Ammonia Concentrations of Musts of Different Grape Cultivars and Vineyards in the Stellenbosch Area

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The ammonia concentrations of a large number of loads of grapes from different farms and of different cultivars were measured. Varietal differences were noted and statistical verifications made. Nine different cultivars were investigated. The average mean ammonia values for the cultivars varied from 54,9 to 148,1 mg/ℓ. Where enough loads from individual vineyards or growers were available, statistical differences were demonstrated. The conditions, treatment, and soil of the vines were shown to be reflected in the extremes by the juice ammonia concentrations. The use of these data is suggested as a means of assessing the vineyard's relative worth for winemaking purposes.

There is relatively little real information on the ammonia content of grapes in relation to the cultivar of grapes. Ough (1969) found in California that ammonia content varied with cultivar but did not have enough samples for any definitive evaluations. The ammonia generally decreases with increasing maturity. The warmer the climate, the greater the loss. Puissant *et al.* (1960) noted that in poorer years (wet and cold) the ammonia content was higher in grapes in France.

It is common practice to add ammonia, either as diammoium phosphate or ammonium sulfate, to wines low in nitrogen to improve yeast growth and fermentation and to prevent hydrogen sulfide formation (Vos *et al.* 1979). This is seldom done in Calfornia but is not uncommon in other areas of the world where soils are poorer or improperly fertilized. However, Bell *et al.* (1979) showed that even very fertile soil depleted of nitrogen by leaching with grasses and having no nitrogen added would, after a period of time, yield grapes so low in nitrogen as to be very difficult to ferment properly and yield wine of lesser quality. Agenbach (1977) as well as Ough & Kunkee (1968) showed the relationship of nitrogen source to fermentation efficiency.

The ammonia content of juice is easy to determine with the use of the ammonia electrode (McWilliam & Ough, 1974).

This study was done to determine the average ammonia content in the grapes of the various cultivars most commonly grown in the Stellenbosch area. The value of the data is severalfold: it gives an indication of the nitrogen status of the vine and the fermentation properties of the juice and some indication of the worth of grapes from a specific cultivar and vineyard for the production of dry table wine. It has been shown that the fruity fermentation esters increase with increased nutrient status of the grape, and the fusel oils decrease (Ough & Bell, 1980; and Ough & Lee, 1981). This was also shown by Vos *et al.* (1979) for the addition of diammonium phosphate to wines low in free amino acids.

MATERIALS AND METHODS

Samples of juice taken for must analysis from trucks and gondolas arriving at the winery were analysed for ammonia. Sufficient loads were sampled to get statistical evaluations of the results. Each sample was identified according to the vineyard. The samples of the loads represented a reasonable sampling of each vineyard. All the loads from a specific vineyard were not necessarily picked in one day; hence, some maturity variation is included. The maturity was that which was acceptable to the winery. The °Brix would vary from less than 19° to over 26°. One hundred ml of each sample was made basic (10 ml 50 % NaOH) to about pH 11.0; while being stirred the sample was read immediately on an Orion Digital Ion-analyzer (Model 801A) using an Orion ammonia electrode. A standard curve was made using ammonium sulfate. Readings were compared to the standard curve. Samples were all read at a room temperature of 20 °C ± 1 °C.

All statistical analyses were performed in the standard way (Snedecor, 1956). Vineyards were compared statistically by analysis of variance. Only those with five or more loads of grapes measured were used. In comparing cultivars data from all the loads were used, except for Chenin blanc (Steen), where there were more than sufficient data.

The error in the actual measurement is very low. Table 1 shows the standard deviation on nine different musts, each measured three times. The coefficient error of the gondolas and trucks would be expected to be larger (Berg & Marsh, 1954). Variations in the vineyard would also be larger than this (Amerine & Roessler, 1958).

TABLE 1

Repeatablity of the ammonia measurements on individual samples of juice

Samples Number	Repetitions of same Samples (mg NH_3/ℓ)	S	CV %
1	87,84,81	±3.00	±3.57
2	55,54,55	±0.58	±1.06
3	79,79,79	±0.00	0.00
4	73,69,73	±2.31	±3.22
5	58,57,55	±1.53	±2.70
6	60,60,61	±0.58	±0.96
7	62,61,63	±1.00	±0.16
8	57,59,57	±1.15	±2.00
9	79,79,79	0.00	0.00

Average Coefficient of Variation = ±1.52

Estimates of the vine vigour, crop load, soil depth, nitrogen fertilizer applications and other viticultural facts were obtained on a number of the vineyards measured by actual observation and consultation with the grower.

