A Review on Phytochemistry of *Cuminum cyminum* seeds and its Standards from Field to Market

Ahmad Reza Gohari and Soodabeh Saeidnia*

Medicinal Plants Research Center, Faculty of Pharmacy, Tehran University of Medical Sciences, Tehran, Iran.

ABSTRACT

The small boat shaped seeds of Cumin (*Cuminum cyminum*) has been used for many medicinal and culinary purposes from the ancient time in the various countries. Cumin is a popular spice in the world from Latin America to Northern Africa and all over the Asia and also used as a flavoring agent in many products such as cheese, pickle, soup, bean dishes or liqueurs. Essential oils of the seeds are also used as a flavor or in aromatherapy. Many pharmacological effects have been reported from this spicy plant as, anti-diabetic, Immunologic, anti-epileptic, anti-tumor and antimicrobial activities. Cumin used in the medicinal preparations is supposed to be produced with high quality encompasses all the properties of the final product which makes it optimal suitable for use. Reproducible quality is a goal, which achieved by the process of standardization. The focus here is rather on harvesting and processing of the cultivated species, because the quality of plant material and processing technology lead to the high quality of the final product. The quality of Cumin seeds and its essential oil can only be assessed with analytical methods, which include physical, microscopic and chemical analyzing assays. In this paper, the phytochemistry, medicinal properties and the standards from the field cultivation, harvesting and storage until marketing are reviewed.

Key words: *Cuminum cyminum,* phytochemistry, adulterants, standards.

INTRODUCTION

Cuminum cyminum L., belonging to the family Apaiaceae, is one of the old cultivated medicinal food herbs in Asia, Africa and Europe. This plant is well-known as Cumin and named Zireh-Sabz or Cravieh in Persian language. Its seeds have been commonly used for culinary and flavoring purposes and folklore therapy since antiquity in various countries.[1-3] There are two species of *Cuminum* which growing wildly in Iran, *C. cyminum* L (Zireh-Sabz means green Cumin) and *C. setifolium* Boisskos. Pol (Zireh-Sefid means white Cumin). Some literature reported that *C. setifolium* is the sub-species of *C. cyminum*.[1-4]

C. cyminum is an annual herbaceous plant which grows up to 15-50 cm height somewhat angular and tends to droop under its own weight. It has a long, white root. The leaves are 5-10 cm long, pinnate or bi pinnate, with thread-like leaflets and blue green in color and are finely divided, generally turned back at the ends. The leaves are highly dissected. Whitish-red flowers are on a compound umbel (arrangement of flowers looks like an umbrella). The fruit is an elongated, oval shaped schizocarp (an aggregate fruiting body which doesn't break open naturally and has two single seeded units called mericarps). The fruits are similar to fennel seeds, when chewed has bitter and pungent taste. The fruit are thicker in the middle, compressed laterally about 5 inch long, containing a single seed.[5-6]

***Address for correspondence:**
Medicinal Plants Research Center, Faculty of Pharmacy,
Tehran University of Medical Sciences,
PO Box 14155-6451, Tehran, Iran.
Fax: +98-21-66461178.
E-mail: saeidnia_s@sina.tums.ac.ir

DOI: 10.5530/pj.2011.25.1

MEDICINAL PLANT MATERIAL

Dried ripe seeds of *C. cyminum* are usually used for medicinal or culinary purposes. In Iranian traditional medicine, Cumin seeds were used for their therapeutic effects on gastrointestinal, gynecological and respiratory disorders, and also for the treatment of toothache, diarrhea and epilepsy. The seeds were also documented as stimulant, carminative and astringent.[2] Johri has been recently reported that medicinal usage of Cumin seeds has also been widespread in diverse ethnomedical systems from Northern Europe to the Mediterranean regions, Russia, Iran, Indonesia and North America, where these have remained as an integral part of their folk medicines.[7]

PHYTOCHEMISTRY AND MEDICINAL PROPETIES

Antimicrobial activity has been reported from the volatile oils and aqueous extract of Cumin. Cumin seed oil and alcoholic extract inhibited the growth of *Klebsiella pneumoniae* and its clinical isolates by improvement of cell morphology, capsule expression and decreasing urease activity. Cuminaldehyde (**1**) is the main active compound of Cumin for this property.[8-9] Limonene (**2**), eugenol (**3**), α- and β-pinenes(**4, 5**) and some other minor constituents have been found in cumin oil and suggested as the active antimicrobial agents.[7,10]

