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The Characteristics of Lavender Oils from Eastern Europe*

Ukraine, Moldova and Bulgaria

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Lavender oil (ex. *Lavandula angustifolia* Mill.) is produced commercially by a number of countries: France (the main supplier), Bulgaria, Moldova, Ukraine and Australia. The oils from each of these regions possess distinctive aroma characters, which range from the fine, flowery, fresh notes in the French oils to herbal, woody and camphoraceous with fatty notes in the Australian oils.

Herein, it will be shown that these differences in aroma can be translated into a visual form (map) that assists comparisons with chemical analysis data.

Oils Examined

The following lavender oils were exam–ined in this study:

- Type I — Bulgaria (30 oils over a period of two years)
- Type II — France (more than 200 samples over a period of 15 years)
- Type III — Ukraine (22 oils)
- Type IV — Australia (46 oils over a period of five years)
- Type V — Moldova (6 oils)

All of these types are 100 percent clonal lavender. Population types were excluded from the study.

Methodology

Chemical analysis: An objective, scientific analysis of the oil samples was conducted by GC and GC/MS. Addition-ally, the results obtained were checked for typical properties against those published for the various origins in the International Standard for Oils of Lavender, ISO 3515. The statistical mean value was then calculated and used.

Aroma evaluation: Aroma evaluation of the oils was necessarily empiric, but the results were subjected to statistical analysis. The evaluations of the were undertaken by 12 professional perfumers and 22 "semi-profession–als," i.e. people who deal in essential oils or are producers, but who do not possess "professional noses."

Each of those involved in the evaluation exercise was given a questionnaire, which was designed to distinguish the characteristic aroma attributes of the five oil types (see T-1). Participants were asked to give a weighting for characters such as flowery (floral), earthy, etc. on a scale of 0 to 5, using gradations of 0.5.

After statistical analysis, the evaluation results were used to create a specially developed olfactogram for each of the oil types, from which overlaying of the diagrams permits identification of their main aroma differences (F-1).

Results

Chemical analysis: T-2 shows the results for the mean composition values of for each of the five oil types, as analyzed on a 50-m non-polar column (DB-5, 0.25 µ inner diameter, film thickness 0.1 µm). It reveals that the oil composition is very complex with more than 50 components. They are all necessary for a good and valuable lavender oil.

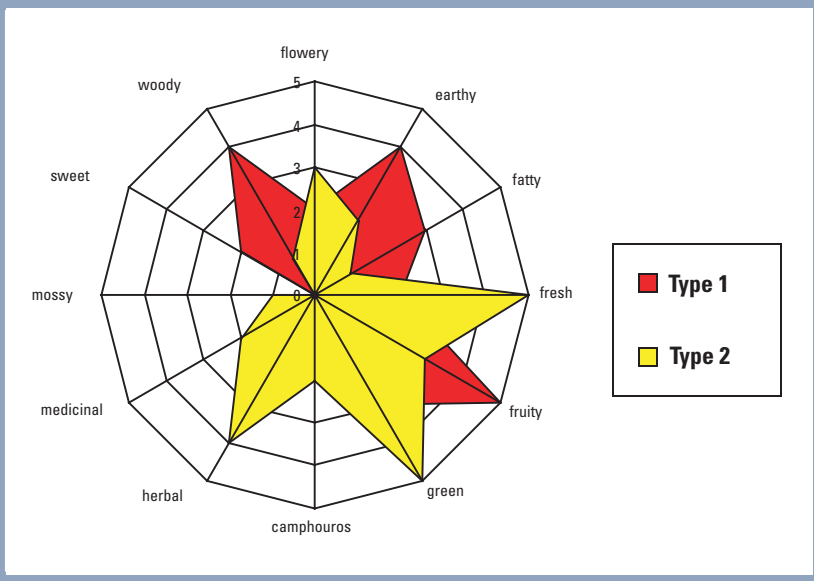
For comparison, T-3 lists the analytical data in ISO 3515 for lavender oils of various origins, published in 2001. To establish this ISO standard, thousands of samples were tested and retested by ring trials in analytical laboratories all over the world in order to obtain very good and reproducible data. In this ISO chromatographic profile, one can see that there is a distinction between French "spontaneous" ("popula-

° This paper was originally presented at the IFEAT International Conference in Warsaw, Poland, October 13-17, 2002.

The aroma evaluation questionnaire **T-1**

	Type 1	Type 2	Type 3	Type 4	Type 5
flowery					
earthy					
fatty					
fresh					
fruity					
green					
camphoraceous					
herbal					
medicinal					
mossy					
sweet					
woody					

Example of olfactogram **F-1**



tion") lavender and clonal lavenders from France, Bulgaria, the Russian Federation, Australia and "other origins."

Neither the data from our sample analysis, nor the ISO study immediately explained why there are such big olfactory differences between the various oil origins. An explanation may reside in the presence of minor and trace components, which are often very effective at very low dosage — e.g. aldehydes, Werner Hofmann.[2] In our samples, however, there was no sign of furfural or furans (such as 2-methyl-furane), nor of nitrogen compounds (pyridines, methyl anthranylate, etc.), while sulphur compounds (e.g. dimethyl sulfide) could be detected only in the baseline noise.

