Morphological Characteristics and Oil Contents of Fennel (*Foeniculum vulgare* Mill.) Accessions from Different Regions of Pakistan

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Summary: Fifty accessions of Fennel (*Foeniculum vulgare* Mill.) were collected from different parts of Pakistan and grown in the field to evaluate their morphological and essential oil compositions. All parameters were recorded from sowing to harvesting and essential oils isolated by hydrodistillation were analyzed by gas chromatography-mass spectrophotometry (GC-MS). The accessions with more height (120-129 cm), MP00164, MP00183, MP00280, MP00293, MP00307, MP00526, MP00557, MP00769, MP0001061 and MP00483 were found to have higher oil contents and a large number of umbels mainly due to a considerable presence of secondary inflorescence. The same accessions were also characterized by more biomass and a higher percentage of umbels. The morphological characters showed positive relationship among the number of umbels per plant, the plant weight, umbel weight and oil contents. The essential oils evidenced five main chemical groups characterized by α-phellandrene, limonene, *trans*-anethole, methylchavicol and pinene while fifteen minor chemical groups were also detected. The accessions MP 00240, MP 00329 and MP 01084 showed higher level of methylchavicol (38 %) with lower amount of fenchone were regarded as sweeter genotypes possessed potential for utilization in food items. The highest level of *trans*-anethole (58.04 %) was noted in MP00526 that was considered suitable for extraction of ansi tasting compound. The α-phellandrene (46.20 %) was found as a dominant compound in MP00318, indicating the accession as a particular source for it. The chemical differences observed in oil composition can mainly be attributed to the genetic factors depicting good magnitude of genetic diversity in the available fennel germplasm of Pakistan.

Introduction

Fennel (*Foeniculum vulgare* Mill.) is an annual, biennial or perennial hemicryptophyte in the Mediterranean basin, well known as a medicinal and spice herb [1]. Essential oils are mainly concentrated in the mericarps (fruits) and provide the unique aroma and taste. They are composed of a mixture of several monoterpenes and phenylpropanoids, with *trans*-anethole, estragole, fenchone and limonene as main constituents. *Trans*-anethole, often the most prevalent constituent, counts for the ansi taste, fenchone provides the bitterness, and estragole (methylchavicol) the sweetness [2]. The major constituents of fennel include 50-60 % of anethole and 20 % fenchone, plus 18 compounds extracted in monoterpene fraction of the fruit. The minor constituents accounted for 1-5 % v/w of volatile oil [3]. Other minor constituents are α-pinene, camphene α-phellandrene, dipentene, methylcharvicol, foeniculum, anisic acid, comphene-β pinene, sabenine, β-phellandrene, gamma terpipene, myrcene, limonene, β-phellandrene, *cis*-ocimene, terpinolene and ρ-cymene [4]. Fennel essential oil of dried seeds obtained through steam distillation is commonly used for flavoring purpose in western countries. [5]. Fennel contains about 60 % oil in its fruit and 40 % in the rays of umbel and other green parts. Sweet fennel has more pleasing aroma and lack of fenchone (bitter mixture like odor and flavor), more limonene and less anethole [6]. On account of its aromatic and carminative properties, fennel fruit is chiefly used medicinally as an antispasmodic, diuretic, laxative, stimulant, hepatoprotective and stomachic [7, 8]. Fennel oil has wide range of applications and is used for food flavoring, in liqueurs, toothpaste together with mint oil, perfumes and pharmaceutical [8, 9]. In Pakistan fennel seed is an essential part of several herbal medicinal formulations and pickles. The extracted fennel water containing oil is commonly used for stomach problems. Much work has recently been done on the yield and composition of both extracts and volatile oils of fennel of several varieties from various locations [10-13].

