Turkish Rose Oil*

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The strong and pleasant fragrance attributed to roses has been known to mankind from ancient times. Reference is made in old Chinese and Sanskrit texts to rose fragrance. It is widely believed that the so-called "Rose Oil" mentioned in these ancient texts was prepared by macerating fresh rose flowers in a liquid fixed oil. This technique is still practiced in India as "Attar" manufacture.

According to Hippocrate during the 4th century B.C. "Rosaceum oleum" (Rose oil) was prepared in Anatolia by macerating fresh roses in olive oil. A similar description of rose oil manufacture was given by Dioscorides (who lived in the lst century A.D.). To the best of my knowledge these are the earliest reports of rose cultivation and its use in Turkey.[1,2]

History of Rose Oil Industry

Ibni Haldun mentioned the production and use of rose oil and rose water for the first time in his books. He reported that the best quality rose oil was obtained by distillation. The distillate waters were used as rose water which was traded to India and China as an important commodity in the 8th and 9th centuries.[3,4]

Although no definite information exists, in my estimation the production of rose oil by distillation probably originated in Iran. By the 17th century, rose cultivation had spread from Iran to India, northern Africa and Turkey.

Katip Çelebi mentioned in his work that, in the early 17th century, cultivation of roses existed around Edirne in Thrace (the European portion of Turkey) and rose water was manufactured.[1] By the mid 17th century, Evliya Çelebi had detected 300 shops selling rose water in Istanbul.[5]

Towards the end of the 17th century, rose cultivation was introduced by a Turkish merchant in Bulgaria which was, then, a province of the Ottoman Empire. Soon after, Kizanlik, Eski Zagra and Karliova regions became the world center for the cultivation of rose and the production of rose oil. By 1750, Bulgaria had become the principle source of rose oil.

At that time rose oil was produced by water distillation of fresh roses, and consequent cohobation of the distillates in open-fire copper stills. The oils collected by merchants were exported from the ports of Gallipoli, Istanbul and Izmir.[6] Annual production of rose oil in the region was recorded as 1500-1800 kg in the 1850s.

Although at one time various rose species were used for the production of rose oil, later *Rosa damascena* Miller (Damask Rose, Oil Rose, Isparta Rose) became established as the only source. It is widely accepted to have originated from the hybridization of *Rosa gallica* L. and *Rosa phoenicia* Boiss., both of which grow wild in Turkey.

During the reign of the Ottoman Sultan Abdulhamid the second (in the 1880s), with royal incentives, systematic cultivation of roses for the production of rose oil and rose water was initiated in several provinces of Turkey.

This period coincided with the fleeing of Turkish immigrants from Bulgaria following the 1877-1878 Turkish-Russian War. It is believed that these Turkish immigrants brought with them rose root stock.

It is believed that rose cultivation must have started in the early 1880s, since the first production of oil by distillation commenced in Bursa in 1885 and in Istanbul the following year.[6]

Nowadays, the production of rose oil and rose water is confined almost solely to the Isparta and Burdur provinces of Turkey. Hence, rose oil has been produced in Turkey for over a century. Initial production by cottage industry was largely replaced by modern industrial techniques, with the establishment of the first large distillery in Isparta in 1934.

Cultivation Practices

In December and January, rows of ditches 50 cm in depth and 50 cm in width are prepared and manured. Rose twigs cut at the soil level are placed in the ditches which are then covered with soil.

It takes at least three years for a rose plant to attain maturity. A mature rose field normally yields 5 tons of fresh roses per hectare. However, in a carefully nurtured field the yield may go up to 7-8 tons per hectare. It is normal for a field to be productive for up to 20-30 years.

