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VOLATILE COMPONENTS IN TROPICAL FRUIT ESSENCES: YELLOW PASSION FRUIT (*PASSIFLORA EDULIS SIMS F. FLAVICARPA DEGNER*) AND BANANA (*MUSA SAPIENTUM L.*)

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Abstract. **A total of 51 and 45 compounds have been identified in yellow passion fruit and banana essences respectively. In both cases alcohols were the major components quantified, representing 56.94% and 55.61% of the total components identified in these products. In yellow passion fruit, the most abundant compounds identified were linalool (characterized by its contribution to a floral, citrus, and lemon flavor), octanol (fatty, citrus, and green), hexanol (herbaceous, fragrant, and sweet), and α-terpineol (fragrant, floral and lilac). A previously unreported compound has been identified, 3-methyl-2-butenol. Regarding the banana essence, the major compounds quantified were 3-methyl-1-butanol, 2-methyl-1-butanol, 1-butanol-3-methyl acetate, 2-pentanone and 1-butanol. In this study, previously unreported compounds are identified for the first time including: fenchol, borneol, terpinen-4-ol, α-terpineol and 1,1-diethoxy ethane. According to the flavor characteristics defined for these new compounds, they should contribute to the fruity and floral flavor described for banana essence.**

Flavor and aroma are very important properties of food and help to decide its acceptance by consumers. This is especially true for tropical and subtropical fruits. Tropical fruits have attracted people with their exotic appearance and unique flavors since antiquity (Shibamoto and Tang, 1990). In recent years tropical fruits have become economically important in a number of countries, where due to their unique and highly attractive flavor, their juices are used in carbonated beverages. Yellow passion fruit and banana are two popular and well-known tropical fruits. Several researchers have studied the aromatic composition of yellow passion fruit. Whitfield and Last (1986), Shibamoto and Tang (1990) and Werkhoff et al. (1998) agree that the aroma of yellow passion fruit is characterized as floral and estery with an exotic tropical sulfur note.

Tressl et al. (1970) found that the aroma compounds identified in banana fruit were mostly 3-methyl-butyl esters, acetates and butanoates. Furthermore, the fruity, estery odor is reported to be due to acetates and butanoates of butanol, 2-methylpropanol, pentan-2-ol and ethyl acetate (Berger et al., 1986). More recently Shiota (1993) found 86 new volatile components in banana fruit.

Previous investigations reported the aromatic profiles present in fresh fruits. Nevertheless, the study of the aromatic composition in the aqueous essence of these fruits has not been sufficiently studied. This should be taken into consideration, since aqueous essences are widely used by the food industry, and affect the flavor quality of the final products. For this reason the aim of this study is to know the aromatic profile of these aqueous essences which is preliminary to determining the importance of each component in the quality of these essences.

Material and Methods

Essence samples. Essence samples were obtained from a local processor in Florida. The essences were obtained from a whole fruit puree using steam distillation.

Extraction of volatile compounds. Isolation of volatile compounds was made using a liquid extraction technique. Volatile components present in 3 ml of each essence were extracted with 2 ml of methylene chloride and subsequently concentrated to 1 ml using a flow of nitrogen.

GC-MS analysis. The qualitative and relative abundance analyses of the volatile compounds were made using a Hewlett-Packard model 5973N MSD MS and model 6890 GC equipped with a 30 m × 0.25 mm HP-5 (cross-linked Phenyl-Methyl Siloxane) column with 0.25 Fm film thickness (Palo Alto, CA). The initial oven temperature was held at 40°C for 6 min. It was then increased at 2.5°C/min to 150°C, and finally at 90°C/min to 250°C. The injection port and ionizing source were kept at 250°C and 280°C, respectively. The split ratio was 10:1 with 2 µl of sample injected. Compound identifications were made by comparison of the mass spectra and retention times with those of corresponding standard compounds (Aldrich Chemical Co., St. Louis, MO; Bedoukian Research, Inc., Danbury, CT). Retention indices were also used for the identification of the compounds. They were made running a sequence of hydrocarbons compounds as described by Kovat (1965).

Results and Discussion

Volatile components in yellow passion fruit essence. A total of 51 volatile components were identified, including: 20 alcohols, 20 esters, 2 aldehydes, 4 ketones, 2 acids, 1 acetal, 1 furan and 1 hydrocarbon (Table 1).

Several researchers have studied the aromatic profile of yellow passion fruit and all of them have found that this fruit is characterized by an exotic ester aroma with a sharp sulphury note. However, no sulphur compounds were identified in this study. Previously these components have been identified at trace levels in the juice (Werkhoff et al., 1998), and for this reason these sulphur compounds may be very difficult to extract from the juice so as to be detected in the essence.