The Cumin oil is reported as a high antioxidant mainly due to the presence of monoterpene alcohols.[11] The presence of phytoestrogens in Cumin has been reported which related to its anti-osteoporotic effects. Methanol extract of Cumin showed a significant reduction in urinary calcium excretion and augmentation of calcium content and mechanical strength of bones in animals.[12] Furthermore, the aqueous extract of Cumin seeds indicated the protective effect against gentamycin-induced nephrotoxicity, which decreased the gentamycin-induced elevated levels of serum urea and enhanced the clearance of the drug.[13]

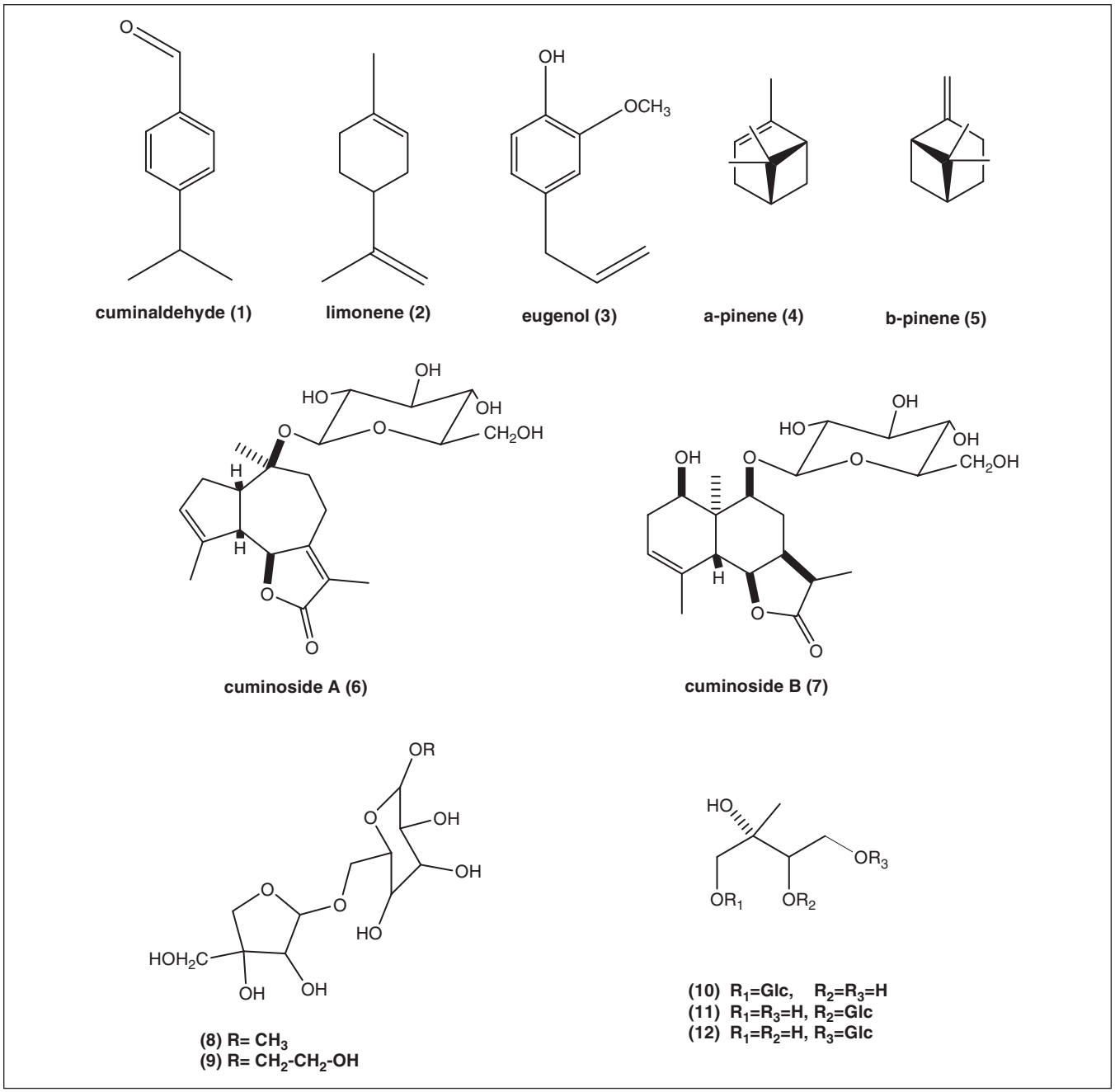

Figure 1: Chemical structures of the isolated compounds from Cumin.