In Pakistan, fennel is grown in Peshawar, D. I. Khan, Dadu and Sehvin Sharif with an annual production of 650 tonnes [14]. Pakistan is gifted with

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a variety of herbs; medicinal and aromatic plant resources in its diversified ecological conditions. These valuable resources can be commonly exploited for the farming community to the advantage of Pakistan economy. Pakistan as a developing country has limited capacity to supply valuable products of medicinal plants to the world market that meet the standards of quality control. As a result the country has become the major exporter of bulk of cheap crude material leading to rapid depletion of medicinal plant resources [15]. The germplasm of fennel in Pakistan has never been subjected for evaluation of essential oil diversity. Because of the interest in improving the knowledge and exploitation of the biodiversity of aromatic plants several indigenous accessions of fennel were collected from different localities and grown in field to evaluate their morphological traits, agronomic yields and oil components.

Table-1: Oil contents (%) of fifty local accessions of fennel.

Accession No.	Plant Height (cm)	Oil contents (% age)	Accession No.	Plant Height (cm)	Oil contents (% age)
MP 0009	72.00	0.2	MP 00526	125.00	0.53
MP 0016	75.00	0.33	MP 00533	97.00	0.39
MP 0024	69.00	0.06	MP 00557	128.00	0.46
MP 0031	75.00	0.31	MP 00693	97.00	0.45
MP 0045	86.00	0.24	MP 00724	98.00	0.5
MP 0063	87.00	0.44	MP 00758	103.00	0.35
MP 0074	97.00	0.26	MP 00769	123.00	0.49
MP 0092	98.00	0.45	MP 00792	104.00	0.42
MP 00116	100.00	0.2	MP 00808	108.00	0.32
MP 00164	122.00	0.46	MP 00826	109.00	0.37
MP 00179	113.00	0.08	MP 00851	107.00	0.4
MP 00183	124.00	0.46	MP 00860	106.00	0.32
MP 00207	122.00	0.37	MP 00900	104.00	0.38
MP 00230	110.00	0.04	MP 00937	101.00	0.14
MP 00240	111.00	0.08	MP 00976	102.00	0.61
MP 00248	113.00	0.21	MP 00989	104.00	0.41
MP 00274	103.00	0.34	MP 00990	101.00	0.3
MP 00280	110.00	0.52	MP 01026	105.00	0.29
MP 00293	129.00	0.48	MP 01032	106.00	0.26
MP 00296	119.00	0.35	MP 01036	105.00	0.32
MP 00307	126.00	0.56	MP 01061	100.00	0.48
MP 00318	96.00	0.38	MP 01064	107.00	0.28
MP 00326	98.00	0.27	MP 01084	107.00	0.17
MP 00329	96.00	0.29	MP 01085	103.00	0.17
MP 00401	80.00	0.27	MP 00483	124.00	0.56

Results and Discussion

The essential oil contents of fifty local accessions of fennel varied from 0.04 % to 0.56 % (Table-1). Fifty accessions of fennel evaluated in the present study revealed significant difference in their morphological traits and agronomic yields (Table-2a). The essential oil was characterized by the presence of 20 (five main and fifteen minor) different compounds out of which α-pinene, α-phellandrene, limonene, fenchone, methylchavicol and *trans*-anethole were the main compounds (Tables-2a, b). In the accession MP00179 highest level of methyl-chevicol (39.53 %) a sweetening component along with maximum contents of fenchone (11.2 %) a bitterness imparting compound with fair amount of limonene was recorded. However the accessions MP 00240, MP 00329 and MP 01084 showed higher level of methylchevicol (38 %) with lower amount of fenchone were regarded as sweeter genotypes possessed potential as additive in food items. The highest level of *trans*-anethole (58.04 %) was noted in MP00526 that was considered suitable for extraction of ansi tasting compound. Yield and composition of fennel oil of several varieties have been well described by many researchers [16-20]. Although the highest oil content (0.61 %) was detected in the MP 00976 accession but it contained low levels of methylchavicol and *trans*-anethole rendering toward poor oil quality. The higher level of good quality oil content (0.56 %) was detected in the MP 00483 accession with plant height (124 cm) that makes it suitable for cultivation to get higher oil yields. The accessions with more height (120-129 cm), MP00164, MP00183, MP00280, MP00293, MP00307, MP00526, MP00557, MP00769 and MP0001061 were found to have higher oil contents (Fig. 1) and more number of umbels mainly due to a considerable presence of secondary inflorescence. The same accessions were also characterized by more biomass and a higher percentage of umbels. The relationship among different characteristics has shown that fennel with high oil contents could be identified with a type characterized by a tall plant with numerous umbels and late flowering stage (Table-1). The difference observed can be mainly attributed to genetic factors. These results are in accordance with previous studies [4, 21], in which highest number of umbels are observed in the accessions of Italian fennel having presence of secondary inflorescence.