The Olfactograms

F-2 shows the olfactograms arising from evaluation of the lavender oil types by 12 professional perfumers. The results may be summarized as:

- Moldova — highly flowery characteristics.
- Bulgaria — some differences from Molodova, but again a highly flowery accent.
- Ukraine — again a flowery note but not too herbal.
- France— distinctively different from the Eastern European oils; mossy and sweet as well as highly camphoraceous aspects.
- Australia — displays the maximum of difference from all other origins; fatty notes are prominent, green and herbal accents are present, and there are nearly no flowery notes.

F-3 shows the evaluation of the semi-professionals. Here, we see a difference in the results from those obtained by the professionals. While the latter gave very exact descriptions and judgements, making fine distinctions and ranking figures from 0 to 5, the semi-professionals tended to be more rounding. For example, the area in the olfactogram of Moldavan lavender from semi-professionals is much higher; a similar large field was obtained with Bulgarian lavender oil; the olfactogram for French lavender looks very similar — just a little more fresh and camphoracerous. Like the professionals, however, the semi-professionals noted an absolute difference in the character of Australian lavender, noting that it was much more fatty, fruity, green and camphoraceous.

Composite (over-laid) olfactograms are shown in F-4 for both the professionals and the semi-professionals. These clearly reveal the observed significant differences in the aroma characteristics of the various lavender oil origins.

Reconsideration of the Effect of Oil Composition on Aroma Character

Lavender oil contains linalol and linalyl acetate as the main components. As shown in F-5, France and

The mean composition of the lavender oil types (by GC/MS) **T-2**

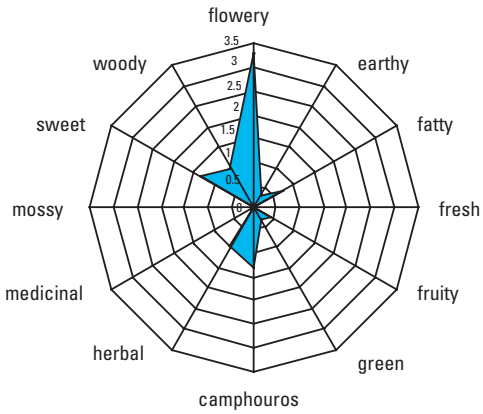
Component	France	Moldova	Ukraine	Bulgaria	Australia
2-butanoic acid	t	t	t	0	0
ethanol	0	0	0	0	t
acetone	0.03	0.01	t	0.01	0.01
amylacetate iso	t	0	0	0	t
prenol	t	t	0	t	0
acetaldehyd	0	t	t	0	t
benzylisoamylether	0	t	0.01	0	t
butylacetate	t	t	0	0.01	t
n-hexanal	0	0	t	0	0
methyl-n-hexylether	0.01	0.01	0.01	0.01	0.03
hexenal-*trans*-2	0	0	t	0	0
cis-3-hexenol	t	0	t	0	0.07
n-hexanol	0.01	t	t	t	0.02
tricyclen	0	0.01	0.01	t	t
thujene α	t	0.02	0.03	0.03	0.01
pinene α	0.02	0.1	0.1	0.09	0.07
isobutylisobutyrate	0	0	t	0	t
camphene	0.03	0.11	0.17	0.06	0.03
1-octen-3-ol	0.04	0.2	0.15	0.06	0.23
3-octanone	0.21	0.13	0.07	0.23	2.85
myrcene	0.1	0.45	0.4	0.33	0.27
3-octanol	0.02	0.01	t	0.02	0.34
cis-3-hexenyleacetate	0	0	t	0	0.01
n-hexylacetate	0.08	0.11	0.15	0.24	0.09
3-carene	0.01	0.17	0.21	0.03	0.02
terpinene α	0	0.01	0.01	0.01	t
o-cymene	0.01	0.03	0.11	0.01	0.03
p-cymene	0.16	0.11	0.28	0.07	0.09
limonene	0.04	0.36	0.25	0.11	0.07
ocimene *cis* β	0.34	5.45	4.21	5.49	4.34
cineolee 1,8	0.13	1.62	1.53	0.31	t
ocimene *trans* β	0.13	1.31	2.41	2.24	0.56
phellandrene β	t	0.03	0.05	0	0.03
terpinene γ	0.01	0.01	0.02	0.06	0.02
linalooloxide *trans*	0.09	0.02	0.02	0.03	0.22
terpinolene	0	0.01	0.01	0.06	t
linalooloxide *cis*	0.1	0.07	0.06	0.01	0.18
terpineol 1	0.02	0.01	t	0	0.01
linalool	44.35	33.96	27.46	27.11	39.06
3-octanylacetate	0.02	1.08	1.07	1.05	1.84
allo-ocimene	t	0.05	0.04	0.04	0.04
linalylformiate	t	0	0	0	0.02
myroxide	t	0	0	t	0
hexylisobutyrate	0.02	0.02	0.03	0.03	0.03
3,7,7, trimethylbicyclo[4.1.0]hepten-3-ol	t	0	0	0	0
sabinol	0	t	0.01	t	0.01
camphor	0.3	0.23	0.32	0.11	0.14
lavandulol	0.3	0.24	0.19	0.29	0.52
undecatriene	0	0.01	0.02	0.01	0.03
ocimenol	0.02	0.01	0.01	0	0.01
borneol	1.03	0.65	1.04	0.35	0.69
terpinen-4-ol	1.51	2	2.09	4.63	2.99
dehydro-p-cymene	0.07	0.04	0.08	0.03	0.05
cryptone	0.01	0.25	0.18	0.05	0.05
terpineol α	0.66	1.09	0.57	0.83	0.42

