Similarities in the Aroma Chemistry of Gewürztraminer Variety Wines and Lychee (*Litchi chinesis* Sonn.) Fruit

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GC/O analysis of canned lychees indicated that *cis*-rose oxide, linalool, ethyl isohexanoate, geraniol, furaneol, vanillin, (*E*)-2-nonenal, β-damascenone, isovaleric acid, and (*E*)-furan linalool oxide were the most odor potent compounds detected in the fruit extracts. However, on the basis of calculated odor activity values (OAVs), *cis*-rose oxide, β-damascenone, linalool, furaneol, ethyl isobutyrate, (*E*)-2-nonenal, ethyl isohexanoate, geraniol, and δ-decalactone were determined to be the main contributors of canned lychee aroma. When these results were compared with GC/O results of fresh lychees and Gewürztraminer wine, 12 common odor-active volatile compounds were found in all three products. These included *cis*-rose oxide, ethyl hexanoate/ethyl isohexanoate, β-damascenone, linalool, ethyl isobutyrate, geraniol, ethyl 2-methylbutyrate, 2-phenylethanol, furaneol, vanillin, citronellol, and phenethyl acetate. On the basis of OAVs, *cis*-rose oxide had the highest values among the common odorants in the three products, indicating its importance to the aroma of both lychee fruit and Gewürztraminer wines. Other compounds that had significant OAVs included β-damascenone, linalool, furaneol, ethyl hexanoate, and geraniol. This indicated that while differences exist in the aroma profile of lychee and Gewürztraminer, the common odorants detected in both fruit and wine, particularly *cis*-rose oxide, were responsible for the lychee aroma in Gewürztraminer wine. When headspace SPME was used as a rapid analytical tool to detect the levels of selected aroma compounds deemed important to lychee aroma in Gewürztraminer-type wines, *cis*-rose oxide, linalool, and geraniol were found to be at relatively higher levels in Gewürztraminers. No *cis*-rose oxide was detected in the control wines (Chardonnay and Riesling), while lower levels were detected in the Gewürztraminer-hybrid wine Traminette. Gewürztraminers produced in the Alsace region showed differences in the levels of the 3 monoterpenes when compared to those from New York State, which could be attributed to differences in viticultural and enological practices between regions.

Keywords: *Aroma; GC/O; Gewürztraminer; SPME; lychee; volatile*

INTRODUCTION

Gewürztraminer is a unique grape variety that produces aromatic and full bodied white wines with easily identifiable character. We can characterize the unique aroma of the wines from this grape as having a "Traminer" smell or aroma quality reminiscent of the tropical fruit lychee. Many have attributed the spicy and floral aromas of Gewürztraminer to the presence of phenylethanol, phenethyl acetate, etc. (Etievant, 1991). However, no one has been able to directly determine the compound(s) responsible for the "lychee-odor" character in the Gewürztraminer wine.

Various studies have attributed the distinct flavor of Gewürztraminer, as well as Riesling and Muscat, grapes and wines to the presence of certain monoterpenes such as linalool, geraniol, nerol, and linalool oxides (Etievant, 1991; Marais and Rapp, 1991; Macaulay and Morris, 1993; Reynolds and Wardle, 1996; Rapp, 1988; Schreier, 1976). It has been suggested that the ability to predict and regulate the major monoterpenes of various cultivars would greatly enhance the wine potential of the grapes (Macaulay and Morris, 1993), as these aroma compounds are typically unchanged by yeast metabolism during fermentation and are suitable for the varietal characterization of wines made from different grape varieties (Rapp, 1988).