Once in every six years, plants are cut to soil level to rejuvenate the field. Blossomed flowers are hand picked during the early hours of the day. A skilled worker can pick about 40 kg of roses in 8 hours.[7]

Objectives of the Present Study

Turkish rose oils have been analyzed previously in several studies.[4,8-10] For the last four years, we have been

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engaged in a comprehensive study of the Turkish rose oils. Some of the results were presented elsewhere.[11]

Here, the results of GC and GC/MS analyses of the Turkish rose oils produced by both peasants and industry will be presented. The processing conditions at commercial and bench scale production and an exhaustive olfactory evaluation of the entire range of Turkish rose oils will also be presented. The objective of the last exercise was to determine whether there is any correlation between the odor profile and the GC results of the oils.

The oils used in this study were as follows:

1. Fourteen (14) village-produced rose oils (12 samples of 1989 produce; one each of 1987 and 1990 blends) from 11 villages in Isparta region.
2. Twenty (20) factory-produced rose oils from several factories in Isparta region (nine samples of 1990 produce; five samples of 1989 produce; two samples of 1988 produce; three samples of 1987 produce; one sample of 1986 produce).
3. First, second and total oils of fresh flowers produced by bench scale and commercial scale water distillation.
4. First, second and total oils of fermented flowers produced by bench scale and commercial scale water distillation.

Method of Production

Rose oil is produced by water distillation of fresh *Rosa damascena* flowers.

In the village-type distillation, freshly picked flowers are loaded into 150 to 1000 liter copper or galvanized steel open fire stills, most stills have a 300-liter capacity and consist of a retort and a head. The removable spherical head is connected to a pipe which leads through a pool filled with lukewarm water to cool the condensate. At the outlet, there is a nine-liter glass collecting flask.

Typically, ten kg of flowers and 60 liters of water are loaded into 300 liter stills and are distilled for 1-2 hours to collect two flasks full of the distillate (18 liters). Due to the low concentration of oil in the distillate, the oil does not separate. To get oil, about 60 liters of the distillate are redistilled, yielding another 18 liters of distillate from which the oil that floats to the top is decanted. The aqueous phase is diluted with distilled water and marketed as rose water.

For the industrial production, generally 3000 liter copper or stainless steel stills are employed. Each still has a charge size of 400 to 500 kg flowers, and 1500 to 2000 liters of warm water. The stills are steam jacketed. There may also be provision for the injection of live steam to speed up distillation. The distillation is carried out for 1.5 hours. The condenser temperature is kept at 35°C to avoid the solidification of waxes.

The distillate is collected in 200 liter stainless steel florentine flasks. The oil that separates out is called "Crude oil, first oil or direct oil." Distillation is terminated when the distillate is no longer bitter to the taste.

The overflow of the florentine flasks is collected in 500 liter tanks. These "Bottom waters" or "First waters" are then pumped into 5000 liter stainless steel tanks. These are cohobated in 3000 liter stills for 1-1.5 hours to get what is called the "Second oil," "cooked oil" or "Indirect oil." The distillate after removal of the oil is also sold as rose water.

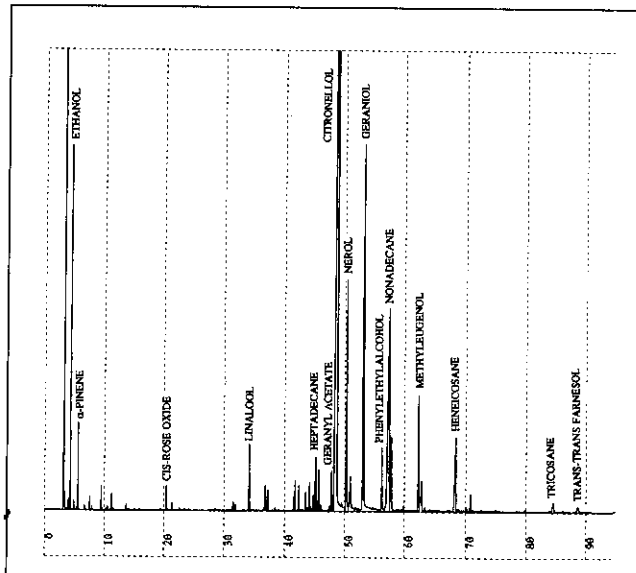

Figure 1. GC of factory-produced Turkish rose oil (1989)
Total components detected: 85; components identified: 68; 96% of total components detected Column: Thermon 600T FSC column (50 mL, 0.25 mm I.D.); Carrier gas: Nitrogen (GC), Helium (GC/MS); Injector temp: 250°C; Column temp: 10 min at 70°C to 180°C, 2°C/min at 180°C for 30 min; Detector temp: 250°C; Split ratio: 60:1

