IV- Results and Discussion

A- Basil Oil

The basil oil samples in this study were obtained at four different stages of plant growth:

1- The first stage was before flowering.

2- The second one was start of flowering.

3- The third one was after 50 % flowering.

4- The fourth one was approximately 100 % seeding

Oil percentage at the different stages of plant growth was determined. Also, the physiochemical properties and the chemical composition of the four oil samples were determined.

1- Oil percentage

From Table (1) it could be noticed that, The oil percentages of basil plant were (0.06 %, 0.04 %, 0.20 % and 0.06%) at the four stages of plant growth respectively. The maximum value was at the third stage (after 50 % flowering). These results were in agreement with the results obtained by **Lemberkovics et al** (1996). They reported that, The sweet basil essential oil contained increased up to the full flowering stage.

2- The physical properties

a- Specific gravity

Data presented in Table (2) indicated that, the specific gravity at 15° C of the oil samples indicated obtained from the different stages of plant growth were ranged from 0.9181 to 0.9274 and these values were found to be with in the values recorded by **Guenther (1961a) and Karawya (1974)**.

b- Refractive index

The refractive index of the oil samples at 20^0 c was 1.4875, 1.4843, 1.4868 and 1.4881 at the four stages previously mentioned respectively. The lowest value was at start of flowering stage and the highest one was at approximately 100 % seeding stage. However, All this values appeared to be in accordance with the range obtained by **Nelson and Lowmon (1935), Guenther (1961a), Eid (1964), Ridy (1965), Kapetanovica (1968) and Gubta and Thopa (1971)**.

c- Optical rotation

Data of optical rotation tabulated in Table (2) showed that, the values varied from -4.02^0 for the oil sample at the stage after 50 % flowering to -13.82^0 for the

oil sample at the stage start of flowering. It could be observed that oil samples recorded high value of optical rotation during the stages of vegetative growth (before flowering) and before 50% flowering. On the other hand, the oil samples of basil plant recorded low values of optical rotation during the last two stages of plant growth. However, All the obtained values were found to be within the standard reported by **Schimmel and Co (1932), Khorana and Vongiker (1950), El-Zahwey (1978) and Gabr (1994)**.

d – Solubility

Data in Table (2) pointed out that, All oil samples produced from basil plant at the different stages under this study soluble in 75 % ethyl alcohol and this result was found to be similar to the result obtained by **Gabr (1994).**

It could be concluded that, The growth stage of basil plant greatly affected the oil characters (in term of oil percent and values of optical rotation) and slightly affected the specific gravity, Refractive index and solubility in alcohol.

3- Chemical properties

Oil samples of basil plant extracted at the four stages were analyzed for its chemical properties. i.e the acid number, ester number and ester number after acetylation were determined in the oil sample at the stages of before flowering, start of flowering, after 50 % flowering and approximately 100 % seeding respectively. The data were presented in Table (3).

a- Acid number

Data in Table (3) indicated that, The acid number values of basil plant essential oil at the four stages of growth previously mentioned were (6.171, 6.165, 5.049 and 5.049) respectively. It could be noticed that, No differences between two values of acid number of oil sample at the first two stages of basil plant growth. Also the same noticing was obtained in case of the oil samples at the last two stages of basil plant growth but the values were slightly lower than the values obtained at first two stages. However, All the values at the four stages were found to be within the range reported by **Gabr (1994)**.

b- Saponification Number

Data in Table (3) showed that, The saponification number of basil oil was (11.18, 15.36, 13.99 and 22.03) at

the four growth stages. It could be noticed that, The highest value was at the fourth growth stage (approximately 100 % seeding) where as the lowest one was at the first growth stage (before flowering) however, all the values of saponification number were found to be in accordance with the values reported by **Handa et al (1955), Guenther (1961b), Eid (1964), Kapstanovica (1968) and Gabr (1994)**.

c- Ester number

Data in Table (3) showed that, Ester number of the basil plant oil samples at the four stages of plant growth were (5.01, 9.20, 8.95 and 16.99) respectively. It could be observed that, The value of ester number was low for the oil sample at the first stage of basil plant growth (vegetative growth stage) and it reached maximum value at the fourth stage (approximately 100 % seeding). i.e the oil at this stage contains high amount of ester compounds in comparison with amount of the same compounds at the first three stages. However, All the values were found to be within the standard range, which mentioned by **Guenther (1961b) and Gupta and Thopa (1971)**.

c- Ester number after acetylation

Data of ester number after acetylation recorded in Table (3) showed that, The values were 131.80, 146.52, 142.96 and 144.38 in case of the oil samples isolated from the basil plant at the stages from (1 - 4) respectively. It could be noticed that, Ester number after acetylation which is expressed about amount of alcohol that the oil contains was at the highest value in case of the oil sample obtained start of flowering while the lowest value was in case the oil produced at the vegetative growth (before flowering). However, All the values previously mentioned were found to be within the range recorded by **Guenther (1961b), El-Zahwey (1978) and Gabr (1994)**.

In general it could be concluded that, The chemical properties of basil oil were influenced by growth stage especially ester number and ester number after acetylation.

Table (1) Oil percent of white basil plant at different growth stages

Samples of white basil	Oil percent
Before flowering	0.06 %
Start of flowering	0.04 %
After 50% flowering	0.20 %
Approximately 100% seeding	0.06 %

Table (2) The physical properties of white basil plant oil at different growth stages

Properties / Samples	Specific gravity At 15° c	Refractive index At 20° c	Optical rotation	Solubility
Before flowering	0.9274	1.4875	-8.22	Soluble in 1.28 (1.28 – 10) 75% alcohol
Start of flowering	0.9181	1.4843	-13.82	(1.52 – 10) 75% alcohol
After 50% flowering	0.9229	1.4868	-4.02	(1.70 – 10) 75% alcohol
Approximately 100% seeding	0.9259	1.4881	-5.02	(1.56 – 10) 75% alcohol

Table (3) The chemical properties of white basil plant oil at different growth stages

Properties / Samples	Acid number	Saponification number	Ester number	Ester number After acetylation
Before flowering	6.171	11.18	5.01	131.80
Start of flowering	6.165	15.36	9.20	146.52
After 50% flowering	5.049	13.99	8.95	142.96
Approximately 100% seeding	5.049	22.03	16.99	144.38

4- Gas liquid chromatographic analysis of sweet basil oil samples

This experiment was carried out to separate and identify the main components of basil oil obtained at four stages (before flowering, start of flowering, after 50 % flowering and approximately 100 % seeding) the gas chromatographic technique was used.