Recently, Guth (1997b) identified *cis*-rose oxide as being the most characteristic odor compound found in Gewürztraminer wine on the basis of a sensory test, even though the wine lactone was determined by static headspace analysis using GC/O to be the most odor potent compound (Guth, 1997a). Interestingly, work on lychees (Ong and Acree, 1998) showed that *cis*-rose oxide was present as one of the most important odor potent compounds in the fresh fruit. Informal sensory tests of this compound showed that this compound was an important contributor to the aroma of fresh lychee and Gewürztraminer wine (Ong and Acree, 1998; Guth, 1997b). Since it is widely known that differences commonly exist in the flavor quality of fresh and canned fruits, it was also essential that the flavor chemistry of canned lychees be investigated.

Until recently, most analyses of wine and grape aroma compounds involved the use of conventional GC sample preparation methods such as liquid−liquid extraction and static headspace sampling. The development of solid-phase microextraction (SPME) (Arthur and Pawliszyn, 1990) as a rapid and inexpensive sampling and screening tool and its wide application in the analysis of flavor volatiles in foods and beverages has made SPME a useful tool in the analysis of aroma

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Table 1. List of Wines Analyzed by Headspace-SPME

abbrev	wine sample	origin of grape	vintage	alc %
Gewu-KF97	Gewürztraminer, Dr. Konstantein Frank	Finger Lakes, NY	1997	12.0
Gewu-PJ97	Gewürztraminer, PreJean	Finger Lakes, NY	1997	12.4
Gewu-HW95	Gewürztraminer, Herman Wiemer	Finger Lakes, NY	1995	12.0
Gewu-PL97	Gewürztraminer, Palmer	Long Island, NY	1997	11.5
Gewu-SC95	Gewürztraminer, Domaine Schoffit	Alsace, France	1995	13.5
Gewu-ZH94	Gewürztraminer, Domaine Zind-Humbrecht	Alsace, France	1994	14.0
Gewu-MK93	Gewürztraminer, Domaine Mittnacht-Klack	Alsace, France	1993	12.0
Gewu-HU92	Gewürztraminer, Hugel	Alsace, France	1992	13.5
Tramin-AH96	Traminette, Arbor Hill	Finger Lakes, NY	1996	10.2
Tramin-NY97	Traminette, NY State Agri Expt Station	Finger Lakes, NY	1997	12.0
Tramin-NY95	Traminette, NY State Agri Expt Station	Finger Lakes, NY	1995	12.5
Chardon-NY97	Chardonnay, NY State Agri Expt Station	Finger Lakes, NY	1997	11.8
Riesling-NY97	Riesling, NY State Agri Expt Station	Finger Lakes, NY	1997	12.8
Riesling-NY92	Riesling, NY State Agri Expt Station	Finger Lakes, NY	1992	11.4

compounds in wines (Yang and Peppard, 1994; Fischer and Fischer, 1997). Recently, Garcia et al. (1996, 1997) applied SPME in the analysis of aroma volatiles in wines.

This study describes the most potent odorants in canned lychee fruit using gas chromatography/olfactory (GC/O) (Acree et al., 1984) and attempts to determine similarities in odor-active volatiles between lychee (fresh and canned) and Gewürztraminer-type wines. A rapid analytical method using SPME was also utilized to determine the relative amounts of selected odorants present in various white wines.

MATERIALS AND METHODS

Materials. Canned lychees imported from China were selected for GC/O analysis as they were the most commonly imported in the U.S. For the SPME analysis, 10 commercial wines were selected and canned lychees imported from China, as well as Taiwan and Thailand, were used. All commercial wines were produced from Gewürztraminer varietal and Traminette grapes (Table 1). Traminette, a cross between Gewürztraminer and Joannes-Seyve 23.416, recently introduced at the NYSAES—Cornell University, is described as being distinctively spicy and fragrant, much like its Gewürztraminer parent (Reisch et al., 1997). All Gewürztraminer and Traminette wines selected for analysis were evaluated by an informal panel of three wine experts familiar with such wines and were judged to have lycheelike aromas characteristic of Gewürztraminer wines.

