The quality of Valencia orange peel oil as related to rootstocks

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In the early stages of the Florida citrus industry, Hood reported wide variation in quantity of rind oil in several Florida citrus cultivars.[10] DeVillers later reported that the navel oranges in South Africa contained less oil than Valencia oranges.[4] Feliu, working with Spanish sour oranges, found that oil content decreased progressively during the growing season in relation to both fruit weight and surface area.[6] Bartholomew and Sinclair expanded these findings by reporting that microenvironment and climate influenced peel oil content and that the stylar end of the fruit contained more oil than the stem end.[1] Also, oil yield was related to fruit size on a weight basis and small fruit contained more oil than large fruit due to an increased surface area of small fruit.

Kesterson and coworkers differentiated citrus species and varieties by gas liquid chromatography of leaf oils.[11] Scora and Bitters showed that rind oil varied widely with the position of the fruit on the tree and fruit maturity.[19] Hendrickson and coworkers indicated that the quantity of peel oil in Florida Valencia oranges increased per given unit of surface area as well as per unit of fresh weight as the fruit matured.[8] Also, the larger the fruit the greater the quantity of peel oil per unit of peel area.

Hendrickson and coworkers demonstrated that budwood had an influence on the peel oil content of Valencia oranges, and that rootstocks did not appear to offer the same potential for increased oil yield as did budwood selections.[9] Bitters and Scora studied the effect of twenty-five different rootstocks upon the amount and composition of oil in the rind of Valencia oranges.[2] They found that the amount of oil production was influenced more than the composition of the terpene fractions. Drescher and coworkers stated that rootstock had no influence on the oil content of Bearss lemons, and that budwood selection could increase the yield of peel oil.[5] Kesterson and coworkers showed that rootstock could influence the aldehyde content of orange oil.[12] Kesterson and coworkers showed that by proper selection of budwood the peel oil content of lemons could be increased, rootstock had no significant effect on oil yield, and cultural practices such as fertilization and irrigation could also influence peel oil content.[13] Scora discussed the use of volatile oil components in the taxonomy of lemons[20] and Kesterson and Braddock showed the total peel oil content for thirteen Florida citrus cultivars.[14] Kesterson and coworkers demonstrated that the essential nutrient nitrogen increased oil yield while potassium decreased the oil content of Pineapple oranges.[15] Kesterson and Braddock discussed the influence of cultural practices and scion and rootstock selection on citrus peel oil production.[16] Ortiz and coworkers used leaf and rind oils as criteria for establishing the taxonomy of the sour orange group.[18] A diurnal study of the leaf oils showed considerable variation in the volume of essential oil with a minimum at 0200 h. Malik and Scora used the essential leaf oils to distinguish between rough lemon and the true lemons.[17]

There are few references in the literature dealing with the influence of rootstock on the quantity and quality (chemical composition) of peel oil. Most studies have been conducted on distilled rind or distilled leaf oils. Consequently, this experiment was designed to show the influence of rootstock on commercially prepared expressed orange peel oil.

Experimental

The composition of Valencia orange oil as related to rootstock was studied using trees on rough lemon, sour orange, trifoliate orange, Cleopatra mandarin, Rangpur lime, and Parson Brown sweet orange rootstocks. Fruit from trees on trifoliate orange and Rangpur lime came from trees propagated from a single budwood source tree. Trees on the other rootstocks were propagated from two source trees, one of which was the same as that used for trifoliate orange and Rangpur lime. Trees were planted in December 1950 as a rootstock experiment in a replicated and randomized pattern. The planting is located at the Agricultural Research Center, Fort Pierce, Florida, on Parkwood soil and has received standard commercial care.[3] Ten box lots of fruit (900 lbs) were

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harvested equally from all plots for each rootstock source on April 1, 1978 and April 1, 1979. The fruit was processed using a FMC juice extractor to fractionate the fruit into its various components and at the same time produce cold pressed peel oil samples.

Total peel oil content of the fruit was determined in accordance with the procedure of Hendrickson and coworkers.[8] The values for refractive index, optical rotation, specific gravity, aldehyde content, evaporation residue, and ultraviolet absorption of the peel oils were determined in accordance with the procedures of the United States Pharmacopoeia (U.S.P.).[21] The percent free acid, percent free ester, and percent free alcohol were determined with the procedures given by Guenther.[7] In making ester determinations it is necessary to first remove the aldehydes because they, too, will consume caustic during saponification, yielding erroneously high results.

Results and discussion

The physical and chemical properties of expressed Valencia orange oils prepared during the 1978 and 1979 processing seasons from six different rootstocks are shown in Tables I-VI. These oils generally met U.S.P. standards except in some instances where the refractive index values and evaporation residue values were slightly below the lower limits. Evaporation residue values were consistently high during the 1979 processing season. Differences of this nature are to be expected when working with biological crops and small oil lots. However, all of the oil samples were considered to be representative of those produced commercially. Average values for the 1978 and 1979 seasons combined met all U.S.P. standards.

