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Essential oil constituents and unsaturated fatty acids in Indian *Cuminum cyminum* L. seed oil under varying agro climatic environments

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Abstract

Cumin growing areas in India encompasses the agro-ecological sub-regions (AESRs) 2.1, 2.3, 2.4, 4.2 and 5.1. Seed oil yield varied across the AESRs. Twenty four aroma compounds and 17 lipids were identified by GC-MS. Oleic acid was the major lipid in all the AESRs, having higher value in 2.3. MUFA content varied between 40.39 to 64.24% in AESR 4.2 and 2.4 respectively. Cumin seed oil contained significant quantity of phenolic compounds (73.37 mg GAE g^{-1} seed in AESR 4.2 and 65.95 mg GAE g^{-1} seed in AESR 5.1) and DPPH free radical scavenging activity (52.76% in AESR 2.1 and 45.11% in AESR 5.1). The biochemical investigation advocates that AESRs have prominent bearing on cumin seed oil content and composition.

Key words : AESRs, cumin seed oil, essential oil constituents, lipid composition, mono saturated fatty acids, phenolics, radical scavenging.

Introduction

Cuminum cyminum L. (cumin) belonging to *Apiaceae* is prominently cultivated as a cash crop in the arid and semi-arid agro-eco sub regions (AESRs) of India, having soothing soil and climatic conditions. Agro-ecological region (AGR) is the land unit derived from agro-climatic region through integration of land form and soil conditions acting as modifiers of the length of growing period (LGP) into AGR. In the AESR maps the soil map is superimposed on bioclimatic map and LGP data using Geographical Information System (GIS) tools. India has 20 AER and 60 Agro-ecological sub regions (AESRs) which are incorporated with the information for mean monthly temperature, monthly precipitation, soil type and LGP. Cumin is cultivated under the Indian Agro-ecological sub regions (AESR) 2.1, 2.3, 4.2 and 2.3, 2.4, and 5.1 covering the states of Rajasthan and Gujarat (Velayutham *et al.*, 1999). The area and production of cumin in the states of Gujarat and Rajasthan collectively accounts to 0.70 M ha and 0.37 M tonnes, respectively (Spice Board India, 2016). Cumin seeds are highly nutritious and are also well oleaginous due to the presence of oil canals in seed carpel. It bears immense economic importance due to its use in food flavouring, perfumes, cosmetics industries and medicinal uses viz. epilepsy, flatulence, dyspepsia and diarrhoeea. Cumin extracts are reported to possess antiallergic, antioxidant, antiplatelet aggregation and hypoglycaemic properties (Singh *et al.*, 2002; Lee *et al.*, 2005; Allahghadri *et al.*, 2010). The essential oil components specifically have antioxidant, antispasmodic, diuretic, carminative and antibacterial properties (Bettaieb *et al.*, 2010). Cumin and value added products from cumin, *viz.*, essential oil, cumin seed oil/oleoresin, powder mix etc. are important commodities in domestic use as well as export (Beis *et al.*, 2000). Bioactive and nutraceutical constituents of composite cumin seed oil from in these AESR are different in terms of flavour, lipid components and radical scavenging characteristics due to variation in agro-climatic conditions. Cumin tagged from AESR 2.1 and parts of 2.3 is preferred by consumers in India, hence, attracts premium price than cumin from other areas. Due to these quality attributes in international market Indian cumin fetches preference over other cumin producing countries (Dubey *et al.*, 2017).

Cumin seeds have been reported to contain 3-4.5% essential oil (Dubey *et al.*, 2017). Among major constituent of cumin essential oil, cuminaldehyde is present to an extent of 45–54% and considered to be as an important phytochemical possessing many health benefits (Varo *et al.*, 1970; Li *et al.*, 2004). The cuminaldehyde content in some cumin growing areas of Rajasthan and Gujarat was 44.5, 44.2 and 40.3% in Jodhpur, Nagaur (Rajasthan) and Patan (Gujarat) respectively. Cumin seed oil export which contains both volatile and fixed oil is gaining importance for industrial uses. A kilogram of cumin oleoresin is equivalent to 15-20 kg of cumin seeds and can be stored safely having enough shelf life. Indian cumin seed oil is exported mainly to Vietnam, Egypt, US, Spain, Morocco,