Gas Chromatography−Olfactometry (GC/O) of Lychee. Two batches of 1.5 kg of the canned Chinese lychees were blended with 1.0 M $CaCl_2$ for 1 min to inactivate enzymes (Shure, 1992), yielding 1.4 L of juice. The juice was sequentially extracted with Freon 113 and ethyl acetate. Both extracts were dried with anhydrous magnesium sulfate, and serially diluted or concentrated by 3-fold. The most concentrated extract was 243-fold and the least $^{1}/_{27}$-fold. Extracted samples were analyzed by a single sniffer on a GC/O system (CharmAnalysis) (Datu, Inc., Geneva, NY) equipped with either a HP-1 (15 m × 0.32 mm) or a HP-Innowax (15 m × 0.32 mm) column (Acree et al., 1984). The GC effluent was combined with an olfactometer airstream at 7 L/min and 1 cm in diameter. The oven temperature was programmed from 35 to 250 °C at 6 °C/min. The sniffer was screened for olfactory acuity according to a training procedure described by Marin et al. (1988). The sniffer was able to detect 0.82 ng of ethyl butyrate, 0.99 ng of ethyl hexanoate, 0.82 ng of 1,8-cineole, 1.20 ng of carvone, 0.046 ng of β-damascenone, and 0.41 ng of *o*-aminoacetophenone eluting from the GC/O. All extract dilutions were sniffed twice (repeated measure) until no odor was observed (detection threshold), and the retention time of each odorant was converted to Kovats indices using 7−28 carbon normal paraffins. Caramel, citrus, earthy, floral, fruity, green, medicine, balsamic, coconut, rancid, urine, and woody were the words used to describe the most potent odorants. The lexicon was developed by sniffing the 243-fold sample three times and selecting the most frequently used words.

Quantitative Analyses and Determination of Odor Activity Values (OAVs). The most odor potent volatiles in lychee, as determined by GC/O, were quantified using GC mass fragmentography of the most abundant ion. The concentration of each volatile was adjusted for loss during extraction by determining the percent recovery of each compound in a model system (Table 3). OAVs were determined by dividing the concentration by its odor detection threshold (Guadagni et al., 1966). All threshold values were measured using a modified Retronasal Aroma Simulator (RAS) previously described by Ong and Acree (1998) and determined in μg/L units.

Capillary Gas Chromatography/Mass Spectrometry (GC/MS). A HP model 5970 MSD GC/MS was used with a HP-1 (25 m × 0.20 mm) or HP-Innowax (25 m × 0.25 mm) column. The oven temperature was programmed from 35 to 250 °C at 4 °C/min. Compounds were tentatively identified by matching the retention index (RI) of the unknown compound with the RI of standard compounds. Confirmation of unknowns was based upon odor, mass spectral, and RI matches with authentic standards.

Headspace Solid-Phase Microextraction (SPME) Analyses. Wine samples of 2 mL were filled into a 4 mL glass vial saturated with 2 g/L of NaCl, closed with a Teflon-coated septum, and agitated at a constant velocity at 1036 rpm with a magnetic stirrer at 20 °C. Canned whole lychee fruits were blended in water/ethanol (90:10 v/v), and 2 mL samples were transferred into glass vials and prepared for SPME analysis as described for the wine samples. The extraction procedure involved the direct exposure of a 100 μm poly(dimethylsiloxane) coated fiber to the headspace of each sample in the closed vial. The fiber was exposed to the headspace for 15 min, followed by a 3 min desorption period in the injection port of a GC-MS. Five compounds (*cis*-rose oxide, linalool, geraniol, 2-phenylethanol, and ethyl hexanoate) were selected to be monitored by SPME in the various wines and fruit samples. Standards of each compound at 0.01, 0.1, and 1.0 μg/mL levels were prepared and analyzed by headspace SPME similar to the conditions for the wine and fruit samples. The response from the most abundant ion for each compound was quantified and used to obtain standard curves. All measurements were made in triplicate.

