International Journal of Farming and Allied Sciences
Available online at www.ijfas.com
©2017 IJFAS Journal-2017-6-1/24-29/ 31 Jan, 2017
ISSN 2322-4134 ©2017 IJFAS

Properties, cultivation method and requirements of cumin (Cuminum cyminum L.) - an overview

Javad roustakhiz[1*], Abdolshakoor Raissi[2]

1. Higher Educational Complex Of Saravan, saravan, iran
2 .Faculty of agriculture, Department of Horticulture, Velayat University, Iranshahr, Iran

Corresponding author: Javad roustakhiz

ABSTRACT: Cumin (Cuminum cyminum L.) is a small annual and herbaceous plant belonging to the Apiaceae family with the flowers in white or pink color and spindle-shaped fruits in green and gray color which produces highly nutritional oleaginous seeds. C. cyminum is mainly cultivated in India, China, Saudi Arabia and neighboring countries of the Mediterranean. This crop has many uses in the pharmaceutical, food and cosmetics industry. Due to its flavor, cumin seed powder can be used as an additive in various foods, and it is the second most popular spice in the world. This plant is traditionally used in the treatment of dyspepsia, diarrhea, toothache, digestive disorders and to increase breast milk and as a disinfectant. Cumin seeds contain 2 to 5% essential oils, which is obtained from steam distillation of crushed cumin, and the composition of it depends on many factors including the time of harvest, method of extraction, type of cultivar, geographical origin and storage conditions.

Keywords**:** Cumin, Cuminum cyminum L**.,** Cuminaldehyde**,** spice

INTRODUCTION

Since ancient times, medicinal herbs and aromatic herbs have been used by humans respectively to treat diseases and as spice in food preparation because they are less toxic and generally have no side effects. In addition, exploration of natural antimicrobial substances for preserving foodstuffs has attracted a lot of attention (Gould., 1995). One of the plants that has all three intended characters, is cumin (Cuminum Cyminum L). C. Cyminum is a small annual and herbaceous plant belonging to the Apiaceae family that is grown in the neighboring countries of the Mediterranean Sea (Hajlaoui et al., 2010). Traditionally, it is used in the treatment of many diseases and, its powder can be used as an additive in various foods (De et al., 2003; Hashemian et al., 2013; Nostro et al., 2005; Bettaieb Rebey et al., 2012a; Muthamma et al., 2008; Eikani et al., 1999; Joshi., 2000; Norman., 1990). The findings of various studies indicate that Cumin essential oils have considerable toxicity against insect pests of stored food, and moreover, due to the anti-bacterial and anti-Aspergillus property of this plant, it can prevent from food spoilage (Mohammadpour et al., 2012; Oroojalian et al., 2010; Hajlaoui et al., 2010; Iacobellis et al., 2005; Ziaee et al., 2014; Yeom et al., 2012; Tunc et al., 2000; Chaubey., 2008; Abdelgaleil et al., 2009). Thus, this review briefly introduces and represents this useful plant.

1- History and distribution

Cumin originates from Egypt, Turkestan and East Mediterranean, but it is cultivated in Iran, China, India, Morocco, South Russia, Japan, Indonesia, Algeria, Pakistan, Saudi Arabia, Turkey, Cyprus, Lebanon, Malta, Spain and on a small scale in Central America (Tuncturk and Tuncturk., 2006; Ebrahimie et al., 2003; Thippeswamy and Naidu., 2005; Arctander., 1960). Medicinal plants has been traditionally used in Iran (Ghorbani, 2005), and cumin is an important medicinal product for Iran due to its commercial aspects, and it is commonly cultivated in arid and

semiarid regions of Iran (Kafi et al., 2006; Kamkar et al., 2011; Rezvani Moghaddam et al., 2007). Cumin occupies about 26% of the land area devoted to medicinal plants in Iran (Koocheki et al., 2004).

2- Morphological description

Cumin (Cuminum cyminum L.) is a diploid species with 14 chromosomes (i.e. 2n = 14). It is a small annual and herbaceous plant belonging to the Apiaceae family which grows to a height of about 60 cm. Its flowers are small, with white or pink color in compound umbel form that appear at the end of the stem in the months of May – June. The leaves are 5–10 cm long, pinnate or bipinnate, thread-like leaflets. The fruit is a lateral fusiform or ovoid achene with a length of 4–5 mm, containing a single seed, which can be seen in green and gray, even white and yellow in some varieties (Hashim and E1-Kiey., 1962). Cuminum cyminum L produces highly nutritional oleaginous seeds, which consist of a stripped paired or separate carpel (Pottier-Alapetite., 1979). The root is long and vertical and the stem is grooved with double or triple splits.

