Characterization of Volatile Compounds of Virgin Olive Oil Originated in the United States

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Introduction

- The consumption of virgin olive oil (VOO) in the United States have increased from around 30 million gallons to over 70 million gallons in the past 20 years [1].
- Volatile compounds (C2-C12 aldehydes, alcohols, esters, hydrocarbons and ketones *etc.*) are responsible for the unique flavor of VOO.
- Volatile composition in VOO varies depending on genotype and cultivation conditions and processing methods.

Objectives

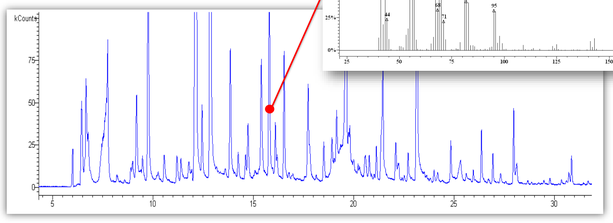
- Volatile profiles of VOOs produced in the United State were first studied.
- The volatile compositions were compared based on variety and origin to evaluate the importance of genetic and geographic effects on volatile profile.

Methods

2) GC/MS
- DB-1 column
- Injector temp.: 240ºC
- Oven: 60ºC / 5 min, ramp to 300 ºC at 5 ºC/min
- Ion-trap EI/MS

1) SPME
- Sample size, 0.5 g
- Equilibrium time, 30 min
- Extraction time, 60 min
- Room temperature

3) Compound Identification
- Retention index
- Mass spectra



Samples

Table 1. Geographical origin and variety of VOO samples

No.	Variety	Origin	No.	Variety	Origin	No.	Variety	Origin
1	Arbequina	Lakeland, GA	8	Leccino	Dundee, OR	15	Arbosana	Davis, CA
2	Arbosana	Lakeland, GA	9	Picual	Davis, CA	16	Picual	Corning, CA
3	Koroneiki	Lakeland, GA	10	Pendolino	Davis, CA	17	Arbequina	Imperial Valley, CA
4	Arbequina	Carson City, NV	11	Leccino	Davis, CA	18	Arbosana	Imperial Valley, CA
5	Arbequina	Dundee, OR	12	Barnea	Davis, CA	19	Koroneiki	Imperial Valley, CA
6	Picual	Dundee, OR	13	Arbequina	Davis, CA	20	Pendolino	Marin, CA
7	Koroneiki	Dundee, OR	14	Koroneiki	Davis, CA	21	Leccino	Marin, CA

Result & Discussion

Table 2. Volatile compounds determined by SPME-GC/MS in seven virgin olive oil originated in Davis, CA