RESULTS AND DISCUSSION

GC/O analysis of canned lychee detected a total of 37 odor potent compounds in both the Freon and ethyl acetate extracts, of which the 24 of the most odor potent compounds based on OSV are listed in Table 2. Odor spectrum values (OSV), defined as the normalized charm value modified with an approximate Steven's law exponent ($n = 0.5$) (Ong et al., 1998), indicated *cis*-rose oxide, linalool, ethyl isohexanoate, geraniol, furaneol, vanillin, (*E*)-2-nonenal, β-damascenone, isovaleric acid, and (*E*)-furan linalool oxide to be the most odor potent

Table 2. Most Potent Odorants Found in the Extracts of Canned Lychee

				retention index					detected by	
peak no.	compd detected	CAS no.	extract[a]	HP-1	HP-wax	descriptor	charm[b]	OSV[c]	GC/O	M/S
17	*cis*-rose oxide	876-17-5	FR	1092	1338	green, floral	25732	100	+	+
15	linalool	78-70-6	EAC	1083	1548	citrus green	21938	92	+	+
7	ethyl isohexanoate[d]	25415-67-2	EAC	951	1181	fruity	13338	72	−	+
26	geraniol	106-24-1	EAC	1230	1850	fruity	12517	70	+	+
11	furaneol	3658-77-3	EAC	1029	2020	caramel	6679	51	+	+
32	vanillin	121-33	EAC	1345	2591	vanilla	6129	49	+	+
20	(*E*)-2-nonenal	18829-56-6	EAC/FR	1130	1519	plastic	5953	48	+	+
33	*β*-damascenone	23726-93-4	FR	1356	1790	fruity	5397	46	+	+
5	isovaleric acid	503-74-2	EAC	840	1660	rancid	5192	45	+	+
13	(*E*)-furan linalool oxide	34995-77-2	EAC	1065	1453	green	4144	40	+	+
28	phenylacetic acid	103-82-2	EAC	1236	2568	urine	3340	36	+	+
12	guaiacol	90-05-1	EAC	1056	1848	medicine	3244	36	+	+
14	2-phenylethanol	60-12-8	EAC	1078	1905	floral	2788	33	+	+
25	citronellol	7540-51-4	EAC/FR	1212	1764	citrus	2136	29	+	+
35	cinnamic acid	140-10-3	EAC	1394	2852	woody	2114	29	+	+
19	(*Z*)-2-nonenal	60784-31-8	EAC/FR	1121	1492	plastic	1852	27	+	+
37	*δ*-decalactone	705-86-2	EAC	1440	2160	coconut	1689	26	+	+
31	hydrocinnamic acid	501-52-0	EAC	1304	2650	balsamic	1620	25	+	+
6		unknown	FR	894		green	1420	23	−	−
8	1-octen-3-ol	3391-86-4	EAC	958	1445	earthy	1339	23	+	+
30	(*E*,*E*)-2,4-decadienal	25152-84-5	EAC/FR	1281	1778	citrus, fatty	810	18	+	+
27	phenethyl acetate	103-45-7	EAC/FR	1233	1803	rose, floral	600	15	+	+
1	ethyl isobutyrate	97-62-1	EAC	767	984	fruity	550	14	+	+
4	ethyl 2-methylbutyrate	7452-79-1	FR	837	1041	fruity	550	14	+	+

[a] Extract in which most of the compound was detected: Freon (FR); ethyl acetate (EAC). [b] Charm values were the sum total of both Freon and ethyl acetate extracts. [c] Odor spectrum value (OSV) is the normalized charm value modified with an approximate Steven's law ($n = 0.5$). [d] Tentatively identified by GC/MS.