3- Chemical compounds

The analysis of cumin fruits determined that they contain fixed oil (approximately 10%) and volatile oil (1–5%) that it is because of the special aroma of cumin, in addition, protein, cellulose, sugar and minerals are also available in Cumin (Li and Jiang., 2004; Spices Board Statistics., 2006). Volatile oil mainly contains monoterpene hydrocarbons (α-pinene, β-pinene, ρ-cymene and γ-terpinene) and oxygenated monoterpene (1, 8-cineole, cuminaldehyde, cuminyl alcohol and safranal) (Bettaieb Rebey et al., 2012a; Burt., 2004; Gachkar et al., 2007; Naveed et al., 2013; Oroojalian et al., 2010; Jirovetz et al., 2005; El-Hamidi and Ahmed., 1966; Nestorova et al., 1977; Lis-Balchin et al., 1998; Hiller., 1999). Cuminaldehyde or 4-isopropylbenzaldehyde ($C_{10}H_{12}O$) which is the main components of cumin essential oil can induce different biological activities (Jayathilakan et al., 2007; Rasooli et al., 2007; Oroojalian et al., 2010, Al-Gaby., 1998; Farag., 1997). Due to low levels of anti-nutritional factors, such as tannin, oxalic acid and phytate in cumin, thus making it a good candidate as a bionutrient.

4- Factors Affecting the Composition of Cumin

Cumin oil possesses various compounds at different concentrations in different regions. This difference in chemical composition of the oils depends on various factors, including plant part, harvest time, type of cultivar, storage conditions, climatic effects on the plants, seasonal changes even sunlight duration, geographic origin and processing of plant materials such as extraction methods and the conditions of analysis (Behera et al., 2004; Bettaieb Rebey et al., 2012b; Wang et al., 2006 and 2009; Zhang et al., 2011; Oroojalian et al., 2010; Telci et al., 2006; Moghaddam et al., 2007 and 2015; Koenen., 2001; Lawrence., 2002; Hussain et al., 2008).

5- Uses

5-1- Food

Due to its distinctive aroma, C. cyminum seeds are used as a spice in the food industries of India, Pakistan, North Africa, Middle East, Sri Lanka, Cuba, Northern Mexico, and the Western countries (Hajlaoui et al., 2010; Daniel and Maria., 2000). Cumin powder is an important element in curry mixes and many other tasty spice mixtures and some bakery products. Furthermore, it can be used to prepare fish dishes in mixture with salt and olive oil. In Turkey it is widely cultivated in Central Anatolian region and as a spice used in the preparation of sucuk (a type of Turkish sausage) (Baser et al., 1992).

5-2- Pharmaceutical

In traditional medicine, the C. cyminum seeds have been used for treatment of digestive disorders, dyspepsia, flatulence, diarrhea, toothache, epilepsy, jaundice and colic as well as stimulating breast milk production in Iranian traditional medicine (Iacobellis et al., 2005; De et al., 2003; Hashemian et al., 2013; Nostro et al., 2005; Bettaieb Rebey et al., 2012a; Muthamma et al., 2008; Eikani et al., 1999; Joshi., 2000; Norman., 1990). It also has diuretic, cytotoxic, anti-tumor, anti-inflammatory, emmenagogic, anti-fungal and antispasmodic properties (Hajlaoui et al., 2010; Einafshar et al., 2012; Janahmadi et al., 2006; Singh et al., 2002; Allahghadri et al., 2010; Oroojalian et al., 2010). The extract of C. cyminum can reduce the blood glucose and plasma and tissue lipids, and it can also improve eyesight (Konczak and Zhang., 2004; Dhandapani et al., 2002; Roman-Ramos., 1995). Anthocyanin found in cumin oil not only prevents tumors and cancer cells growth in humans, but also reduces the neurodegenerative processes in Parkinson and Alzheimer disease (Joseph et al., 2005). Even at a very low concentration, C. cyminum oil is as good as standard antibiotics or even acts more effective than them (Gachkar et al., 2007; Singh et al., 2002).

5-3- Improving the Food

Due to the presence of phenolic compounds and essential oils and anthocyanin in cumin (Cuminum cyminum L.), antimicrobial and antioxidant effects were obtained with this plant (Gachkar et al., 2007; Leopold et al., 2005; Özcan and Erkmen., 2001; Viuda-Martos et al., 2008; Hajlaoui et al., 2010; Khosravi et al., 2011a,b; Mohammadpour et al., 2012; Singh et al., 2002, Panico et al., 2005; Quina et al., 2009). Furthermore, it has anti-Aspergillus activity (Mohammadpour et al., 2012) and antibacterial activity against Gram-positive and Gram-negative bacterial species as well as yeast strains (Oroojalian et al., 2010; Hajlaoui et al., 2010; Iacobellis et al., 2005).