Volatile	LRI	Picual	Pendolino	Leccino	Barnea	Arbequina	Koroneiki	Arbosana
		% Peak Area						
acetaldehyde [a]	<600	0.18	0.09	0.33	0.38	0.49	1.06	0.64
ethanol [a]	<600	ND [c]	ND	ND	ND	0.29	0.00	0.29
acetone [a]	<600	ND	ND	ND	0.14	ND	ND	ND
2-pentene [a]	<600	0.54	0.14	0.08	ND	ND	ND	ND
1,3-pentadiene [a]	<600	0.64	0.22	0.49	0.44	ND	ND	ND
2-methylpropanol	606	ND	ND	ND	0.09	1.06	2.81	3.12
1-penten-3-one	665	3.34	0.32	1.79	0.63	1.43	2.97	2.62
pentan-2-one	666	3.65	1.67	ND	ND	ND	ND	ND
pentanal	668	ND	ND	5.51	1.67	3.66	5.59	4.31
pentan-3-one	670	0.18	0.12	ND	ND	ND	0.72	0.49
3-hydroxybutanone	689	0.29	ND	0.07	ND	ND	ND	ND
E-2-pentenal	720	0.27	0.06	0.16	ND	0.17	0.35	ND
Z-2-pentenal [a]	731	0.53	0.04	0.17	ND	0.06	0.28	ND
2-penten-1-ol	757	1.25	0.31	0.40	ND	0.51	2.10	1.44
3-hexenal	775	40.27	0.32	0.30	4.55	1.02	7.58	5.36
hexanal	778	0.00	1.72	1.92	ND	3.90	10.91	10.65
octane	801	0.54	0.24	1.34	0.16	0.13	0.59	0.33
Z-2-hexenal	824	7.19	0.57	ND	ND	1.37	1.42	1.11
E-2-hexenal	830	14.51	82.05	57.78	77.34	75.77	7.64	36.21
Z-3-hexen-1-ol	843	1.16	ND	ND	ND	ND	0.72	ND
E-2-hexen-1-ol	850	ND	2.93	ND	ND	ND	ND	ND
hexanol	857	ND	ND	ND	ND	ND	0.23	ND
p-xylene	861	ND	ND	ND	ND	ND	0.00	ND
heptanal	877	ND	ND	0.23	0.19	0.10	0.23	0.21
2,4-hexadienal	886	4.74	0.82	0.52	1.43	0.20	0.34	ND
3,4-diethyl-1,5-hexadiene [a]	896	0.44	0.20	0.43	ND	ND	0.21	0.45
3,4-diethyl-1,5-hexadiene isomer [a]	899	0.37	0.23	0.32	ND	ND	0.15	0.23
2,2-dimethyl-3-pentenoic acid [a]	922	1.88	ND	ND	0.18	ND	0.00	0.61
3-ethyl-1,5-octadiene [a]	936	2.51	1.38	1.78	0.77	1.40	3.09	4.35
3-ethyl-1,5-octadiene isomer [a]	944	2.45	1.04	1.22	0.43	0.99	1.87	3.27
1-octen-3-ol	965	ND	ND	0.19	0.09	ND	ND	ND
octanal	984	ND	0.08	0.35	0.38	0.12	0.55	0.26
Z-3-hexenyl acetate	989	ND	ND	ND	ND	0.18	4.76	1.35
decadiene [a]	990	0.99	0.28	0.51	0.69	0.84	1.50	3.09
decadiene isomer [a]	993	2.69	2.21	1.79	1.87	3.49	8.35	10.80
hexyl acetate	996	0.53	ND	ND	ND	ND	0.85	ND
heptyl acetate	1026	0.71	ND	ND	ND	ND	ND	ND
limonene	1026	ND	ND	4.33	ND	ND	0.00	ND
E-β-ocimene	1039	ND	0.04	0.65	ND	0.23	0.13	ND
γ-terpinene	1053	ND	ND	ND	0.14	ND	ND	ND
octanol	1058	ND	ND	0.20	0.00	0.04	0.21	ND
nonan-2-one	1067	ND	ND	ND	ND	ND	ND	ND
nonanal	1086	0.32	0.34	0.19	1.63	0.47	2.52	1.60
2-ethylhexanoic acid [b]	1105	0.06	ND	ND	0.14	ND	ND	0.16
2-methyl-5-(1-propenyl)pyrazine	1108	0.22	0.46	2.13	0.19	0.18	4.11	1.10
3-methylbutyl pentanoate	1138	ND	ND	0.18	0.25	ND	0.21	ND
decanal	1188	ND	ND	0.56	0.27	0.04	0.34	0.34
decan-2-ol	1191	ND	0.19	ND	ND	0.04	0.00	ND
dodecane	1200	ND	0.09	0.06	0.17	0.07	0.30	0.44
nonanol [a]	1206	6.72	0.19	0.30	0.07	0.18	19.20	0.60
E-3-decen-1-ol	1225	0.05	ND	ND	ND	ND	0.23	ND
Z-3-decen-1-ol	1228	ND	ND	ND	0.08	ND	0.11	ND
E-2-decenal	1242	ND	ND	1.28	1.02	0.37	1.81	1.30
octanoic acid	1253	0.58	0.70	ND	0.13	0.24	0.00	ND
E,E-2,4-decadienal	1285	ND	ND	0.14	ND	ND	ND	ND
1-tridecene	1288	ND	ND	0.11	0.09	ND	0.19	0.20
tridecane	1300	0.11	0.22	0.10	0.11	0.11	0.44	0.86
2-Undecenal	1343	ND	ND	0.94	0.28	0.14	1.10	0.89
2-tetradecyne [b]	1395	ND	0.15	2.43	0.57	ND	ND	ND
tetradecane	1400	ND	0.05	0.17	ND	ND	0.20	0.11
5-decanolide	1449	ND	ND	ND	ND	0.09	0.49	0.49
tridecanol	1488	ND	ND	0.03	0.04	0.02	0.10	ND
tridecanol isomer [b]	1491	ND	ND	0.12	0.06	0.03	0.13	ND
1,2,5-trithiepane	1500	0.07	0.07	0.12	0.20	0.35	0.70	0.37
1-hexadecene	1596	ND	0.05	0.66	1.22	0.10	0.30	0.21
tetradecanal	1603	0.05	0.42	7.65	1.92	0.09	0.31	0.16

[a] Compound only identified by mass spectra.
[b] Compound only identified by LRI.
[c] Compound not detected.