Anti-epileptic activity of cumin oil was also reported, which decreased the frequency of spontaneous activity induced by pentylene tetrazol (PTZ).[14] Recently, Cumin oil has been found to act as a significant analgesic by formalin test in rats and suppress the development and expression of morphine tolerance and also reverse the morphine dependence.[15-17]

Other important reports consider that dietary Cumin can inhibit benzopyrene-induced for stomach tumorigenesis, 3-methylcholanthrene induced uterine cervix tumorigenesis, and 3-methyl-4-dimethyaminoazobenzene induced hepatomas in mice, which was attributed to the ability of Cumin in modulating carcinogen metabolism *via* carcinogen-xenobiotic metabolizing phase I and phase II enzymes.[18]

Literature review on phytochemistry of the Cumin seeds revealed the presence of various bioactive compounds, the important secondary metabolites of which are discussed as followed.[19-20]

Two sesquiterpenoid glucosides, cuminoside A (**6**) and B (**7**), and two alkyl glycosides (**8, 9**) were isolated (Figure 1) together with some known compounds from the methanol extract of Cumin seeds. Their structures were established as (1*S*,5*S*,6*S*,10*S*)-10-hydroxyguaia-3,7(11)-dien-12,6-olide β-D-glucopyranoside (**6**), (1*R*,5*R*,6*S*,7*S*,9*S*,10*R*,11*R*)-1, 9-dihydroxyeudesm-3-en-12, 6-olide 9-*O*-β-D-glucopyranoside (**7**), methyl β-D-apiofuranosyl-(1→6)-β-D-glucopyranoside (**8**) and ethane-1,2-diol 1-*O*-β-D-apiofuranosyl-(1→6)-β-D-glucopyranoside (**9**).[19] In another report, three glycosides (Figure 1), 1-*O*-β-D-glucopyranoside (**10**), 3-*O*-β-D-glucopyranoside (**11**) and 4-*O*-β-D-glucopyranoside (**12**) have been isolated and structural elucidated from the seeds (fruits) of Cumin.[20]

NATURAL HABITAT AND THE LAND UNDER CULTIVATION

Cumin is the native species growing in Egypt (North Africa) and Asia. It was originally cultivated in Iran and the Mediterranean region. In Iran, Cumin is wildly growing in Khorasan. The species, *C. setifolium* is also found in desert aria such as Damghan, Sabzevar, Tabas and Borazjan. Cumin (*C. cyminum*) is mainly cultivated in Khorasan followed by East Azerbaijan, Yazd, Semnan, Esfahan and some parts of Golestanand Kerman provinces. Ninety percent of the whole products for the export are cultivated in Khorasan. Iran provides 20-40% of the world production and export of Cumin. The Cumin seeds are valuable, because the prices of one kilogram seeds are equal to 10 kilogram wheat. Cultivation of cumin requires a long, hot summer of 3-4 months, with daytime temperatures around 30 °C. This herb is resistant to drought, and is mostly grown in Mediterranean climates. It is grown from seed, sown in spring, and needs fertile, well-drained soil. The plant blooms in June and July. The seeds are normally ripe four months after planting. The plants are threshed when the fruit is ripe and the seeds are dried.[21-22]

STANDARDS CRITERIA FOR HARVESTING, DRYING AND STORAGE

Appropriate Season

The Cumin seeds are usually ready to harvest during 100-120 days after cultivation. Seed harvesting season is different from June to July on the basis of the weather conditions, because the flowering season is influenced by day long and temperature.[23] Literature showed that Cumin is better to be in rotation with summer crops such as soybean, millet and sesame. In order to produce satisfied yield in Iran, application of 30 kg N, 60 kg P and 30 kg K per hectare has been recommended. Cumin crop water requirement is 335 mm/ha. Average yield of Cumin is reported 1000 kg/ha with percentage of 2.1 to 3.5 for seed volatile oils.[24]

