

Ambersweet Orange Hybrid: Compositional Evidence for Variety Classification

Manuel G. Moshonas,*† Philip E. Shaw,† and Robert D. Carter†

U.S. Citrus and Subtropical Products Laboratory, South Atlantic Area, Agricultural Research Service, U.S. Department of Agriculture, P.O. Box 1909, Winter Haven, Florida 33883-1909, and Florida Department of Citrus, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, Florida 33850

The Ambersweet orange is a new orange hybrid that ripens in October and has good juice color. For the citrus-processing industry to be able to take full advantage of Ambersweet, its variety classification as an orange has to be established. Compositional analyses of volatile flavor and aroma constituents of Ambersweet fruit products were compared with those of similar products from the parent fruits, orange, tangerine, and grapefruit. All 21 constituents identified in Ambersweet fresh juice were identical with those in fresh orange juice with no appreciable quantitative differences. All 30 constituents identified in Ambersweet aqueous juice essence were identical with those in aqueous orange essence with no appreciable quantitative differences. Selected components of Ambersweet peel and essence oils important to flavor were found to be identical with those in orange peel and essence oils with no significant quantitative differences. Analogous compositional comparisons of these Ambersweet products with those of tangerine, Orlando tangelo, and grapefruit showed major qualitative and quantitative differences in all products analyzed.

INTRODUCTION

The Ambersweet orange is a hybrid resulting from a cross in 1963 of Clementine tangerine (*Citrus reticulata* Blanco) × Orlando tangelo (*C. paradisi* Macf. × *C. reticulata*) × midseason sweet orange (*C. sinensis* (L.) Osb.) made by C. J. Hearn and P. C. Reece of the USDA Horticultural Research Laboratory, Orlando, FL. The fruits of Ambersweet are 3–4 in. in diameter, have a thick rind that can be removed easily, and are orange at maturity. The dark orange flesh and juice have excellent flavor. In Florida, the fruit reaches orange juice maturity standards for the fresh fruit market in mid-October and for processing in mid-November (Florida Department of Citrus, 1990) and keeps well on the tree through December. In 1988 the average yield of Ambersweet fruit on 14-year-old trees grafted to Carrizo, Cleopatra, sour orange, and rough lemon rootstocks was 6.5 boxes (1.6 bu/box) per tree (Hearn, 1989). The optimum storage conditions for Ambersweet fruit were similar to those of orange; conditions were 1 °C for 14 days followed by 21 °C for 14 days (Hearn, 1990).

The many desirable characteristics of the Ambersweet orange hybrid have created great interest in the fruit by the growers, fresh fruit shippers, and processors of the Florida citrus industry. On July 26, 1990, the Florida Citrus Commission officially classified Ambersweet as an orange for purposes of fresh fruit sales. For use in processed products, however, the Ambersweet is not currently considered part of the *C. sinensis* species. *C. sinensis* is the only species that can be used in orange juice without limitation under U.S. Food and Drug Administration standards of identity for orange juice. Presently, only 10% of the juice from citrus hybrids or mandarins is allowed to be used in standard orange juice products. Therefore, to permit unlimited use of Ambersweet juice in orange juice products, the FDA's standard of identity for orange juice products would have to be modified to include Ambersweet juice. Although the

standard of identity for orange specifies *C. sinensis* as the sole species permitted, publications on citrus taxonomy by Scora (1975), Barrett and Rhodes (1976), and Hearn (1977) support the conclusion that *C. sinensis* is not a valid species but is in fact a hybrid involving *C. reticulata*.

The purpose of the current study is to obtain objective evidence that will help determine the variety classification of Ambersweet fruit. This paper compares the volatile flavor and aroma composition of freshly squeezed Ambersweet juice, aqueous juice essence, juice essence oil, and cold-pressed peel oil with the composition of flavor volatiles from similar products obtained from parent fruit, including orange, tangerine, Orlando tangelo, and grapefruit. Although products from all parentage fruit were evaluated, a principal concern of the citrus industry is to determine the extent, if any, of mandarin characteristics.