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Malaysia, Brazil and Bangladesh (http://www.commodityindia.com/; http://www.mydigitalfc.com). According to the Commerce Ministry, Govt. of India, export of cumin was 98,700 tonnes generating foreign revenue of 261.2 million USD in 2016 (Spice Board India, 2016). The composition of *C. cyminum* essential oil from different geographic locations has been the common subject of earlier studies (Hemavathy *et al.*, 1988; Beis *et al.*, 2000). In an earlier communication we reported variation in essential oil constituents in cumin grown in different AESRs of India (Dubey *et al.*, 2017). In present Investigation morphometry of cumin seeds and chemical properties of oil extracted from Gujarat Cumin-4 (GC4) variety grown under various AESR were studied to correlate the effect of agro-ecology on physico-chemical characteristics of seeds and seed oil of cumin to be used as an additive in food and pharmaceutical preparations and export after screening. The cumin variety GC-4 is being more or less exclusively cultivated in India due to its resistivity to wilt and minor diseases to good extent (Lal *et al.*, 2014). Earlier studies were mainly focussed on essential oil content and antioxidants of some cumin varieties from specific places in India and Middle East (Singh *et al.*, 2006). Through this analytical manifesto, we hereby evaluated the morphometric, physical and chemical properties of cumin grown under AESRs of Rajasthan and Gujarat, India. This will help in strengthen the valorisation of AESR concept towards identifying the potential areas as a source for quality cumin seed oil export promotion and also presents comprehensive information on cumin quality.

Material and methods

Plant material

Fresh harvested seeds of cumin variety GC-4 were collected from farmer's fields located in the districts of Ajmer, Barmer, Jaisalmer, Jalore, Jodhpur, Nagaur and Pali under Rajasthan state and Banaskantha, Kuchchh, Patan and Surendranagar under Gujarat state of India during April, 2016. The sampling sites were tagged with GPS co-ordinates so as to identify their AESRs. The AESR 2.1 comprises of Jaisalmer, Barmer and Jodhpur; 2.3 includes Nagaur, Pali, Jalore, Banaskantha and Patan; 2.4- Kuchchh; 4.2- Ajmer and 5.1- Surendra Nagar respectively (Velayutham *et al.*, 1999; Dubey *et al.*, 2017). The sample are collectively situated between the co-ordinates 22° 45' 06" N and 71° 65' 63" E to 27° 13'38" N and 72° 49' 23" E with Mean Sea Level (MSL) elevation ranging between 36 to 456 metres. More than five representative samples from each district under the AESRs were collected, air dried and processed by removal of extraneous matter and stored at 4°C until further analysis.

All chemicals and reagents (analytical HPLC grade) used in present study were procured from Merck Co. (Germany) and Sigma-Aldrich (USA). Authentic standards of major constituents of fennel essential oil (homologous series of C5–C24 alkanes and fatty acid standards were procured from Sigma-Aldrich, USA).

Seed oil extraction

Cumin seeds were finely ground in mixer-grinder (Morphy Richards, Icon DLX). Three replicates comprising of 60 g each homogenized samples were subjected to Accelerated Solvent Extraction System (Dionex India Pvt. Ltd.) for oil extraction. Hexane was used as extracting solvent at elevated temperature and pressure. Pressure was maintained in the sample cells to keep the heated solvent in liquid state during extraction process. The extract was rinsed from the sample cell automatically and collected in a collection vessel. The cumin seed oil was finally collected after evaporating the hexane in rotary evaporator. The replications of cumin seed oil from each district were mixed together. Finally only one sample from each district in three replicates were analysed to identify the chemical composition.

GC-MS analysis of seed oil

The methyl esters of the cumin seed oil were derived according to AOCS Method CE 1-62 (AOCS, 2005). Diluted FAME were separated on an Agilent Series GC-MS (Agilent, USA; GC-7820 A, MS-5975) equipped with an HP5 (Universal column) (30m x0.32mm x0.25µm); Agilent J&W GC column with an auto sampler. A sample of 1 µL was used in split mode (20:1) with an auto sampler. Helium was used as the carrier gas at a flow rate of 0.8 ml min^{-1}. The column temperature was programmed from 50°C to 280°C with equilibrium time of 3 minutes, held for 30 min. The fatty acids were identified by a comparison of their retention indices and their identification was confirmed by computer matching of their mass spectral fragmentation patterns of compounds in the NIST-MS library and published mass spectra with the help of Chemstation software (Agilent Technologies, USA).