The mean composition of the lavender oil types (by GC/MS) (continued) **T-2**

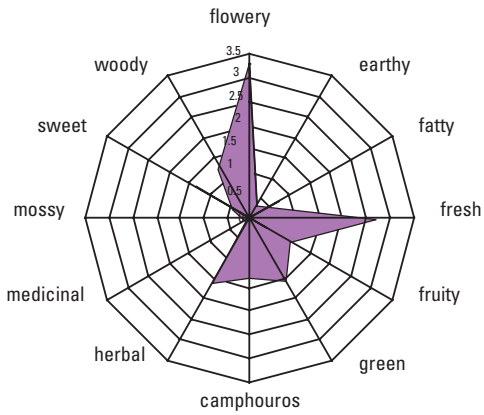
Component	France	Moldova	Ukraine	Bulgaria	Australia
octanol-acetate	0.01	0.01	0.01	0.01	0
geranylbutyrate	0	0	t	0	0
eucarvon	0	t	0.01	t	t
4-thujanole	0.08	0.12	0.01	0.09	0.05
hexyl-methyl-3-butyrate	0.05	0	0	0	0
bornylformiate	0.02	0.01	0.06	0.02	0.02
linalylacetate	41.63	38.62	43.32	42.62	36.19
thuylacetate	0.02	0	0.03	0	0.01
bergamottene *trans* α	0.01	0	0	0	0
sabinenhydrat *trans*	0.02	0	0.01	0.02	0
lavandulylacetate	3.65	2.54	2.09	4.65	2.47
bornylacetate	0.05	0.12	0.12	0.15	0.02
p-mentha-2,4-diene	0	t	0	0	0
cuminalcohol	t	t	t	t	t
hexyltigliat	0.1	0.01	0.01	0.01	0.04
pinocarvylformiate	0.02	0	t	t	0.01
verbenylacetate *cis*	0.05	0	t	t	0
terpinene-4-ol-acetate	t	t	0.02	t	0.01
linalylformiate	0.21	0.31	0.17	0.27	0.13
geranylacetate	0.39	0.62	0.3	0.5	0.28
hexenylhexanoate	0.02	0	0	0	0.02
cubeben α	0.01	t	0.01	t	t
bourbonene β	0.04	0.01	0.02	t	0.02
zingiberene α	0.09	0	0.01	0	0.01
sesquithujene α	0.05	0.02	0.01	0.01	0
lavandulylisobutyrat	0.02	0	0	0	0
bergamottene *cis* α	0.02	0.03	0.04	0.02	0.04
farnesene *cis* α	0.01	0	0	0	0.01
santalene α	0.28	0.65	0.67	0.37	0.74
cadin-4-en-10-ol	0.01	t	0.01	0	t
caryophyllene β	1.82	3.91	5.92	4.11	2.57
zingiberene β	0.12	0.15	0.16	0.1	0.17
germacrene D	0.01	0.01	0.01	t	t
farnesene *cis* β	0.02	0.02	0.01	0	0.01
farnesene *trans* β	0.62	1.62	2.04	2.43	0.4
coumarine	0.03	0	0	0	0
nerolidolacetate	0.01	0	0.02	0	0
santalene epi α	0	0.02	0.03	0.01	0.04
sesquisabinene α	0	0.05	0.06	0.03	0.05
farnesene *cis* β	0	0.02	0	0.01	0
humulen α	0.03	0.05	0.08	0.05	0.04
cadinol δ	0.01	t	0.01	0	t
sesquiphellandrene	0.02	0.04	0.05	0	0.04
bicyclosesquiphellandrene	0.05	0.53	0.54	0.16	0.25
farnesen α	0	0.01	0.01	0.02	0
bisabolol β	0.02	0.02	0.01	0.01	0.1
cadinen γ	0.1	0.15	t	0.05	0.18
T-cadinol	t	0.06	0.08	0.01	0.05
calamenene *cis*	0.01	t	t	0	t
caryophylleneoxid	0	0.14	0.19	0.08	0.13
Total	99.61	99.87	99.53	99.86	99.6

t = trace (<0.01 percent)