Chen et al. in 1982 analyzed the volatile compounds present in the headspace of this fruit juice. These authors identified about 60 components and over half the compo-

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Table 1. Volatile components in Passion fruit essence

ALCOHOLS	R. T.[z]	K. I.[y]	% in the sample
3-Methyl-2-butanol/ 2-pentanol	2.924	660	0.10
3-Methyl-1-butanol	3.555	737	2.80
2-Methyl-1-butanol	3.631	744	0.75
3-Methyl-2buten-1-ol	4.603	758	0.28
Cyclpoentanol	4.833	769	0.13
trans-3-Hexen-1-ol	7.756	861	0.38
cis-3-Hexen-1-ol	7.929	865	1.17
1-Hexanol	8.686	883	9.01
2-Heptanol	10.372	917	0.36
Benzyl alcohol	18.213	1005	1.60
3-Octen-1-ol	19.29	899	0.14
1-Octanol	20.703	1053	11.51
Linalool	22.331	1086	15.37
Phenylethyl alcohol	22.921	1097	0.50
Terpinen-4-ol	26.594	1170	1.05
α-Terpineol	27.412	1185	6.51
Nerol	29.671	1231	0.77
Citronellol	29.781	1232	0.62
Geraniol	31.195	1261	2.44
Undecanol	32.189	1280	1.45
Total			56.94
ESTERS			
n-Propyl acetate	3.19	688	trace
Ethyl butanoate	5.474	793	9.44
2-Hydroxethyl propionate	5.979	810	0.61
Ethyl *cis*-2-butenoate	7.402	852	0.41
3-Methylbutyl acetate	9.141	893	0.19
Ethyl 3-hydroxy butanoate	12.29	952	0.65
Ethyl hexanoate	16.373	968	11.11
3-Hexenyl acetate	16.799	976	0.67
Acetic acid, hexyl ester	17.238	985	0.72
Ethyl 2-hexanoate	19.065	895	0.28
2-Furancarboxylic acid, ethyl ester	19.538	1031	0.31
Propanedioic acid, diethyl ester	20.927	1058	0.17
Ethyl 3-hydroxy hexanoate	23.985	1118	0.35
Phenylmethyl acetate	25.872	1159	1.44
Ethyl benzoate	26.029	1164	3.00
Butanedioic acid, diethyl ester	27.292	1004	0.32
Ethyl 4-octanoate	27.59	1189	0.20
Hexyl butanoate	27.8	1193	0.10
Octanoic acid, ethyl ester	28.131	1200	0.19
Phenylmethyl butanoate	35.97	1354	0.22
Total			30.38
ALDEHYDES			
Benzene acetaldehyde	18.718	891	0.22
Benzaldehyde	13.552	971	4.47
Total			4.69
KETONES			
2-Pentanone	2.786	661	0.24
3-Hydroxy-2-butanone	3.088	681	1.0
Cyclopentanone	5.001	776	1.5
2-Heptanone	9.797	906	0.5
Total			3.3
ACIDS			
Hexanoic acid	15.913	966	0.9
Octanoic acid	27.15	1188	0.4
Total			1.2

[z]R. T. = Retention time.
[y]K. I. = Kovats Index.

Table 1. (Continued) Volatile components in Passion fruit essence

	R. T.[z]	K. I.[y]	% in the sample
ACETALS			
1,1-Diethoxy ethane	3.511	706	1.06
Total			1.06
FURANS			
cis-Linalool oxide	20.526	1050	0.62
Total			0.62
HYDROCARBONS			
Methyl cyclopentane	5.089	777	1.77
Total			1.77

[z]R. T. = Retention time.
[y]K. I. = Kovats Index.

nents were esters, including: ethyl acetate, ethyl butanoate, ethyl hexanoate, hexyl butanoate and hexyl hexanoate as the major esters identified. Later Werkhoff et al. (1998) found that the major part of volatiles identified as constituents of yellow passion fruit flavor consisted of esters. Moreover these authors noted that unsaturated aliphatic alcohols are important contributors to the overall flavor associated in general with a green, floral and fruity odor impression.

These results differ from those found in this study, where alcohols represented 56.94% of the total volatile components determined. Linalool, followed by octanol, hexanol, and α-terpineol were the alcohols present in highest concentration. These compounds are characterized by their contribution to a floral, green, waxy, citrus, refreshing, fragrant and sweet flavor.

All of the alcohols found in this study have been identified previously by Werkhoff et al. in 1998, with the exception of 3-methyl-2-buten-1-ol. This compound has not been found before in yellow passion fruit essence, but has been identified in other fruits such as orange, lemon, wild berries, guava and grapes (Maarse and Visscher, 1989).

The next most abundant compounds were the esters comprising 30.38% of the total volatile components identified. Among these esters, ethyl hexanoate, ethyl butyrate, ethyl benzoate and phenylmethyl acetate were the esters found in greatest concentration. These results agree with those of Chen et al. (1982).