5-4- Elimination of the pests

The findings of various studies showed that the essential oil of C. cyminum has significant toxicity against food insect pests (Ziaee et al., 2014; Yeom et al., 2012; Tunc et al., 2000; Chaubey., 2008; Abdelgaleil et al., 2009). The insect pests of the stored products can be eliminated through fumigant, contact, and ingestion action of the poisons that contain cumin monoterpenes (Prates et al., 1998; Lee et al., 2003; Rozman et al., 2007; Abdelgaleil et al., 2009).

6- Cultivation

C. cyminum mostly grows in Mediterranean climates, and its cultivation requires a long, hot summer of 3–4 months, with daytime temperatures around 30°C. It is grown from seed. Planting date depends on climatic conditions of region, so that in temperate regions, it is an autumn crops and in cold areas, it is grown for a spring production, and needs fertile, well-drained soil (Hajlaoui et al., 2010). November is a good time for autumn sowing, while spring planting is done in March. Compared with the spring, planting cumin in the autumn yields more seed production and better oil function. The superiority of autumn planting of cumin to enhance the cumin seed production was attributed to a better control of the diseases (Rezvani Moghaddam et al., 2014).

12-15 kg of high quality seed is required per hectare. Seed depth depending on soil texture is between 1/5 - 2 cm, and seeds are directly planted in the ground. Seeds should be soaked in water for 24-36 hours to enhance the growing power. The ground should be irrigated immediately after planting but not so hard that may wash the seeds. The next irrigation is done 8-10 day after the first irrigation which leads to seed germination. After that, depending on weather conditions, irrigation should be done every 12-20 days.

Agriculture factors such as planting date, density, irrigation, nitrogen fertilizer, weed control, harvest time and different climates can influence the quantitative and qualitative components of cumin (Chandhary and Gupta., 1982; Jangir and Singh., 1996; Ehteramian., 2003). Also, rate of seed for planting depends on soil type, moisture and fertility of soil, culturing area, type and method of culturing, planting date, germination rate, 1000 seeds weight, seed purity and agronomical managements (Sefa., 1986; Patel et al., 1991; Sadeghi., 1991).

7- Harvest Time

100 to 120 days after planting cumin, the crop is ready to harvest, and harvesting is done manually. The rate of seed is different depending on the climatic conditions; seed production ranges eight to one ton per hectare.

8- Cumin Requirements

During the growing time, cumin needs enough heat and light. The amount of essential oil in hot regions with abundant light is more than other areas. During flowering and fruit production, less moisture is required. Cumin has good resistance to water shortage; therefore, it can be planted in dry lands. Its cultivation in light sandy soils which are free of nutrients and materials is not suitable because such kinds of soil are susceptible to prepare condition suitable to get fungal disease. Cumin Seedling is weak thus it does not like heavy soil. Therefore, the best soil is sandy soil with medium texture. The suitable PH for the cultivation of cumin is 4.5 - 8.2. Increasing of phosphor dissolved in the soil improves plant nutrient status and leads to a higher seed yield (Rodriguez and Fraga., 1999).

9- Resistance to Drought

Cumin is a drought tolerant species with high antioxidant levels. At drought stress, endogenous cytokinin acts as an antioxidant and reduces the damaging effects of drought (Alinian et al., 2016; Zhang and Ervin., 2004; Musgrave., 1994). Studies show that droughts have positive effects on the biosynthesis of secondary metabolites in aromatic plants such as cumin, and moderate drought conditions increases nutritional value and growth of aerial parts of cumin (Petropoulos et al., 2008; Alinian et al., 2016; Bettaieb Rebey et al., 2012b; Jaafar et al., 2012;

Bettaieb Rebey et al., 2011). However, the drought has adverse effects on fatty acid content of cumin seeds, and although the phenolic compounds increase during moderate drought, but in severe drought, the reducing of phenolic compounds occurs (Bettaieb Rebey et al., 2011).