Data collected on the processed fruit were as follows: °Brix of the juice, % acid content of the juice, juice ratio, gals juice/box, lbs juice/box, lbs soluble solids/box, total peel oil content—lbs/T fruit, % aldehyde content, acid number, % free acid content, ester number before acetylation, % free ester content, ester number after acetylation, % ester after acetylation, % free alcohol content, and % total alcohol content of the oil. These data were analyzed for statistical differences and five of the above parameters, °Brix of the juice, lbs soluble solids/box, % aldehyde content, ester number before acetylation, and % free ester content, were significant at the 1% level. Fruit from trees on trifoliate orange and Parson Brown had the highest °Brix of the juice and lbs soluble solids/box, whereas those from trees on Rangpur lime and rough lemon had the lowest values.

In our studies, rootstock had no significant influence on the total quantity of oil produced in the peel of Valencia oranges, confirming findings by Hendrickson and coworkers[9] and Drescher and coworkers[5] in Florida, but in contrast to a report by Bitters and Scora[2] on Valencia oranges in California. Only two chemical components of the expressed Valencia orange oils, % aldehyde content (Table VII) and % free ester content (Table VIII), were shown to differ significantly by rootstock within a given processing season. When data were combined for two processing seasons, sour orange, rough lemon, Rangpur lime, and Parson Brown rootstock were equal in the production of aldehydes in the essential oils. The highest ester content was in the peel oil from fruit on rough lemon.

The aldehyde and ester content of citrus oils have long been considered important indicators of flavor and aroma, and rootstocks can have an influence on this important quality of an orange oil. However, the limited amount of data accumulated regarding the influence of rootstock on oil quality and yield indicate

Table 1--Physicochemical properties of peel oil extracted from the fruit of Valencia orange on rough lemon rootstock during the 1978 and 1979 processing seasons

	1978	1979	Avg.
Sp. Grav. 25°C/25°C	0.8439	0.8444	0.8442
Ref. Ind. N_D^{20}	1.4728	1.4727	1.4728
10% dist.	1.4716	1.4718	1.4717
Difference	0.0012	0.0009	0.0011
Opt. Rot. α_D^{25}	+97.43	+96.79	+97.11
10% dist.	+98.13	+97.64	+97.89
Difference	+ 0.70	+ 0.85	+ 0.78
Evap. Residue	50.1	52.0	51.1
U.V. Spectrum:			
CD	0.435	0.364	0.400
Peak	0.695	0.565	0.630
M_μ	329.0	328.0	328.5
% - Aldehyde	1.78	1.72	1.75
% - Free Acid	0.14	0.07	0.11
% - Free Ester	0.79	0.76	0.78
% - Free Alcohol	0.69	0.46	0.58

Table 2--Physicochemical properties of peel oil extracted from the fruit of Valencia orange on Cleopatra rootstock during the 1978 and 1979 processing seasons

	1978	1979	Avg.
Sp. Grav. 25°C/25°C	0.8434	0.8451	0.8443
Ref. Ind. N_D^{20}	1.4728	1.4729	1.4729
10% dist.	1.4717	1.4718	1.4718
Difference	0.0011	0.0011	0.0011
Opt. Rot. α_D^{25}	+97.46	+96.80	+97.13
10% dist.	+98.14	+97.74	+97.94
Difference	+ 0.68	+ 0.94	+ 0.81
Evap. Residue	44.7	56.7	50.7
U.V. Spectrum:			
CD	0.488	0.406	0.447
Peak	0.740	0.625	0.683
M_μ	329.0	329.0	329.0
% - Aldehyde	1.54	1.57	1.56
% - Free Acid	0.13	0.10	0.12
% - Free Ester	0.61	0.69	0.65
% - Free Alcohol	0.67	0.84	0.76

Table 3--Physicochemical properties of peel oil extracted from the fruit of Valencia orange on sour orange rootstock during the 1978 and 1979 processing seasons

	1978	1979	Avg.
Sp. Grav. 25°C/25°C	0.8423	0.8435	0.8429
Ref. Ind. N_D^{20}	1.4727	1.4727	1.4727
10% dist.	1.4715	1.4716	1.4716
Difference	0.0011	0.0011	0.0011
Opt. Rot. α_D^{25}	+97.46	+96.68	+97.07
10% dist.	+97.75	+97.71	+97.73
Difference	+ 0.39	+ 1.03	+ 0.71
Evap. Residue	41.8	53.6	47.7
U.V. Spectrum:			
CD	0.417	0.404	0.411
Peak	0.659	0.604	0.632
M_n	329.0	329.0	329.0
% - Aldehyde	1.73	1.82	1.77
% - Free Acid	0.12	0.09	0.11
% - Free Ester	0.64	0.57	0.61
% - Free Alcohol	0.76	0.91	0.83

