The Selection of Aroma-Rich Clones of *Vitis vinifera* L. cv. Gewürztraminer and Weisser Riesling by Means of Terpene Analyses

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Differences in grape aroma between five Gewürztraminer clones (457/48, 14Gm D35, N20 Kieselberg, 925/643 and FR 46/106) and between fifteen Weisser Riesling clones (239/17Gm, T68, B21, 34, 35, W1, 110/11Gm, N90 Winkel, 813/49, W17, 37, 24/196Gm, 239, 327 and 198/10Gm) from the Stellenbosch region were investigated over four seasons. Grape samples were analysed for free and bound terpenes. Under the specific conditions of this investigation it was possible to differentiate between some clones of Gewürztraminer and of Weisser Riesling on the basis of grape-aroma analyses. It, therefore, appears possible to select clones with a higher potential to produce aroma-rich and cultivar-typical wines.

Clones of a cultivar may differ substantially in viticultural performance and in their potential to produce aroma-rich and cultivar-typical wines. In practice, the viticultural and oenological selection of aroma-rich clones involves long-term projects. When wines are produced, the most appropriate wine-making technique for the enhancement of the typical cultivar character has to be selected. Furthermore, the sensory evaluation of wines is subjective and when used in isolation may give misleading results. Therefore, much time and cost would be saved if the selection of aroma-rich clones could be based solely on grape analyses.

Terpenes have long been recognised as important components of grape and wine flavour. Analyses of muscat and aroma-related cultivars showed high concentrations of certain terpenes (Schreier *et al.*, 1976; Williams, Strauss & Wilson, 1980; Rapp, Mandery & Güntert, 1984), Versini *et al.* (1988) demonstrated differences between four Chardonnay clones by utilizing the concentrations of free and bound monoterpenes, benzyl alcohol, 2 - phenyl ethanol, 3-oxo-alpha-ionol and 2,6,6-trimethyl-2-(1-oxo-2-butenyl) - cyclohexen-3-one in grapes.

Using properties such as fruit weight, number of berries per bunch and bunches per vine, McCarthy (1988a) found significant differences between clones of Pinot noir and Chardonnay. No significant differences were found between the clones of Weisser Riesling. Ewart & Sitters (1988) evaluated the wine qualities of the same material and found significant differences between the clones of each cultivar. With regard to Weisser Riesling, the clone BVRC 17 showed the highest quality and Gm 110 the lowest.

Differentiation between Muscat de Frontignac clones was obtained by using total free and bound terpene concentrations (McCarthy, 1988b). McDaniel *et al.* (1988) distinguished between four Gewürztraminer clones by the sensory evaluation of cultivar characteristics, such as spiciness. With respect to this characteristic, clone Colmar 457 was rated the highest. Ampelographic differences, as well as differences in terpene concentrations, were demonstrated between the aroma-rich, spicy Gewürztraminer (Savagnin rose aromatic) clones and the relatively neutral Traminer (Savagnin rose) clones (Schaeffer *et al.*, 1990; Scienza *et al.*, 1990; Versini *et al.*, 1990). However, confusion still exists as to the authenticity of these two types of Savagnin rose and the names Gewürztraminer and Traminer are probably incorrectly used in some countries.

Gewürztraminer and Weisser Riesling are well-known aroma-rich cultivars from Europe, also cultivated in warmer wine-producing countries. Wines produced from these cultivars in South Africa often lack sufficient and characteristic aromas. The purpose of this research was to select Gewürztraminer and Weisser Riesling clones with more pronounced cultivar aroma properties by utilizing the concentrations of certain monoterpenes.

MATERIALS AND METHODS

Aroma differences between five clones of *Vitis vinifera* L. cv. Gewürztraminer (457/48, 14Gm D35, N20 Kieselberg, 925/643 and FR 46/106) from the Stellenbosch region (VORI vineyards) were investigated between 1987 and 1990. Five clones of *Vitis vinifera* L. cv. Weisser Riesling (239/17Gm, T68, B21, 34 and 35) from the same region were investigated for differences in grape aroma during the 1988 vintage. During the 1989 and 1990 vintages ten additional Weisser Riesling clones (W1, 110/11Gm, N90 Winkel, 813/49, W17, 37, 24/196Gm, 239, 327 and 198/10Gm) from the same region were studied. During the 1987 and 1988 vintages grape samples were collected at three ripening stages, i.e. at approximately 16 degrees Balling (°B) and twice between 20°B and 22°B. During the 1989 and 1990 vintages grape samples were collected at two ripening stages between 20°B and 22°B.