The first and second oils are filtered and kept in glass flasks in the dark. When the production season is over, all the first and second oils are mixed to yield the Turkish rose oil and packed in special 2-5 kg tinned steel containers called "Kumkuma."

Generally, 3.5-4 tons of flowers yield 1 kg of rose oil. So the yield is about 0.02%.

Chemical and Olfactory Evaluation

GC/MS analysis of the Turkish rose oil revealed the presence of 85 components of which 68 have been identified making up 96% of the total components detected (Figure 1, Table I).

For comparison purposes, only percentages of certain components shall be considered. Criteria in selecting these components were based on their contribution to the overall odor quality of the oils examined and on the fact that any change in percentages of these components resulted in some kind of change in the typical olfactory character of the oil. A perfumer helped define the selection criteria.

Basic rosaceous character of rose oils is determined by the citronellol content. The citronellol content found in the village oils (25-39%) was lower than that found in factory oils (31-43%).

Higher citronellol contents lead to increased sweetness which, when combined with almost equivalent quantities of

Table I. The composition of Turkish rose oil

Peak No.	Components	Z. Konur blend of village oils 1987	Z. Konur blend of village oils 1990	Z. Konur 1989	Gülbirlik 1990	E. Ercetin 1990	M. Gürkan 1990
1	acetone	t	0.011	0.022	0.016	0.041	0.025
2	ethyl acetate	0.028	0.040	0.356	0.096	0.125	0.146
3	ethanol	0.419	0.772	5.182	2.310	2.532	4.337
4	pentanal	-	0.017	0.084	0.143	0.057	0.088
5	2-butanol	-	0.006	0.013	0.019	0.025	0.019
6	α-pinene	0.086	0.084	1.071	0.546	0.628	0.416
7	isobutanol	-	0.016	0.024	0.079	0.062	0.075
8	β-pinene	0.018	0.024	0.217	0.142	0.155	0.104
9	sabinene	-	0.009	0.085	0.051	0.047	0.037
10	1-butanol	-	0.006	0.012	0.009	0.018	0.010
11	2-propen-1-ol	-	-	-	0.008	0.007	0.009
12	myrcene	0.065	0.063	0.453	0.283	0.285	0.183
13	α-terpinene	-	0.006	0.026	0.019	0.006	0.006
14	heptanal	-	0.035	0.146	0.203	0.075	0.125
15	2-methyl-1-butanol	0.061	0.120	0.166	0.347	0.317	0.393
16	1,8-cineole	-	0.018	0.013	0.014	0.013	0.009
17	2-hexenal	-	-	0.011	-	-	-
18	2-amylfuran	-	-	-	-	-	0.007
19	(Z)-β-ocimene	-	0.005	0.012	-	-	0.006
20	1-pentanol	-	} 0.064	} 0.103	} 0.111	} 0.089	} 0.107
21	γ-terpinene	-					