The levels of essential oil components were used for a cluster analysis to point out possible groups among the samples. The resulting dendrogram (Fig. 2) showed the main groups of different sizes, determined mainly by the contents of their main components of oil. As an example three GC profiles of oils belonging to different clusters are shown in (Figs. 3-5). The cluster-5 consists of 35 accessions and was characterized by α-phellandrene, methylchavicol constituents (6.0 to 40.16 % and 24 to 38.12 %) respectively. Ozcan *et al.* [22] has depicted that volatile components of fennel seed extracts contain methylchavicol, α-phellandrene, limonene, *trans*-anethole, fenchone, α-pinene *etc.*

Table-2a: Chemical composition (%) of 50 different accessions of fennel.

Accessions	α-pinene	Camphene	Sabinene	*P*-pinene	Myrencene	Methylchavicol	Aectate	Mythcarene	Pcymene	Limonene
MP 00164	5.02	0.2	0.26	0.53	2.02	28.66	0.24	0.03	1.71	4.8
MP 00179	0.9	0.18	0.31	0.01	2.08	39.53	0.25	0.15	1.12	6.81
MP 00183	3.82	0.19	0.24	0.42	1.68	24.78	0.09	0.05	0.62	3.94
MP 00207	0.84	0.17	0.27	0.09	1.68	33.75	0.18	0.03	0.91	5.09
MP 00230	1.8	0.12	0.43	0.23	1.72	36.75	0.29	0.04	0.85	7.36
MP 00240	21.28	0.1	0.44	2.39	2.59	38.12	0.27	0	2.24	2.69
MP 00248	1.25	0.14	0.39	0.16	1.84	30.8	0.69	0.02	2.23	11.35
MP 00274	23.19	0.09	0.37	2.49	3.12	7.75	0.3	3.4	0.9	3.34
MP 00280	13.81	0.05	0.34	1.67	1.38	9.09	0.18	1.64	0.59	1.74
MP 00293	26.54	0.14	0.38	2.61	2.83	1.97	0.22	3.49	0.38	3.38
MP 00296	24.02	0.11	0.47	2.66	2.74	15.70	0.38	0.05	0.19	22.66
MP 00307	0.7	0.18	0.22	0.11	1.77	30.66	0.1	0.03	2	5.12
MP 00318	0.8	0.18	0.26	0.08	1.65	38.01	0.22	0	0.89	5.69
MP 00326	5	0.2	0.25	0.52	2	28.65	0.03	0.04	1.65	4.65
MP 00329	0.85	0.2	0.3	0.1	2.02	38.53	0.35	0.16	1.12	6.8
MP 00401	3.7	0.16	0.23	0.4	1.67	24.7	0.1	0.06	0.62	3.85
MP 00483	33.1	0.17	0.38	0.14	1.49	35.75	0.07	0.03	0.31	3.10
MP 00502	1.75	0.16	0.42	0.22	1.7	30.05	0.23	0.04	1.15	7.46