EXPERIMENTAL PROCEDURES

Citrus Fruit Product Samples. Freshly squeezed juice samples include the following: Ambersweet orange hybrid samples harvested from Leesburg and from Lake Wales, FL, and processed on December 7, 1989; Valencia orange, Clementine tangerine (December 7, 1989); Orlando tangelo (January 19, 1989). Aqueous juice essence samples studied were as follows: Ambersweet orange (Leesburg, December 7, 1989); Pineapple (*C. sinensis*) and Valencia (*C. sinensis*) orange samples described by Shaw et al. (1990) and four commercial samples described by Moshonas and Shaw (1990); Dancy tangerine (*C. reticulata*); Orlando tangelo (*C. paradisi* × *C. reticulata*). The latter two samples were from the "Collection of Authentic Orange Juice Samples" (1987). Juice essence oils were from Ambersweet orange hybrid, Valencia orange, commercial tangerine, and commercial grapefruit. Cold-pressed peel essential oil was from Ambersweet orange hybrid, Valencia orange, tangerine, and grapefruit. Pure commercial peel oils were used for all peel oil samples except Ambersweet. All Ambersweet orange samples were prepared at the Citrus Research and Education Center, Lake Alfred, FL, as described by Barros et al. (1990). The Dancy tangerine and Orlando tangelo aqueous essences and the tangerine essence oil sample were all prepared with the unit described by Bates and Carter (1984).

Gas Chromatography (GC) of Aqueous Essences, Essence Oils, and Cold-Pressed Peel Oils. Three replicates of each

† U.S. Citrus and Subtropical Products Laboratory.

‡ Florida Department of Citrus.

sample were analyzed as follows. A Hewlett-Packard Model 5880A instrument equipped with a flame ionization detector was used with a 50-m (0.31–0.32 mm i.d.) fused silica capillary, cross-linked 5% phenylmethyl silicone column (Hewlett-Packard, Avondale, PA), and a capillary inlet system fitted with a split line that allows the helium flow to be split at 100:1. Helium flow through the column was 1.5 mL/min. Injection port and detector temperatures were 275 °C. The column temperature was held at 60 °C for 4 min and then programmed to 200 °C at 6 °C/min and held for 15–45 min. The threshold was set at 0, peak width at 0.02, and chart speed at 1 cm/min. Aqueous essence samples (1.0 μ L) and essence oil and cold-pressed peel oil samples (0.2 μ L each) were injected manually.

Mass Spectra. Identification of aqueous essences, essence oils, and cold-pressed peel oil constituents was made by gas chromatography–mass spectrometry (GC–MS). A Hewlett-Packard Model 5970B, MSD, GC–MS was used with a 50 m \times 0.32 mm fused silica column of cross-linked 5% phenylmethyl silicone. The initial oven temperature was held at 55 °C for 9 min and then programmed at 7.5 °C/min to 220 °C and held there for 30 min. Injection port and ionizing source were kept at 280 °C. Mass units were monitored from 25 to 350 at 70 eV. Mass spectral matches were made by comparison of mass spectra and retention time with those of authentic compounds.

Gas Chromatography (GC) of Juices. For freshly squeezed juices, three replicate samples of each juice were analyzed as follows. A Perkin-Elmer Model 8500 gas chromatograph with a Model HS-6 headspace sampler was used. A 0.53 mm \times 30 m DB-Wax column with 1.0- μ m film thickness (J&W Scientific, Folsom, CA) was employed with an FID detector at 250 °C set for high sensitivity (amplifier range setting). Temperature programming was 40 °C for 6 min and then increased at 6 °C/min to 180 °C final temperature. Column head pressure was 0.4 kg/cm² (6 psi) of He, providing a column flow rate of 81 cm/s linear gas velocity. Sample injections were carried out by equilibrating a 2-mL sample of juice for 15 min at 80 °C in the headspace sampler prior to injection. A 0.5-min vial pressurization time followed by a 0.02-min injection time was used to inject each sample onto the capillary column.