The chromatograms generated through GC-MS were analysed for C_5-C_{24} constituent of essential oil as well as lipids by comparing of their retention indices and further confirmation by matching of mass spectral fragmentation patterns of the compounds in NIST08 (National Institute of Standards and Technology) mass spectral library of the GC-MS data system.

Total phenolic content (TPC)

Total phenol concentrations were determined using Folin-Ciocalteu assay, as described by Amin *et al*., (2006). Ground seeds (10 gm) of cumin were extracted with 50 ml methanol twice. Supernatant from both extraction were pooled and methanol was evaporated in rotary evaporator. This crude methanol seed extract was used for determination of total phenolic content and antioxidant activity. An aliquot of 0.1ml from 1000 ppm crude methanol extract was taken in a test tube and the volume was made to 1 ml by adding solvent. 3 ml of 10% sodium carbonate was also added. Previously 10-fold diluted Folin-Ciocalteu reagent was added to the mixture. The mixture was allowed to stand at room temperature for 90 minutes and absorbance was measured at 710 nm. Gallic acid was used as the standard phenol. The amount of phenolic content was calculated by using the standard curve of gallic acid having R^2 value ranging from 0.96-0.99 and was expressed as mg GAE g^{-1} seeds.

DPPH scavenging capacity

The antioxidant activity of crude seed extract in methanol was evaluated on the basis of its activity in scavenging the stable DPPH radical (Shimada *et al*., 1992). Crude seed extract was diluted in methanol to give at least 5 different concentrations. An aliquot (1, 1.5, 2, 2.5 ml) of the extract of each concentration was mixed with 1ml of 1M DPPH solution. The mixture was then homogenized and left to stand for 30 min in the dark. The absorbance was measured at 517 nm against methanol as blank. DPPH solution plus methanol was used as control and Butyl Hydroxyl Toluene (BHT) (0-80ppm) was used as a standard reference (synthetic antioxidant) with R^2 value ranging from 0.95- 0.99. The percent scavenging effect was calculated from equation (1).

Scavenging effect (%) =

$$\frac{A_{517} \text{ of control} - A_{517} \text{ of extract}}{A_{517} \text{ of control}} \times 100 \quad \ldots (1)$$

Data was analysed using Microsoft Excel (Microsoft Inc.). All analysis was carried out in triplicates and results expressed as means and standard deviations. Significant differences between means were determined using analysis of variance (ANOVA).

Results and discussion

Cumin seed oil content in the seeds from various AESR's has been presented in Fig 1. The perusal of data revealed that cumin grown under AESR 4.2 contained higher quantity of oil followed by AESR 2.3 and 5.1. Agro climatic conditions are more conducive in these AESRs as compared to AESR 2.1 and 5.1 where the climate is harsh due to higher temperature and lower humidity. Thus, AESR 4.2 and 2.3 may be prioritised for production of cumin seed oil and export.

The data for aromatic components of cumin seed oil under various AESRs is presented in Table 1. Twenty four compounds belonging to aromatic group terpinenes, aldehydes, alcohols, ketones, aromatic acids and esters were identified. The isolated terpinenes are summarised as monoterpinenes comprising of α-Terpinene (2.13-3.46%) and α-Pinene (0.15-0.73%). The sesquiterpinenes comprises of α-Cedrene (0.11-0.54%), α-Farnescene (0.13-0.83%) and naphthalene (0.13-0.47%). The major aldehyde identified was cumin aldehyde also known as cuminal (15.66-28.19%). Among alcohol group of compounds identified after esterification in cumin seed oil were cuminic alcohol (0.25-0.52%), p-Cymen-7-ol (0.27-0.93%), estragole (0.53-0.65%), caratol (0.13-0.37%), p-Mentha-1,4-dien-7-ol (5.35-13.68%), and p-Cuminol (0.09-0.21%). Other compounds in decreasing order belonging to miscellaneous organic compounds was santolinatriene (0.22-2.52%), benzoic acid (0.20-0.54%), α-Thujene (0.33-0.55%), camphene (0.20-2.52%) and phellandrene (0.65-0.66 %), respectively.