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Approximately 2 kg of grapes were collected as whole clusters on a representative basis from five vines per cultivar. The samples were crushed by hand and filtered through cheesecloth by applying slight pressure. During the 1988 vintage each juice was divided into two parts (250ml). Sodium chloride (25g) was immediately added to one part to inhibit enzyme activity. The pH of the second part was adjusted to 5,0 by the addition of sodium hydroxide. This was followed by the addition of beta-glucosidases (Seravac; Code 071202; 0,05 g/250ml) for the enzymatic liberation of terpenes from their glycosidically bound forms. The juice was left for one hour before NaCl (25g) was added. During the 1990 vintage, no enzymatic liberation of aroma was conducted and only free terpenes were determined. Terpene concentrations as well as some other compounds which showed prominent increases in concentration as a result of the beta-glucosidases treatment were determined gas chromatographically (Marais, 1986). Total free volatile terpene and total potentially volatile (bound) terpene concentrations were determined by the method of Dimitriadis & Williams (1984). Wines were produced from ripe grapes according to standard VORI techniques. Differentiation between clones was obtained by using standard analysis-of-variance methods (Snedecor & Cochran, 1982; Payne *et al.*, 1987). Data for the individual ripening stages were considered as replicates.

RESULTS AND DISCUSSION

Since data obtained during the 1987 and 1989 vintages correspond with those of the 1988 and 1990 vintages, only data of the last-mentioned vintages are evaluated.

Gewürztraminer clones: It is clear that grapes of the clone N20 Kieselberg lacked free and potentially free (bound) aroma, since certain key terpene concentrations were significantly lower when compared to those of the other relevant clones (Table 1). Clone 925/643 appeared to have higher citronellol, nerol, geraniol and trans-geranic acid concentrations than the other clones. With respect to the pyran linalool oxides, linalool, alpha-terpineol and diendiol-1, clone 457/48 appeared to be more flavourful.

Enzyme treatment of the juice resulted in marked increases in terpene concentrations. This phenomenon is explained by the existence of glycosidically bound monoterpenes, previously demonstrated by Williams *et al.* (1982a, 1982b, 1982c). This phenonemon was especially illustrated by an unknown terpene or nor-isoprenoid compound (Table 1), which was practically absent in the free form, whereas pronounced increases were observed when it was liberated from its bound form.

It is interesting to note that the concentrations of linalool, alpha-terpineol and diendiol-1 decreased when glucosidases were added. These decreases in total (free plus bound) terpene concentrations are contradictory to what could be expected, but can probably be ascribed to transformations to other terpenes (Usseglio-Tomasset & Di Stefano, 1980). The alteration of the pH to 5,0 could also result in transformations of terpenes, which would not happen under natural conditions.

Free and bound terpene concentrations, determined by the method of Dimitriadis & Williams (1984), showed slight differences when compared to individual terpene concentrations (Table 1). Clone N20 Kieselberg, however, also showed much lower total (free plus bound) terpene concentrations than the other relevant clones. Since this method often does not reflect individual terpene concentrations, it was not applied again.

Other aroma-rich compounds, such as benzyl alcohol (almond-like), 2-phenyl ethanol (rose-like) and 4-vinyl guaiacol (clove-like) were also investigated (Table 1). These compounds showed similar increases in concentrations with the enzyme treatment. The differentiation capacities of these compounds, however, differed from monoterpenes, and deductions with regard to clonal selection could differ completely.

It is not possible to evaluate the contribution of each compound in this study. It is, however, accepted that terpenes with low flavour threshold values, such as citronellol, nerol and geraniol, contribute to the typical aroma of Gewürztraminer grapes and wines. Therefore, clone 925/643 could be selected as the most flavourful clone according to this study.

The gas chromatographic results were also reflected in the sensory evaluation data of the corresponding wines. According to the evaluation panel, clone N20 Kieselberg lacked the typical spicy character, whereas clone 925/643 showed a rose-like character, typical of Gewürztraminer. In conclusion, the possibility that the N20 Kieselberg clone is in fact the neutral Traminer (Savagnin rose) type is not excluded. Similar studies on Gewürztraminer clones were conducted in Germany and Northern Italy (G. Versini, personal communication, 1990). It was found that clones FR 46/107 and N23 showed the lowest monoterpene concentrations, whereas the rest of the clones, especially Lb 14, had much higher monoterpene concentrations. These data were to some extent reflected in the sensory evaluation data of the relevant wines. Clones FR 46/107 and N23 were consistently ranked last, whereas clone Lb 14 was consistently ranked first (G. Versini, personal communication, 1990).