10- pests and diseases

Fusarium wilt and blight diseases caused by the pathogen Fusarium oxysporum and Alternaria burnsii respectively, are threatening diseases of cumin (Azza et al., 2004; Kafi et al., 2006; Lodha.,1995). Fungal blight disease of cumin damages the plant at the time of flowering. The symptoms of the disease include brown spots on the stems. To treat this disease, fungicides containing copper compounds such as dithane, Blitox 50 and cupro can be used. Diseases usually increase in warm and humid conditions, and they are considered as the limiting factors of production (Lodha., 1995; Kafi et al., 2006). Infected field may not be replanted with cumin for at least 10 years (Azza et al., 2004). Seed pre-sowing treatment with a fungicide such as benlate (Azza et al., 2004; Champawat and Pathak., 1991) or fumigation the soil with methyle bromide (Larkin and Fravel., 1998), can provide a control measure against the disease, (however, the use of methyl bromide in large scale in the open field is limited).

11- Conclusion

Cumin (Cuminum cyminum L.) is a small annual plant belonging to the Apiaceae family. In addition to its fragrance and good taste which makes it the second most popular spice of the world, C. cyminum has therapeutic properties for digestive diseases, toothache, dyspepsia, flatulence and so on that has traditionally promoted its use since old times (Iacobellis et al., 2005; De et al., 2003; Hashemian et al., 2013; Nostro et al., 2005; Bettaieb Rebey et al., 2012a; Muthamma et al., 2008; Eikani et al., 1999; Joshi., 2000; Norman., 1990). Moreover, due to its preventing effect on fungal development and its power to eliminate the free radicals and due its safety effects, its effectiveness in low concentration and high performance of the oil, cumin has been recognized as a reproducible source of compounds which protect food against the quantitative and qualitative damages and consequently improve their useful life (Hajlaoui et al., 2010; Kedia et al., 2014; Mohammadpour et al., 2012).

REFERENCES

Abdelgaleil, S. A., Mohamed, M. I., Badawy, M. E., El-arami, S. A., 2009. Fumigant and contact toxicities of monoterpenes to Sitophilus oryzae (L.) and Tribolium castaneum (Herbst) and their inhibitory effects on acetylcholinesterase activity. J. Chem. Ecol. 35, 518–525.

Allahghadri, T., Rasooli, I., Owlia, P., Nadooshan, M. J., Ghazanfari, T., Taghizadeh, M., et al., 2010. Antimicrobial property, antioxidant capacity, and cytotoxicity of essential oil from cumin produced in Iran. Journal of the Food Sciences. 75, 54–61.

Al-Gaby, A. M. 1998. Nahrung. 42(5), 290–294.

Azza, A., Tawfik, A., Allam, A. D., 2004. Improving cumin production undersoil infestation with Fusarium wilt pathogen. I. Screening of biocontrol agents. Assiut University Bulletin for Environmental Research. 7, 35–45.

Alinian, S., Razmjoo, J., Zeinali, H., 2016. Flavonoids, anthocynins, phenolics and essential oil produced incumin (Cuminum cyminum L.) accessions under different irrigationregimes. Industrial Crops and Products. 81, 49–55

Banerjee, M., Sarkar, P. K., 2003. Microbiological quality of some retail spices in India. Food. Res. Int. 36, 469–474.

Baser, K. H. C., Kurkzuoglu, M., Ozek T., 1992. Journal of Essential Oil Research. 4, 133.

Behera, S., Nagarajan, S., Jagan Mohan Rao L. Microwave heating and conventional roasting of cumin seeds (Cuminum cyminum L.) and effect on chemical composition of volatiles. Food Chem. 2004; 87(1):25-9.

Bettaieb Rebey I, Jabri-Karoui I, Hamrouni-Sellami I, Bourgou S, Limam F, Marzouk B. Effect of drought on the biochemical composition and antioxidant activities of cumin (Cuminum cyminum L.) seeds. Industrial Crops and Products 36 (2012a) 238–245.

Bettaieb Rebey I., Knioua, S., Hamrouni, I., Limam, F., Marzouk, B., 2011. Water-deficit impact on fatty acid and essential oil composition and antioxidant activities of cumin (Cuminum cyminum L.) aerial parts. J. Agric. Food. Chem. 59, 328–334.

Bettaieb Rebey I., Zakhama, N., Jabri, I., Marzouk, B., 2012b. Polyphenol composition andantioxidant activity of cumin (Cuminum cyminum L.) seed extract underdrought. J. Food Sci. 77, 734–739.

Burt, S. (2004). Essential oils: their antibacterial properties and potential applications in foods: a review. International Journal of Food Microbiology, 94, 223–253.

Champawat RS, Pathak VN, 1991. Effect of fungicidal seed treatment onwilt disease of cumin. Journal of Turkish Phytopathology 20 (1), 23–26.

Chandhary, G.R. and Gupta O.P., 1982. Effect of weed control, sowing method and nitrogen application on growth and quality of cumin (Cuminum cyminum L.) Haryana. Agron. Y, 5: 79-82.