Components were identified by comparison of retention times with those of standards and by enrichment of juice with authentic samples. Quantitative determinations were carried out with external standards prepared as mixtures of the volatile components quantitatively added to a bland juice base. The juice base was prepared by reconstitution to 11.8 °Brix without added flavor fractions using concentrated juice from an evaporator. Standard mixtures were used the same day they were prepared. All standard determinations were carried out as described earlier (Nisperos-Carriedo and Shaw, 1990).

Statistical Analyses. Data were analyzed by analysis of variance using the general linear model (GLM) procedure, a package program of the Statistical Analysis System (SAS Institute Inc., Cary, NC). Specific differences between treatments were determined by Tukey's Studentized range (HSD). All comparisons were made at the 5% level of significance.

RESULTS AND DISCUSSION

To develop objective evidence that will help classify the Ambersweet fruit, compositional analyses were carried out on the volatile flavor and aroma constituents from freshly squeezed juices, aqueous juice essences, juice essence oils, and cold-pressed essential peel oils obtained from Ambersweet fruit harvested in mid-December (1989) and from its parentage fruit, orange, tangerine, Orlando tangelo, and grapefruit. The compositional analyses of the Ambersweet fruit products were then compared to compositional analyses of similar products from parent fruit to determine significant qualitative and quantitative similarities and differences that would help establish proper variety classification for Ambersweet fruit.

Fresh Juices. In Figure 1 the headspace GC compositional profile of freshly squeezed juice from Ambersweet is compared to that of Valencia orange juice. There are

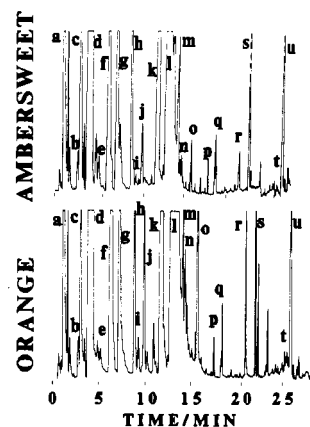


Figure 1. Gas chromatograms of the volatile components of fresh juices from Ambersweet orange hybrid and Valencia orange. Letters identifying peaks correspond to letters preceding components in Table I.

no qualitative differences. All 21 constituents identified in orange juice were also identified in Ambersweet juice. Table I lists the qualitative and quantitative data for orange juices reported previously compared to those in Ambersweet. For all but one component, the quantities found in Ambersweet fall within the range reported elsewhere. For the one exception, α -pinene, values in Ambersweet were higher than the highest reported value in fresh juice; its content is known to be affected by the peel oil content of the juice (Nisperos-Carriedo and Shaw, 1990).

Figure 2 and Table I compare the compositional profiles of freshly squeezed juices from Ambersweet orange hybrid and tangerine. Major qualitative and quantitative differences are immediately obvious when these compositional profiles are compared. Qualitatively, 6 of the 21 compounds identified as Ambersweet flavor volatiles were absent in tangerine juice (Table I). These include ethyl acetate, methyl butyrate, ethyl hexanoate, hexanol, α -terpineol, and valencene. Of the remaining 15 Ambersweet juice compounds, significant quantitative differences from tangerine juice were found in all components including limonene, whose quantity was determined by titration rather than GC.

Figure 3 compares the headspace GC compositional profiles of freshly squeezed juices from Ambersweet and Orlando tangelo. Significant qualitative differences in the juice were documented in that 8 of the 21 constituents identified as Ambersweet juice components were absent in Orlando tangelo juice. These constituents are methyl butyrate, 2-methyl-1-propanol, sabinene, ethyl hexanoate, hexanol, *cis*-3-hexenol, decanal, and α -terpineol. There were also significant quantitative differences found between tangelo and both Ambersweet samples in the acetaldehyde, methanol, α -pinene, ethyl butyrate, hexanal, octanal, linalool, and valencene contents present. Significant quantitative differences between tangelo and at least one Ambersweet sample were found in all remaining components identified in Table I. A comparison of the headspace GC compositional profiles of freshly squeezed juices from Ambersweet and Duncan grapefruit (GC curve not shown) also shows significant qualitative and quantitative differences.