There are many reports on aroma compounds when essential oil constituents of cumin seed oil were separated in GC-MS. (Adams *et al*., 2007) reported 19 components in Chinese cultivar, 21 components in Tunisian cultivar and 38 compounds in Tunisian varieties. (Viuda-Martos *et al*., 2007) during GC-MS analyses of cumin essential oil identified 26 constituents, representing the 80% of the total oil. In a recent publication (Sharma *et al*., 2016). also reported presence of 19 major constituents in cumin essential oil. However, in present study, composite cumin seed oil containing both volatile and fixed oil components were analysed which showed 54.26% aromatic compounds in oil from AESR 4.2, while AESR 2.4 contain only 28.63% aromatic compounds (Fig 3). It is well studied that constituents of essential oil are dependent upon intrinsic and extrinsic factors influencing the plant genetic frame work, ecological situations and agricultural practices (Telci *et al*., 2009). The process of esterification for separation of fatty acids also affects the relative quantity of various essential oil constituents. In earlier study the cuminaldehyde content estimated in the cumin seed oil from the various AESRs showed appreciable cuminaldehyde content level (25.84-39.90 g kg^{-1}) (Dubey *et al*., 2017). Esterification of the seed oil for FAME analysis showed reduction in cuminaldehyde content *vis-*

Table 1. Aroma components in cumin seed oil from various agro-eco sub regions

Aromatic components of cumin seed oil		RT	RI	Agro-eco sub regions (AESRs)				
				AESR-2.1	AESR-2.3	AESR-2.4	AESR-4.2	AESR-5.1
Terpenic hydrocarbons								
1	β-Pinene	5.510	943	0.48 (±0.27)	0.39 (±0.20)	0.15 (±0.01)	0.42 (±0.25)	0.73 (±0.07)
2	α-Terpinene	9.639	998	2.13 (±1.14)	3.46 (±3.34)	2.27 (±0.04)	2.44 (±2.18)	2.21 (±0.17)
3	Camphene	10.773	950	-	0.66 (±2.20)	-	2.52 (±0.62)	0.20 (±0.03)
4	Santolina triene	10.791	894	0.61 (±0.21)	0.67 (±0.1.17)	-	2.52 (±1.52)	0.22 (±0.01)
5	α-Thujene	11.082	902	0.55 (±0.23)	-	-	-	-
6	Caryophyllene	13.054	1386	-	0.15 (±0.08)	-	-	-
7	β-Farnesene	13.425	1440	-	0.13 (±0.04)	-	-	0.83(±0.06)
8	α-Cedrene	13.769	1403	0.11 (±0.13)	0.54 (±0.32)	-	-	-
9	Naphthalene	12.485	1231	0.47 (±0.25)	0.30 (±0.19)	0.13 (±0.01)	0.34 (±0.09)	0.17 (±0.01)
Aldehydes								
10	Cuminaldehyde	10.433	1230	21.52 (±5.78)	22.03 (±11.87)	15.66 (±3.27)	28.19 (±6.75)	22.48 (±1.05)
11	Phellandral	10.949	959	-	0.65 (±0.30)	-	-	0.66 (±0.05)
Alcohols								
12	p-Cuminol	11.082	1236	0.20 (± 0.02)	0.20 (±0.02)	0.09 (±0.01)	0.14 (±0.02)	0.21 (±0.03)
13	p-Cymen-7-ol	11.148	1284	0.27 (±0.14)	0.35 (±0.20)	0.46 (±0.04)	0.93 (±0.72)	0.92(±0.20)
14	Estragole	11.082	1172	-	0.53 (±0.05)	-	-	0.65 (±0.06)
15	Cumin alcohol	11.098	1231	0.25 (±0.14)	0.35 (±0.20)	0.44 (±0.06)	0.52 (±0.72)	-
16	p-Mentha-1,4-dien-7-ol	11.704	1240	5.35 (±0.19)	7.21 (±0.30)	7.35(±0.30)	13.68 (±0.39)	8.06 (±0.02)
17	Carotol	15.304	1593	0.13 (±0.07)	0.29 (±0.17)	0.37 (±1.02)	0.32 (±0.10)	0.13 (±0.02)
18	5-(4-isobutyl- phenyl) -2h- pyrazol-3-ol	16.627	1522	1.08 (±0.59)	1.45 (±0.82)	-	2.05 (±1.66)	2.69 (±0.24)
19	Cyclohexanol	16.628	1536	0.62 (±0.31)	1.51 (±0.85)	1.60 (±0.45)	0.76 (±0.89)	1.20(±0.30)
Ketones								
20	1H- benz ie) indole-1,2 (3H)-dione	17.685	1932	0.46 (±0.27)	0.27 (±0.15)	-	0.18 (±0.07)	-
21	1'- Acetonaphthone, 2'- hydroxy-4' -methoxy	17.448	1579	0.28 (±0.16)	0.14 (±0.40)	0.11(±0.02)	0.67 (±0.44)	0.40 (±0.02)
Aromatic acid								
22	Benzoic acid	12.352	1150	0.31 (±0.13)	0.54 (±0.32)	-	0.41 (±0.15)	0.20(±0.30)
Esters								
23	Z, Z-10, 12 -hexadecadien-1-ol acetate	20.161	1738	-	-	-	0.43 (±0.02)	0.40(±0.30)
24	2,6-pyrazinedicarbonitrile	17.448	1332	0.10 (±0.04)	0.36 (±0.10)	-	0.26 (±0.15)	1.40(±0.32)
			Total (%)	34.92	42.18	28.63	54.26	43.36