22	(E)-β-ocimene	-	0.008	0.036	0.025	0.012	0.018
23	p-cymene	-	0.012	0.028	0.025	0.068	0.015
24	α-terpinolene	-	0.006	0.029	0.019	-	0.013
25	(E)-3-hexen-1-ol	-	-	0.009	-	-	-
28	6-methyl-5-hepten-2-one	-	0.035	0.019	0.047	0.040	0.030
29	cis-rose oxide	0.404	0.431	0.570	0.747	0.621	0.706
30	trans-rose oxide	0.078	0.111	0.178	0.194	0.158	0.199
31	(Z)-3-hexen-1-ol	0.040	0.061	0.036	0.049	0.050	0.041
32	benzyl methyl ether	-	-	t	-	-	0.008
33	nonanal	-	0.026	0.076	0.089	0.039	0.081
38	6-methyl-5-hepten-2-ol	-	0.019	0.020	0.022	0.023	0.021
42	citronellal	-	-	-	-	-	-
43	pentadecane	0.184	0.225	0.270	0.349	0.425	0.377
45	benzaldehyde	0.034	0.053	0.048	0.108	-	-
46	linalool	1.138	1.422	0.530	1.249	1.148	0.812
47	α-guaiene	0.381	0.543	0.930	1.179	0.945	0.833
48	terpinen-4-ol	0.308	0.358	0.299	0.369	0.451	0.271
49	hexadecane	0.060	0.041	0.076	0.061	0.072	0.069
50	citronellyl formate	0.036	0.044	0.029	0.036	0.223	0.027
51	citronellyl acetate	0.151	0.189	0.322	0.360	0.317	0.292
52	α-humulene	0.479	0.520	0.677	0.729	0.718	0.628
53	neral	0.367	0.561	0.423	0.536	0.457	0.723
54	α-terpineol	0.284	0.327	0.153	0.299	0.320	0.184
57	γ-muurolene	0.364	0.511	0.635	0.902	0.476	0.708
58	δ-guaiene	} 1.647	0.214	0.361	0.525	0.387	0.349
59	heptadecane		0.822	1.642	1.079	1.449	1.179
60	geranial	} 1.020	0.952	0.633	0.930	1.009	0.926
61	heptadecene		0.102	0.256	0.129	0.186	0.140
62	geranyl acetate	1.519	1.598	0.923	1.215	1.194	0.668
63	citronellol	26.740	32.863	36.439	42.436	35.832	43.545
65	nerol	9.722	10.586	5.362	6.249	6.195	5.266
66	octadecane	} 0.813	0.231	0.158	1.255	} 1.027	} 1.210
67	2-phenylethyl acetate		0.847	0.951	0.567		
68	geraniol	24.105	25.834	11.090	12.360	13.447	10.182
69	phenylethylalcohol	3.450	2.918	1.877	1.432	1.989	1.078
70	nonadecane	7.720	5.287	9.834	7.692	8.379	8.217
71	cis-9-nonadecene*	2.296	1.670	2.729	2.189	2.994	2.331
73	methyl eugenol	1.861	2.436	} 3.342	2.485	2.607	3.099
74	eicosane	2.373	0.430		0.765	0.869	0.786
75	(E)-9-eicosene	0.111	-	0.126	0.127	0.445	0.122
76	(Z)-nerolidol	0.060	-	0.082	0.058	0.132	0.054
77	heneicosane	1.920	0.554	3.278	2.745	2.603	3.079
79	(E)-5-eicosene	0.100	0.016	0.108	0.083	0.147	0.102
80	eugenol	1.517	1.232	1.266	0.509	0.354	0.563
82	docosane	-	0.082	0.064	0.070	0.055	0.104
83	tricosane	0.329	0.206	0.688	0.500	0.408	0.623
85	(E,E)-farnesol	0.753	0.693	0.427	0.332	0.426	0.381

* tentatively identified; t = trace (<0.003%)