Aqueous Essences. Figure 4 shows GC compositional profiles of aqueous juice essences from Ambersweet and Valencia orange obtained by direct injection of the aqueous essences into a gas chromatograph. All constituents identified in Ambersweet essence were identical with those in orange essence (Table II). In addition to the 30 identified components in Table II, 12 minor components

Table I. Volatile Components in Fresh Ambersweet and Other Citrus Juices^a

component	orange (range ^b)	ambersweet ^c		Clementine tangerine	Orlando tangelo	
		1	2			
a	acetaldehyde	3-15	9.9	6.9	1.2	3.1
b	ethyl acetate	0.01-0.58	0.15	0.08	ND ^d	0.08
c	methanol	0.8-80	34	29	<1	11
d	ethanol	64-900	264	101	23	98
e	methyl butyrate	0.01-0.1	0.04	0.02	ND	ND
f	α -pinene	0.02-0.22	0.31	0.43	0.04	0.03
g	ethyl butyrate	0.08-1.02	0.65	0.13	0.01	tr ^e
h	hexanal	0.02-0.65	0.53	0.61	tr	0.03
i	2-methyl-1-propanol	0-0.07	tr	tr	tr	ND
j	sabinene	0-0.15	0.13	0.11	0.05	ND
k	myrcene	0.068-5.5	NC/	NC	NC	NC
l	limonene	1-278	270 ^g	290 ^g	18 ^g	13 ^g
m	ethyl hexanoate	0.01-0.06 ^h	0.07	0.06	ND	ND
n	γ -terpinene	0.04-0.46	0.04	0.06	0.008	0.03
o	octanal	0.01-0.28	0.02	0.02	<0.001	0.007
p	hexanol	0.02-0.22	0.13	0.13	ND	ND
q	<i>cis</i> -3-hexenol	0.01-0.65	0.46	0.58	0.07	ND
r	decanal	0.01-0.15	0.04	0.03	0.005	ND
s	linalool	tr-4.69	0.49	0.55	0.06	0.07
t	α -terpineol	tr-1.1	0.21	0.25	ND	ND
u	valencene	0.04-15.3	0.49	0.51	ND	0.16

^a Values are in ppm and represent averages of three determinations. ^b Combined range of values previously reported for all varieties by Nisperos-Carriedo and Shaw (1990) and summarized by Shaw (1986). ^c 1 = Leesburg; 2, Lake Wales juice samples. ^d ND, not detected. ^e tr, trace; less than 0.01 ppm. /NC, not calculated. ^g Value is average of three determinations by method of Scott and Veldhuis (1966). ^h Unpublished data from our laboratory.

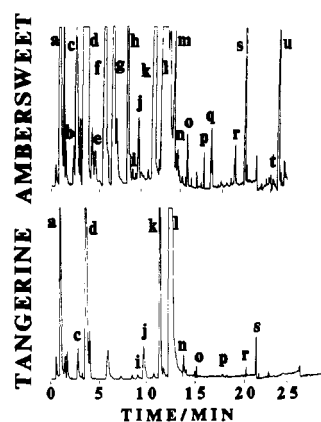


Figure 2. Gas chromatograms of the volatile components of fresh juices from Ambersweet orange hybrid and tangerine. Letters identifying peaks correspond to letters preceding components in Table I.

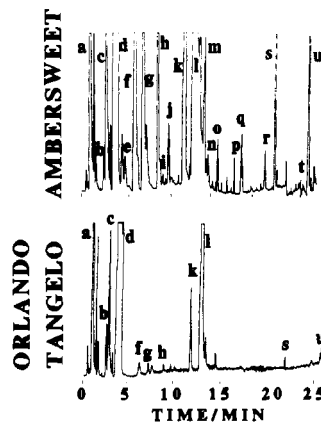


Figure 3. Gas chromatograms of the volatile components of fresh juices from Ambersweet orange hybrid and Orlando tangelo. Letters identifying peaks correspond to letters preceding components in Table I.

were not identified but their mass spectra and GC retention times in Ambersweet essence matched with matching peaks in orange essence. Statistical quantitative com-