The gas chromatograms of basil oil samples distilled before flowering stage, start of flowering, after 50 % flowering and approximately 100 % seeding were shown in figures (1), (2), (3) and (4) respectively.

The gas chromatograms showed 32 peaks for all samples, by gas chromatographic analysis 12 of this peaks were identified. These identified components represented 86.75 % of the total components of the oil samples. The identified components of the oil samples maybe classified into five categories namely (hydrocarbons, alcohol, oxides, esters, aldehydes and ketones). All of these components showed from Table (4) to Table (7).

The hydrocarbons are namely (α pinene, β pinene, myrcene and limonene). These components represented the peaks shown from Table (4) to Table (7).

The identified alcohol represented the linalool, borneol, geraniol and eugenol. Linalool was the main alcohol identified in the oil sample obtained (before flowering stage, start of flowering stage, after 50 % flowering and approximately 100 % seeding) which amounted as 50.74 %, 55.37 %, 49.46 % and 52.19 % respectively.

Moreover, the eugenol was the second main alcohol component which reached 20.55 %, 19.35 %, 21.16 % and 20.62% for the oil distilled (before flowering stage, start of flowering stage, after 50 % flowering and approximately 100 % seeding) respectively. It could observed that, The largest value of linalool was at the stage of start of flowering (55.37 %) and decreased to (49.36 %) at the stage of after 50 % flowering. This result was found to be in agreement with the result obtained by **Lemberkovics (1996).**

The oxide component namely cineol and the ester namely methyl chavicol, this component represented the peaks shown from Table (4) to Table (7).

The identified aldehyde namely citral and ketone namely carvon. These results were agreement with the result obtained by **El-Leithy (1983), Awaad (1987) and Gabr (1994)**.

It could be revealed that, The time after 50 % flowering was the suitable time to isolate the basil oil from the plant comparatively with the time before flowering stage, start of flowering stage and approximately 100 % seeding due to the higher oil percentage and higher content of linalool and good quality of the oil samples.