MP 00526	20.15	0.11	0.43	2.29	2.55	32.05	0.26	0	0.23	2.89
MP 00533	1.11	0.1	0.38	0.15	1.46	15.7	0.07	0.03	2.2	11.45
MP 00557	21.15	0.03	0.36	2.48	3.1	7.55	0.15	3.42	0.89	3.44
MP 00693	12.7	0.08	0.33	1.66	1.36	9	0.27	1.62	0.57	1.84
MP 00724	25.55	0.05	0.37	2.6	2.8	31.95	0.26	3.46	0.37	3.88
MP 00758	23.1	0.13	0.46	2.65	2.72	0.3	0.05	0.05	0.18	22.18
MP 00769	0.72	0.1	0.23	0.1	1.78	30	0.3	0.04	2.2	5.25
MP 00792	6.95	0.17	0.26	1	1.9	15	0.17	0.02	2.5	5.93
MP 00808	4.9	0.15	0.24	0.52	2.92	26	0.2	0.03	1.77	3.34
MP 00826	0.92	0.09	0.32	0.1	2.05	39	0.36	0.16	1	4.86
MP 00851	3.78	0.21	0.23	0.43	1.65	24	0.12	0.05	0.7	6.78
MP 00860	0.82	0.19	0.25	0.07	1.67	33	0.24	0.04	0.99	3.14
MP 00900	1.78	0.18	0.25	0.22	1.69	36	0.24	0.03	0.79	5.28
MP 00937	21.1	0.17	0.42	2.37	2.55	30.0	0.26	0	0.45	7.86
MP 00976	1.12	0.12	0.41	0.15	1.42	18	0.29	0.03	2.1	2.39
MP 00989	22.1	0.1	0.4	2.48	3	7	0.19	3.43	2.89	11.47
MP 00990	11.79	0.04	0.38	1.66	1.35	9	0.3	1.62	0.67	3.93
MP 01026	25.65	0.08	0.35	2.6	2.79	1.9	0.29	3.45	0.4	1.94
MP 01032	23.8	0.05	0.37	2.65	2.7	0.33	0.05	0.06	0.18	3.58
MP 01036	22.12	0.04	0.46	0.11	1.79	24.50	0.29	0.04	2	22.18
MP 01061	21.74	0.11	0.24	1.01	1.92	14.95	0.17	0.03	2.4	5.23
MP 01064	7.15	0.13	0.23	0.53	2	27.56	0.21	0.02	1.79	3.36
MP 01084	5	0.19	0.25	0.1	2.07	38.43	0.37	0.16	1	4.14
MP 01085	0.88	0.08	0.31	0.42	1.69	23.97	0.1	0.05	1.25	6.78
MP 0009	11.77	0.2	0.25	0.09	1.67	30.95	0.23	0.04	0.75	3.95
MP 0016	20.95	0.02	0.25	0.2	1.7	35.85	0.22	0.03	1	5.39
MP 0024	1.15	0.18	0.42	2.3	2.75	18	0.24	0	0.91	7.83
MP 0031	7.11	0.08	0.24	1	1.92	15.6	0.23	0.02	2.1	3.75
MP 0045	12.98	0.11	0.36	2.45	3	7.47	0.19	3.25	2.4	11.35
MP 0063	26.2	0.1	0.33	1.6	1.36	9.15	0.2	1.6	0.95	3.84
MP 0074	24.1	0.04	0.32	2.59	2.59	1.99	27	3.35	0.67	13.46

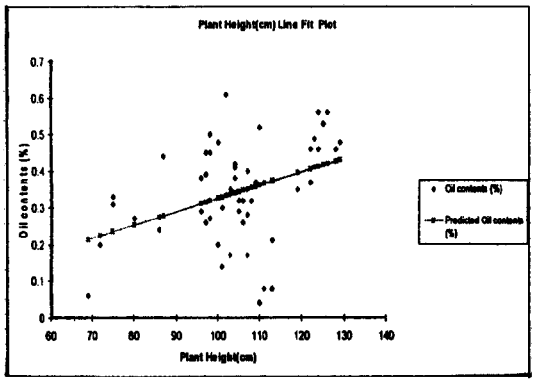


Fig. 1: The oil contents are highly dependent on plant height and correlation is significantly positive.