In general, aldehydes are common in fruit flavors and are believed to play an important role in many fruits. For this reason, it is surprising to observe only two aldehydes in the passion fruit essence. These are benzene acetaldehyde and benzaldehyde and these represent a total of 4.69% of the total volatile compounds found.

Ketones are the next more abundant compounds comprising 3.3% of the volatile components determined. Among these cyclopentanone was detected at the highest level.

Regarding the rest of the compounds identified, it is important to highlight the presence of the acetal 1,1-diethoxy ethane. This compound is characterized for its contribution to a tart, strong, fruity, refreshing and green odor and represents 1.06% of the total volatile compounds identified.

Volatile components in banana essence. In the analysis of the volatile components present in banana essence a total of 45 compounds were identified including: 18 alcohols, 19 esters,

Table 2. Volatile components in Banana essence

ALCOHOLS	R.T.[z]	K.I.[y]	% in the sample
1-Butanol	2.48	617	5.11
2-Pentanol	2.93	672	8.67
3-Methyl-1-butanol	3.65	714	24.04
2-Methyl-1-butanol	3.68	716	14.00
1-Pentanol	4.36	749	0.07
trans-2-Hexen-1-ol	8.53	874	0.14
1-Hexanol	8.69	884	2.05
trans-4-Hexen-1-ol	8.82	888	0.14
trans-4-Hepten-2-ol	9.4	900	0.24
2-Heptanol	10.34	918	0.01
trans-3-Octen-1-ol	19.28	1030	0.01
cis-3-Octen-1-ol	20.11	1053	0.48
cis-5-Octen-1-ol	20.67	1054	0.34
Fenchol	22.82	1095	0.06
Borneol	25.87	1155	0.06
Terpinen-4-ol	26.58	1170	0.10
-Terpineol	27.39	1185	0.06
cis-3-Nonen-1-ol	31.32	1210	0.04
Total			55.61
ESTERS			
n-Propyl acetate	3.19	688	0.40
Methyl butanoate	3.34	697	0.03
2-Methylpropyl acetate	4.57	759	7.36
Ethyl butanoate	5.48	794	0.57
n-Butyl acetate	6.03	812	3.83
2-Pentyl acetate	7.72	861	5.61
3-Methylbutyl acetate	9.13	893	10.79
Butyl 2-methylpropionate	13.54	970	0.01
2-Methylpropyl butenoate	13.64	972	0.83
Ethyl 2-hydroxy-3-methyl butanoate	14.22	980	0.02
Butyl butyrate	16.11	1005	0.62
Hexyl acetate	17.22	985	0.12
cis-3-Hexenyl acetate	17.68	988	0.12
1-Methylbutyl 2-methyl propionate	17.92	881	0.35
Butyl pentanoate	19.19	1023	0.02
3-Methylbutyl butanoate	19.77	1035	1.38
2,3 Butanediol diacetate	21.09	1061	0.05
3-Methylbutyl-3-methyl butanoate	22.91	1097	0.02
Ethyl 3-hydroxy hexanoate	26.579	1169	0.02
Total			32.16
ALDEHYDES			
3-Methyl-2-butenal	2.4	630	0.29
Hexanal	5.36	790	0.77
Total			1.06
KETONES			
2-Pentanone	2.77	663	8.89
2-Butanone-3-hydroxy	3.09	682	0.32
2-Hexanone	5.03	777	0.12
2-Heptanone	9.76	906	0.60
3-Hepten-2-one	12.4	954	0.09
Total			10.02
ACETALS			
1,1-Diethoxy ethane	3.5	707	0.38
Total			0.38

[z]R.T. = Retention time.
[y]K.I. = Kovats Index.

2 aldehydes, 5 ketones and 1 acetal (Table 2). Quantitatively the alcohols were the most abundant components, representing 55.61% of the total compounds identified, followed by esters with 32.16%, ketones 10.02%, aldehydes 1.06% and acetals 0.38%. The major compounds identified were 3-methyl-1-butanol (24%), followed by 2-methyl-1-butanol (14%), 1-butanol-3-methyl acetate (10.79%), 2-pentanone (8.89%) and 1-butanol (5.11%). The remaining compounds which are present in lower quantities are esters, including: isobutyl acetate, butyl acetate and isoamyl butyrate.

Studies reported by Shiota in 1993 showed that the principal compound found in banana fruit was 2-pentanone (23.3%); other important compounds present in lower concentration were esters and alcohols, which contribute significantly to banana aroma. Differences found between these results and those obtained by us may be due to the different techniques utilized in the isolation of the volatile components.

In addition to these results, new components are reported that were not identified in the previous studies of banana essence including: fenchol, borneol, terpinen-4-ol, alpha-terpineol and 1,1-diethoxy ethane. Acetal and α-terpineol are both characterized as imparting a floral and fruity flavor, while borneol and fenchol impart a camphorous, lemon and dry flavor. For this reason, these compounds should contribute to the fruity and floral flavor described for banana.

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