Table 3. Concentrations, Odor Thresholds, and Odor Activity Values (OAV) of Most Potent Odorants in Canned Lychee As Detected by GC/O

peak no.	compd	% recovery[a]	concn (μg/L of juice)	threshold values[b] (ppb in water)	OAV[c]
17	*cis*-rose oxide	102	21.5	0.1	215
15	linalool	100	84.0	1.5	56
7	ethyl isohexanoate[d]	95	40.3	5	8
26	geraniol	92	32.6	5	7
11	furaneol	104	883.9	25	35
32	vanillin	112	38.7	1200	<1
20	(*E*)-2-nonenal	95	1.2	0.1	12
33	*β*-damascenone	115	1.4	0.01	140
5	isovaleric acid	102	21.5	12	2
13	(*E*)-furan linalool oxide	105	5.6	60	<1
28	phenylacetic acid	104	239.1	2000	<1
12	guaiacol	109	2.5	2	1
14	2-phenylethanol	95	20.4	2000	<1
25	citronellol	98	11.2	8	1
35	cinnamic acid	114	167.9	2000	<1
19	(*Z*)-2-nonenal		n/d[e]		
37	*δ*-decalactone	105	14.6	2.5	6
31	hydrocinnamic acid	104	33.8	5000	<1
8	1-octen-3-ol	79	3.9	18	<1
30	(*E*,*E*)-2,4-decadienal	100	0.1	0.2	<1
27	phenethyl acetate	102	0.2	20	<1
1	ethyl isobutyrate	104	289.4	15	19
4	ethyl 2-methylbutyrate	105	n/d[e]	0.5	

[a] Percent recovery based on the combined recovery of Freon and ethyl acetate. [b] Concentration of combined Freon and ethyl acetate extracts. [c] Determined using a modified RAS. [d] OAVs were calculated by dividing the concentration by its odor threshold. Values were rounded to 2 significant figures. [e] n/d: below detection threshold.

compounds. Every compound identified in Table 2 has been previously identified in fresh lychee (Ong and Acree, 1998). However, almost twice as many odor-active volatiles were detected in the fresh fruit, suggesting that there may be differences in the sensory qualities of the canned and fresh fruit.

To determine the relative potency of each odorant identified by GC/O in a matrix more representative of the actual food matrix, the OAV of each compound was calculated by dividing the concentration of a compound by its odor threshold (Table 3). As previously defined by Acree (1997) and Ong et al. (1998), OSVs are independent of concentration and approximate the relative importance of component odorants, while Charm and OAVs as true activity measures are linear functions of concentration. All threshold values were determined using a modified RAS to provide a more accurate approximation of actual release in the mouth (Ong and Acree, 1998; Roberts, 1996). Results show that *cis*-rose oxide had the highest OAV, confirming its importance to the aroma of the processed fruit. Other compounds that had significant OAVs included *β*-damascenone, linalool, furaneol, ethyl isohexanoate, and geraniol.

The odor spectra of fresh and processed lychee and Gewürztraminer wine are presented in Figure 1. Results from the study on Gewürztraminer wine by Guth