Regression equation is Oil content=0.031+0.00357 plant height (cm).
**highly significant at $p \leq 0.05$ with b = 0.00357 which indicates a good relationship between plant height and oil content.

[23]. The cluster-2 comprises 2 accessions showed methylchavicol and α-pipene as major constituents from 6.95 to 24.02 % and 9.15 to 30 % respectively (Fig. 2). The cluster 3 comprises of three accessions and was characterized by α-phellandrene, methyl-chavicol and *trans*-anethole as major constituents (33.31, 15.70, 38.78 %), (21.23, 24.5, 42.3 % and 18.0 %, 26 %, 29 %) for the accessions MP00296, MP00808 and MP01036 respectively. The results are also supported by [18, 24-26] who characterized some fennel species for seed oil and anethole content in sweet fennel [18]. The cluster-4 was represented by a single fennel type MP00483 that showed main compounds methylchavicol, limonene, fenchone and *p*-cymene 35.75 %, 3.1 %, 3.2 % and 1.15 % respectively (Fig. 3). Results similar to the present study were also demonstrated by different researchers [24, 25, 27]. The fifth cluster was formed by the fennel accession MP00318, which differed greatly

Table-2b: Chemical composition (%) of 50 different accessions of fennel.

Acessions	Ocimene	*Trans*-cousmine	Terpene	Fenchone	Camphore	*Trans*-anethole	*Trans*-carveol	Carvone	Ansidelhyde	α-Pheldrene
MP 00164	0.5	0.3	0.13	8.02	0.09	43.1	0	0.14	0	6.19
MP 00179	0.89	0.02	0.95	11.22	0.06	40.75	0	0.05	0	0.83
MP 00183	0.32	0.02	0.47	7.56	0.05	50.52	0	0.16	0	0.9
MP 00207	0.5	0.09	1.3	9.84	0.08	35.02	0.11	0.31	0	4
MP 00230	2.29	0.06	0.36	10.74	0.07	45.07	0	0.14	0	4.32
MP 00240	1.79	0	0.26	2.21	0.11	49.35	0	0	0	0.14
MP 00248	0.48	0	0.97	2.37	0.1	24	0	0.06	0	0.62
MP 00274	0.4	0.05	0.33	1.7	0.07	38.98	0	0.09	0	11.57
MP 00280	0.72	0.1	0.49	3.38	0	52.17	0.14	0.08	0.13	15.26
MP 00293	0.64	0.07	0.58	2.16	0.01	47.98	0.03	0.02	0.05	2.53
MP 00296	1.61	0	0.83	4.58	0.1	38.78	0.04	3.8	0.13	33.31
MP 00307	1.8	0.4	0.38	1.8	0.12	23.88	0.5	0.15	0.06	21
MP 00318	0.51	0.48	0.48	0.11	0.08	35	0	0.14	0	46.20
MP 00326	0.51	0.03	0.28	0.1	0.07	42	0	0.12	0	6
MP 00329	0.9	0.03	0.14	0.12	0.09	40	0	0.02	0	0.8
MP 00401	0.33	0.1	0.69	0.07	0.05	50	0	0.31	0	0.9
MP 00483	1.81	0.04	19.0	3.02	0.7	50	0	0.08	0	0.27
MP 00502	2.3	0.14	0.14	0.15	0.08	45	0.12	0	0	4
MP 00526	1.8	0.37	0.37	0	0.12	58.04	0	0.05	0	0.15