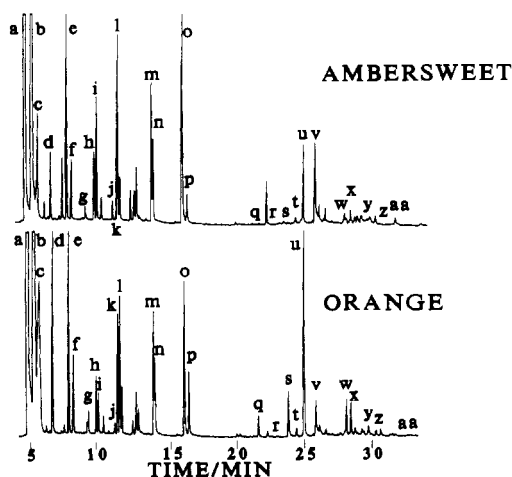


Figure 4. Gas chromatograms of the volatile components of aqueous juice essences from Ambersweet orange hybrid and Valencia orange. Letters identifying peaks correspond to letters preceding components in Table II.

parisons of the Ambersweet essence constituents with those of previously reported orange essence show significant differences in nine components listed in Table II when compared individually with six aqueous orange essence samples, four of which were commercial samples. The low quantity of octanal found in Ambersweet essence can be attributed to the low quantity found in fresh juice. However, the quantity found is within the range of octanal values found in juice from Hamlin, Pineapple, and Valencia cultivars reported earlier (Nisperos-Carriedo and Shaw, 1990). There were also significant differences in quantities of all 30 components quantified when compared individually among the six orange essences used for comparison; these probably represent orange varietal differences. Thus, there are just as many quantitative differences among constituents of various orange essence samples as there are between Ambersweet and individual orange essence samples.

Figure 5 shows the GC compositional profiles of aqueous juice essences from Ambersweet and tangerine. Major qualitative and quantitative differences between Amber-

Table II. Qualitative and Quantitative^a Comparison of Ambersweet and Orange Aqueous Essence Composition

compd	Ambersweet	commercial orange samples					
		United States					
		A	B	C	Brazil	Pineapple	
a	acetaldehyde + methanol	3.080A	3.504B	3.875C	3.109A	5.187D	4.464E
b	ethanol	96.096A ^b	96.139A	95.637B	96.445C	94.239D	94.282D ^c
c	acetone	0.007A	0.008B	0.014C	0.012D	0.014C	0.022E
d	1-propanol	0.028A	0.040B	0.045CD	0.042BD	0.047C	0.047C
e	ethyl acetate + 2-methyl-3-buten-2-ol	0.088A	0.054B	0.081A	0.067C	0.083A	0.131D
f	2-methyl-1-propanol	0.024A	0.011B	0.012BC	0.013C	0.008D	0.015E
g	1-butanol	0.007A	0.004BC	0.005B	0.004C	0.009D	0.012E
h	1-penten-3-ol	0.031A	0.004B	0.007C	0.004B	0.015D	0.014D
i	ethyl vinyl ketone	0.003A	0.005A	0.009B	0.007B	0.021C	0.027D
j	methyl butyrate	0.005AB	0.002C	0.001D	0.002C	0.002C	0.006A
k	1,1-diethoxyethane	0.005A	0.014A	0.044B	0.074C	0.007A	ND ^e
l	isoamyl alcohol	0.095A	0.022B	0.023BC	0.024BC	0.022C	0.028C
m	ethyl butyrate	0.056A	0.019B	0.037C	0.042C	0.055A	0.223D
n	hexanal	tr ^f	0.010A	0.010A	0.009A	0.031B	tr
o	trans-2-hexenal	0.151A	0.015B	0.029C	0.018B	0.032C	0.081D
p	trans-2-hexenol + cis-3-hexen-1-ol	0.018A	0.002B	0.001B	0.001B	0.005C	0.011D
q	octanal	tr	0.009AB	0.010A	0.007C	0.007C	0.017D
r	limonene	tr	0.002A	tr	0.001A	0.001A	0.321B
s	octanol	0.001A	0.007B	0.007B	0.003A	0.015C	0.012C
t	linalool oxide	0.001A	0.006B	0.003C	0.002D	0.001AD	0.001A
u	linalool	0.053A	0.079B	0.076B	0.049A	0.143C	0.017D
v	ethyl 3-hydroxyhexanoate	0.085A	0.004B	0.010B	0.011B	0.004B	0.041C
w	terpinen-4-ol	0.005A	0.009BC	0.007AB	0.007AB	0.005A	0.014D
x	α -terpineol	0.011AB	0.015C	0.020D	0.011A	0.033E	0.020D
y	neral	0.002A	0.002A	0.001A	0.001A	0.001A	0.006B
z	geranial	0.001	0.002	0.001	0.001	0.001	0.005
aa	perillaldehyde	0.008	tr	tr	tr	tr	ND