Table 4--Physicochemical properties of peel oil extracted from the fruit of Valencia orange on Trifoliate orange rootstock during the 1978 and 1979 processing seasons

	1978	1979	Avg.
Sp. Grav. 25°C/25°C	0.8440	0.8450	0.8445
Ref. Ind. N_D^{20}	1.4729	1.4728	1.4729
10% dist.	1.4717	1.4716	1.4717
Difference	0.0012	0.0012	0.0012
Opt. Rot. α_D^{25}	+97.63	+96.64	+97.14
10% dist.	+97.97	+97.76	+97.87
Difference	+ 0.34	+ 1.12	+ 0.73
Evap. Residue	42.1	56.4	49.3
U.V. Spectrum:			
CD	0.446	0.423	0.435
Peak	0.691	0.645	0.668
M_n	329.0	329.0	329.0
% - Aldehyde	1.40	1.55	1.48
% - Free Acid	0.11	0.10	0.11
% - Free Ester	0.68	0.62	0.65
% - Free Alcohol	0.97	0.74	0.86

Table 5--Physicochemical properties of peel oil extracted from the fruit of Valencia orange on Rangpur lime rootstock during the 1978 and 1979 processing seasons

	1978	1979	Avg.
Sp. Grav. 25°C/25°C	0.8423	0.8434	0.8429
Ref. Ind. N_D^{20}	1.4727	1.4726	1.4727
10% dist.	1.4716	1.4717	1.4717
Difference	0.0011	0.0009	0.0010
Opt. Rot. α_D^{25}	+97.34	+96.80	+97.07
10% dist.	+97.78	+97.59	+97.69
Difference	+ 0.44	+ 0.79	+ 0.62
Evap. Residue	40.3	49.3	44.8
U.V. Spectrum:			
CD	0.412	0.383	0.398
Peak	0.645	0.560	0.603
M_n	329.0	329.0	329.0
% - Aldehyde	1.73	1.76	1.75
% - Free Acid	0.12	0.10	0.11
% - Free Ester	0.65	0.56	0.61
% - Free Alcohol	0.73	0.62	0.68

Table 6--Physicochemical properties of peel oil extracted from the fruit of Valencia orange on Parson Brown rootstock during the 1978 and 1979 processing seasons

	1978	1979	Avg.
Sp. Grav. 25°C/25°C	0.8427	0.8438	0.8433
Ref. Ind. N_D^{20}	1.4728	1.4728	1.4728
10% dist.	1.4714	1.4717	1.4716
Difference	0.0014	0.0011	0.0013
Opt. Rot. α_D^{25}	+97.54	+96.84	+97.19
10% dist.	+97.62	+97.86	+97.74
Difference	+ 0.08	+ 1.02	+ 0.55
Evap. Residue	40.3	53.1	46.7
U.V. Spectrum:			
CD	0.418	0.415	0.417
Peak	0.648	0.620	0.634
M_n	329.0	329.0	329.0
% - Aldehyde	1.62	1.64	1.63
% - Free Acid	0.12	0.09	0.11
% - Free Ester	0.55	0.67	0.61
% - Free Alcohol	0.97	0.52	0.75

the need for further study and research to include other varieties and rootstocks of citrus.

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Table 7--Influence of rootstock on the aldehyde content of expressed Valencia peel oil

Treatment	% - Aldehyde 1978 (Avg.) **	% - Aldehyde 1979 (Avg.) **	Mean **	
Sour orange	1.710 b	1.820 a	1.765	A
Rough lemon	1.780 a	1.720 ab	1.750	A
Rangpur lime	1.730 b	1.760 a	1.745	A
Parson Brown	1.620 c	1.640 bc	1.630	A B
Cleopatra	1.540 d	1.570 c	1.555	B C
Trifoliate	1.400 e	1.555 c	1.475	C

** Significant at 1% level.

Table 8--Influence of rootstock on the %-free ester content of expressed Valencia peel oil

Rootstock	% - Free Ester 1978 (Avg.) **	% - Free Ester 1979 (Avg.) **	Mean **	
Rough lemon	0.790 a	0.755 a	0.772	A
Trifoliate	0.680 b	0.620 bc	0.650	B
Cleopatra	0.605 bc	0.685 ab	0.645	B
Parson Brown	0.550 c	0.675 b	0.610	B
Rangpur lime	0.650 b	0.560 c	0.605	B
Sour orange	0.635 bc	0.565 c	0.600	B

** Significant at 1% level.

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