RI- Retention Index and RT- Retention time

Table 2. Lipid components of *cuminun cyminum* L. seed oil from various agro-eco sub regions

S. No.	Methyl ester components of oleoresin	RT	RI	Agro-eco sub regions (AESRs)				
				AESR-2.1	AESR-2.3	AESR2.4	AESR-4.2	AESR-5.1
1	Myristic acid (*C14:0*)	16.561	1769	0.11 (±0.03)	0.18 (±0.14)	-	-	-
2	Pentadecanoic acid (*C15:0*)	17.634	1869	0.06 (±0.06)	0.12 (±0.04)	-	-	-
3	Palmitoleic acid (*C16: 1ω7*)	18.454	1886	0.56 (±0.26)	0.58 (±0.39)	0.59 (±0.09)	0.41 (±0.13)	0.38 (±0.40)
4	Palmitic acid (*C16:0*)	18.679	1968	3.55 (±1.55)	3.42 (±3.64)	4.03 (±0.07)	2.08 (±1.20)	2.63 (±0.03)
5	Cis-10- heptadecenoic (*C17:1 ω10*)	19.420	2075	0.18 (±0.01)	0.21 (±0.01)	0.17 (±0.02)	-	-
6	1-Heptadecene (*C17: 1 ω 2*)	22.028	2231	-	0.95 (±0.10)	-	-	-
7	Linoleic acid (*C18.2 ω6*)	20.228	2183	0.54 (±0.49)	0.47 (±0.40)	-	0.42 (±0.04)	0.22 (±0.05)
8	6, 9-octadecadienoic acid (*C18:2ω6*)	20.230	2439	0.35 (±0.16)	0.32 (±0.20)	0.38 (±0.16)	0.23 (±0.12)	0.15 (±0.32)
9	Oleic acid (*C18:1ω9*)	20.479	2085	72.48 (±3.39)	78.42 (±3.13)	59.79 (±6.80)	53.26 (±2.87)	59.29 (±2.45)
10	Stearic acid (*C18:0*)	20.598	2167	0.77 (±0.56)	0.78 (±0.72)	0.81 (±0.12)	0.43 (±0.17)	0.50 (±0.11)
11	7, 10-octadecadienoic acid (*C19:2 ω7*)	20.175	2091	-	-	0.35 (±0.05)	-	-
12	9- Noradecene (*C19:0*)	22.769	2311	-	-	-	0.20 (±0.01)	-
13	Cis-11- eicosadienoic acid (*C20:1ω11*)	21.922	2212	-	0.29 (±0.01)	-	-	-
14	Eicosene (*C20:1ω12*)	22.054	2276	0.50 (±0.13)	0.55 (±0.24)	0.45 (±0.06)	-	-
15	Cis-11-eicosenoic acid (*C20:1ω9*)	22.107	2296	0.50 (±0.21)	0.55 (±0.28)	0.44 (±0.08)	-	-
16	Heneicosene (*C21:0*)	29.162	2985	-	-	-	1.12 (±0.19)	-
17	Erucic acid (*C22: 1ω9*)	24.172	2572	0.30 (±0.06)	0.68 (±0.30)	-	-	-

RI- Retention Index and RT- Retention time

a-vis an increase in alcoholic group of compounds. This may be due to the fact that during esterification some part of the cuminaldehyde gets converted into alcoholic compounds. This transformation can be supported by Cannizzaro's reaction mechanism, wherein, the base induced disproportionation of an aldehyde lacking a hydrogen atom in the alpha position takes place (Cannizzaro *et al*., 1853). The oxidation product of this reaction is a salt of a carboxylic acid and the reduction product is an alcohol. This can be one of the causes for decreased cuminaldehyde content in composite cumin seed oil. Still the seed oil contains an appreciable quantity of major aroma bearing compound cuminal.