Daniel, Z., Maria, H., 2000. Domestication of Plants in the Old World, vol. 531., third ed. University Press, Oxford, p. 206.

De, M., De, A. K., Mukhopadhvay, R., Banerjee, A. B., & Micro, M. (2003). Ars Pharmaceutica, 44, 257–269.

Dhandapani S, Subramanian VR, Rajagopal S and Namasivayam N. hypolipidemic effect of cuminum cyminum l. On Alloxan-induced diabetic rats. Pharmacological research, vol. 46, no. 3, 2002. 251- 255.

Ebrahimie E, Habashi A, Ghareyazie B, Ghannadha M, Mohammadie M (2003) A rapid and efficient method for regeneration of plantlets from embryo explants of cumin (Cuminum cyminum). Plant Cell Tissue Organ Cult 75:19–25.

Ehteramian, K., 2003. The effects of different levels of nitrogen fertilizer and plant dating on Black Cumin (Cuminum carvi L.) in Kooshkak region in the Fars province. Master of Science Thesis of arid area management. Shiraz Univ., Shiraz, Iran.

Eikani, H.M., Goodarznia, I., Mirza, M., 1999. Supercritical carbon dioxide extraction of cumin seeds (Cuminum cyminum L.). Flavour and Fragrance Journal 14, 29–31.

Einafshar, S., Poorazrang, H., Farhoosh, R., Seiedi, S.M., 2012. Antioxidant activity of the essential oil and methanolic extract of cumin seed (Cuminum cyminum). Eur. J. Lipid Sci. Technol. 114, 168–174.

El-Hamidi, A., Ahmed, S.S., 1966. The content and composition of some umbelliferous essential oils. Die Pharmazie 7, 438–439.