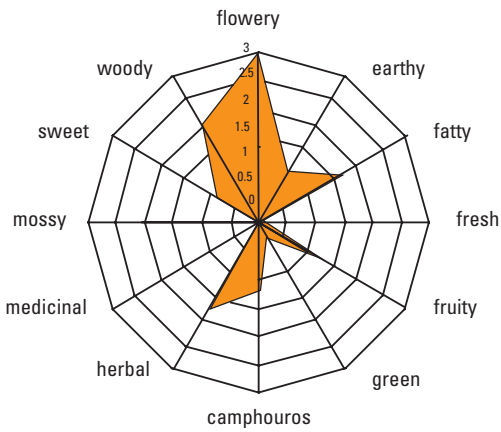
Moldova



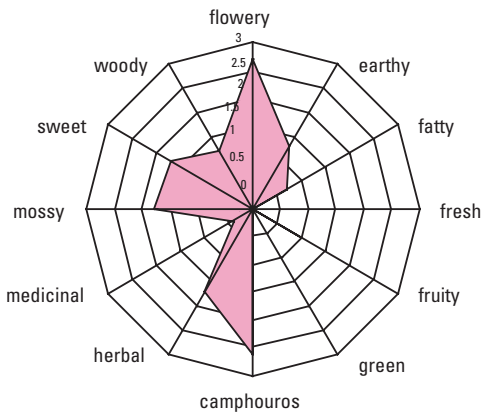
Bulgaria



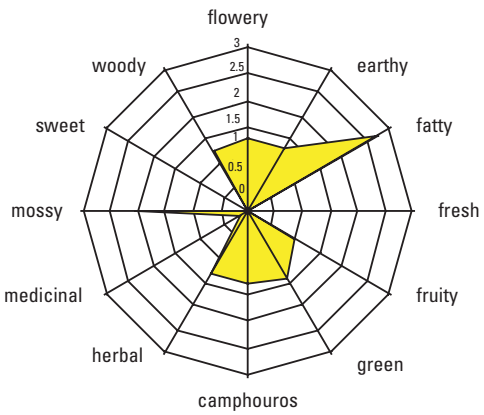
Ukraine



France



Australia



ISO 3515 — oil of lavender (2001)

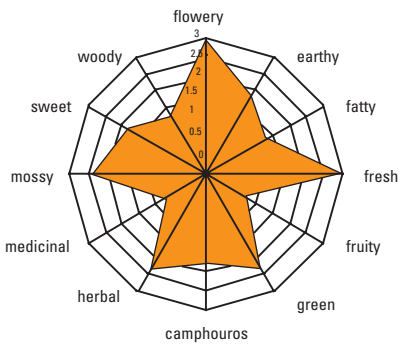
Constituent	Spontaneouslavender France		Clonal lavender — principal origins France"Mailette"		Bulgaria
	Min. percent	Max. percent	Min. percent	Max. percent	Min. percent
limonene	-	0.5	-	0.3	-
1,8-cineolee	-	1	-	0.5	-
β-phellandrene	t	0.5	-	0.2	-
cis-β-ocimene	4	10	-	2.5	3
trans-β-ocimene	1.5	6	-	2	2
3-octanone	t	2	1	2.5	0.2
camphor	t	0.5	-	1.2	-
linalool	25	38	30	45	22
linalyl acetate	25	45	33	46	30
lavandulol	0.3	-	-	0.5	0.3
terpinen-4-ol	2	6	-	1.5	2
lavandulyl acetate	2	-	-	1.3	2
α-terpineol	-	1	0.5	1.5	0.8

t = trace (<0.1 percent)

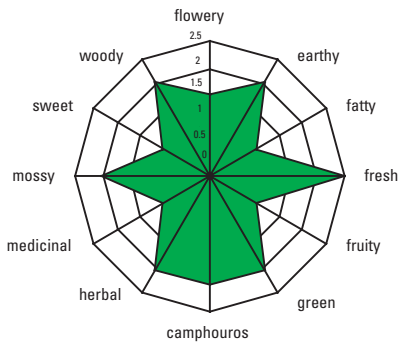
Lavender oil olfactograms — by semi-professionals