MP 00533	0.49	0.27	0.27	0.05	0.11	0.17	0	0.08	0.01	0.3
MP 00557	0.05	0.91	0.91	0.04	0.07	38.5	0	0.07	0	11
MP 00693	0.04	0.38	0.38	0	0	24.5	0	0.17	0	15
MP 00724	0.76	0.5	0.5	0.03	0.08	46.75	0.15	3.79	0	3
MP 00758	0.66	0.59	0.59	0.07	0.09	8.72	0.04	0.59	0	28
MP 00769	0.16	0.84	0.84	0	0.11	22.98	0.23	0.34	0	20
MP 00792	1.81	0.04	0.04	0.13	0	24.2	0.49	0.15	0	6.12
MP 00808	0.31	0.02	0.37	0.1	0.09	29.00	0.19	0.06	0	40.16
MP 00826	0.48	0.03	0.25	0.12	0.08	41	0	0.17	0.12	0.93
MP 00851	0.88	0.09	0.12	0.08	0.05	51	0.01	0.41	0.06	0.95
MP 00860	0.31	0.07	0.93	0.1	0.06	36	0	0.16	0.12	4.15
MP 00900	0.49	0	0.45	0.15	0.07	46	0.11	0	0.13	4.52
MP 00937	2.28	0	0.14	0	0.09	52	0	0.07	0.05	0.16
MP 00976	1.78	0.05	0.34	0.04	0	0.56	0	0.01	0.12	0.26
MP 00989	0.47	0.06	0.24	0.03	0	26.5	0.01	0.09	0	11.25
MP 00990	0.03	0.01	0.95	0	0.12	38.17	0	0.19	0	14.75
MP 01026	0.71	0.08	0.31	0.02	0.13	52.15	0.12	3.9	0	2.7
MP 01032	0.66	0	0.48	0.07	0.15	47.7	0.02	0.57	0	29
MP 01036	1.6	0.04	0.57	0.02	0.06	42.3	0.02	0.32	0	21.23
MP 01061	1.79	0.03	0.84	0	0.07	24	0.5	0.15	0	41.75
MP 01064	1.3	0.02	0.36	0.1	0.08	26	0.18	0.06	0	7.1
MP 01084	0.5	0.03	0.25	0.01	0.02	44	0	0.17	0.12	1
MP 01085	0.89	0.01	0.12	1.02	0.05	41	0	0.3	0.05	1
MP 0009	0.34	0.06	0.93	0.07	0.09	49	0	0.12	0.12	4.5
MP 0016	0.51	0	0.45	0.01	0.8	36	0.1	0	0.08	4.4
MP 0024	2.31	0	1.1	0.12	0.01	46	0	0.07	0.23	0.91
MP 0031	0.31	0.4	0.37	0.11	0.08	23.45	0.2	0.32	0.21	42
MP 0045	0.49	0.05	0.25	0.06	0	0.19	0	0.07	0	11.7
MP 0063	0.05	0.2	0.95	0.05	0.01	38.79	0	0.09	0	1.4
MP 0074	0.74	0.03	0.3	0	0.03	50.7	0	0.19	0	0.02

from the other ones because α-phellandrene (46.20 %) was dominant compound (Fig. 5). Based on the peculiarity of having one main compound, it can be supposed that accession MP00318 was relatively pure and probably less subjected to hybridization in the past by having the presence of high amounts of α-phellandrene (which confers an aromatic pungent note) and the lack of *trans*-anethole and methylchavicol (known for their sweet note). The fennel accession MP00318 may prove a good source of high production of α- phellandrene in aromatic processing industry. In other accessions the presence of considerable amounts of *trans*-anethole or methylchavicol or both along with relatively larger percentages of α-phellandrene, could suggest the hypothesis of a marked hybridizations by cross pollination.