Appropriate Harvesting Methods

The seeds are harvested about 4 months after planting when the plant begins to wither and the seeds change to brown-yellow color. In traditional method, the whole plants were removed from the soil and collected as sheaves. The sheaves were set up in the fields and sifting and cleaning by winnower. The isolated seeds were then further dried to 10% (moisture content), wither by placing on mats or trays in the sun or using a drier in the humid conditions (Like Pakistan). The dried seeds are winnowed using a traditional winnowing basket to remove the dirt, dust, leaves and twigs. Nowadays, the modern and high capacity combines are used for harvesting, sifting and cleaning of the plants.[23]

Main Physicochemical Characteristics

The seeds are elongated, oval shaped schizocarp and similar to fennel seeds, when chewed have bitter and pungent taste. The seeds (fruits) are thicker in the middle, compressed laterally about 5 inch long. Five out-standing lines are observed in each parts of mericarp. The seeds are too flavored and covered by hairs (sometimes without hair). The fruit pericarp contains high amount of tannins which change color in presence of Iron contained compounds. The seeds must contain at least 7% of oil, 13 & resin and 2.5-4% essential oil. The maximum total crude ashes are 9.5% and the maximum acid insoluble ashes are 2% with no more than 9% humidity.[22]

Qualification and Quantification Parameters of Essential oil

Different factors may impact on the physicochemical properties of the essential oil of Cumin seeds, of which plant

variety, cultivation area and conditions, date of harvesting and extraction methods are important. Quantification of the total essential oil of seeds is conducted by hydro-distillation method. In this method, about 20 g of the grind fruits disperse in 500 ml of distilled water (in a 1000 ml flask) and hydro-distilled for 4 h with 3-4 ml/min distillation rate. The oil volume is measured by using xylol.[25-26] Physical Properties of the essential oil obtained by steam distillation from Cumin seeds are summarized in Table 1.[22,27]

Packaging and Storage

Cumin seeds are sensitive to crashing and mechanical damages hence protection of seeds during sifting and cleaning or winnower is too important. Sometimes the products lose some parts of humidity and become drier than standards. The quality of seeds has been decrease during the prolonged storage. Today, Cumin is packed in gunny bags and cleaned by machines in order to remove the stalks, other foreign material, stones and dust in advance. Cumin may also pack in tissue, paper or polythene bags depending on the requirements of the buyer. It is preserved at least one to two feet away from the walls in order to save it from moisture in humid countries. The bags should be sealed to prevent moisture entering or exiting. Labels should be applied to the products. The label needs to contain all relevant product and legal information such as the name of the product, brand name, names, address and date of manufacture, expiration date, weight of the contents, added ingredients (if relevant) plus any other information that the country of origin and of import may require.[22,28] The essential oils of Cumin should be conserved in the amber and tight closed glass or aluminum containers even better to seal by inner epoxy covers. The oil packages should be storage far from the direct sunlight and temperate places.[2]

Adulterants

Regarding to this point that the characteristic odor of Cumin is caused mainly by aldehydes which are present the essential oil, synthetic Cumin aldehyde is sometimes added as an adulterant in Cumin oil.[29] Frauds distinguish is very difficult to detect chemically but it is possible because the synthetic Cumin aldehyde may change the refractive index of the oil.[22,30]

Table 1: Physical Properties of the essential oil of Cumin seeds obtained by steam distillation

Physicochemical Properties	Level
Extraction Percentage	2.3-5.7 %
Color	Colorless or pale yellow
Refractive Index (20 ºC)	1.47-1.50
Density (20 ºC)	0.90-0.94
Alcohol solubility (80% v/v)	1:1.3-1:2
Aldehyde percentage (on the basis of Cuminaldehyde)	35-63%
Acidity (on the basis of Cuminic acid)	0.36-1.8
Alcohol percentage (on the basis of Cuminol)	3.5
Carbonyl Index	9.32
Steric Index	19.24

Detection of Purity by Microscope

Many of the Cumin products contain grinded seeds of Cumin. Therefore, microscopic analysis is considered for purity determination. Grinded Cumin is a yellowish-brown powder with a characteristic, aromatic, slightly camphor-like odor and taste. The diagnostic characters are summarized below.[31]