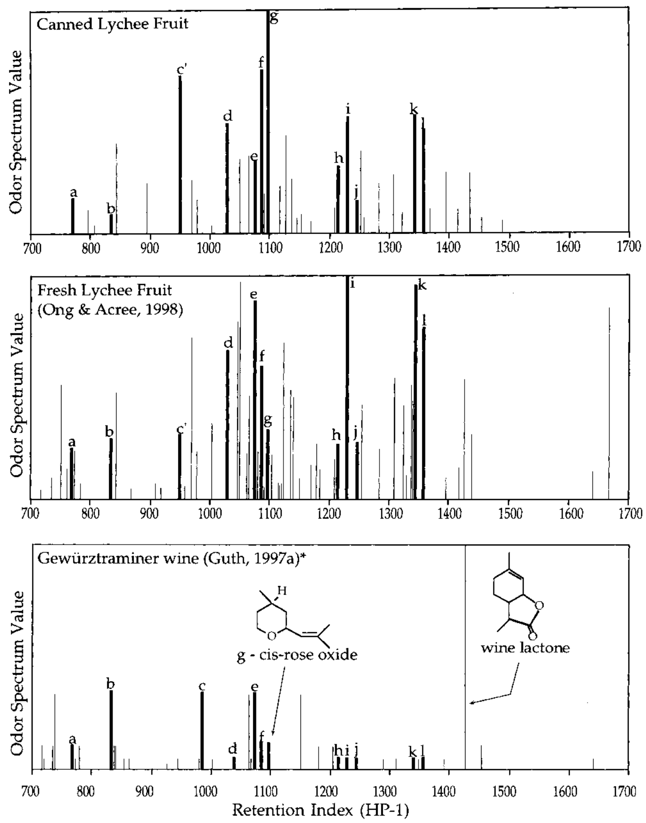

Figure 1. Odor spectra of fresh and canned lychee and Gewürztraminer wine.

(1997a) were converted to an odor spectrum to provide a better visual comparison of the odor spectra of the three different products. From Figure 1, it can be observed that although there were 12 odorants that were common among the wine and lychee fruit, differences in the aroma profile clearly exist. The odor spectrum of Gewürztraminer wine showed that wine lactone was the most odor potent compound (Guth, 1997a) and contributed to the aroma of Gewürztraminer wines. However, the odor spectra of the three products also suggested similarities in their aroma profiles, i.e., that the presence of *cis*-rose oxide and the other 11 common odorants (highlighted in bold in Figure 1) impart a lychee character in Gewürztraminer wine.

Of the 12 common odorants that were detected in the wine and lychee, *cis*-rose oxide was found to have the highest OAV (Table 4) in all three products. The concentration of *cis*-rose oxide in canned lychee was found to be 2-fold higher of that in the fresh lychee. The higher amounts of *cis*-rose oxide in the canned fruit could be attributed to the conditions during processing, such as high heat. However, due to the lack of direct comparison between product sample, no definite conclusion can be drawn.

While ethyl hexanoate was found in extremely high levels in the wine, which was likely a result of the fermentation process, it was not found in the lychees. Instead, ethyl isohexanoate, which has sensory characteristics very similar to those of ethyl hexanoate, was detected in both fresh and processed lychees. The odor threshold for isoethyl hexanoate was not known or determined, while the published threshold for ethyl hexanoate was low enough for it to contribute to the aroma of the canned and fresh fruit.

β-Damascenone, with a characteristic fruity-floral aroma, had a similarly high OAV in both fruit and wine. The OAV for β-damascenone was twice as high in the canned fruit than was detected in the fresh, again suggesting that processing was likely responsible for its increase in the canned fruit (Roberts, 1993; Buttery et al., 1990). This was shown in tomatoes, where levels of β-damascenone was found to significantly increase after tomatoes were processed (Buttery et al., 1990). Although β-damascenone has been widely reported in many natural products (Braell et al., 1990; Cunningham et al., 1986; Ong et al., 1998), mainly due to its extremely low odor threshold (0.01 ppb; Table 3), it has seldom been reported as a character-impact compound of the product in which it is found. Guth (1997b) demonstrated in a sensory study with Gewürztraminer wine that β-damascenone had a high OAV, whereas it was found that the importance of β-damascenone as a character-impact compound in the wine was minimal.

Among the other common aroma compounds reported in Table 4 are three monoterpenes, linalool, geraniol, and citronellol. These compounds have often been considered as important contributors to the aroma of Gewürztraminer and have been used to predict and improve wine quality and viticultural practices (Marais and Rapp, 1991; Reynolds and Wardle, 1996). Marais (1987) suggested that these terpenes were important to the typical character and quality of Gewürztraminer grapes and wines, since these compounds have relatively low odor thresholds and occur in relatively high concentrations.