The analysis of data pertaining to the methyl ester components of cumin seed oil revealed presence of seventeen lipid compounds in the order oleic acid > palmitic acid > stearic acid > erucic acid > 6-9 octadecanoic acid > palmitoleic acid > eicosenoic acid > linoleic acid and other fractions *viz*., myristic acid, pentadecanoic acid, heptadecanoic acid, and 7-10 octadecanoic acid etc. being present in trace quantities. The classification of fatty acid methyl ester based on their saturation characteristics is presented in Table 2.

The substantial quantity of mono unsaturated fatty acids (MUFA) fractions in cumin seed oil renders it to be useful for food purposes. The total aroma compounds, total lipids and their grouping under saturated fatty acids *viz* MUFA, poly unsaturated fatty acids (PUFA) and saturated fatty acids (SFA) has been presented in Fig. 2. The analytical data revealed that maximum total lipid and MUFA content was available in the cumin seed oil from AESR 2.4 followed by AESR 2.1, 2.3, 5.1 and 4.2. Analysis of cumin seed oil showed that lipid contains 84.8% neutral lipids, 10.1% glycolipids and 5.1% phospholipids (Hemavathy *et al*., 1988). Neutral lipids consisted mostly of triacylglycerols (89.4%) and small amounts of diacylglycerols, free fatty acids, sterols, sterolesters and hydrocarbons.

Present study revealed cumin seed oil is a potential source of medicinally important and aroma bearing compounds in significant quantity and suitable proportion. Cumin seed oil contains appreciable proportion of MUFA which are renowned for their health promoting properties particularly their potentially positive impact on cardio-vascular health due to ω 3 & 6 compounds (Ramasamy *et al*., 2007; Allahghadri *et al*., 2010). Presence of significant quantity of phenolic compounds (73.37 mg GAE g^{-1} seed in AESR 4.2 and 65.95 mg GAE g^{-1} seed in AESR 5.1) in cumin seed oil and DPPH free radical scavenging activity (52.76% in AESR 2.1 and 45.11% in AESR 5.1) (Fig. 3)

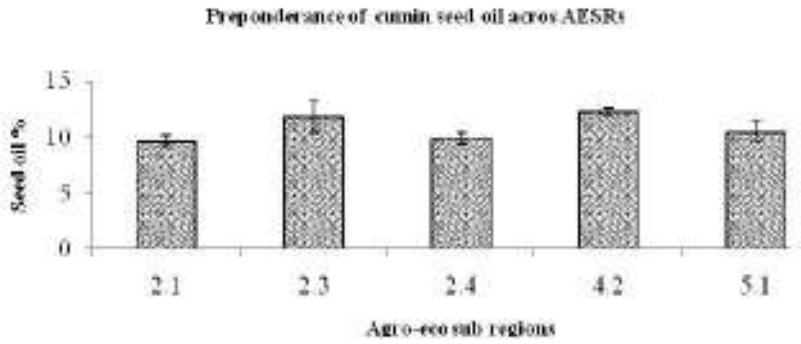

Fig. 1. Cumin seed oil content in various AESR's.