^a Listed as GC area percent values; averages of three determinations. Means in the same row followed by the same letter are not significantly different ($P \leq 0.05$). ^b 8.0% ethanol content. ^c 8.25% ethanol content. ^d 8.75% ethanol content. ^e ND, not detected. ^f tr, trace; less than 0.001.

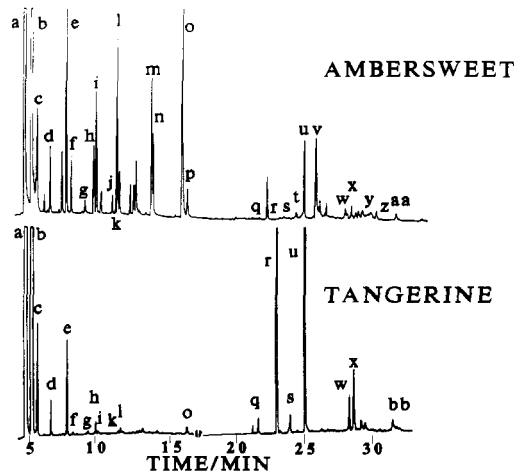


Figure 5. Gas chromatograms of the volatile components of aqueous juice essences of Ambersweet orange hybrid and tangerine. Letters identifying peaks correspond to letters preceding components in Table II, with one addition (bb = thymol) in tangerine.

sweet and tangerine were observed. Ten of the 30 constituents identified in Ambersweet essence were not present in tangerine essence. These compounds are 1,1-diethoxyethane, methyl butyrate, ethyl butyrate, *cis*-3-hexen-1-ol, *trans*-2-hexenol, linalool oxide, ethyl-3-hydroxyhexanoate, neral, geranial, and perillaldehyde. Thymol, an important tangerine flavor component (Kugler and Kovats, 1963), was completely absent from Ambersweet essences. Of the 20 compounds identified in both essences, the quantitative differences are extreme and thus have a differing impact on the characteristic flavor of each essence.

Essence Oils. Figure 6 shows one portion of the GC compositional profiles of Ambersweet, orange, and tangerine juice essence oils where significant qualitative and quantitative differences were found. There are significant

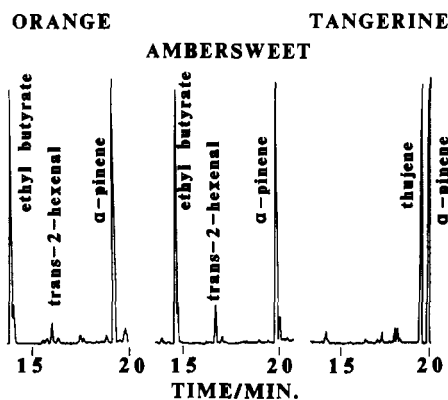


Figure 6. Partial gas chromatograms of the volatile components of juice essence oils from Ambersweet orange hybrid, orange, and tangerine.