Table III. Percentage composition of some village type rose oils

Components	Cardak 1989	Ilyas 1989	Cigri 1989	Saracik Tepecik (M. Sari) 1989	Senir 1989	Inar 1989	Ardich 1989	Müslümler 1989	Karagent 1989	Saracik 1989	Cimbili 1989	Asagi Cimbilli	Z. Konur Village blends 1987	1990
total terpenes	0.27	0.23	0.26	0.40	0.23	1.31	0.27	0.27	0.27	0.37	0.48	0.15	0.17	0.30
nonanal	0.33	-	0.03	-	0.03	0.02	0.03	0.03	0.03	0.04	0.04	0.02	-	0.03
linalool	0.96	0.97	0.82	1.27	2.01	0.85	1.65	1.27	0.96	1.29	0.99	1.10	1.14	1.42
citronellyl formate } citronellyl acetate }	0.24	0.23	0.26	0.23	0.19	0.29	0.28	0.29	0.22	0.29	0.25	0.21	0.19	0.23
α-terpineol	0.20	0.24	0.22	0.28	0.53	0.21	0.52	0.24	0.24	0.31	0.23	0.24	0.28	0.33
geranyl acetate	1.57	1.71	1.73	1.97	1.22	1.96	0.74	1.60	1.77	1.74	2.55	1.34	1.52	1.60
citronellol	26.38	33.24	29.11	29.44	27.95	25.04	25.07	32.33	38.50	28.52	26.35	29.03	26.74	32.86
nerol	8.99	10.73	11.06	13.36	11.96	10.04	9.77	7.50	8.39	9.83	11.70	8.53	9.72	10.59
geraniol	31.51	25.42	29.14	30.15	30.14	27.74	24.52	25.24	20.06	25.67	31.80	30.16	24.11	25.84
(E,E)-farnesol	1.32	0.65	0.82	0.43	0.94	1.32	1.13	1.01	0.66	0.87	0.83	1.08	0.75	0.69
citronellol/geraniol	0.84	1.31	1.00	0.98	0.93	0.90	1.02	1.28	1.92	1.11	0.83	0.96	1.11	1.27

* relative percentage amounts in GC

Table II. Ranges of percentage amounts of the main components of village and factory type rose oils

Components	Village oils 14 samples (1987-1990)	Factory oils 20 samples (1986-1990)
ethanol	0.00-1.67*	0.50-5.18
total terpenes	0.15-1.31	0.80-2.71
nonanal	0.00-0.04	0.03-0.09
linalool	0.85-2.01	0.53-1.27
citronellyl formate } citronellyl acetate }	0.19-0.34	0.24-0.54
α-terpineol	0.20-0.53	0.13-0.46
geranyl acetate	0.74-2.54	0.55-1.67
citronellol	25.04-38.97	30.67-45.83
nerol	7.50-13.36	4.52-8.89
geraniol	20.05-31.80	8.50-16.65
phenylethyl alcohol	1.85-3.55	1.16-2.60
methyl eugenol	1.40-2.67	1.93-3.37
(E,E)-farnesol	0.43-1.32	0.24-0.64
stearoptenes	12.20-19.83	14.00-25.96
citronellol/geraniol	0.83-1.92	2.30-4.84

* ranges of relative percentage amounts according to GC

geraniol, leads to strength and fortification of the body note. Conversely, when geraniol is comparatively low, the sweetness of the body note is maintained but strength diminishes. The geraniol content of village oils was found to range between 20-32% while for factory oils, it was 8.5-16.65%. In some village oils, it was observed that the geraniol content was higher than the citronellol content.

In such cases while the rossaceous character is maintained, it acquires an undesirable green grassy aspect.

In order to simplify the comparison of GC results, citronellol/geraniol ratios of each oil were taken. This ratio was previously used in 1934 by Parry and Seager for the evaluation of the quality of Bulgarian rose oil.[3] Village oils gave a ratio of 0.83-1.92% while the factory oils gave 2.30-4.84% (Tables II-IV).

The basic character of rose oil, established by citronellol and geraniol, is further modified by nerol and farnesol. In the village oils, nerol was in the range of 7.5-13.4% as compared to 4.52-8.89% for the factory oils. On the other hand, the farnesol content ranged between 0.43-1.32% in village oils and 0.24-0.64% in factory oils. Higher contents of farnesol lead to the establishment of a strong floral character and overall improvement of volume of the body note.

Nerol not only adds to the rosaceous character but also to its freshness. However, in those cases where the geraniol content is low, the freshness of nerol manifests itself as a slightly citrusy aspect. The corollary of this is that when the geraniol content is high, the combination of citronellol, geraniol, farnesol and nerol has a strong, sweet, floral, fresh, rosaceous character.