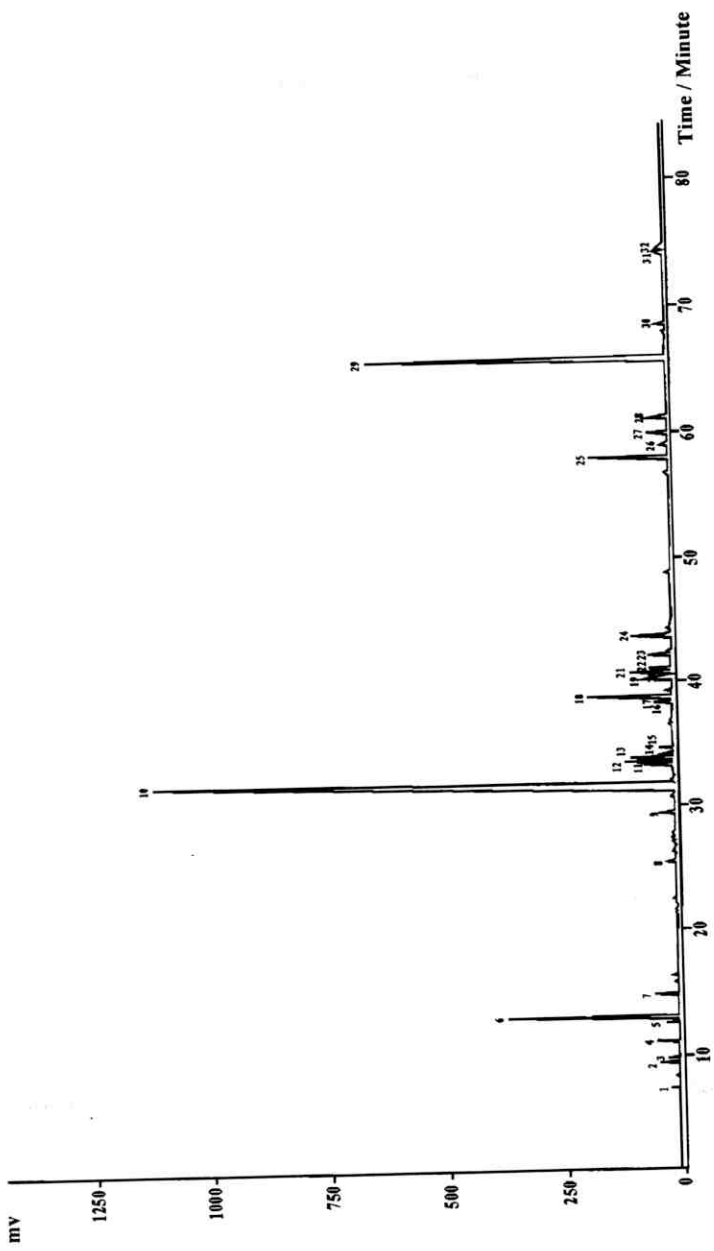

Fig. (1) Gas Chromatogram of Basil Oil Distilled before Flowering

Table (4) The Chemical Composition of White Basil Oil Distilled before Flowering

Component	Peak	Rt	Height	Area	Amount	% Area (Norm)	Pwm H
Unknown	1	7.282	10.828	42.981	0.1058	0.209	3.60
α Pinene	2	9.386	30.324	130.122	0.3203	0.631	4.02
β Pinene	3	9.750	14.665	62.331	0.1534	0.302	3.87
Myrcene	4	11.069	38.520	177.281	0.4364	0.860	4.26
Limonene	5	12.514	15.618	83.134	0.2046	0.403	5.02
Cineol	6	12.961	356.257	2257.785	5.5583	10.954	6.06
Unknown	7	14.743	42.146	213.881	0.5265	1.038	4.79
Unknown	8	25.351	9.442	55.615	0.1369	0.270	5.62
Unknown	9	29.395	18.542	151.418	0.3727	0.735	7.77
Linalool	10	31.721	1096.003	20611.529	50.7427	100.000	18.36
Unknown	11	33.316	50.322	352.267	0.8672	1.709	7.51
Unknown	12	33.511	94.769	757.624	1.8651	3.676	7.94
Unknown	13	33.814	84.653	575.672	1.4172	2.793	6.44
Unknown	14	34.158	9.415	62.554	0.1540	0.303	6.36
Unknown	15	34.546	26.597	179.994	0.4431	0.873	6.38
Unknown	16	38.296	29.141	257.129	0.6330	1.248	9.71
Unknown	17	38.407	19.782	103.665	0.2552	0.503	5.27
Methyl Chavicol	18	38.765	169.864	1357.124	3.3410	6.584	7.61
Unknown	19	40.162	51.193	422.240	1.0394	2.049	6.53
Unknown	20	40.316	9.635	49.817	0.1226	0.242	5.30
Citral	21	40.681	78.026	641.143	1.5784	3.111	7.85
Unknown	22	40.995	34.868	238.819	0.5879	1.159	6.59
Borneol	23	42.065	38.171	269.988	0.6646	1.310	6.84
Unknown	24	43.594	73.788	752.549	1.8526	3.651	8.42
Carvon	25	57.874	156.850	1231.858	3.0326	5.977	7.41
Unknown	26	58.942	10.717	85.931	0.2115	0.417	7.20
Unknown	27	59.864	37.694	283.002	0.6967	1.373	7.16
Geraniol	28	61.120	33.867	271.452	0.6682	1.317	7.38
Eugenol	29	65.716	624.928	8351.081	20.5592	40.517	13.74
Unknown	30	68.441	10.975	128.954	0.3174	0.626	10.46
Unknown	31	74.143	10.607	236.109	0.5812	1.146	16.99
Unknown	32	74.335	9.954	242.633	0.5530	1.090	21.74

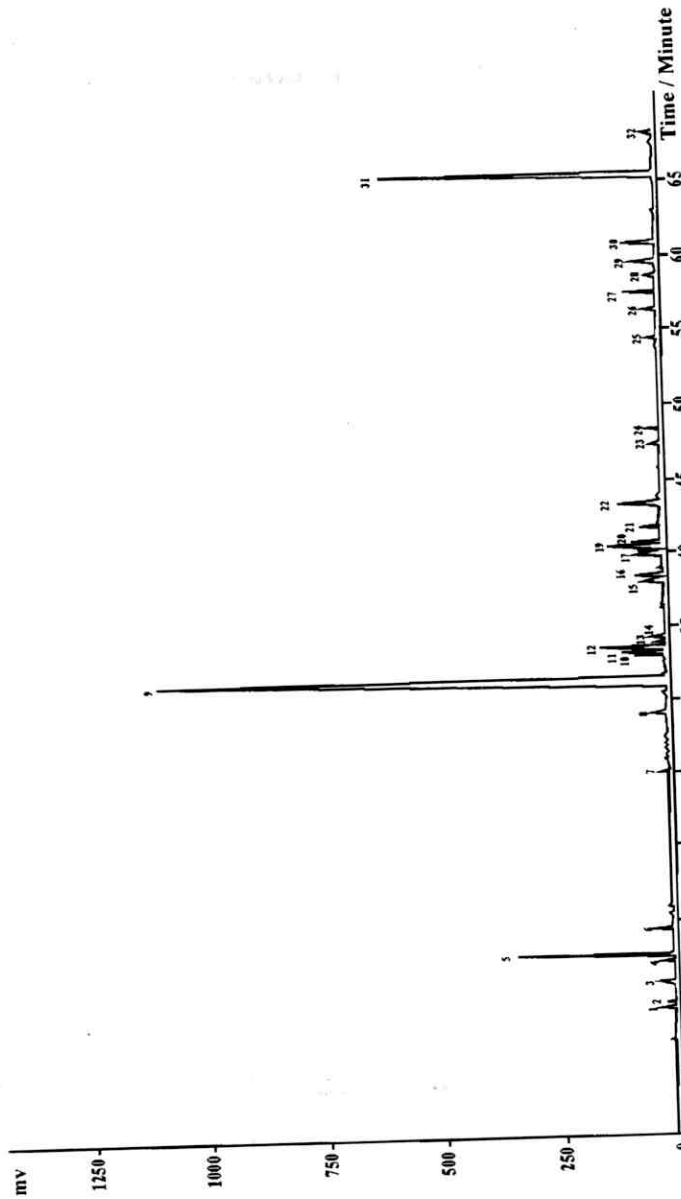

Fig. (2) Gas Chromatogram of Basil Oil Distilled start of Flowering

Table (5) The Chemical Composition of White Basil Oil Distilled start of flowering

Component	Peak	Rt	Height	Area	Amount	% Area (Norm)	Pwm H
α Pinene	1	9.436	21.999	98.536	0.234	0.422	4.15
β Pinene	2	9.802	10.571	46.864	0.111	0.201	4.11
Myrcene	3	11.130	25.080	123.642	0.294	0.530	4.46
Limonene	4	12.579	13.257	74.529	0.177	0.320	5.22
Cineol	5	13.021	332.113	2017.726	4.791	8.650	5.68
Unknown	6	14.814	31.773	161.444	0.383	0.692	4.92
Unknown	7	25.444	10.882	66.152	0.157	0.284	5.83
Unknown	8	29.502	22.694	199.562	0.474	0.856	8.40
Linalool	9	31.836	1096.653	23325.062	55.379	100.000	20.48
Unknown	10	33.438	54.063	356.569	0.847	1.529	7.21
Unknown	11	33.638	84.654	691.372	1.641	2.964	8.46
Unknown	12	33.961	132.224	965.732	2.293	4.140	6.89
Unknown	13	34.286	10.624	69.061	0.164	0.296	6.29
Unknown	14	34.654	23.848	161.297	0.383	0.692	6.32
Unknown	15	38.408	34.342	420.928	0.999	1.805	13.18
Methyl Chavicol	16	38.811	54.319	410.003	0.973	1.758	7.27
Unknown	17	40.270	48.404	419.486	0.996	1.798	6.87
Unknown	18	40.423	9.307	44.139	0.105	0.189	5.08
Citral	19	40.822	105.366	927.521	2.202	3.977	8.34
Unknown	20	41.127	54.404	390.704	0.928	1.675	6.81
Borneol	21	42.170	33.419	239.034	0.568	1.025	6.90
Unknown	22	43.725	84.470	901.413	2.140	3.865	8.80
Unknown	23	47.740	8.123	60.521	0.144	0.259	7.02
Unknown	24	48.756	13.770	94.158	0.224	0.404	6.57
Unknown	25	54.868	8.774	65.044	0.154	0.279	7.08
Unknown	26	56.800	16.457	123.693	0.294	0.530	7.18
Carvon	27	57.931	59.109	436.605	1.037	1.872	7.03
Unknown	28	59.047	13.970	105.581	0.251	0.453	6.92
Unknown	29	59.967	42.209	324.281	0.770	1.390	7.31
Geraniol	30	61.238	62.432	498.091	1.183	2.135	7.43
Eugenol	31	65.820	583.028	8153.709	19.359	34.957	14.49
Unknown	32	68.550	12.637	146.325	0.347	0.627	10.60