F-3

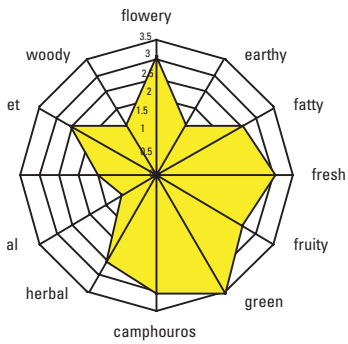
Moldova



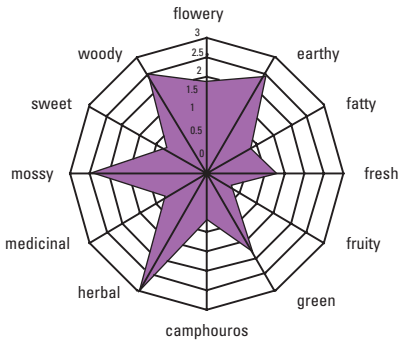
Bulgaria



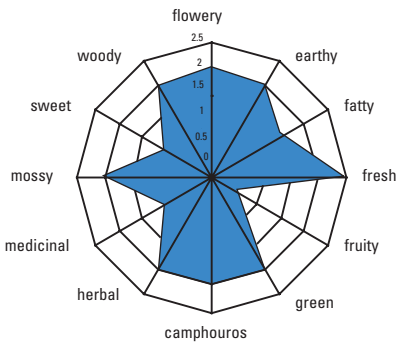
Australia



Ukraine



France



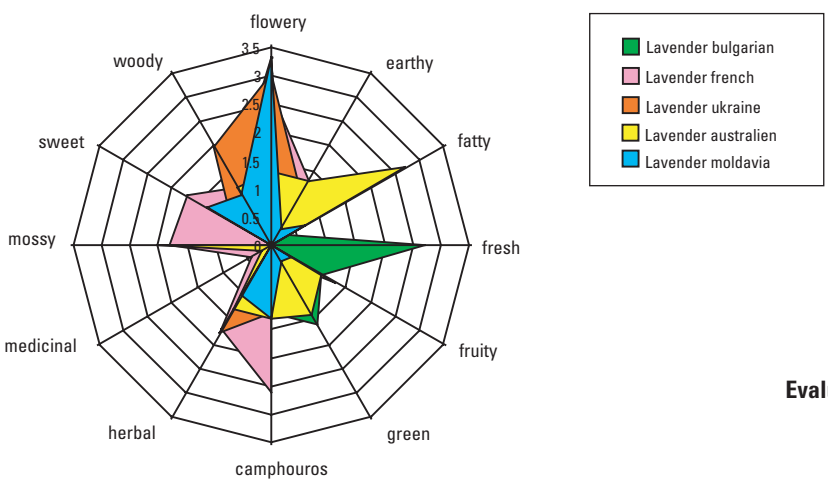
T-3

Max. percent	Russian Federation Min. percent	Russian Federation Max. percent	Australia Min. percent	Australia Max. percent	Other origins Min. percent	Other origins Max. percent
0.6	-	1	-	0.5	-	1
2	-	2.5	-	1	-	3
0.6	-	1	-	0.5	-	1
9	3	8	3	9	1	10
5	2	5	0.5	1	0.5	6
1.6	-	0.6	2	5	-	3
0.6	-	0.6	-	0.5	-	1.5
34	20	35	25	38	20	43
42	29	44	25	45	25	47
-	0.1	-	0.3	-	-	3
5	1.2	5	1.5	6	-	8
5	1	3.5	1	-	-	8
2	0.5	2	-	1.0	-	2

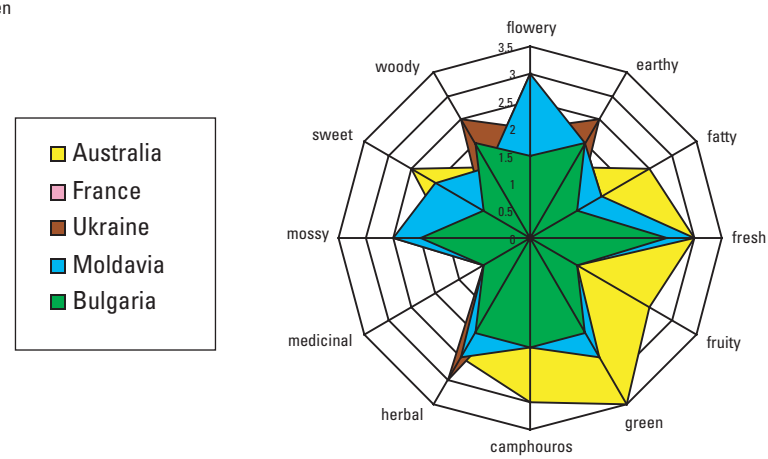
Composite (overlaid) olfactograms

F-4

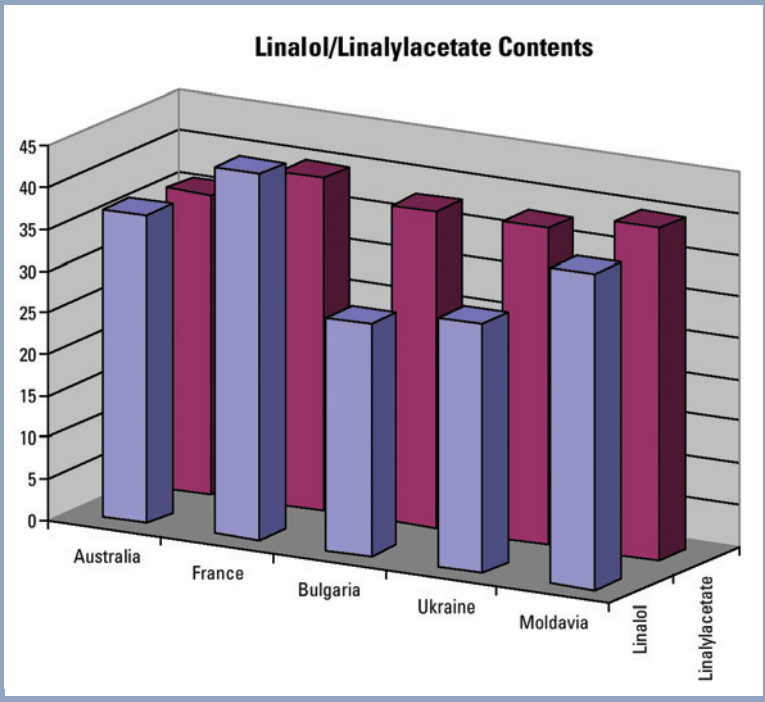
Evaluation by professional perfumers



Evaluation by semi-professionals



Major component (% content) comparison by origin **F-5**



Moldova samples have the highest con–tents of linalool, but the quantitative difference is not great between any of the origin types. In the case of linalyl acetate, the differences between types are very small.