This odor picture changes when geraniol content is low, which allows the citrusy aspect of nerol to become apparent in the overall odor profile of the rose oil.

Similarly, the geranyl acetate present in the rose oil adds to the freshness and the top note in those oils where geraniol content is high. However, when the geraniol content is low, the geranyl acetate tends to boost the citrusy aspect in combination with nerol and thus, becomes typical for those rose oils where the geraniol content is proportionately less than citronellol content. In factory oils, the geranyl acetate content (0.55-1.67%) is relatively lower than in village oils (0.74-2.54%).

The overall strength, sweetness and typical rosaceous character of the rose oil is determined by the content of monoterpene hydrocarbons, nonanal, linalool, citronellyl formate and citronellyl acetate.

Total monoterpene hydrocarbon content in village oils (0.15-1.31%) was found to be relatively lower than in factory oils (0.80-2.71%). In addition the nonanal content

Table IV. Percentage composition of some factory type rose oils

Components	Gülbirlik					Z. Konur			Rosette 1990 blends		
	1986	1987	1988	1989	1990	1987	1988	1989	1	2	3
total terpenes	1.31*	1.09	1.57	1.42	1.23	1.37	2.14	2.07	0.93	1.46	1.23
nonanal	0.05	0.05	0.06	0.06	0.09	0.03	0.04	0.08	0.07	0.08	0.05
linalool	1.20	1.01	1.21	1.21	1.25	0.53	0.78	0.53	0.96	0.86	0.61
citronellyl formate } citronellyl acetate }	0.24	0.37	0.38	0.37	0.40	0.27	0.34	0.35	0.18	0.33	0.37
α-terpineol	0.29	0.29	0.31	0.38	0.30	0.13	0.22	0.15	0.23	0.19	0.17
geranyl acetate	1.67	0.91	1.04	1.03	1.21	1.18	1.23	0.92	0.97	1.09	0.89
citronellol	35.33	42.98	41.28	38.46	42.44	30.67	38.30	36.44	45.83	40.87	40.66
nerol	7.37	5.79	5.77	5.53	6.25	5.33	8.59	5.36	7.42	7.11	6.33
geraniol	14.41	10.44	10.72	11.96	12.36	10.88	16.61	11.09	14.59	14.31	13.82
(E,E)-farnesol	0.60	0.50	0.37	0.38	0.33	0.58	0.40	0.43	0.35	0.39	0.43
citronellol/geraniol	2.45	4.12	3.85	3.22	3.43	2.82	2.30	3.29	3.14	2.86	2.94

* relative percentage amounts in GC

was similarly lower (0.00-0.04%) in village oils as compared to factory oils (0.03-0.09%). The combined citronellyl formate and citronellyl acetate contents were also slightly lower (0.19-0.34%) in village oils than in factory oils (0.24-0.54%). In contrast the linalool content of village oils was relatively higher (0.85-2.01%) as compared with factory oils (0.53-1.27%).

Oils rich in citronellol and geraniol, but low in monoterpene hydrocarbon, nonanal, linalool, citronellyl formate and citronellyl acetate contents tend to have weak top notes relative to those oils where these components are present in higher quantities.

Citronellyl formate and citronellyl acetate create the typical fresh rosaceous character in the top note which, in turn, is boosted by the monoterpene hydrocarbon and nonanal contents.

The strength of the top note as well as its floral character is affected by the percentage of linalool. Higher linalool contents add to the volume and floral character of the top note.

Ethanol has been accepted as a natural ingredient of the rose oil, although the amount found in Turkish rose oils varies within a wide range.

In general, village oils have a low content of ethanol (0.00-1.67%), while it ranges between 0.5-5.2% for factory oils. Even though it is considered to be a genuine constituent, a high ethanol content should be suggestive of the use of an appreciable amount of fermented roses during the process.

This is especially the case with factory oils since the influx of roses into factories during the peak season is unmanageable, and the roses have to stand in bags for more than 24 hours before distillation.

On the other hand, in village-type distillation, roses are immediately processed; hence, their ethanol content is low.