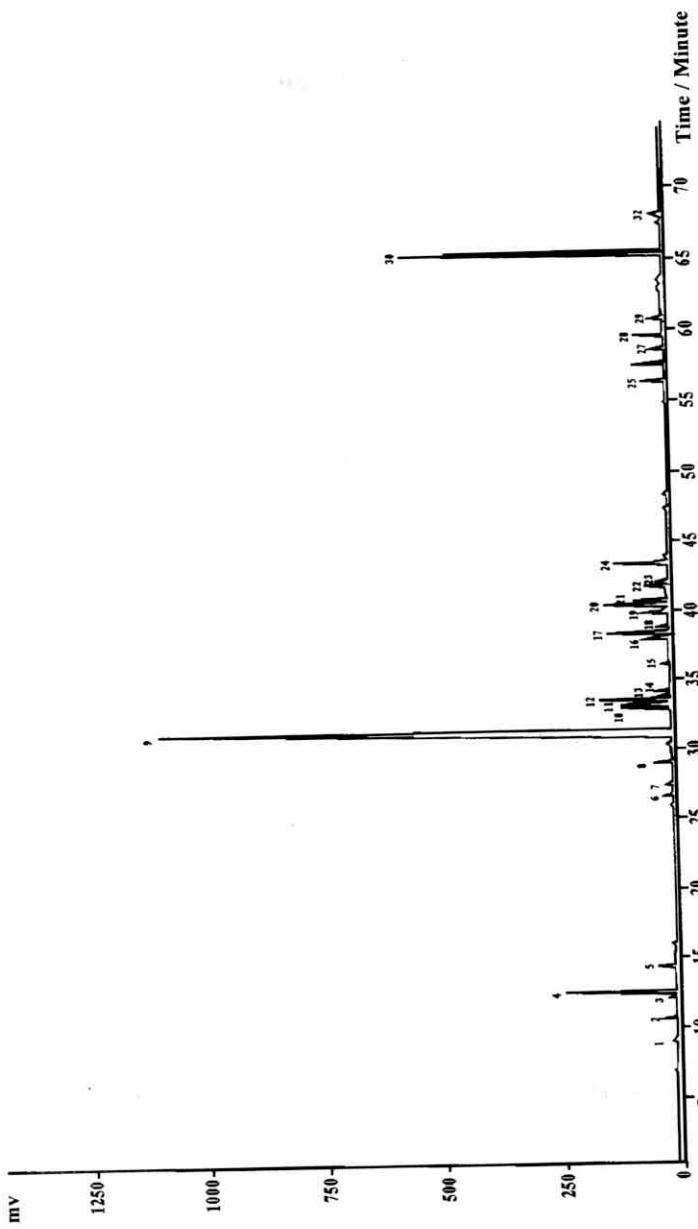

Fig. (3) Gas Chromatogram of Basil Oil Distilled after 50% Flowering

Table (6) The Chemical Composition of White Basil Oil Distilled After 50 % Flowering

Component	Peak	Rt	Height	Area	Amount	% Area (Norm)	Pwm H
α Pinene	1	9.316	12.497	52.364	0.134	0.272	4.05
Myrcene	2	10.990	16.862	75.196	0.193	0.391	4.31
Limonene	3	12.431	10.939	56.363	0.145	0.293	4.89
Cineol	4	12.847	231.828	1276.396	3.278	6.641	5.25
Unknown	5	14.661	29.140	148.612	0.382	0.773	4.82
Unknown	6	26.915	8.810	61.600	0.158	0.321	6.73
Unknown	7	27.719	8.593	92.453	0.237	0.481	10.48
Unknown	8	29.354	32.377	264.831	0.680	1.378	7.81
Linalool	9	31.669	1089.817	19219.314	49.362	100.000	17.27
Unknown	10	33.297	90.100	656.846	1.687	3.418	6.83
Unknown	11	33.509	94.588	794.618	2.041	4.134	8.78
Unknown	12	33.826	143.770	1056.896	2.715	5.499	6.98
Unknown	13	34.142	12.082	79.651	0.205	0.414	6.38
Unknown	14	34.515	16.982	132.159	0.339	0.688	6.69
Unknown	15	36.472	8.765	58.604	0.151	0.305	6.42
Unknown	16	38.298	41.280	499.198	1.282	2.597	13.11
Methyl Chavicol	17	38.728	123.121	911.932	2.342	4.745	6.96
Unknown	18	39.154	8.704	78.063	0.201	0.406	6.77
Unknown	19	40.163	39.165	377.288	0.969	1.963	7.10
Citral	20	40.728	126.870	1220.770	3.135	6.352	9.18
Unknown	21	41.030	67.262	505.003	1.297	2.628	7.08
Borneol	22	42.066	35.275	244.079	0.627	1.270	6.74
Unknown	23	42.313	13.441	104.103	0.267	0.542	7.63
Unknown	24	43.660	105.732	1.179.312	3.029	6.136	9.06
Unknown	25	56.738	40.166	308.098	0.791	1.603	7.28
Carvon	26	57.858	59.866	451.626	1.160	2.350	7.00
Unknown	27	58.968	14.100	121.947	0.313	0.634	7.74
Unknown	28	59.899	52.818	403.464	1.036	2.099	7.27
Geraniol	29	61.145	12.917	97.363	0.250	0.507	7.09
Eugenol	30	65.739	547.198	5934.783	15.243	30.897	11.01
	31	65.856	450.808	2307.189	5.926	12.005	5.25
Unknown	32	68.477	15.588	164.987	0.424	0.858	10.37