Farag, S. E., & Abo-Zeid, M. (1997). Nahrung, 41(6), 359–361.
Gachkar, L., Yadegari, D., Rezaei, M. B., Taghizadeh, M., Astaneh, S. A., & Rasooli, I. (2007). Chemical and biological characteristics of Cuminum cyminum and Rosmarinus officinalis essential oils. Food Chemistry, 102, 898–904.
Chaubey MK (2008) Fumigant toxicity of essential oils from some common spices against pulse beetle, Callosobruchus chinensis (Coleoptera: Bruchidae). J Oleo Sci 57:171–179.
Ghorbani A, 2005. Studies on pharmaceutical ethnobotany in the regionof Turkmen Sahra, north of Iran (Part 1): general results. Journal ofEthnopharmacology 102, 58–68.
Gould, G. W. (1995). Homeostatic mechanisms during food preservation by combined methods. In G. Barbosa-Canovas & J. Welti-Chanes (Eds.), Food preservation by moisture control (pp. 397–410). Lancaster: Techromic Publishing Co., Inc.
Hajlaoui H, Mighri H, Noumi E, Snoussi M, Trabelsi N, Ksouri R, Bakhrouf A. Chemical composition and biological activities of Tunisian Cuminum cyminum L. essential oil: A high effectiveness against Vibrio spp. Strains. Food and Chemical Toxicology 48 (2010) 2186–2192.
Hashemian, N., Ghasemi Pirbalouti, A., Hashemi, M., Golparvar, A., Hamedi, B., 2013. Diversity in chemical composition and antibacterial activity of essential oils of cumin (Cuminum cyminum L.) diverse from northeast of Iran. Aust. J. Crop Sci. 7, 1752.
Hashim, E.M., E1-Kiey, M.A., 1962. Nigella sativa seeds of Egypt, Egypt. Journal of Pharmaceutical Sciences United Arab Republic 3, 121–133.
Hiller, K., 1999. Cuminum cyminum L. In: Hiller, K., Melzig, M. (Eds.), Lexikon der Arzneipflanzen und Drogen. Spektrum–Akademischer Verlag, Heidelberg, p. 229.
Hussain, A.I., Anwar, F., Sherazi, S.T.H., Przybylski, R., 2008. Chemical composition, antioxidant and antimicrobial activities of basil (Ocimum basilicum) essential oils depends on seasonal variations. Food Chem. 108, 986–995.
Iacobellis, N. S., Lo Cantore, P., Capasso, F., & Senatore, F. (2005). Antibacterial activity of Cuminum cyminum L. and Carum carvi L. essential oils. Journal of Agricultural and Food Chemistry, 53(1), 57–61.
Jaafar, H.Z.E., Ibrahim, M.H., Fakri, N.F.M., 2012. Impact of soil field water capacityon secondary metabolites, phenylalanine ammonia-lyase (PAL) malondialdehyde (MDA) and photosynthetic responses of malaysian kacipfatimah (Labisia Pumila Benth.). Molecules 17, 7305–7322.
Janahmadi, M., Niazi, F., Danyali, S., Kamalinejad, M., 2006. Effects of the fruit essential oil of Cuminum cyminum Linn. (Apiaceae) on pentylenetetrazolinduced epileptiform activity in F1 neurones of Helix aspersa. Journal of Ethnopharmacology 104, 278–282.
Jangir, R.P. and Singh Z., 1996. Effect of irrigation and nitrogen on seed yield of cumin. Indian J. Agron.
Jayathilakan K, Sharma G, Radhakrishna K, Bawa A (2007) Antioxidant potential of synthetic and natural antioxidants and its effect on warmed over flavour in different species of meat. Food Chem 105:908–916
Jirovetz LBG, Stoyanova AS, Georgiey EV, Damianova ST: Composition, quality control and antimicrobial activity of the essential oil of cumin (Cuminum cyminum L.) seeds from Bulgaria that had been stored for up to 36 years. Int J Food Sci Tech 2005, 40:305–310.
Joseph, J.A., Shukitt-Hale, B., Casadesus, G., 2005. Reversing the deleterious effectsof aging on neuronal communication and behavior: beneficial properties offruit polyphenolic compounds. Am. J. Clin. Nutr. 81, 313s–316s.
Joshi SG, Medicinal plants: family Apiaceae. 1st edn. Oxford and IBH Publishing Co. Pvt. Ltd., 2000: 34–5.