Higher ethanol contents tend to lead to stronger top notes; however, high ethanol contents in rose oil are not desirable.

General Remarks on Other Constituents

Although eugenol and methyl eugenol have no effect on the rosaceous character of the oils, they do have an effect on the overall general odor picture in terms of volume, strength, and lift, where they impart a green, spicy note. Eugenol contents in village oils are higher (1.17-2.25%) than in factory oils (0.35-1.27%). While the methyl eugenol content in factory oil is higher (2.27-3.10%) in proportion than in village oils (1.40-2.65%). Higher quantities of both of these constitu-

Table V. Percentage composition of a blend of village + factory type Turkish rose oils

Components	Blend of village + factory oils
total terpenes	0.578
nonanal	0.054
linalool	0.802
citronellyl formate } citronellyl acetate }	0.277
α-terpineol	0.212
geranyl acetate	1.164
citronellol	35.645
nerol	7.785
geraniol	19.089
(E,E)-farnesol	0.580
citronellol/geraniol	1.870

ents lead to some improvement in the body notes.

It has been determined that higher percentages of cis-rose oxide lead to stronger top notes. The cis-rose oxide content in factory oils was higher (0.47-0.72%) as compared to the village oils (0.29-0.48%). This difference is reflected in the difference between the strength of the top notes of the two types of oils.

The α-terpineol content was almost the same for both village (0.20-0.53%) and factory (0.13-0.46%) oils. In higher percentages it increases the floralcy of the body note.

The phenylethyl alcohol content varied between 1.35 to 3.55% in village oils, while it was relatively lower in factory oils (1.13-1.99%). This component also adds to the floral character of the oil.

Higher stearopten contents would lead to dilution of the body note. According to a gravimetric method mentioned in the rose oil monograph of Turkish Standards Institute, the stearopten content of village oils is generally found to be lower than in factory oils.[12]

Very minor constituents such as damascenones and some sulphur compounds which have been detected in Bulgarian rose oil,[13] would tend to enhance the power and volume of the top note.

Odor Description of Typical Turkish Oils

(a) *Village-type*

- Village-type oils with citronellol/geraniol ratio greater than 1:
  Subdued top note, body note sweet, rosaceous and strong. Ideally, best odor is produced when ratio is between 1.25-1.30%.
- Village-type oils with citronellol/geraniol ratio less than 1:
  Subdued top note, strong, sweet, rosaceous body note, but with a slightly grassy aspect.

(b) *Factory-type*

Strong, fresh top note. Overall more terpenic with rosaceous and sweet characters being slightly subdued. Body note, sweet and rosaceous but somewhat thin. This is due to the high citronellol to geraniol ratios where geraniol content is low.

The above-noted descriptions of typical village- and factory-type oils have been correlated to their GC analysis picture. It is evident from this that the difference in the odor picture of village oils as compared to factory oils and vice versa can be explained quite clearly in terms of the differences in their analysis picture vis-a-vis the constituents that have been described before.

To verify the validity of our assumption and to establish the fact that the odor is significantly influenced by these aforementioned constituents, samples of Turkish rose oils were selected on the basis of their analysis in such a way that they were complementary to each other in terms of these particular constituents.

Upon blending these oils together in proportions which maximized the percentages of the significant constituents identified in this study we created a blend of natural oils which, upon independent odor evaluation, was found to be significantly better in all of its odor attributes when compared with any other sample of rose oil of Turkish origin.

After odor evaluation, the oil was analyzed and the odor evaluation done prior to the analysis was found to have direct correlation with the critical components identified as having a significant effect on the odor quality of rose oils (Table V).

The Case of Fermented Flowers

As per tradition and ideal practice, only fresh flowers should be used for the distillation of rose oil. However, in actual practice, due to large quantities of flowers that have to be handled during the season, it is not possible to use only fresh flowers for distillation purposes. As a result flowers that have not been freshly picked have to be accepted by the distillation companies.