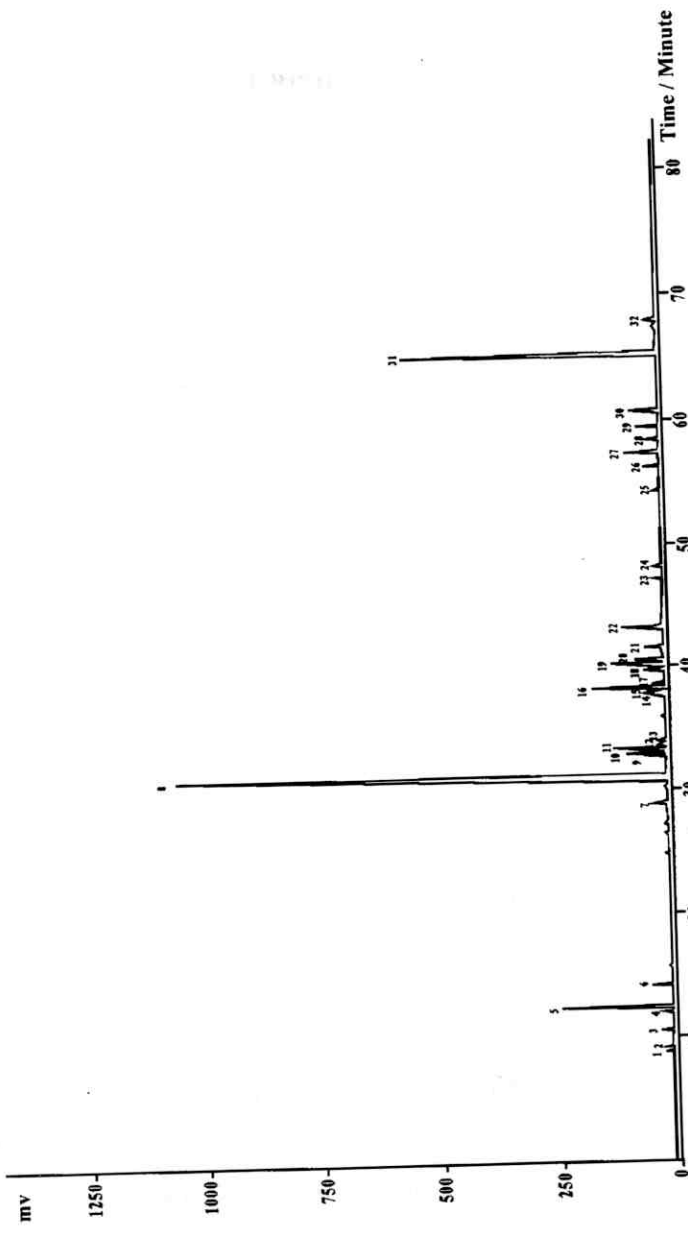

Fig. (4) Gas Chromatogram of Basil Oil Distilled approximately 100% Flowering

Table (7) The Chemical Composition of White Basil Oil Distilled Approximately 100 % Seeding

Component	Peak	Rt	Height	Area	Amount	% Area (Norm)	Pwm H
α Pinene	1	9.420	14.747	61.442	0.167	0.320	3.98
β Pinene	2	9.785	7.638	30.574	0.083	0.159	3.75
Myrcene	3	11.112	16.207	72.146	0.196	0.376	4.29
Limonene	4	12.555	9.469	47.864	0.130	0.249	4.73
Cineol	5	12.981	234.367	1308.371	3.555	6.811	5.33
Unknown	6	14.797	36.600	181.015	0.492	0.942	4.80
Unknown	7	29.496	19.172	150.814	0.410	0.785	7.51
Linalool	8	31.805	1082.776	19210.398	52.196	100.000	17.10
Unknown	9	33.412	39.980	286.489	0.778	1.491	7.64
Unknown	10	33.619	78.303	653.098	1.775	3.400	8.29
Unknown	11	33.941	116.992	860.753	2.339	4.481	7.02
Unknown	12	34.268	9.330	60.525	0.164	0.315	6.36
Unknown	13	34.647	12.748	96.352	0.262	0.502	6.48
Unknown	14	38.429	32.772	292.493	0.795	1.523	9.77
Unknown	15	38.521	21.772	102.464	0.278	0.533	4.69
Methyl Chavicol	16	38.875	151.923	1117.911	3.037	5.819	6.90
Unknown	17	39.281	7.523	48.172	0.131	0.251	6.22
Unknown	18	40.284	34.553	336.578	0.915	1.852	7.08
Citral	19	40.838	105.546	950.455	2.582	4.948	8.57
Unknown	20	41.142	55.506	403.142	1.095	2.099	6.91
Borneol	21	42.188	29.905	214.068	0.582	1.114	6.90
Unknown	22	43.756	79.365	890.566	2.420	4.636	8.93
Unknown	23	47.771	6.265	45.642	0.124	0.238	6.86
Unknown	24	48.786	9.667	67.365	0.183	0.351	6.74
Unknown	25	54.907	7.734	57.766	0.157	0.301	7.09
Unknown	26	56.846	22.656	169.943	0.462	0.885	7.17
Carvon	27	57.975	67.462	502.427	1.365	2.615	7.05
Unknown	28	59.084	13.276	109.301	0.297	0.569	7.26
Unknown	29	60.011	40.647	309.786	0.842	1.613	7.31
Geraniol	30	61.279	54.015	427.957	1.163	2.228	7.41
Eugenol	31	65.864	540.791	7592.134	20.628	39.521	14.36
Unknown	32	68.596	12.679	146.497	0.398	0.763	10.64

B- Cardamom Oil

The samples used in this work were obtained from whole fruits, seeds and coats of the fruits of cardamom. The oil percent was determined and the oil samples were analyzed for their specific gravity, refractive index, optical rotation, solubility, acid number, ester number and ester number after acetylation.

1- Oil percentage

The volatile oil percent in the different parts of fruit were 3.2 %, 5.52 % and 0.5 % in the whole fruits, seeds and coats respectively. Data in table (8) showed that the oil percent in the seeds was higher than the oil in the whole fruits and the coats. Such observation agrees with that previously reported by **Az Alden (1961), Badei (1991a) and Al Degoy (1996)**.

2- The physical properties

a- Specific gravity

From Table (9) it could be concluded that the specific gravity of the cardamom oil isolated from whole fruits, seeds and the coats were 0.9312, 0.9353 and 0.9254 respectively. It could be observed that the specific gravity of the oil samples are within the normal range particularly those reported by **Masada (1960) and Afnor et al (1982)**.

b- Refractive index

The refractive index at 20° C was 1.4671, 1.4683 and 1.4685 from the oil samples obtained from whole fruits, seeds and coats respectively. The refractive index

of the oil sample obtained from the coats was slightly higher than that obtained from seeds and the whole fruits. These results were found to be in agreement with those reported by **Sri Lanka (1978), Afnor et al (1982) and Parry (1945)**.