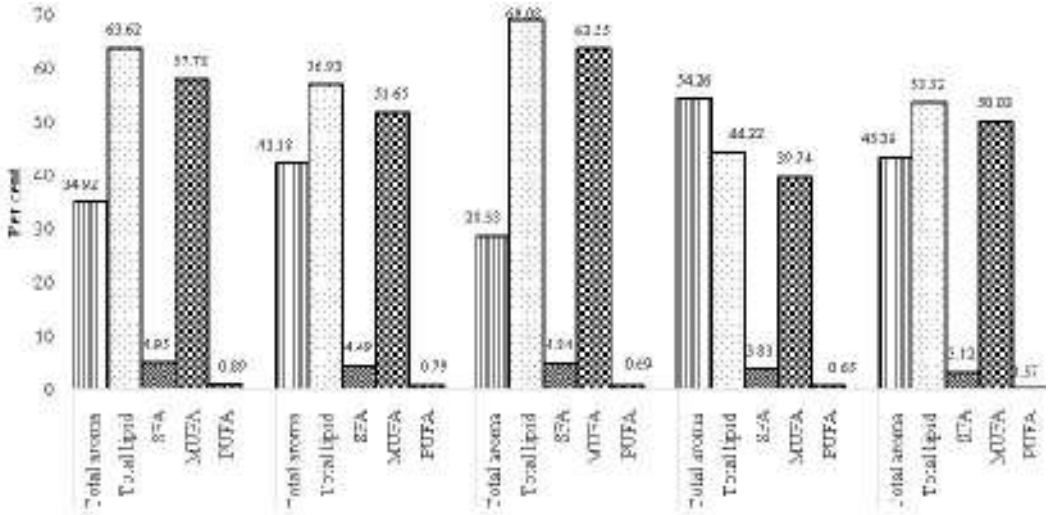

Fig. 2. Total aroma compounds, SUFA, MUFA and PUFA in cumin seed oil under AESRs

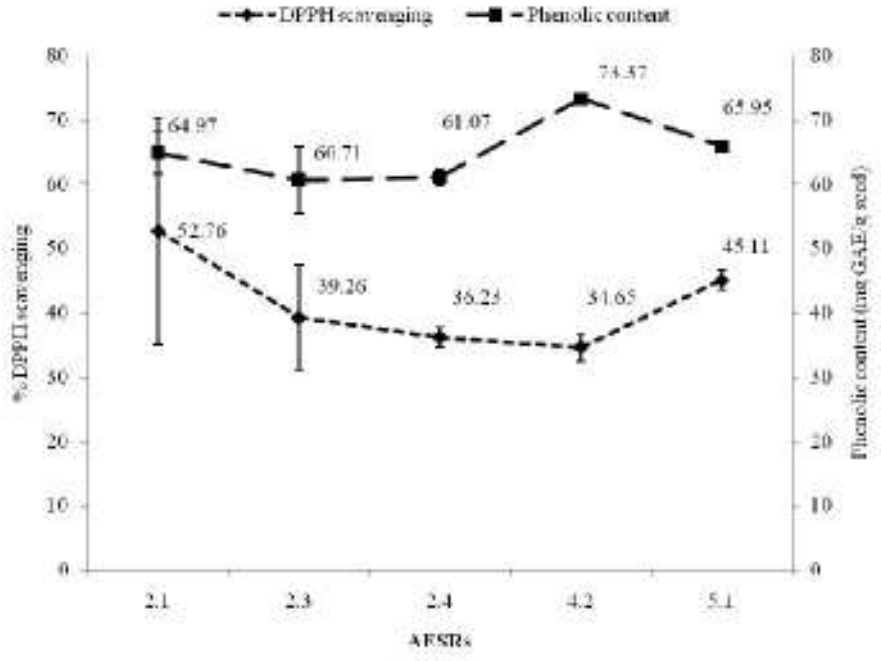

Fig. 3. Antioxidant activity and total phenolic content in cumin seed extracts in AESRs.

also support the fitness of oil to be used as a medicinal (antioxidant) entity and for its industrial production.

The scientific perusal and auditing of the results obtained for the aroma and lipid content in composite cumin seed oil reveals that agro-ecological factors play a dominant role on the qualitative attributes. The area specific data classified as AESRs can be used selectively for the desired quality of cumin and its derivatives. For harnessing higher aroma attributes in cumin seed oil AESR 4.2 and 5.1 can be the appropriate zone, similarly for MUFA derivatives AESR 2.4 will be the right option in India. Presence of appreciable quantity of aroma components is a valuable feature of Indian cumin. The seed oil also shows the presence of natural bio-active compounds *viz*. α-Terpinene, α-Pinene, α-Thujene, α-Farnesene and α-Cedrene. Oleic acid (C18:1ω9) was the major lipid in all the AESRs, with a higher value in 2.3. The cumin seed oil signifies to be a valuable source for vegetable oil enriched with oleic acid having potential significance in health management.

The conclusive observations to be mentioned are that, cumin seed oil can be exploited as low cost renewable source for health promotion, perfumery, cosmetics and nutraceuticals through industrial processing after screening, *vis-a-vis* agro-ecological suitability for quality cumin cultivation. These information are valuable inputs as geographical indicators (GIs) of cumin in international trade, in the era of Intellectual Property Rights and Trade Related Intellectual Properties.

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References

Adams, R. P. 2007. Identification of essential oil components by gas chromatography/ mass spectrometry. Allured publications, Carol stream, IL.

Allahghadri, T., Rasooli, I., Owlia, P., Nadooshan, M. J., Ghazanfari, T., Taghizadeh, M. 2010. Antimicrobial property, antioxidant capacity and cytotoxity of essential oil from cumin produced in *Iran. J. Food Sci.* 75, 54–61.