The data presented in Table 4 suggests that *cis*-rose oxide, together with the remaining compounds listed, contributes to the lychee odor in Gewürztraminer wine. The high levels of *cis*-rose oxide in the canned fruit as compared to the fresh fruit further suggests that canned lychee is more representative of the lychee aroma detected in Gewürztraminer wines. Guth (1997b) has demonstrated that *cis*-rose oxide was the character-impact compound in Gewürztraminer wines. This strongly suggests that the dominant odor perceived in Gewürztraminer wine is the same compound that is responsible for the lychee aroma often described in Gewürztraminers, as well as in fresh and processed lychee.

To obtain a better appreciation of the relative contribution of *cis*-rose oxide in various Gewürztraminer wines, a rapid analytical procedure using headspace SPME was developed. Also monitored were linalool, geraniol, 2-phenylethanol, and ethyl hexanoate, all of which were shown to have high OAVs (Table 4) in both Gewürztraminer wine and lychee fruit. β-Damascenone was not selected for monitoring as this compound was shown to be minimally important in contributing to the character of the wine.

Presented in Table 5 are the relative amounts of each compound obtained from the headspace of each sample wine (listed in Table 1), as calculated on the basis of OAVs. Among the wines that were sampled were Gewürztraminer and Traminette (a Gewürztraminer hybrid introduced by Cornell University) wines produced in the Finger Lakes region. These varieties have seen an increased acreage in this region between 1990 and 1996 (Martinson and Pool, 1998), and the wines that have been produced could be ranked among the wines of the Alsace. Alsace-Gewürztraminer brand wines, however, have often been associated with excellence and finesse, and many still consider the finest

Table 4. Common Odorants Detected in Lychee Fruit and Gewürztraminer Wine

compd	odor threshold value (μg/L)[a]	Gewürztraminer[e] (OAV)	fresh lychee[f] (OAV)[b]	canned lychee (OAV)[b]
cis-rose oxide	0.2	105	43	108
ethyl hexanoate/ethyl isohexanoate[c]	5/not known[d]	98	<1[c]	8[c]
β-damascenone	0.05	17	14	28
linalool	15	12	1	6
ethyl isobutyrate	15	10	10	19
geraniol	30	7	2	1
ethyl 2-methylbutyrate	1	4	<1	<1
2-phenylethanol	10 000	2	<1	<1
furaneol	500	<1	2	2
vanillin	200	<1	<1	<1
citronellol	100	<1	<1	<1
phenethyl acetate	250	<1	<1	<1

[a] Odor thresholds were determined in water/ethanol (90:10 v/v) as reported by Guth (1997b). [b] OAVs were recalculated based on threshold values measured in water/ethanol (90:10 v/v). [c] Ethyl hexanoate was detected in the wine, while ethyl isohexanoate was detected in the fruit. [d] OAV of ethyl isohexanoate was calculated on the basis of an approximation of the concentration and threshold of ethyl hexanoate. [e] Data were summarized from Guth (1997a). [f] Data were summarized from Ong and Acree (1998).

Table 5. OAVs of Selected Odorants Detected in Canned Lychee and Various White Wines

sample	origin	*cis*-rose oxide (OAV)[a]	linalool (OAV)[a]	2-phenylethanol (OAV)[a]	geraniol (OAV)[a]	ethyl hexanoate (OAV)[a]
lychee[b]	China	59	5	0.6	1.5	n/d[c]
lychee[b]	Taiwan	88	6	0.6	1.8	n/d[c]
lychee[b]	Thailand	75	6	0.6	2.5	n/d[c]
Gewu-SC95	Alsace, France	103	15	5.4	4.9	358
Gewu-ZH94	Alsace, France	99	10	3.8	5.2	97
Gewu-MK93	Alsace, France	76	7	5.6	3.3	297
Gewu-HU92	Alsace, France	54	7	2.3	1.5	530
Gewu-KF97	Finger Lakes, NY	44	8	1.4	4.6	40
Gewu-PJ97	Finger Lakes, NY	45	7	1.6	3.5	48
Gewu-HW95	Finger Lakes, NY	42	7	6.5	4.1	38
Gewu-PL97	Long Island, NY	55	4	1.2	5.7	248
Tramin-AH96	Finger Lakes, NY	35	7	8.5	3.0	47
Tramin-NY97	Finger Lakes, NY	29	3	2.2	1.5	28
Tramin-NY95	Finger Lakes, NY	31	3	2.1	1.3	110
Chardon-NY97	Finger Lakes, NY	n/d[c]	n/d[c]	1.4	1.3	334
Riesling-NY97	Finger Lakes, NY	n/d[c]	4	1.5	0.6	651
Riesling-NY92	Finger Lakes, NY	n/d[c]	3	1.5	1.2	592