The specific gravity and the refractive index could hardly be considered true constants to identify or characterize this type of essential oil since the value representing each property is influenced by environmental factors, agricultural treatments and the industrial processes employed to isolate the oil. In fact, most of the various constituents of the oil are quite close in their specific gravity and refractive index and subsequently. It is expected that the natural mixture should give practically a similar value or arrange of values within the limits of the values of the constituents. However, if the ratio of the constituents of the oil differs or become disturbed due to the industrial processes employed to the isolate the oil, the change in such properties would be small and unreliable. However, only structural changes due to certain chemical reactions could eventually lead to marked differences in the specific gravity and the refractive index especially when the new compound are structurally different from the original material.

c- Optical rotation

The specific optical rotation of cardamom oil samples was determined at room temperature. The results were tabulated in Table (9). The specific optical rotation

of the samples obtained from the whole fruits, seeds and the coats were +23.07°, +32.51° and +28.97° respectively. The specific optical rotation of the oil samples isolated from the seeds was greatly higher in comparison with the other samples. These results were found to be in agreement with those mentioned by **Guenther (1952), Afnor et al (1982) and Barakat (1999)**.

d- Solubility

The essential cardamom oil produced from the different parts of fruits did not dissolves in 70 % and 75% ethanol. Therefore, the solubility was once more tried in 80 % ethanol. The oil sample produced from the whole fruits dissolved in 1.2 volumes of 80 % alcohol and more up to 10 volumes. The oil sample obtained from the seeds also dissolved in 1.2 volumes of 80 % alcohol and more up to 10 volumes and the oil sample obtained from the coats of the fruits soluble in 1.3 volumes of 80 % alcohol and more up to 10 volumes. In general, oils rich in oxygenated constituents are more readily soluble in dilute alcohol than oils rich in trepenes. It is interesting to note that these values are in agreement with those reported by **Parry (1945).**

3- Chemical properties

a- Acid number

The acid number of cardamom oil samples under investigation were 2.01, 2.01 and 2.5 for the oil samples obtained from the whole fruits, the seeds and the coats of fruits respectively. This properly can hardly be given much attention since it depends on the environmental conditions and the methods of isolation of such oil. The acid number of the oil sample obtained from the coats of fruits was slightly higher than that the seeds. These values fell within the range of the reference values, **Az Alden (1961).**

b- Saponification number

From Table (10) it could be concluded that the saponification number of cardamom oil samples under investigation were 95.86, 117.49 and 116.04 obtained from the whole fruits, seeds and the coats of fruits respectively. The saponification number produced from the seeds of cardamom fruits was higher than that produced from the coats of fruits and greatly higher than that produced from the whole fruits.

c- Ester number

The ester number of the oil sample obtained from the whole fruits was 93.85, 115.48 from the oil sample obtained from the seeds and 113.53 from the oil sample obtained from the coats of fruits and the results were

tabulated in Table (10). It could be noticed that the ester number of the oil sample obtained from the seeds was greatly higher than the obtained from the whole fruits and slightly higher from the oil sample obtained from the coats of fruits due to the presence of ester more than that in the other samples. These results were found to be in agreement with those mentioned by **Guenther (1952) and Afnor et al (1982)**.

d- Ester number after acetylation

From the data presented in Table (10) it could be noticed that the ester number after acetylation was 94.77 for the oil sample isolated from the whole fruits of cardamom, 83.75 from the seeds and 148.12 for the oil sample isolated from the coats of fruits. The ester number after acetylation of the oil sample isolated from the coats was the highest one due to the presence of alcohol more than that in the oil samples isolated from the whole fruits and the coats.

Table (8) Cardamom essential oil from the different parts of the fruits

Samples of cardamom	Oil percent
Whole fruits	3.2 %
Seeds	5.52 %
Coats of fruits	0.5 %

Table (9) The physical properties of cardamom oil samples from the different parts of the fruits

Properties / Samples	Specific gravity At 15° c	Refractive index At 15° c	Optical rotation	Solubility
Whole fruits	0.9312	1.4671	+ 23.07°	Soluble in 1.2 vol. of 80 % alcohol
Seeds	0.9353	1.4683	+ 32.51°	Soluble in 1.2 vol. of 80 % alcohol
Coats of fruits	0.9254	1.4685	+ 28.97°	Soluble in 1.3 vol. of 80 % alcohol

Table (10) The chemical properties of cardamom oil samples from the different parts of the fruits

Properties / Samples	Acid number	Saponification number	Ester number	Ester number After acetylation
Whole fruits	2.01	95.86	93.85	94.77
Seeds	2.01	117.49	115.48	83.75
Coats of fruits	2.51	116.04	113.53	148.12

5- Gas liquid chromatographic analysis of cardamom oil samples (G.L.C.)

The gas chromatograms of the cardamom oil samples obtained from the whole fruits, seeds and the coats are shown in Figures (5, 6, and 7) and tabled in Tables (11, 12 and 13) respectively.

The gas chromatograms of the cardamom oil samples obtained from the whole fruits and the seeds showed 14 peaks while the oil sample obtained from the coats showed 15 peaks. By gas chromatographic analysis 7 peaks where identified from the whole fruits and the seeds while 9 peaks were identified from the oil samples obtained from the coats. The identified components of the different oil samples could be classified into four categories, namely (alcohol, esters, hydrocarbons and oxides).