Table III. Comparison of Components in Essence Oils from Ambersweet, Orange, Tangerine, and Grapefruit

compd	GC area % value ^a in				
	Ambersweet		orange	tangerine	grapefruit
	1	2			
ethyl butyrate	0.22A	0.16B	0.19C	NF ^b	0.07D
trans-2-hexenol	0.03A	0.04B	0.02C	NF	0.003D
α -pinene	0.52A	0.56A	0.53A	0.45B	0.47C
valencene	1.41A	1.21B	1.02C	0.014D	0.14E
thujene	NF	NF	NF	0.073A	0.002B
thymol	NF	NF	NF	0.05	NF
thymol methyl ether	NF	NF	NF	0.08	NF

^a Values are averages of three determinations. Means in the same row followed by the same letter are not significantly different ($P \leq 0.05$). ^b NF, not found.

similarities both qualitatively and quantitatively between the three components in Ambersweet and orange essence oils (Table III) including ethyl butyrate, which has been shown to be an important flavor component of orange

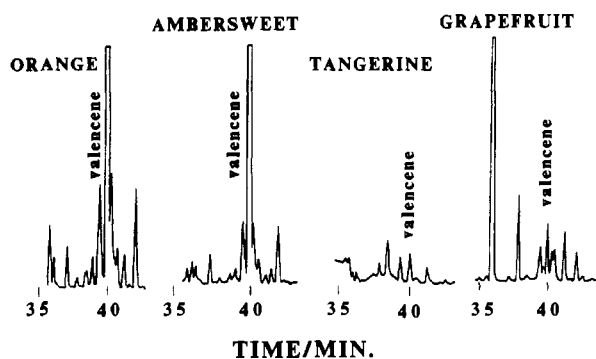


Figure 7. Partial gas chromatograms of the volatile components of juice essence oils from Ambersweet orange hybrid, orange, tangerine, and grapefruit.

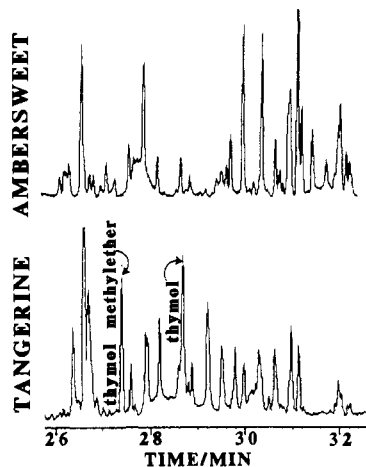


Figure 8. Partial gas chromatograms of the volatile components of juice essence oils from Ambersweet orange hybrid and tangerine.

flavor (Ahmed et al., 1978). Analogous comparisons with tangerine essence oil show major differences in composition. Ethyl butyrate and *trans*-2-hexenal are both absent in tangerine essence oil, while a terpene hydrocarbon (thujene) identified in tangerine oil (Shaw, 1979) was not found in these orange or Ambersweet oils.

Figure 7 shows portions of the GC compositional profiles of juice essence oils from Ambersweet, orange, tangerine, and grapefruit in the area where the sesquiterpene hydrocarbons (SQHC) elute. A comparison of these compounds from the four fruits shows important similarities between Ambersweet and orange in that, qualitatively, mass spectrometry shows that all these compounds are identical. Table III shows that the major SQHC, valencene, is quantitatively similar in orange and Ambersweet but present in much smaller quantity in both tangerine and grapefruit. Another important compositional difference between Ambersweet and orange compared to tangerine is that two components important to tangerine flavor, thymol and thymol methyl ether, are completely absent from both Ambersweet and orange. These compounds can be found in tangerine aqueous essence, essence oils, and cold-pressed peel oils. Figure 8 shows the GC-MS portion of the compositional profile of Ambersweet and tangerine essence oils obtained in the area where thymol and thymol methyl ether eluted. A detailed MS analysis in which scans were examined throughout the peaks and baseline in that area shows that, as with orange, neither of these compounds is present in Ambersweet.

Cold-Pressed Peel Oils. Figure 9 shows the GC-MS portion of the compositional profiles of Ambersweet and

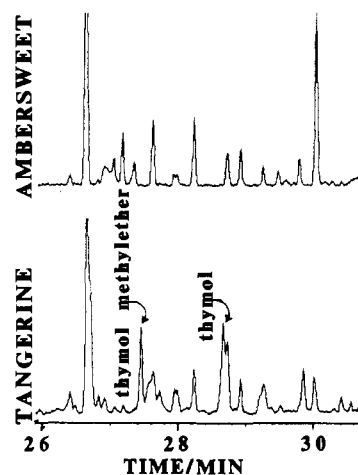


Figure 9. Partial gas chromatograms of the volatile components of cold-pressed peel oils from Ambersweet orange hybrid and tangerine.