RESULT AND DISCUSSION

The differences in the ammonia content of the different cultivars evaluated are shown in Table 2. The cultivars are arranged according to decreasing ammonia content. There is an almost threefold difference in the mean values between the cultivar with the lowest ammonia value, Muscat d' Alexandrie and that with the highest, Pinotage. In this instance nine cultivars could be statistically sorted into six different groups despite the large standard deviations. The between vineyard deviations may be attributed to conditions of soil, moisture, and vineyard practices. Vineyard variations, due to maturity changes over the sampling period, may account for some of the standard deviations (Ough & Singleton, 1968).

The individual cultivars were analysed on a per vineyard block basis. For Pinotage four growers brought in five or more loads which were sampled and analysed. The data are shown in Table 3. The NH_3 content of the grapes on the four vineyards could statistically be divided into three separate groups. Table 4 gives the ammonia values for six vineyards with five or more loads for Cinsaut. Four separate groups could be statistically shown. The Cabernet Sauvignon juice ammonia values are given in Table 5 for 10 vineyards. There were only five statistically different groups in this case. Clairette blanche vineyards (9) showed the least variations of all the cultivars, Table 6. They could only be put into two significantly different groups, even though the number of loads per vineyard was relatively high and the standard deviations were not excessive. What is rather odd is the very definite and clear break between the two groups with no overlap of statistically different mean values. The Chenin blanc (Steen) vineyards, Table 7, with five or more loads numbered 16. These could be statistically broken down into six significantly different groups. The distribution of vineyard mean values for these cultivars appears fairly normal compared to the odd distribution for Clairette blanche.

These data show, despite the rather large standard deviation of the vineyard loads from individual growers, that it was possible to differentiate between certain growers.

To determine if there was any correlation between the high or low ammonia values and the viticultural aspects of the vineyard, those growers who had mean ammonia values more than one half a standard deviation for NH_3 above the mean for the cultivar, and those with mean values for NH_3 one half a standard deviation below, are listed in Tables 8 and 9 respectively. The significant viticultural aspects are compared. In these cases data are used if three or more loads were sampled for the cultivar.

The subjective estimation of the vine condition for the high ammonia vineyards gave eight in good condition, 10 in average condition and none judged poor. In the low ammonia group there was one judged good, 14 judged average and nine judged poor. Most of the good vine condition vineyards were under 12 years old, with the average condition ones of intermediate age, and the poor

TABLE 2

Statistical data on all cultivars measured for ammonia (mg/ℓ)

Cultivar	Number of[1] loads	$\bar{X}$[3]	S	CV %
Pinotage	45	148.1[a]	±31.1	±21.0%
Cinsaut	90	107.0[b]	±23.8	±22.3%
Cabernet Sauvignon	115	104.7[b]	±32.4	±31.0%
South African Riesling	24	92.0[c]	±33.5	±36.4%
Colombard	19	84.8[d]	±26.2	±30.9%
Shiraz	18	72.2[e]	±18.5	±25.6%
Clairette blanche	106	60.6[f]	±14.1	±23.3%
Chenin blanc (Steen)[2]	208	57.5[f]	±18.6	±32.3%
Muscat d' Alexandrie (Hanepoot)	33	54.9[f]	±20.1	±36.6%

[1]Data from all loads used.
[2]Exception to [1]; only data from vineyards delivering 5 or more loads of this cultivar were used. (Mean Variation insignificant).
[3]Those x̄ values with different superscripts are significantly different using $LSD_{.05} = 7.7$.

TABLE 3

Ammonia content (mg/ℓ) of Pinotage grapes from four different vineyards

Grower (Vineyard)	Number of loads	$\bar{X}$	S
1	9	175.8[a]	±14.2
2	11	167.5[a]	±12.6
3	7	150.9[b]	±16.1
4	7	109.9[c]	±13.3

Those x̄ values with different superscripts are significantly different using $LSD_{.05} = 13.67$.

TABLE 4

Ammonia content (mg/ℓ) of Cinsaut grapes from six different vineyards

Grower (Vineyard)	Number of loads	$\bar{X}$	S
7	5	135.4[a]	± 6.0
3	29	120.2[b]	±18.2
8	10	116.2[b]	±13.0
9	7	108.9[b, c]	±24.6
4	6	98.5[c]	±11.9
11	7	75.6[d]	±12.0

Those x̄ values with different superscripts are significantly different using $LSD_{.05} = 15.10$.