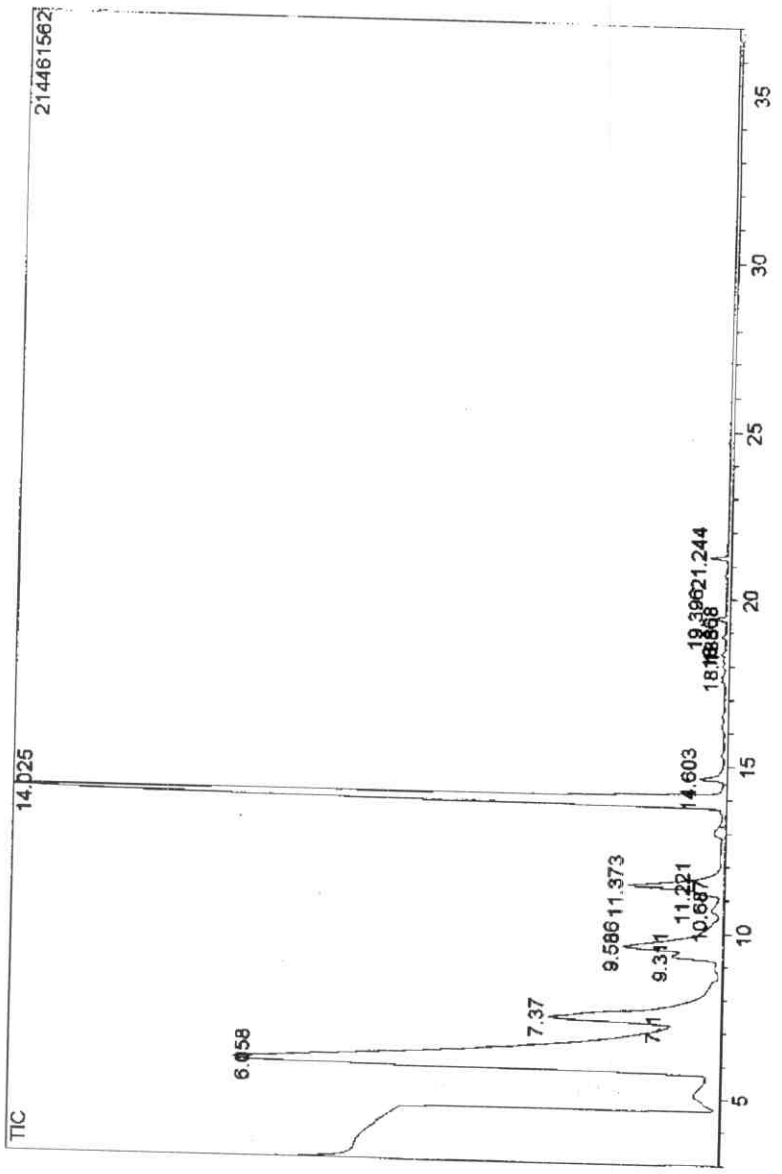

Figure (5) Gas Chromatogram of the Cardamom Oil obtained from the whole Fruits

Table (11) The Chemical Composition of Cardamom Oil obtained from whole Fruits

Component	Peak No.	R. Time	% Total Name
α Ternbinol Acetate	1	6.05	54.21
Unknown	2	7.092	0.00
Linalool	3	7.37	11.52
Limenene	4	9.31	1.63
Menthol	5	9.58	5.18
Unknown	6	10.68	0.15
Unknown	7	11.22	0.55
Geraniol	8	11.37	3.81
1.8 Cineol	9	14.025	21.96
Geranyl Acetate	10	14.60	0.45
Unknown	11	18.18	0.02
Unknown	12	18.86	0.06
Unknown	13	19.39	0.25
Unknown	14	21.24	0.21

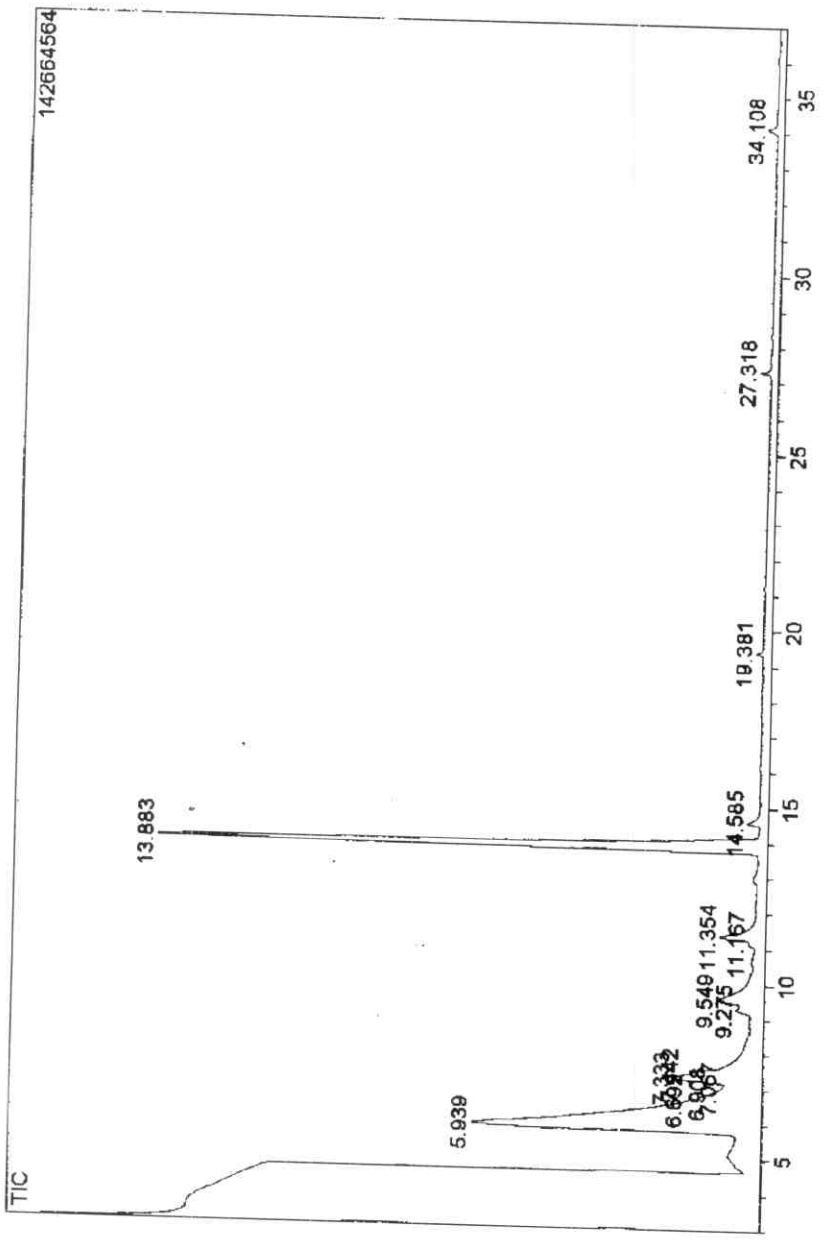

Figure (6) Gas Chromatogram of the Cardamom Oil obtained Seeds

Table (12) The Chemical Composition of Cardamom Oil obtained from Seeds

Component	Peak No.	R. Time	% Total Name
α Ternbinol Acetate	1	6.35	57.32
Linalool	2	7.39	13.82
Limenene	3	9.32	2.11
Menthol	4	9.59	7.86
Unknown	5	10.41	0.37
Unknown	6	10.65	0.23
Unknown	7	11.20	1.11
Geraniol	8	11.38	6.49
Unknown	9	13.00	0.48
1.8 Cineol	10	14.17	19.83
Geranyl Acetate	11	14.63	1.15
Unknown	12	19.40	0.85
Unknown	13	21.24	0.08
Unknown	14	24.71	0.09