[a] OAVs were calculated on the basis of threshold values determined in water/ethanol (90:10 v/v) as reported by guth (1997b). [b] Samples were blended in a water/ethanol (90:10 v/v) mixture. [c] n/d: not detected by GC/MS or GC/O analysis.

examples of the Gewürztraminer to come almost exclusively from this region in eastern France.

The OAVs for *cis*-rose oxide were highest for wines from the Alsace region, while those produced in the New York State regions were about 50% less (Table 5). From Figure 2 it can be observed that the concentration of *cis*-rose oxide in the Gewürztraminer wines from the Alsace is similar to that found in the canned lychees.

Traminette wines had levels of *cis*-rose oxide comparable to the Gewürztraminers produced in the Finger Lakes region, while none was observed in either the Riesling or Chardonnay type wines. Two of the four Alsace wines (Gewu-SC95 and Gewu-ZH94) were found to have the highest OAVs for linalool, while the other two had levels similar to the Gewürztraminers from the Finger Lakes region of New York. The commercially produced Traminette (Tramin-AH96) wine had OAVs similar to those of the Gewürztraminers from the same region, while those produced experimentally (Tramin-NY97 and Tramin-NY95) had half the value. OAVs for geraniol were relatively consistent among the different Gewürztraminer and Traminette wines (Tramin-AH96), while the Traminettes (Tramin-NY97 and Tramin-NY95), Chardonnay, and Rieslings had relatively lower OAVs.

The OAVs for 2-phenylethanol and ethyl hexanoate varied among all wine samples analyzed, suggesting that variations in enological practices affect their levels.

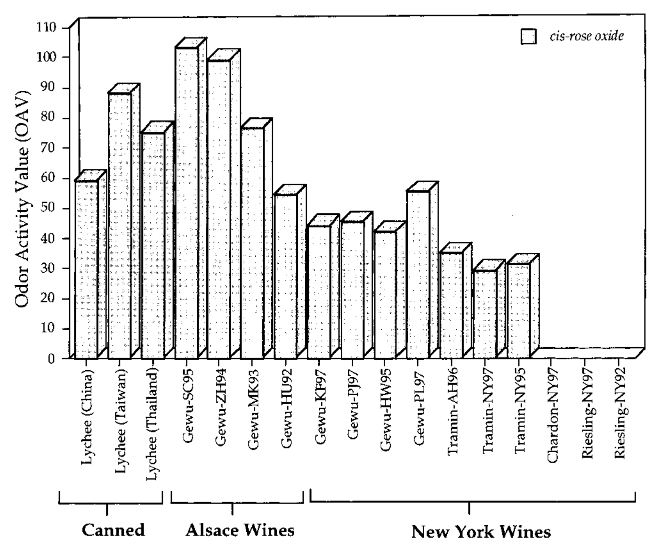

Figure 2. *cis*-Rose oxide detected in various white wines using headspace-SPME.

These compounds are considered by Rapp (1988) as part of the wine bouquet components that are formed during fermentation and as such not suitable for identification of grape varieties or origin.

The results from the SPME analysis of the various wine samples show that the level of *cis*-rose oxide may be an indicator of the intensity of Gewürztraminer character and a good way to determine ideal viticultural and enological practices.

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