Kafi M, Rashed Mohassel MH, Koocheki A, Nassiri M, 2006. Cumin (Cuminum Cyminum): Production and Processing. Science Publishers,U.S., Enfield, New Hampshire.
Kamkar B, Koocheki A, Nassiri Mahallati M, Teixeira da Silva JA, RezvaniMoghaddam P, Kafi M, 2011. Fungal diseases and inappropriate sowing dates, the most important reducing factors in cumin fields of Iran, a case study in Khorasan provinces. Crop Protection 30, 208–215.
Kedia A, Prakash B, Mishra PK, Dubey N.K. Antifungal and antiaflatoxigenic properties of Cuminum cyminum (L.) seed essential oil and its efficacy as a preservative in stored commodities. International Journal of Food Microbiology 168–169 (2014) 1–7.
Khosravi, A.R., Minooeianhaghighi,M.H., Shokri, H., Emami, S.A., Alavi, S.M., Asili, J., 2011a. The potential inhibitory effect of Cuminum cyminum, Ziziphora clinopodioides and Nigella sativa essential oils on the growth of Aspergillus fumigatus and Aspergillus flavus. Braz. J. Microbiol. 42, 216–224.
Khosravi, A.R., Shokri,H., Minooeianhaghighi, M., 2011b. Inhibition of aflatoxin production and growth of Aspergillus parasiticus by Cuminum cyminum, Ziziphora clinopodioides and Nigella sativa essential oils. Foodborne Pathog. Dis. 8 (12), 1275–1280.
Koenen, E. V. (2001). Medicinal poisonous and edible plants in Namibia. Berlin: Klaus Hess.
Konczak, I., Zhang, W., 2004. Anthocyanins—more than nature's colours. J. Biomed.Biotechnol. 5, 239–240.
Koocheki A, Nassiri Mahallati M, Nadjafi F, 2004. The agrobiodiversity ofmedicinal and aromatic plants in Iran. Iranian Field Crop Research 2,208–216 (in Persian).
Larkin RP, Fravel R, 1998. Efficacy of various fungal and bacterial biocontrolorganisms for control of fusarium wilt of tomato. Plant Disease 82, 1022–1028.
Lawrence, B. M. (2002). From the sensation to the synthesis. In K. A. D. Swift (Ed.), Advances in flavours and fragrances. Special publication, vol 277 (pp. 57–83). Cambridge: Royal Society of Chemistry.
Lee S, Peterson CJ, Coats JR (2003) Fumigation toxicity of monoterpenoids to several stored product insects. J Stored Prod Res 39:77–85
Leopold, J., Gerhard, B., Albena, S. Stoyanova, Georgiev, Evgenii V., Stanka, T.D., 2005. Composition, quality control and antimicrobial activity of the essential oil of cumin (Cuminum cyminum L.) seeds from Bulgaria that had been stored for up to 36 years. International Journal of Food Science and Technology 40, 305–310.
Li, R., Jiang, Z.T., 2004. Chemical composition of the essential oil of Cuminum cyminum L. from China. Flavour Fragrance J. 19, 311–313.
Lis-Balchin, M., Deans, S.G., Eaglesham, E., 1998. Relationship between bioactivity and chemical composition of commercial essential oils. Flavour and Fragrance Journal 13, 98–104.
Lodha S, 1995. Soil solarization, summer irrigation and amendments forthe control of Fusarium oxysporum f. sp. cumini and Macrophominaphaseolina in arid soils. Crop Protection 14, 215–219.
Moghaddam, M., Ghasemi Pirbalouti, A., Mehdizadeh, L., Pirmoradi, M.R., 2015. Changes in composition and essential oil yield of Ocimum ciliatum at different phenological stages. Eur. Food Res. Technol. 240, 199–204.
Moghaddam, M., Omidbaigi, R., Sefidkon, F., 2007. Changes in content and chemical composition of Tagetes minuta oil at various harvest times. J. Essent. Oil Res. 19, 18–20.
Mohammadpour H, Moghimipour E, Rasooli I, Fakoor MH, Alipoor Astaneh S, Shehni Moosaie S, Jalili Z. Chemical Composition and Antifungal Activity of Cuminum cyminum L. Essential Oil from Alborz Mountain against Aspergillus species. Jundishapur J Nat Pharm Prod.2012; 7(2):50-55.