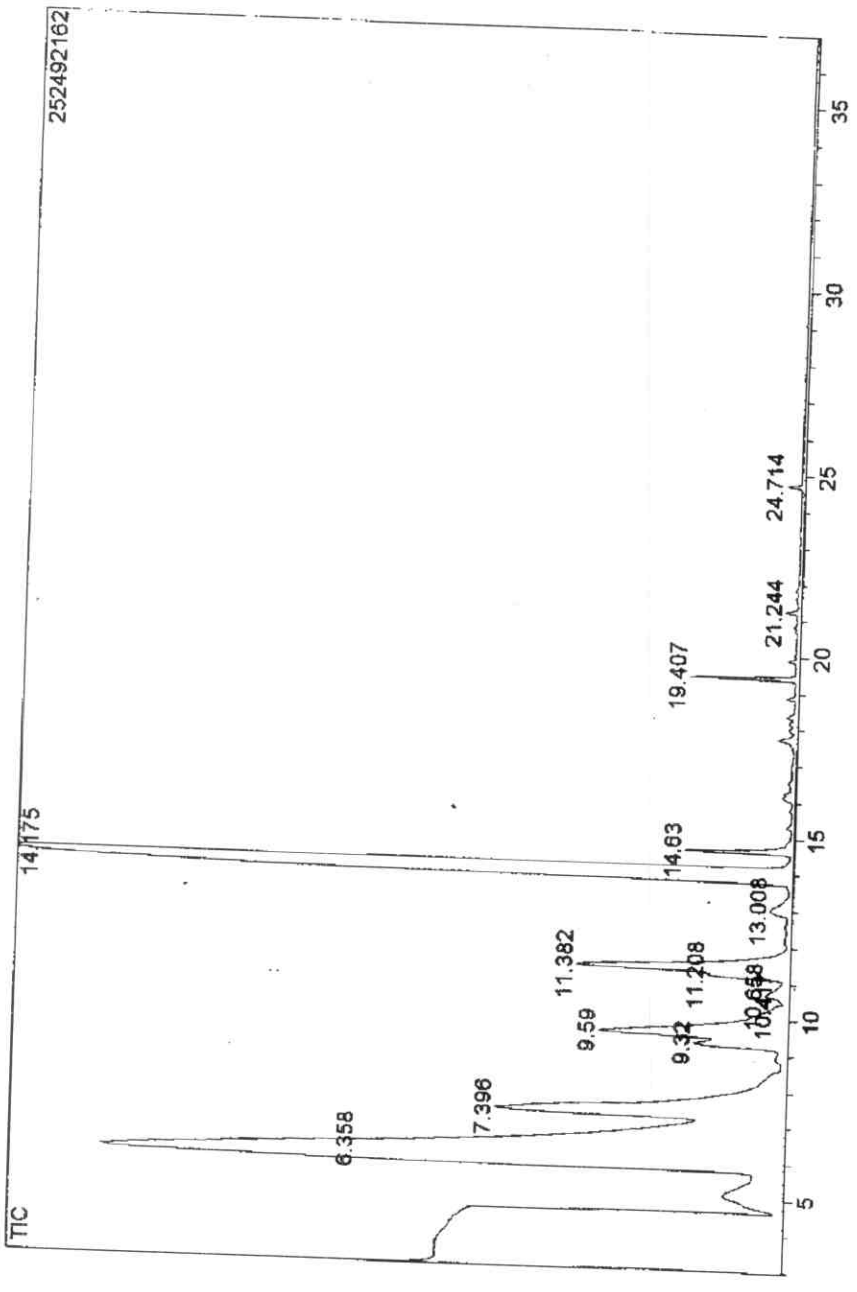

Figure (7) Gas Chromatogram of the Cardamom Oil obtained from the Coats of Fruits

Table (13) The Chemical Composition of Cardamom Oil obtained from Coats of Fruits

Component	Peak No.	R. Time	% Total Name
α Ternbinol Acetate	1	5.93	47.48
Eucalyptol	2	6.69	2.48
Menthane	3	6.90	0.80
Unknown	4	7.06	0.28
Linalool	5	7.33	4.23
Unknown	6	7.44	2.76
Limonene	7	9.27	0.72
Menthol	8	9.54	1.79
Unknown	9	11.16	0.20
Geraniol	10	11.35	1.95
1.8 Cineol	11	13.88	36.33
Geranyl Acetate	12	14.58	0.40
Unknown	13	19.38	0.17
Unknown	14	27.31	0.19

The identified alcohol represented the linalool, menthol and giraniol. Linalool was the main alcohol in the oil samples its contents were 11.52 % , 13.87 % and 4.23 % of the oil samples obtained from the whole fruits, seeds and coats respectively, while menthol and giraniol amounted 5.18 % and 3.81 % of the oil sample obtained from the whole fruits, 7.86 % and 6.49 % of the oil sample obtained from the seeds and 1.79 % and 1.95 % of the oil sample obtained from the coats respectively addition to data which amounted to 2.48 %, 1.8 cineol was the oxide component identified in the oil samples distilled from the whole fruits, seeds and coats, its contained were 21.96 % , 19.63 % and 36.33% respectively.

α terbinyl acetat was identified in the oil samples from the whole fruits, seeds and the coats, which amounted 54.21 % , 57.32 % and 47.46 % respectively while the geraniol acetate were 0.45 % , 1.15 % and 0.40% respectively.

These reports were in agreement with these reported (in the literature) by Rajapakse et al (1979), Adel Z. M. et al (1990) and Badei et al (1991).

It could be generally concluded that the oil sample obtained from the whole fruits was the highest quality due to the largest amount of the esters than that distilled from the seeds and coats while the oil sample obtained from the seeds was the highest quantity than that obtained from the whole fruits and coats.