A re-examination of other oil compo–nents that are listed in ISO 3515 for lavender oil (refer back to T-2) suggests some significant differences between the origin types. For example: cis-β-ocimene is present in small quantities in French oil, but is present in a comparatively high level in Bulgarian, Ukrainian, Moldovan and Australian oils. 3-Octanone, a very typical note for a lavender oil, occurs in higher quantities in the French oil and is very high in the Australian oil, but is very low in the cases of Moldova, Ukraine and Bul-garia. Terpinenol-4 has a very harsh, musty and herbal note. It occurs in low quantities in the French oil but is high in Bulgarian, Moldovan and Australian oils, while the Ukrainian oil levels are intermediate. Similarly, differences are apparent for lavandulyl acetate. However, the most important distinguishing feature appears to be 1,8-cineole. While the French and Australian oils only have small traces, the oils of Bulgaria, Ukraine and Moldova exhibit much higher contents.

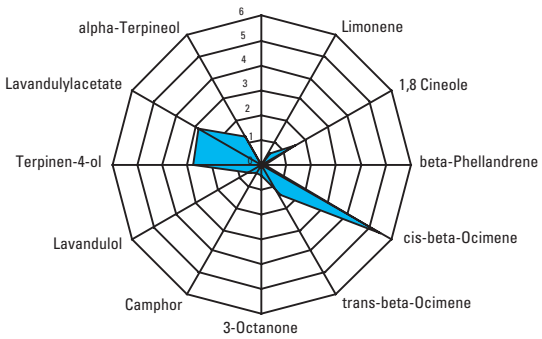
The next step in this process of assessing the impact of these individual oil components (excluding linalool and linalyl acetate) is to create statistical graphs for each origin type (see F-6). In F-6, it can be seen that:

- The Bulgarian, Moldovan and Ukrainian oils are similar, differences being more a case of the individual component concentration.
- French oil differs from the Eastern European oils by displaying different fields.
- The Australian oil exhibits a different pattern again with only a few areas overlapping those of the other oils.

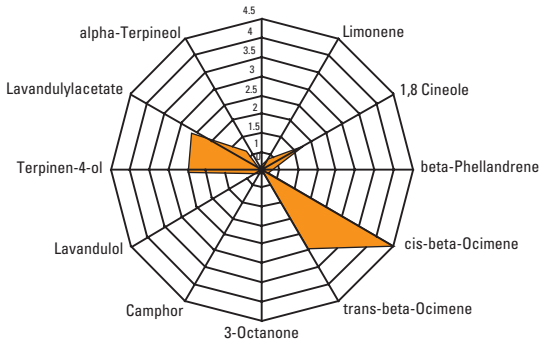
Thus, we have the first distinctive compositional difference indicators between these three groups of oils, which helps to explain the aroma characteristics. This approach is next expanded to consider the wider range of the minor components in lavender oils. Here we exclude any trace components and focus on those that occur in a well-defined quantity as shown in F-7: methyl- and hexylether and n-hexanole, 1-octene-3-ol, 3-octanole and 3-octanylacetate, cineole-1,8, the linalool oxides, hexyl-isobutyrate, undecatriene, borneol, α-terpineol, 4-thujanol, bornyl formate, bornyl acetate, linalyl formate, geranyl acetate, etc.

The translation of the abundance of these minor components to statistical graphs is shown F-8.