Amin, I., Norazaidah, Y., Hainida K. I. E. 2006. Antioxidant activity and phenolic content of raw and blanched *Amaranthus* species. *Food Chem*. 94, 47 –52.

A.O.C.S. 2005. Fatty Acid Composition by Gas Chromatography AOCS Method. AOCS Official Methods. Am. Oil Chem. Soc.1–62.

Beis, S. H., Azcan, T. N., Ozek, I. M., Kara, I. M., Baser, K. H. C. 2000. Production of essential oil from cumin seeds. *Chemistry of Natural Compounds*, *36*, 265–268.

Bettaieb, I., Bourgou, S., Sriti, J., Msaada, K., Limam, F., Marzouk, B. 2010. Essential oil and fatty acids composition of Tunisian and Indian cumin (*Cuminum cyminum* L.) seeds: a comparative study. *J. Sci. Food Agric.* 91, 2100–2107.

Cannizzaro, S. 1853. "Ueber den der Benzoësäure entsprechenden Alkohol" On the alcohol corresponding to benzoic acid. *Liebigs* Annalen. Der. Chemie. Pharmacie. 88, 129–130.

Dubey, P. N., Saxena, S. N., Mishra, B. K., Solanki, R. K., Vishal, M. K., Singh, B., Sharma, L. K., John, S. Agrawal, D., Yogi, A. 2017. Preponderance of cumin (*Cuminum cyminum* L.) essential oil across cumin growing Agro-ecological sub-regions, India. *Indus. Crops Prod.* 95, 50–59.

Hemavathy, J., Prabhakar, J. V. 1988. Lipid composition of cumin (*Cuminum cyminum* L.) seeds. *J. Food Sci.* 53, 1578–1579.

http://www.commodityindia.com/

http://www.mydigitalfc.com/

Lal, G., Mehta, R. S., Godara, A. S., Mahala, H. R., Maheria, S. P., Singh, B. 2014. Performance of cumin varieties and technological interventions at farmers fields in Jaisalmer district of Rajasthan. *Int. J. Seed Spices*, 4, 9–13.

Lee, H. S. 2005. Cuminaldehyde: aldose reductase and r-glucosidase inhibitor derived from *Cuminum cyminum* L. seeds. *J. Agric. Food Chem*. 53, 2446–2450.

Li, R., Jiang, Z. 2004. Chemical composition of the essential oil of *Cuminum cyminum* L. from China. *Flavour and Fragrance J*., 19, 311–313.

Ramasamy, R., Prakash, M., Keshava, B. K. 2007. Aroma characterization of coriander (*Coriandrum sativum* L.) oil samples.*Eur. Food Res. Technol*., 225, 67–374.

Sharma, L. K., Agarwal, D., Rathore, S. S., Malhotra, S. K., Saxena, S. N. 2016. Effect of cryogenic grinding on volatile and fatty oil constituents of cumin (*Cuminum cyminum* L.) genotypes. *J. Food Sci. Technol*., 53, 2827–2834.

Shimada, K., Fujikawa, K., Yahara, K., Nakamura, T. 1992. Antioxidative properties of xanthin on

autoxidation of soybean oil in cyclodextrin emulsion. *J. Agric. Food Chem.* 40, 945–948.

Singh, G., Kapoor, I. P. S., Pandey, S. K., Singh, U. K., Singh, R. K. 2002. Antibacterial activity of volatile oils of some spices. *Phytother. Res.,* 16, 680– 682.

Spice Board India 2016. www. india spices.com.

Telci, I., Demirtas, I., Sahin, A. 2009. Variation in plant properties and essential oil composition of sweet fennel (*Foeniculum vulgare* Mill.) fruits during stages of maturity. *Ind. Crops. Prod.*, 30, 126–130.

Varo, P. T., Heinz, D. E. 1970. Volatile components of cumin seed oil. *J. Agric. Food Chem.* 18 (2): 234–238.

Velayutham, M., Mandal, D. K., Mandal, C., Sehgal, J. 1999. Agro-Ecological Subregions of India for Planning and Development (pp. 372). NBSS and LUP, Publ. No. 35.

Viuda-Martos, M., Ruiz-Navajas, Y., Fernandez Lopez, J., Perez Alvarez, J.A., (2007). Chemical composition of the essential oils obtained from spices widely used in Mediterranean region. Acta Chim. Slov. 54, 921–926.

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