Weisser Riesling clones: When the compounds analysed in five Weisser Riesling clones are considered, no statistical differences between clones were found (Table 2). It appears that clone T68 had lower terpene concentrations than the other four clones (Table 2). With respect to the increase in terpene concentrations as a result of enzymatic action, tendencies similar to those for Gewürztraminer clones were observed for Weisser Riesling clones.

Fifteen Weisser Riesling clones were evaluated during the 1990 vintage. Clone 37 was statistically higher in linalool, trans- and cis-pyran linalool oxide, diendiol-1 and diendiol-2 concentrations than clone 239 (Table 3). Although not significant, clone 327 showed the same tendency as clone 37. Therefore, clones 37 and 327 could possibly be selected as the most flavourful Weisser Riesling clones. It is important to note that similar investigations in other climatic areas or under other viticultural conditions could generate different results.

In similar studies on Weisser Riesling clones from Germany it was found that differences in sensory evaluation data of the wines occurred but no significant differences in chemical analyses were observed (G. Versini, personal communication, 1990).

TABLE 1

Free (F) and total (T) concentrations of individual terpenes and other aroma-rich compounds in five Gewürztraminer clones (1988 vintage).

Terpene		Clone				
		457/48	14Gm D35	N20 Kieselberg	925/643	Fr 46/106
Citronellol	(F)	1,93a	2,00a	0,11a	2,24a	1,46a
	(T)	16,43a	16,20a	0,54b	19,77a	12,37ab
Nerol	(F)	3,03ab	3,18a	0,27b	4,19a	2,70ab
	(T)	25,39a	26,95a	0,99b	31,00a	19,66a
Geraniol	(F)	31,85a	29,32a	1,31b	40,35a	25,69a
	(T)	197,42a	163,56a	5,11b	235,08a	159,76a
trans-Geranic acid	(F)	13,56ab	12,32ab	0,67b	19,30a	9,66ab
	(T)	68,07a	68,14a	1,74b	74,15a	64,31a
Unknown	(F)	traces	traces	traces	traces	traces
	(T)	36,90a	38,03a	4,68b	32,99a	25,09ab
trans-Pyran linalool oxide	(F)	3,61a	3,07a	0,22a	2,17a	2,61a
	(T)	5,82a	5,22a	0,35a	4,19a	3,05a
cis-Pyran linalool oxide	(F)	2,74a	1,80ab	0,18b	1,67ab	2,50ab
	(T)	3,56a	1,73a	0,22a	2,34a	2,43a
Linalool	(F)	1,174a	1,077a	0,077a	0,824a	0,799a
	(T)	0,205a	0,137a	0,000a	0,000a	0,092a
alpha-Terpineol	(F)	1,653a	1,483a	0,504a	1,354a	0,826a
	(T)	1,807a	1,441a	0,583a	1,457a	1,064a
Diendiol-1	(F)	36,443a	30,426a	6,534a	25,013a	30,357a
	(T)	15,167a	12,454a	3,825a	9,333a	9,313a
Total terpenes (g/l)	(F)	0,222a	0,237a	0,223a	0,304a	0,300a
	(T)	0,776a	0,949a	0,356a	0,925a	0,900a
Benzyl alcohol	(F)	3,81a	2,75a	5,47a	4,10a	3,50a
	(T)	102,43a	93,25a	70,57a	99,91a	91,87a
2-Phenyl ethanol	(F)	14,85a	8,49a	16,28a	18,03a	19,00a
	(T)	61,16a	57,73a	60,06a	70,80a	66,07a
4-Vinyl guaiacol	(F)	traces	traces	traces	traces	traces
	(T)	9,78a	4,75a	6,53a	6,76a	5,71a

The values for each clone are the means for three ripening stages.

Values in rows designated by the same symbol do not differ significantly ($p \leq 0,05$).

Compound concentrations are expressed as relative concentrations, using a calibration factor of 1.

TABLE 2

Free (F) and total (T) concentrations of individual terpenes and other aroma-rich compounds in five Weisser Riesling clones (1988 vintage)*.