Musgrave ME (1994) Cytokinins and oxidative processes. In: Mokand DWS, Mok MC (eds) Cytokinins: chemistry, activity, and function. CRC Press, Inc., Boca Raton, FL, pp 167–178
Muthamma, M.K.S., Hemang, D., Purnima, K.T., Prakash, V., 2008. Enhancement of digestive enzymatic activity by cumin (Cuminum cyminum L.) and role of spent cumin as a bionutrient. Food Chem. 110, 678–683.
Naveed R, Hussain I, Tawab A, Tariq M, Rahman M, Hameed S, Mahmood MS, Siddique AB and Iqbal A. Antimicrobial activity of the bioactive components of essential oils from Pakistani spices against Salmonella and other multi-drug resistant bacteria. BMC Complementary and Alternative Medicine 2013, 13:265. 1- 10.
Nestorova, V., Lambrev, B., Georgiev, E., 1977. About the antimicrobial effect of some nutrient spices. I. Cumin oil. In: Georgiev, E. (Ed.), Proceedings of the IV Congress of Microbiology, Sofia, Bulgaria, pp. 415–420.
Norman, J., 1990. The Complete Book on Spices. Doerling Kindersley, London.
Nostro, A., Cellini, L., Di Bartolomeo, S., Di Campli, E., Grande, R., & Cannatelli, M. A. (2005). Antibacterial effect of plant extracts against Helicobacter pylori. Phototherapy Research, 19, 198– 202.
Oroojalian F, Kasra-Kermanshahi R, Azizi M, Bassami M. Phytochemical composition of the essential oils from three Apiaceae species and their antibacterial effects on food-borne pathogens. Food Chemistry. 2010; 120(3):765-70.
Özcan, M., Erkmen, O., 2001. Antimicrobial activity of the essential oils of Turkish plant spices. European Food Research Technology 212, 658–660.
Panico, A.M., Cardile, V., Garufi, F., Puglia, S., Bonina, F., Ronsisvalle, G., 2005.Protective effect of capparisspinosa on chondrocytes. Life Sci. 77, 2479–2488.
Patel, K.S., Patel J.C., Patel B.S., and Sadaria S.G., 1991. Water and nutrient management in cumin. Indian J. Agron.
Petropoulos, S.A., Daferera, D., Polissiou, M.G., Passam, H.C., 2008. The effect ofwater deficit stress on the growth, yield and composition of essential oils ofparsley. Sci. Hortic. 115, 393–397.
Pottier-Alapetite, G. (1979). Flore de la Tunisie. Angiospermes, Dicotylédones Dialypétales (pp. 587–588). Tunis: Imprimerie officielle de la république Tunisienne.
Prates HT, Santos JP, Waquil JM, Fabris JD, Oliveira AB, Foster JE (1998) Insecticidal activity of monoterpenes against Rhyzopertha dominica (F.) and Tribolium castaneum (Herbst). J Stored Prod Res 34:243–249
Quina, F.H., Moreira, P.F., Vautier-Giongo, C., Rettori, D., Rodrigues, R.F., Freitas,A.A., Silva, P.F., Macanita, A.L., 2009. Photochemistry of anthocyanins and theirbiological role in plant tissues. Pure Appl. Chem. 81, 1687–1694.
Rasooli I, Gachkar L, Yadegari D, Bagher-Rezaei M, Taghizadeh M, Alipoor-Astaneh S (2007) Chemical and biological characteristics of Cuminum cyminum and rosmarinus officinalis essential oils. Food Chem 102:898–904
Rezvani Moghaddam P, Huda AKS, Parvez Q, Koocheki A, 2007. Indige-nous knowledge in agriculture with particular reference to medicinalcrop production in Khorasan, Iran. In: Fifth International Conference,Jointly Organised by the World Association for Sustainable Devel-opment (WASD) and Griffith University, Griffith University, BrisbaneAustralia, October 29–31.
Rezvani Moghaddam P, Moradi R, Mansoori H. Influence of planting date, intercropping and plant growthpromoting rhizobacteria on cumin (Cuminum cyminum L.) with particular respect to disease infestation in Iran. Journal of Applied Research on Medicinal and Aromatic Plants 1 (2014) 134–143
Rodriguez H, Fraga R, 1999. Phosphate solubilizing bacteria and their role in plant growth promotion. Biotechnology Advances 17, 319–339.
Roman-Ramos R. Antihyperglycaemic effect of some edible plants. J Ethnopharmacol 1995; 48: 25–32.
Rozman V, Kalinovic I, Korunic Z (2007) Toxicity of naturally occurring compounds of Lamiaceae and Lauraceae to three stored-product insects. J Stored Prod Res 43:349–355
Sadeghi, B., 1991. Rates of nitrogen and irrigation on Cumin Production. I.R.O.S.T. Khorasan center.
Sefa, S., 1986. Nitrogen and phosphorus requirements of cumin (Cuminum cyminum L.) growth under dry an Irrigated conditions in Eskisehir Province, Hortic. Abst, 58: 331.
Singh, G., Kapoor, I. P., Pandey, S. K., Singh, U. K., & Singh, R. K. (2002). Studies on essential oils: part 10; antibacterial activity of volatile oils of some spices. Phytotherapy Research, 16(7), 680–682.
Spices Board Statistics., 2006. Spices Board, Kochi, India.
Telci, I., Toncer, O.G., Sahbaz, N., 2006. Yield, essential oil content and composition of Coriandrum sativum cultivars (var. vulgare Alef. and var. microcarpum DC.) grown in two different locations. J. Essent. Oil Res. 18, 189–193.
Thippeswamy, N.B., Naidu, K.A., 2005. Antioxidant potency of cumin varietiescumin, black cumin and bitter cumin-on antioxidant systems. European Food Research Technology 220, 472–476.
Tunc¸ I, Berger BM, Erler F, Dagll F (2000) Ovicidal activity of essential oils from five plants against two stored-product insects. J Stored Prod Res 36:161–168
Tuncturk, R., & Tuncturk, M. (2006). Effects of different phosphorus levels on the yield and quality components of cumin (Cuminum cyminum L.). Research Journal of Agriculture and Biological Sciences, 2, 336–340.
Viuda-Martos, M., Ruiz-Navajas, Y., Femndez-Lpez, J., Pérez-Alvarez, J.A., 2008. Antibacterial activity fromdifferent essential oil obtained from spices widely used in Mediterranean diet. International Food Science and Technology 43, 526–531.
Wang Z, Ding L, Li T, Zhou X, Wang L, Zhang H, et al. Improved solvent-free microwave extraction of essential oil from dried Cuminum cyminum L. and Zanthoxylum bungeanum Maxim. J Chromatogr A. 2006; 1102(1-2):11-7.
Wang L, Wang Z, Zhang H, Li X. Ultrasonic nebulization extraction coupled with headspace single drop microextraction and gas chromatography-mass spectrometry for analysis of the essential oil in Cuminum cyminum L. Anal Chim Acta. 2009; 647(1):72-7.
Yeom HJ, Kang JS, Kim GH, Park IK (2012) Insecticidal and acetylcholine esterase inhibition activity of Apiaceae plant essential oils and their constituents against adults of German cockroach (Blattella germanica). J Agric Food Chem 60:7194– 7203
Zhang X, Ervin EH (2004) Cytokinin-containing Seaweed and Humic acid extracts associated with creeping bentgrass leaf cytokinins and drought resistance. Crop Sci 44:1–10
Zhang H, Shi Y, Wei S, Wang Y. Ultrasonic nebulization extraction coupled with headspace single-drop microextraction of volatile and semivolatile compounds from the seed of Cuminum cyminum L. Talanta. 2011; 85(2):1081-7.
Ziaee M., Moharramipour S., Mohsenifar A. MA-chitosan nanogel loaded with Cuminum cyminum essential oil for efficient management of two stored product beetle pests. J Pest Sci (2014) 87:691–699.