TABLE 5

Ammonia content (mg/ℓ) of Cabernet Sauvignon grapes from 10 vineyards

Grower (Vineyard)	Number of loads	$\bar{X}$	S
1	13	153.3[a]	±15.6
14	6	134.8[a, b]	±16.5
15	5	134.4[a, b]	±14.3
16	6	127.6[b]	±25.3
17	5	116.8[b, c]	± 8.9
18	5	105.8[c, d]	±36.9
19	10	99.3[c, d, e]	±12.6
20	8	87.8[d, e]	±21.6
21	6	87.5[d, e]	± 7.2
22	5	81.0[e]	± 9.1

Those x̄ values with different superscripts are significantly different using $LSD_{.05} = 19.11$

TABLE 6

Ammonia content (mg/ℓ) of Clairette Blanche grapes from nine vineyards

Grower (Vineyard)	Number of loads	$\bar{X}$	S
7	14	71.6^{a}	± 7.0
1	7	70.7^{a}	± 7.4
8	10	67.2^{a}	±17.2
30	5	64.4^{a}	± 5.8
5	14	63.3^{a}	±16.2
31	7	52.4^{b}	±10.3
26	5	51.0^{b}	± 4.2
9	7	48.4^{b}	± 7.6
4	14	46.5^{b}	± 6.0

Those $\bar{x}$ values with different superscripts are significantly different using $LSD_{.05} = 10.13$.

TABLE 7

Ammonia content (mg/ℓ) of Chenin Blanc (steen) grapes from 16 vineyards

Grower (Vineyards)	Number of loads	$\bar{X}$	S
36	20	78.2^{a}	±13.3
26	11	$73.9^{a,b}$	±21.9
37	6	$66.2^{a,b,c}$	± 8.0
30	5	$65.6^{b,c}$	±20.4
38	5	$64.8^{b,c}$	±14.7
20	20	$62.3^{c,d}$	±15.5
5	18	$60.4^{c,d,e}$	±19.6
2	14	$59.9^{c,d,e}$	± 8.6
16	6	$58.5^{c,d,e}$	±11.7
39	5	$57.8^{c,d,e}$	±15.5
3	20	$54.6^{c,d,e}$	±17.3
29	15	$52.7^{c,d,e}$	±12.8
4	9	$51.7^{d,e}$	± 6.1
14	26	51.2^{e}	±17.2
34	5	$39.8^{e,f}$	±10.0
11	8	35.1^{f}	± 3.4

Those $\bar{x}$ values with different superscripts are significantly different using $LSD_{.05} = 12.85$.

TABLE 8

Comparison of "high[1] ammonia" vineyards to viticultural conditions and treatments

	Cultivars													Viticultural Aspects	
Grower	Pinotage	Cinsaut	Cabernet Sauvignon	Colombard	Clairette blanche	Chenin blanc	Condition of vines[2]	Age (years)	Soil Depth[3]	Soil Type[4]	Fertilization[5]	Irrigation Amount[6]	Yield[7]	Trellis	Remarks
1	√						G	12	D	HA	30	0 600	12	3 wire trellis	Devon Valley – Western slope.
1			√				G	8	D	HA	30	0 600	8	3 wire trellis	Devon Valley – Western slope.
1					√		A	15+	D	HA	30	0 600	12	3 wire trellis	Devon Valley – Western slope.
2	√						G	8	M	LN	25	0 500	12	3 wire trellis	Vlottenburg – Slight eastern slope.
2				√			A	4	S	LN	20	0 500	8	3 wire trellis	Vlottenburg – Slight eastern slope.
3		√					A	15	M	LN	30	100 600	10	untrellised	Stellenbosch – Northern slope.
5	√						G	8	D	HA	30	0 600	12	3 wire trellis	Devon Valley. High altitude – cool climate.
7		√					A	15	M	HA	20	0 550	10	untrellised	Koelenhof – Northern slope.
7			√				A	12	M	HA	20	50 550	6	3 wire trellis	Koelenhof – Western slope.
7					√		A	15	M	HA	20	50 550	12	3 wire trellis	Koelenhof – Western slope.
8					√		A	5	M	HA	20	100 600	12	3 wire trellis	Simonsberg.
14			√				G	9	M	HA	30	100 500	10	3 wire trellis	Koelenhof. (Chicken manure & fertilizer).
15			√				G	8	D	HA	20	0 600	8	3 wire trellis	Devon Valley – adjoining.
16			√				G	7	D	HA	20	0 600	8	3 wire trellis	Devon Valley – adjoining.
24						√	A	4	S	LN	20	? 500	13	3 wire trellis	Young vineyard overcropped.
28						√	A	12	M	LN	20	50 500	10	untrellised	Bottelary.
32					√		A	25	D	HA	20	0 750	8	untrellised	Simonsberg – Western slope.
36						√	G	4	D	LA	30	? 750	16	6 wire trellis	Jonkershoek – low lying dark alluvial soil Drip irrigated – overcropped.

[1]More than ½ standard deviation above the mean value of that cultivar.
[2]G = good; A = average; P = poor.
[3]D = deep; M = medium; S = shallow
[4]H = heavy; L = light; A = acid; N = neutral.
[5]as kg N/ha.
[6]as applied (upper figure) and rainfall (lower figure) in mm.
[7]as tonnes/ha.