Terpene		Clone				
		239/17Gm	T 68	B 21	34	35
Linalool	(F)	3,034	2,823	4,561	5,614	2,954
	(T)	1,250	1,083	2,072	1,873	1,780
Geraniol	(F)	1,272	0,623	0,880	1,835	1,283
	(T)	4,010	3,432	4,049	4,442	5,100
Diendiol-1	(F)	100,466	83,684	119,281	161,411	99,436
	(T)	17,962	16,333	28,783	21,900	27,860
Unknown	(F)	traces	traces	traces	traces	traces
	(T)	126,790	95,100	144,413	142,416	207,012
trans-Pyran linalool oxide	(F)	9,610	8,643	13,830	10,420	11,343
	(T)	11,140	10,620	19,160	11,521	14,901
cis-Pyran linalool oxide	(F)	10,833	6,047	10,338	5,336	5,101
	(T)	11,694	6,873	14,894	5,015	6,374
alpha-Terpineol	(F)	1,757	1,207	1,960	3,119	1,287
	(T)	1,073	0,603	0,888	0,917	0,685
Total Terpenes (g/l)	(F)	0,215	0,261	0,269	0,229	0,260
	(T)	0,755	0,848	0,989	1,088	0,765
Benzyl alcohol	(F)	3,131	1,930	2,370	4,241	2,916
	(T)	100,612	56,370	66,153	116,660	73,932
2-Phenyl ethanol	(F)	22,240	23,133	13,121	19,610	18,155
	(T)	62,841	82,072	43,580	54,840	66,673
4-Vinyl guaiacol	(F)	traces	traces	traces	traces	traces
	(T)	15,665	7,146	9,336	11,212	4,378

The values for each clone are the means for three ripening stages.

Compound concentrations are expressed as relative concentrations, using a calibration factor of 1.

* No statistical differences were observed between Weisser Riesling clones ($p \leq 0,05$).

TABLE 3

Free terpene concentrations in fifteen Weisser Riesling clones (1990 vintage).

Terpene	Clone														
	239/ 17 Gm	T68	B21	34	35	W1	110/ 11 Gm	N90 Winkel	813/49	W17	37	24/ 196 Gm	239	327	198/ 10 Gm
Linalool	6,283ab	5,088ab	7,194ab	6,520ab	5,133ab	5,390ab	3,844ab	9,026ab	3,692ab	7,498ab	10,299a	6,126ab	1,339b	9,547ab	8,981ab
Hotrienol	2,419a	1,925a	2,781a	1,297a	1,327a	0,740a	2,208a	1,243a	1,223a	2,065a	2,616a	2,097a	0,660a	2,947a	2,229a
alpha-Terpineol	0,538c	1,226abc	0,773bc	1,426abc	1,298abc	1,672a	1,493ab	1,526ab	0,675bc	1,276abc	1,555ab	0,673bc	1,680a	1,314abc	0,945abc
trans-Pyran linalool oxide	8,449abcd	4,983cd	9,018abc	6,606bcd	6,410bcd	7,375bcd	5,034cd	7,361bcd	6,643bcd	8,722abcd	10,647ab	7,167bcd	4,058d	12,681a	7,777bcd
cis-Pyran linalool oxide	2,528b	1,521b	2,526b	1,640b	2,147b	1,814b	1,486b	1,944b	2,050b	2,457b	3,921a	2,121b	1,426b	4,709a	2,155b
Nerol	0,393ab	0,291a	0,376a	0,318a	0,334a	0,320a	0,248a	0,273a	0,265a	0,309a	0,338a	0,402a	0,324a	0,421a	0,321a
Geraniol	3,103ab	3,520ab	4,359ab	4,111ab	5,307a	3,923ab	3,303ab	4,332ab	3,375ab	2,951ab	4,002ab	3,823ab	2,281b	4,208ab	4,242ab
Diendiol-1	36,897ab	32,941ab	40,465ab	43,742a	33,569ab	30,963ab	24,592ab	32,279ab	28,644ab	29,070ab	49,645a	31,761ab	14,243b	42,030a	26,021ab
Diendiol-2	2,456ab	1,636ab	2,909ab	2,250ab	2,073ab	2,507ab	1,670ab	2,538ab	1,384ab	2,624ab	3,084a	2,757ab	1,361b	2,715ab	2,312ab

The values for each one are the means for two ripening stages.

Values in rows designated by the same symbol do not differ significantly ($p < 0,05$).

Terpene concentrations are expressed as relative concentrations, using a calibration factor of 1.

CONCLUSIONS

Within the limits of this experiment, it was possible to differentiate between some clones on the basis of terpene concentrations. Gewürztraminer clones 457/48, 14Gm D35, 925/643 and FR46/106 appeared to have a higher potential to produce aroma-rich and cultivar-typical wines than N20 Kieselberg. With respect to Weisser Riesling, two clones, namely 37 and 327, could possibly be selected as more flavourful than the others. Other chemical compounds, such as nor-isoprenoids, should also be investigated for their ability to differentiate between clones.

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