexes and consist brilliant nutritional outline. There is a need for ideal exploitation of such components that comprise product growth as an implement to carry active compounds to specified people (Schieber et al., 2001).

Advancement and expansion of innovative food items is a diverse and ambiguous mission that relies on scientific obstacles, consumers pleasure, suitability, worth, phase, and cultural customs (Siró et al., 2008). Most of the people depend on herbs and plant-based foods to fulfil their nutritional desires such as minerals, carbohydrates, vitamins, proteins and fats. Amongst the food products cereal-based goods along with numerous varieties of sauces inhabit dominant position for public of various age groups to satisfy their dietary necessities. Across the world, the call of several forms of banquets and sauces is ever-increasing with the passage of time.

Coriander and its various parts conventionally employed in preparation of several food products like bakery products, sauces, and spices and in some local items of Indo-Pak regions like “chatne”. Coriander normally employed like flavouring agent in 2 different types, (i) green herb (ii) seed. The odour and flavour of these two forms of coriander goods are obviously diverse from each other. It is mostly employed for the flavouring tenacities of cooking in the Middle East, Asia, and continent of America. Entire plant has been used for formulating of numerous classes of chutneis, sauces, curries and soups (Schieber et al., 2001).

Moreover, seeds of coriander have been utilized as a vital component of curry powders, sausages, pickling spices, buns, seasoning, pastries, cakes and other bakery items. Besides this its oils have been used for flavouring brews, meat, candies and sauces. Coriander juices usually employed for the actions of indigestion, dysentery, nausea ulcerative colitis, and hepatitis by adding it in fresh buttermilk.

Additionally, coriander water prepared by boiling seed of coriander aids in dropping serum cholesterol level by proper working of the kidney functions (Sharma and Sharma, 2012). Today, amongst many vegetable items, numerous classes of sauces are in publicity. Commonly, sauces are characterised by water activity and pH values which let its marketability for a short time under cool conditions (Laribi et al., 2015). However, storing for an extended period required the application of pasteurization and sterilization actions.

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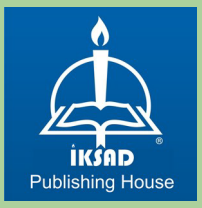

ISBN: 978-625-8423-86-0