In the oils from all accessions except MP00318, the simultaneous presence of terpenic and phenylpropanoid compounds suggests that two biosynthetic path ways occurred, while in this accession MP00318 the presence of only terpenic compounds evidenced that only one biosynthetic pathway was operating. In fact it is well known that *trans*-anethole and methylchavicol have a common biosynthesis originating from the same precursor (L-phenylalanine and cinnamic acid), where as terpenic compounds such as α-phellandrene and limonene follow an other biogenetic pathway from malonic acid via geranyl pyrophosphate [28]. The morphological characters and the yield did not seem to be influenced by the latitude of the original localities because it was not possible to evidence common characteristics in the accessions originated

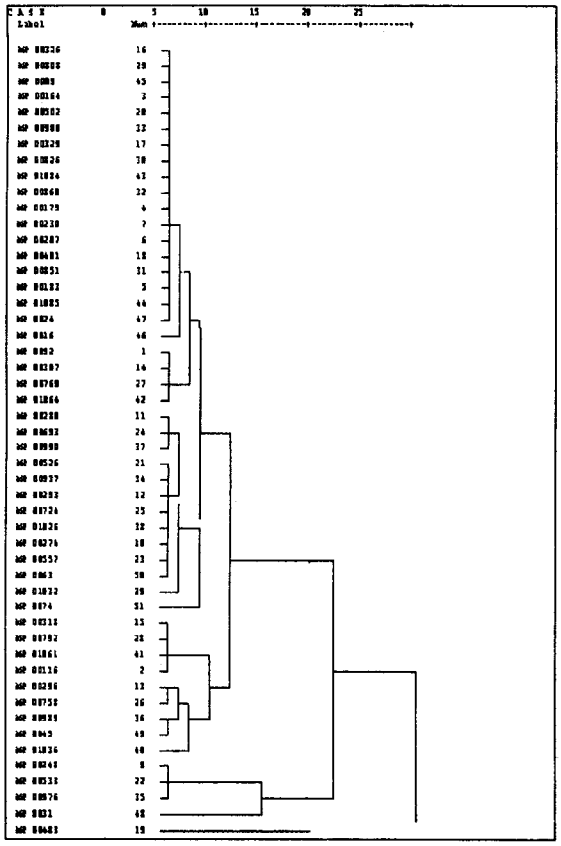
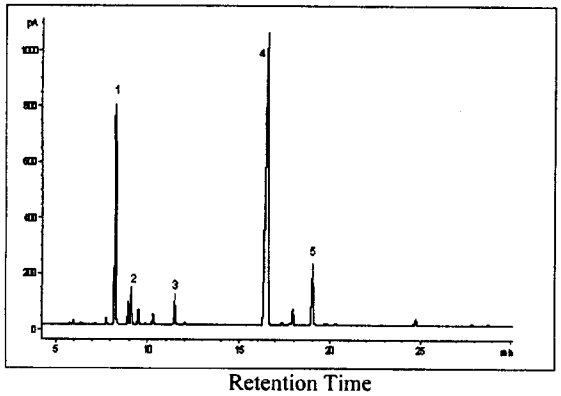


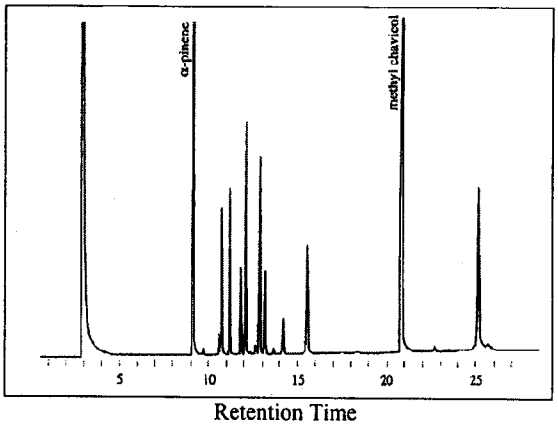
Fig. 2: A Dendrogram based on main groups of different size, determined mainly by the contents of their major components of oil of the 50 accessions of fennel.



Retention Time

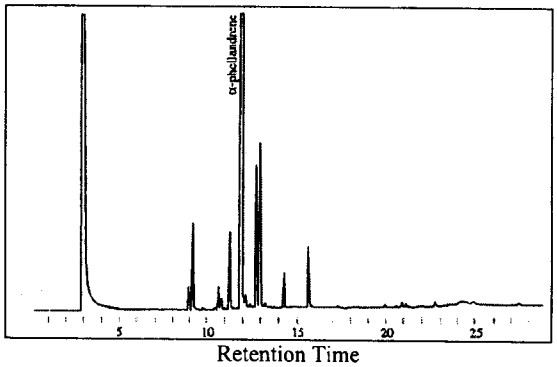
Fig. 3: GC profiles of fennel oils of accession MP00483.