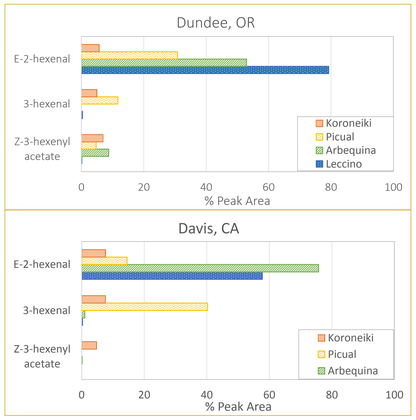


Figure 1. Variation of main C6-Ln compounds in Koroneiki, Picual, Arbequina and Leccino olive oils originated from Dundee, OR and Davis, CA.

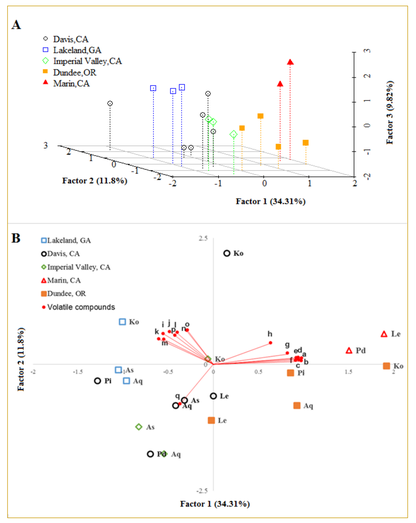


Figure 3. PCA based on 71 variables (all determined volatile compounds) characterizing 18 samples. (A) PCA with first three factors; (B) PCA with first two factors. Ab = Arbosana; Aq = Arbequina; Ko = Koroneiki; Le = Leccino; Pd = Pendolino; Pi = Picual. Letters a-q match with compounds a-q in **Table 3**.

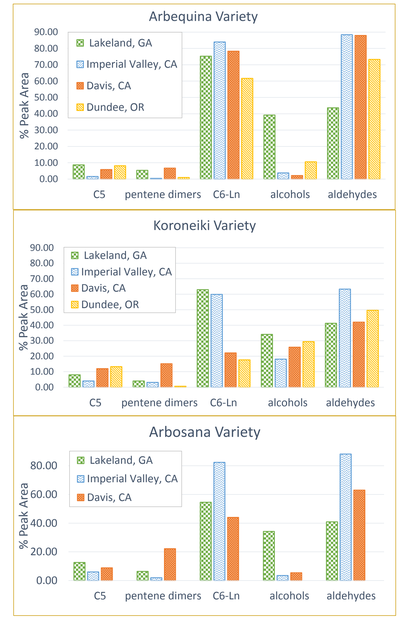


Figure 2. Variation of major volatile fractions in olive oils originated from Lakeland, GA, Imperial Valley, CA, Davis, CA and Dundee, OR in Arbequina, Koroneiki and Arbosana varieties.

Table 3. The 17 volatile compounds considered by the PCA as the most important for the characterization of olive oil samples.

Label[a]	Compound	Sensory descriptor [2,3]
1st. quadrant [b]		
a	E-2-decenal	painty, fishy, fatty
b	Octanal	fatty, honey, citrus
c	Decanal	penetrating, sweet, waxy
d	2-undecenal	
e	Nonanal	soapy, penetrating
f	Pentanal	woody, bitter, oily
g	Heptanal	oily, fatty, woody
h	Octane	sweet, alkane
2nd. quadrant		
i	3-ethyl-1,5-octadiene isomer	
j	2-penten-1-ol	perfumery, woody
k	3,4-diethyl-1,5-hexadiene isomer	
l	2,2-dimethyl-3-pentenoic acid	
m	3,4-diethyl-1,5-hexadiene	
n	Z-2-pentanal	green, pleasant
o	1-penten-3-one	green, sweet
p	3-ethyl-1,5-octadiene	
3rd. quadrant		
q	E-2-hexenal	bitter almond, green

Conclusion

- Volatile profiles of US virgin olive oils were first studied.
- 71 volatiles were determined in 21 oils representing 100% chemical composition.
- Both origin and variety significantly affect volatile profile

References

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2. Morales, M. T.; Rios, J. J.; Aparicio, R., Changes in the volatile composition of virgin olive oil during oxidation: Flavors and off-flavors. *J. Agric. Food Chem.* **1997**, *45*, 2666-2673.
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