The epicarp composed of a layer of colorless cells, with thin, sinuous walls and a faintly and irregularly striated cuticle. Stomata are fairly frequent and cicatrices may be present. Underlying the epicarp the thin-walled cells of the palisade are sometimes visible. The pale yellowish-brown fragments of the vittae composed of fairly large, thin-walled cells. The fragments are usually wider than the most of the other Umbelliferae fruits. The sclereids from the mesocarp are in two main types. One type occurs as a single layer of longitudinally elongated cells with moderately thickened walls and numerous regularly spaced, well-marked pits. Second type is found in small groups and composed of considerably elongated cells placed more or less end to end in a longitudinal direction. The endocarp composed of a layer of fairly large, thin-walled cellsand arranged with their long axes parallel. The endosperm composed of moderately thick-walled cells containing aleuronic microrosette crystals of calcium oxalate.[31]

Thin Layer Chromatographic Analysis

In this analysis, the extract of cumin, obtained by percolation of 1 g of dried seeds, is concentrated and dissolved in 0.5 ml toluene. Thin Layer Chromatography (TLC) is carried out on a silica gel TLC plates with the solvent system as toluene: ethyl acetate (7:93) alongside the standards of α- and β-pinenes and α- and β-phellandrenes. The spots are detectable by the anisaldehyde-H_2SO_4 spray reagent followed by heating (105-110 °C for 5-10 min). The spots of the above mentioned standards can be visible inside the area of 0.2-0.4 (R*f*), respectively. The pinene spots show the brown color and the phellandrene spots indicate a yellowish-brown color.[32]

CONCLUSION

Cumin is the second most popular spice in the world, after black pepper, and used as a medicinal plant for aromatherapy and various illnesses. For this reason, the standardization of the plant material from cultivation to storage is too important. To insure the achievement of quality, acceptance criteria for plant material and validating of the technical

process in manufacturing are considered. Standardized seeds and essential oils are qualitatively optimized the products or preparations with reproducible content. Determination of the physicochemical characteristics of the oil may establish by measurement of extraction yield, refractive index, density, carbonyl and steric indexes together with aldehyde, alcohol and acid contents. Microscopic analyzing is very important in the products containing grinded seeds. In addition, thin layer chromatography may help to detect the pinenes and phellandrenes in the seeds as the main and characteristic monoterpenes. Cumin aldehyde is not only the active constituent of the Cumin seed and its oil but also sometimes added to the oil as a fraud which can difficulty detected by changing the refractive index.