1: α–pinene 33.1 %, 2: α-phellandrene 0.27 %, 3: limonene 3.10%, 4: *trans*-anethole50 %



Retention Time

Fig. 4: GC profiles of fennel oils of MP 00483 with α-pinene 33.1 % and methylchavicol 35.75%.



Retention Time

Fig. 5: GC profiles of a fennel accession MP00318 with highest level of α-phellandrene 46.20 %.

at similar latitude but the difference observed can also be attributed to genetic factors and to some extent to environmental conditions of the growing locality as was reported for other wild species [29].

Experimental

Germplasm of fifty indigenous accessions of fennel, collected from different parts of Pakistan were grown on the farm of Agri Biotechnology and Genetic Resources (IABGR), National Agriculture Research Centre, Islamabad (33.40 °N and 73.07 °E). The experiment was laid out in augmented design under field conditions during winter season of 2003-2004 and 2004-2005. Two rows of 4 m in length with 01 m row spacing were planted for each accession.

Recommended cultural practices were followed throughout the crop season. For plant characters and agronomic traits data were recorded according to (IBPGR Descriptors, 85). Ten plants were sampled at random to study intra accession variation for each accession. Each fennel accession was evaluated for the morphological characteristics and a representative sample obtained from each accession was employed for essential oil extraction and characterization.

a. Oil distillation

Five grams of seeds of randomly selected plants were steam distilled in Soxhlet's extraction apparatus. The oil dried over anhydrous Sodium sulphate that was kept in dark glass bottles at -20°C prior to analysis.

b. Oil analysis

The essential oils were analyzed by using a Pye unicon 04 chromatograph fitted with FID and spectra-physic, SP4100, computing integrator. The separation of compounds was obtained by injecting a 0.5 μ l oil sample in nitrogen fused silica column (30 x 0.2μml film thickness), operating from 60 to 260 °C and holding the initial temperature for10 min. The injection system was on column, the carrier gas was Helium at 1 ml/min and the detection temperature was 300 °C

The GC/MS analysis was performed by using a flame ionizer detector set at 70 *ev.* coupled with a gas chromatograph operating under the same conditions as discussed above. The identification of compounds were obtained by comparing the retention time of peaks with those of standard compounds by enhancement of peaks with pure substances and by matching the obtained MS spectra with those reported in FID (library) and in literature [30]. The quantitative data were exposed as relative percentage of the oil constituents calculated from GC peak areas using correlation factors and each oil sample was analyzed twice.

c. Clustering of samples

Samples were grouped by cluster analysis based on sum of square analysis of quantitative data of essential oils [31].

Conclusions

The samples from fifty local fennel accessions were clearly different in their oil contents and constituents, (Table-1) and the accessions varied significantly in their morphological traits and agronomic yields (Tables-2a, b) that reflects good magnitude of genetic diversity in the germplasm of the crop available in Pakistan and indicates its suitability for multi-dimensional industrial uses. The highest oil content (0.56 %) was detected in the MP 00483 accession with plant height (124 cm) that makes it suitable for cultivation to get higher oil production. However the accessions MP 00240, MP 00329 and MP 01084 showed higher level of methyl-chavicol (38 %) with lower amount of fenchone were regarded as sweeter genotypes possessed potential of anise cultivation for processing in confectionary use. The highest level of *trans*-anethole (58.04 %) was noted in MP00526 that was considered suitable for extraction of ansi flavoring compound at commercial scale. Similarly, the fennel accession MP00318 may prove a good source of high production of α-phellandrene for aromatic processing industry.

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