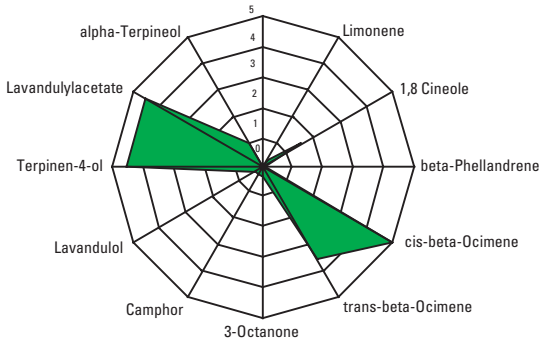
Moldova



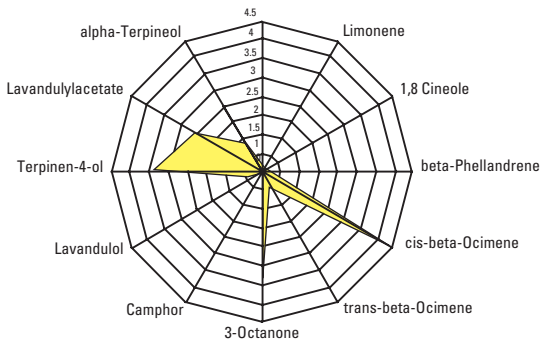
Ukraine



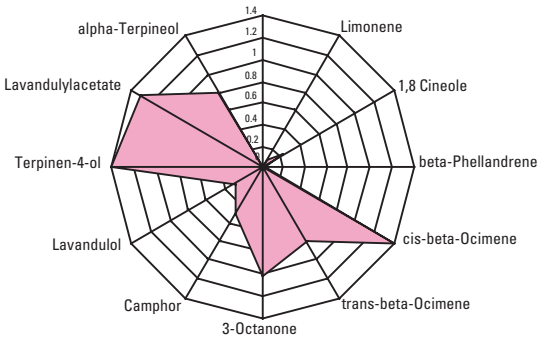
Bulgaria



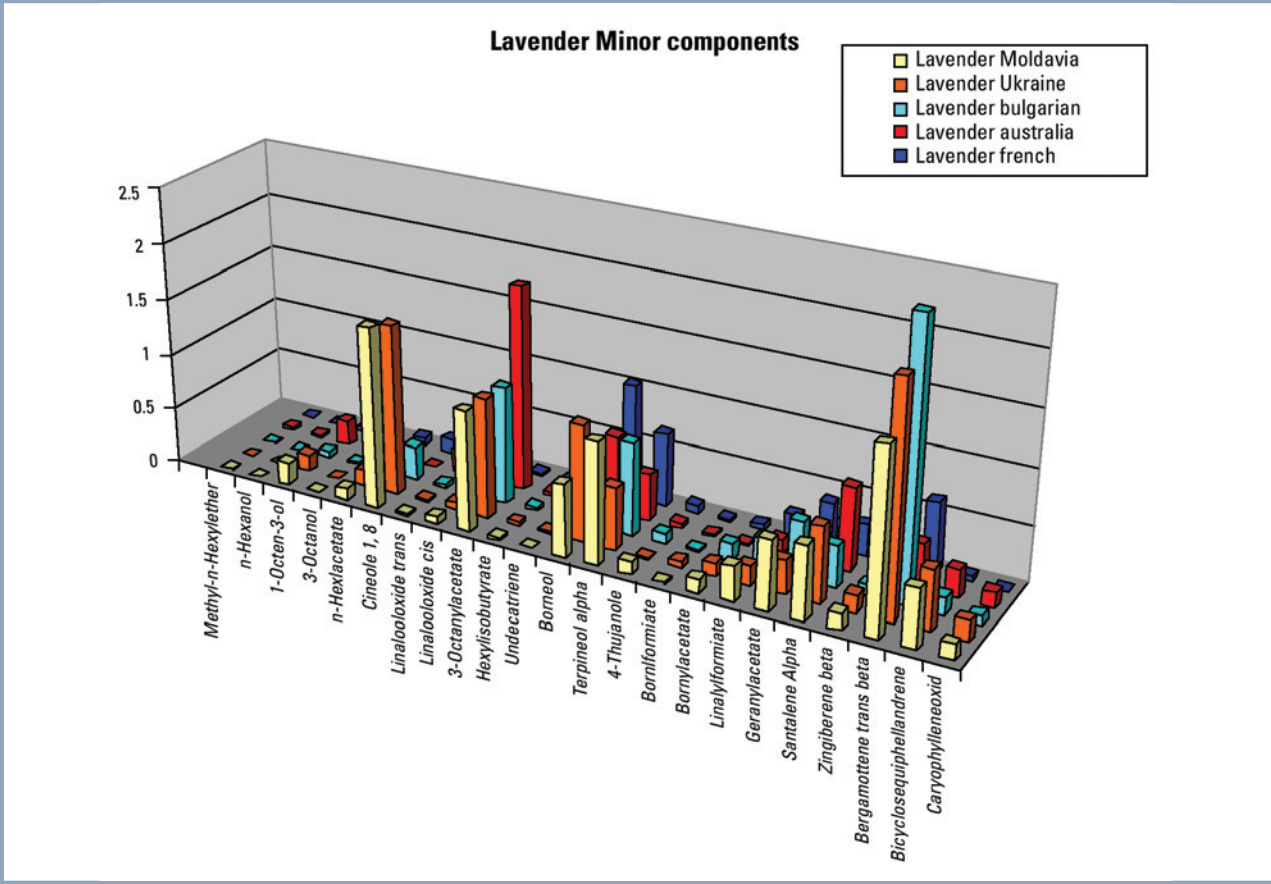
Australia



France



Lavender minor components **F-7**



The graphs in F-8 reveals large distinctive differences for:

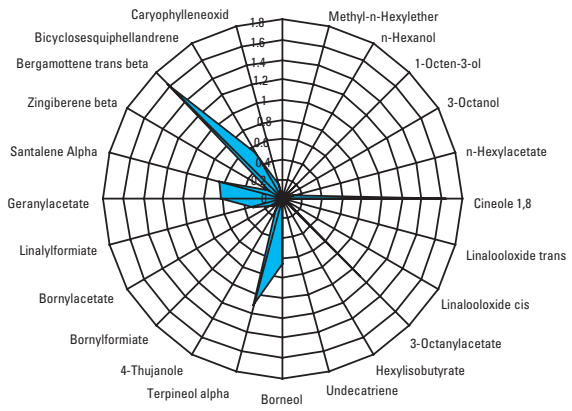
- 1,8-Cineole, once again.
- 3-Octanyl acetate, which is present in comparatively large amounts in Australian oil.
- trans-β-Bergamotene, which comparatively abundant in the oils of Moldova, Ukraine and Bulgaria, but less so in the Australian and French oils.
- Bicyclosesquiphellandrene, while in a generally low abundance, is present at higher levels in bigger quantities in the Moldovan, Ukrainian and Bulgarian oils than is found in Australian and French oils.
- 4-Thujanol does not appear clearly on these graphs because of its relatively low content; however, after preparing a shows as a distinctive marker for the Ukrainian oil as compared to the Bulgarian.
- With Moldovan oil, distinctive features are apparent also with α-terpineol and geranyl acetate.
- French oil also has a distinctive geranyl acetate area but the borneol area is an even greater characteristic.
- The Australian lavender differs absolutely through the smaller values in all the other components, but displaying a very high level of 3-octanyl-acetate.