REFERENCES

1. Rechinger KH. Flora Iranica, Apiaceae. Academische Druck-U-Verganstalt. Graz: Austria. 1981; 162:140-2.
2. Zargari A. Medicinal Plants. 5th ed. Vol. 2. Tehran: Tehran University Publications; 2001.
3. Mozaffarian V. A Dictionary of Iranian Plant Names. Tehran: Farhang Moaser publisher; 1996. p. 168-9.
4. Omidbaigi R. Production and Processing of Medicinal Plants. 5th ed. Tehran: Astan Quds Publication; 2008.
5. Ghahreman A. Chromophytes of Iran. 2nd ed. Tehran: Tehran University Publication; 1994.
6. Anonymous. The Wealth of India: A Dictionary of Indian Raw Material and industrial Products. New Delhi: CSIR; 1985.
7. Johri RK. *Cuminum cyminum* and *Carum carvi*: An update. Phcog Rev. 2011; 5:63-72.
8. Derakhshan S, Sattari M, Bigdeli M. Effect of sub-inhibitory concentrations of cumin (*Cuminum cyminum* L.) seed essential oil and alcoholic extract on the morphology, capsule expression and urease activity of *Klebsiella pneumoniae*. Int J Antimicrob Agents. 2008; 32:432-6.
9. Derakhshan S, Sattari M, Bigdeli M. Effect of cumin (*Cuminum cyminum* L.) seed essential oil on biofilm formation and plasmid integrity by *Klebsiella pneumoniae*. Pharmacog Mag. 2010; 6:57-61.
10. Dorman HJD, Deans SG. Antimicrobial agents from plants: Antibacterial activity of plant volatile oils. J Appl Microbiol. 2000; 88:308-16.
11. De Martino L, De Feo V, Fratianni F, Nazzaro F. Chemistry, antioxidant, antibacterial and antifungal activities of volatile oils and their components. Nat Prod Commu. 2009; 4:1741-50.
12. Shirke SS, Jadhav SR, Jagtap AG. Methanolic extract of *Cuminum cyminum* inhibits ovariectomy-induced bone loss in rats. Exp Biol Med. 2008; 233:1403-10.
13. Mahesh CM, Gowda KPS, Gupta AK. Protective action of *Cuminum cyminum* against gentamicin- induced nephrotoxicity. J Pharmacy Res. 2010; 3:753-7.
14. Janahmadi M, Niazi F, Danyali S, Kamalinejad M. Effects of the fruit essential oil of *Cuminum cyminum* Linn. (Apiaceae) on pentylene tetrazol-induced epileptiform activity in F1 neurones of *Helix aspersa*. J Ethnopharmacol. 2006; 104:278-82.
15. Koppula S, Kopalli SR, Sreemantula S. Adaptogenic and nootropic activities of aqueous extracts of *Carum Carvi* Linn (Caraway) fruit: an experimental study in wistar rats. Aust J Med Herb. 2009; 21:76-9.
16. Haghparast A, Shams J, Khatibi A, Alizaseh AM, Kamalinejad M. Effects of the fruit essential oil of *Cuminum cyminum* Linn. (Apiaceae) on acquisition and expression of morphine tolerance and dependence in mice. NeurosciLett. 2008; 440:134-9.
17. Khatibi A, Haghparast A, Shams J, Dianati E, Komaki A, Kamalinejad M. Effects of the fruit essential oil of *Cuminum cyminum* L. on the acquisition and expression of morphine-induced conditioned place preference in mice. NeurosciLett. 2008; 448:94-8.
18. Gagandeep , Dhanalakshmi S, Mendiz E, Rao AR, Kale RK. Chemopreventive effects of *Cuminum cyminum* in chemically induced forestomach and uterine cervix tumors in murine model systems. Nutr Cancer. 2003; 47(2):171-80.
19. Takayanagi T, Ishikawa T, Kitajima J. Sesquiterpene lactone glucosides and alkyl glycosides from the fruit of cumin. Phytochemistry. 2003; 63:479-84.
20. Kitajima J, Ishikawa T, Fujimatu E, Kondho K, Takayanagi T. Glycosides of 2-C-methyl-D-erythritol from the fruits of anise, coriander and cumin. Phytochemistry. 2003; 62:115-20.
21. Evans WC. Trease and Evans Pharmacognosy. 14 ed. London: WB Saunders Company Ltd; 1997. p. 267-8.
22. Kafi M. Cumin (*Cuminum cyminum*) Production and Processing. Mashhad: Ferdowsi University of Mashhad press; 2002.
23. Sadeghi B, Rashed-Mohassel MH. Effects of nitrogen and irrigation regimes on Cumin (*Cuminum cyminum*) production. Scientific and Industrial Research Center of Iran, Khorasan. 1990.
24. Dehaghi MA, Mollafilabi A. Production technology for Cumin (*Cuminum cyminum*) on the basis of research findings. Acta Hort. (ISHS). 2010; 853:83-92.
25. Steinegger E, Hansel R. Lehrbuch der Pharmacognosie auf Phytochemischer Grundlage. Berlin: Springer Verlag; 1972. p. 348-82.
26. Iranian Herbal Pharmacopoeia Commission. Iranian Herbal Pharmacopoeia. Ministry of Health, Treatment and Medical Education, Tehran. 2002:412-8.
27. Borges P, Pino J. The isolation of volatile oil from cumin seeds by steam distillation. Food / Nahrung. 1993; 37(2): 123-6.
28. Technical Information Online. Cumin Processing. Available from: http://practicalaction.org/practicalanswers/product_info.php?products_id=86
29. Simon JE, Chadwick AF, Craker LE. 1984. Herbs: An Indexed Bibliography. 1971-1980 the Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone.
30. Rekha S, Singhal, Pushpa R. Kulkarni, Dinanath V. Rege. Handbook of indices of food quality and authenticity. Woodhead Publishing, India, 1997.
31. Jackson BP, Snowdon DW. Atlas of microscopy of medicinal plants culinary herbs and spices. Delhi: CBS Publishers; 2000.
32. Wagner H, Blant S. Plant Drug Analysis. 2nd ed. Berlin: Springer Verlag; 1996. p. 192-3.