These flowers are processed as and when distillation units become available during the course of the day. During this time of storage, flowers undergo varying degrees of fermentation which has a direct bearing upon the oil composition of such flowers.

In order to find out how processing conditions affect the composition of the oils, two sets of experiments (one bench scale and one commercial scale) were carried out with fresh and fermented roses.

For the bench scale experiments, the actual practice at the commercial scale was stimulated with a Clevenger apparatus. First and second oils were collected and separately analyzed.

Commercial scale experiments were conducted using 3000 liter stainless steel stills in one of the factories. Again, first and second oils were collected and analyzed by GC. These experiments with fresh flowers were repeated for fermented flowers in the same manner.

The most significant change that was found to occur during fermentation was that the citronellol content increased while the geraniol content decreased. Therefore, oils distilled from fermented flowers have a sweet rosaceous note but relatively weak body strength.

Table VI. Percent composition difference between oils produced from fresh and fermented flowers

Components	Clevenger				Factory				Trend**
	Fresh flowers		Ferm. flowers		Fresh flowers		Ferm. flowers		
	1st oil	2nd oil	1st oil	2nd oil	1st oil	2nd oil	1st oil	2nd oil	
total terpenes	0.63*	0.85	0.29	0.69	3.86	0.27	1.78	0.33	D
nonanal	0.04	-	-	0.03	-	0.04	0.07	0.05	I
linalool	0.24	0.55	0.56	1.06	0.20	1.23	0.40	1.62	I
citronellyl formate } citronellyl acetate }	0.31	0.06	0.31	0.08	0.80	0.19	0.80	0.19	S
α-terpineol	0.67	0.41	0.16	0.28	0.03	0.03	0.05	0.35	V
geranyl acetate	4.31	0.36	0.25	0.11	2.67	0.23	0.35	0.16	D
citronellol	21.79	47.11	34.87	65.49	29.60	50.90	37.26	58.85	I
nerol	8.15	7.53	6.77	4.57	2.58	3.90	1.55	5.36	D
geraniol	16.00	16.55	11.01	7.63	4.22	7.10	2.49	8.58	D
phenylethyl alcohol	1.48	4.40	2.04	5.13	0.67	1.15	0.82	1.77	D
(E,E)-farnesol	1.44	0.26	0.53	0.08	0.44	0.19	0.30	0.14	I
citronellol/geraniol	1.36+	2.85	3.17	8.58	7.01	7.17	14.96	6.86	I

* relative percentage; + ratio
** effect, from fresh to fermented: D = decreasing; I = increasing; S = stable; V = variable

Also, the neral and geranial content increased while nerol and farnesol decreased. Since neral and geranial have a clear citrus odor, oil from fermented flowers tends to have a slightly citrusy aspect which depresses the rosy character and enhances the terpenic aspect.

In those oils where the geraniol content was high, this citrusy terpenic aspect was manifested as freshness. The decrease in nerol and farnesol was compensated to some extent by the increase in phenylethyl alcohol due to fermentation. The nonanal and linalool contents increased as a result of fermentation and this added to the strong top notes of such oils (Table VI).

Citronellol contents in the first oils were found to be lower than in the second oils. The increase in citronellol content was more prominent in fermented roses as indicated above. Higher percentages of citronellol in the second oils may be explained in part by the presence of a lower stearopten content in the second oil.

Conclusion

- There are two types of Turkish rose oil available, namely village- and factory-type. Both have quite distinctive characteristics. But the commercially recognized Turkish rose oil is the factory-produced oil.
- Production techniques are standardized. Variations in chemical composition is due to extrinsic factors such as altitude, climate, picking time and the degree of fermentation before distillation.
- Odor quality of rose oils can be predicted by the examination of gas chromatograms. Careful blending of different varieties of rose oils can produce a rose oil which may more readily satisfy the quality requirements of a perfumer.
- When evaluating any essential oil with a market potential, an essential oil manufacturer should work as closely as possible with a person who can perform odor evaluation.

This way production of quality oils can be guaranteed.

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