TABLE 9

Comparison of "low[1] ammonia" vineyards to viticultural conditions and treatments

Grower	Cultivars														Viticultural Aspects	
	Pinotage	Cinsaut	Cabernet Sauvignon	Colombard	Shiraz	Clairette blanche	Chenin blanc	Condition of the vines[2]	Age (years)	Soil Depth[3]	Soil Type[4]	Fertilization[5]	Irrigation Amount[6]	Yield[7]	Trellis	Remarks
4						√		A	6	D	HA	0-15	0 550	12	1 wire	Low fertilization, overcrop.
4	√							G	8	D	HA	0-15	0 550	5	1 wire	High altitude 3.5 slope.
4			√					A	15	D	HA	0-15	0 550	12	1 wire	Half long pruning.
6	√							A	10	M	LN	20	100 500	15	4 wire veranda	Overcropping (Helderberg).
9			√					P	±15	S	LN	0	0 500	4	1 wire	Neglected. Oidium.
9						√		P	±20	S	LN	0	0 500	6	untrellised	Neglected. Oidium.
11		√						P	±20	S	LN	±15	100 450	6	untrellised	Vines very old.
11			√					P	8	S	LN	±15	150 450	5	3 wire	Spacing 1 m × 1 m straw mulch.
11							√	A	12	S	LN	±15	100 450	10	3 wire	Poor sandy soil. Southern slope.
12		√						P	20+	S	LN	0	0 600	6	untrellised	Cane pruned.
13		√						P	15+	S	LN	0	0 500	5	untrellised	Bad management.
13							√	A	15+	S	LN	0	0 500	6	untrellised	Bad management.
20			√					A	12	M	HA	20	50 500	6	3 wire	Poor selected vines.
20					√			A	9	M	HA	20	50 500	6	3 wire	Poorly pruned. Overripe.
21			√					A	8	M	LN	?	50 500	6	3 wire	Oidium on leaves.
25			√					A	7	M	LN	?	100 500	5	3 wire	
26						√		A	15+	D	HA	10	0 600	10	untrellised	Bad management.
29				√				P	12	M	HA	20	100 600	12	3 wire	Overcropping. Poor drainage.
31						√		A	15+	M	LN	15	0 600	12	3 wire	
33						√		A	12	M	LN	20	0 700	8	untrellised	Southern slope.
34						√		A	15+	M	LN	0	0 500	7	3 wire	New owner. Neglected.
34							√	A	15+	M	LN	0	0 500	8	3 wire	New owner. Neglected.
35						√		P	15+	M	LN	20	600	8	untrellised	Bad management.
45							√	P	15+	M	LN	15	0 750	6	3 wire	Poorly drained dark alluvial soil.

[1]More than ½ standard deviation below the mean value of that cultivar.
[2]G = good; A = average; P = poor.
[3]D = deep; M = medium; S = shallow.
[4]H = heavy; L = light; A = acid; N = neutral.
[5]as kg N/ha.
[6]as applied (upper figure) and rainfall (lower figure) in mm.
[7] as tonnes/ha.

vineyards generally 12 years old or older. Most of the vineyards in good condition were on deep soils, while the poor ones were on shallow soils, and the average ones mostly on medium soils. The good condition vines were on the heavier and acid soils, and the poor ones on the light neutral soils. All the high ammonia vineyards had from 20 to 30+ kg N/ha added, while the low ammonia vineyards generally had from 0–20 kg N/ha added. Crops were somewhat lower for the low ammonia vineyards. Trellising differences were not apparent. The remarks indicate some overcropping in both groups (two for the high ammonia vineyards and four for the low ammonia vineyards). The main adverse notes on the low ammonia vineyards are: neglect, oidium, and bad management.

A large group of growers fall into the intermediate group and are not categorized other than having medium ammonia vineyards and probably would fall somewhere between two groups as far as their vineyard conditions are concerned.

The use of °Brix, pH and NH_3 measurements of fruit seems to be an easy way of judging the potential quality of the fruit from a given area and cultivar. This can be backed up by vineyard inspection and experimental fermentations for wine quality and fermentability. The total acidity and Ph are indicators which can also be considered primarily to indicate the need for acid addition at the crusher. The °Brix is a necessary criterium because of the change in ammonia content with maturity. As long as the °Brix is in the normal range 20–23,5° Brix the ammonia value is consistent with the data furnished (Ough, 1969). However, early picked or 25+ °Brix fruit should not be judged by these standards.

Further data to support the validity of these studies are certainly desirable. Variations in seasons can be a factor in the nitrogen uptake in the vines and the consequent ammonia content of the grape. However, the relative differences between vineyards should not change.

The purpose of such a study as this is to determine which vineyards produce fruit which are valuable, as far as making sound and good quality wines is concerned. It is not a short-range project to screen individual loads of grapes. Further studies relating the quality of wines made from the individual vineyards to the analysis should be the follow-up project.

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