In summarizing these findings, the following facts are obvious:

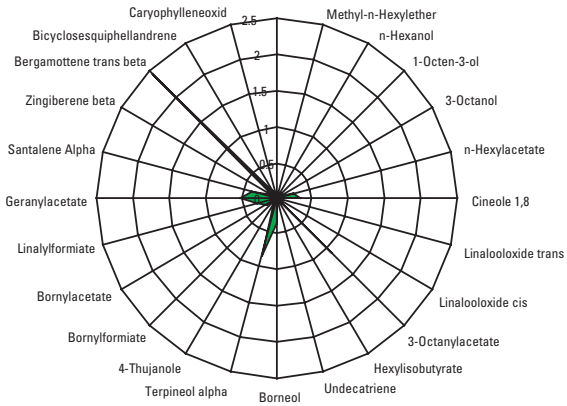
- Some typical minor components of lavender oils are found in higher concentrations in the oils of Moldova, Ukraine and Bulgaria.
- Only a small overlapping occurs in the area of cis- and trans-linalol oxide
- Absolute differences appear in the area of 1,8-cineole, trans-β-bergamotene and hexyl acetate, 4-thujanol, bornyl acetate and bornyl formate.

When we compare the olfactograms to the composition graphs, there is a great similarity.

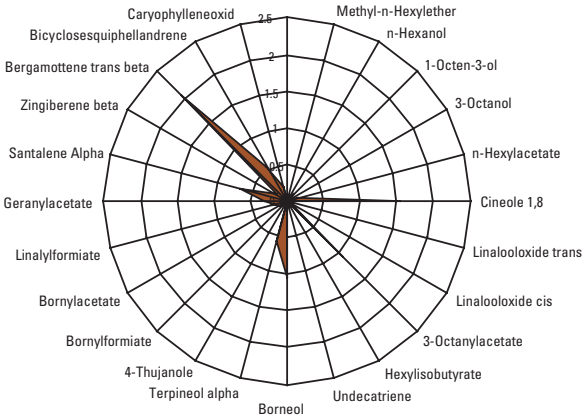
Moldova



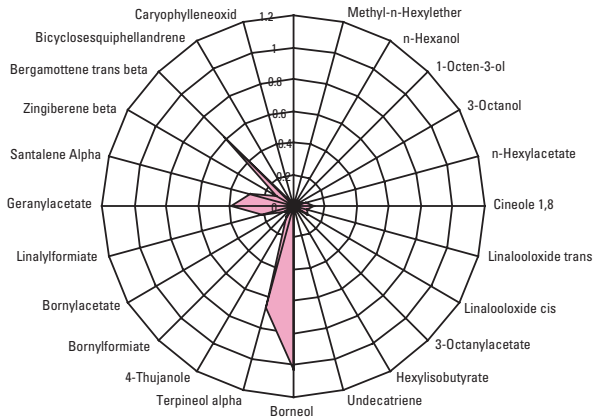
Bulgaria



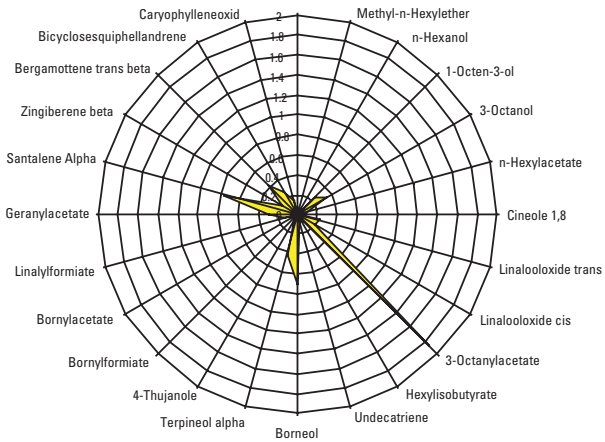
Ukraine



France



Australia



Conclusions

There are clear composition distinctions within lavender oils that are characteris–tic for the origins. Those oils coming from Eastern Europe are more herbal because they contain comparatively more 1:8-cineole, 4-thujanol, bornyl acetate, bornyl formate and even borneol. While present in small amounts, these components significantly influence the aroma and account for the more herbal note; they are sometimes even compared to lavandins rather than to lavenders. Consumers tend to love the French type with its fresh and flowery notes.

What is the reason for these differences? As all the lavender types arise from L. angustifolia Mill., the possible reasons for origin aroma differences could include the locality differences in the climate, the hours of sunshine, the soil, water supply, but also, perhaps, stress from insects and diseases. There could be another cause: namely that plants in the fields of Bulgaria, Ukraine and Moldova originated not from pure, selected clones of true lavender but instead included various hybrids. Also, perhaps, the descendants of such hybrids are now the reason for the distinction in olfactory and analytical character. This matter deserves investigation.

An example of such an investigation can be given for Germany, where we tested a field of L. angustifolia near the Alps, in the so-called "Allgäu." We found the oil to be absolutely within the values of French clonal lavender, even though the local climate and soils are completely different from those of Provence. Perhaps it should be a future target to check out all plantations in Eastern Europe and to determine whether the plants are "true" L. angustifolia Mill. or hybrids.

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