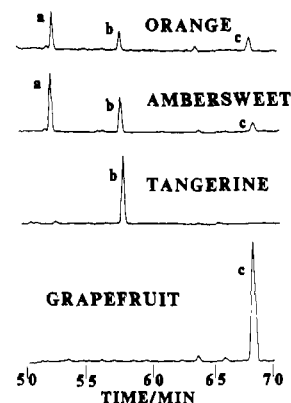


Figure 10. Partial gas chromatograms of the volatile components of cold-pressed peel oils from Ambersweet orange hybrid, orange, tangerine, and grapefruit. Peak identities: a, α -sinensal; b, β -sinensal; c, nootkatone.

Table IV. Comparison of Components in Cold-Pressed Peel Oils from Ambersweet, Orange, Tangerine, and Grapefruit

compd	GC area % value ^a in				
	Ambersweet		orange	tangerine	grapefruit
	1	2			
α -sinensal	0.05A	0.04B	0.024C	0.18D	NF ^b
β -sinensal	0.06A	0.08B	0.033C	NF	NF
nootkatone	0.02A	0.02A	0.02A	NF	0.39B
thymol	NF	NF	NF	0.06	NF
thymol methyl ether	NF	NF	NF	0.10	NF

^a Values are averages of three determinations. Means in the same row followed by the same letter are not significantly different ($P \leq 0.05$). ^b NF, not found.

tangerine cold-pressed peel oils obtained in the area where thymol and thymol methyl ether eluted. As with essence oils, a detailed GC-MS analysis confirmed the absence of these compounds from Ambersweet peel oil.

Figure 10 shows portions of GC compositional profiles of cold-pressed peel oils from Ambersweet, orange, tangerine, and grapefruit. Two sesquiterpene aldehydes, α - and β -sinensal, whose ratio is significant in characterizing orange vs tangerine oil, were found in Ambersweet oil in the approximate ratio found in orange oil (Table IV) rather than that found in tangerine oil, where only β -sinensal is present (Shaw, 1979). One other constituent shown in this figure is the sesquiterpene ketone, nootkatone, which is an important flavor component of grapefruit (MacLeod and Buigues, 1964). The quantity of nootkatone found in grapefruit oil was significantly higher than in Ambersweet

or orange (Table IV). Nootkatone was not found in tangerine oil.

CONCLUSIONS

The most significant factors determining the characteristic flavor and aroma of each citrus fruit are the volatile compositional makeups of the juice, aqueous essence, and oils and the quantitative relationship of those constituents to each other. Compositional comparisons of volatile flavor and aroma constituents of freshly squeezed Ambersweet juice, juice aqueous essence, juice essence oil, and cold-pressed peel oil with analogous products from oranges show every constituent in every product to be qualitatively identical. Furthermore, there were no unique or extra components in any Ambersweet or orange products. Significant quantitative similarities also were determined in every product when compositional comparisons were made between Ambersweet and orange. The quantitative differences that were found in these studies were in the range of quantitative differences that occur between different samples of the same fraction in orange. Compositional data show overwhelming similarities between volatile flavor and aroma constituents in Ambersweet and orange fruit products, strongly suggesting that Ambersweet fruit should be classified as an orange. These similarities preclude being able to distinguish orange juice and any blend of orange and Ambersweet juices by their volatile flavor and aroma constituents. In compositional analyses and comparisons of Ambersweet products with those obtained from tangerine, Orlando tangelo, and grapefruit (the remaining parentage fruit), the composition of every product from each fruit showed major differences both qualitatively and quantitatively. Furthermore, flavor components unique to tangerine and believed important to its flavor, thymol, thymol methyl ether, and thujene, were absent in Ambersweet products. These substantial and important compositional differences demonstrate that the makeup of Ambersweet fruit flavor characteristics is unlike that of tangerine, grapefruit, or Orlando tangelo and inseparable from those of orange characteristics.

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