Fermentation and Post-Fermentation Changes in Israeli Wines

SHELA GORINSTEIN, AMIRAM GOLDBLUM, SVETLANA KITOV, and JOSEPH DEUTSCH

ABSTRACT

Grape juices (*V. vinifera*) from vineyards at three locations in Israel were analyzed for carbon, hydrogen and nitrogen contents, metals, amino acids and glycerol, various stages of fermentation and post-fermentation. The contents varied with respect to the type of grape, area, year of collection and methods of vinification. The glycerol content of wine appears to be related to the duration of fermentation. Correlation analysis reveal relationships between the tartaric acid and calcium contents. A certain correlation is also found with the duration of fermentation. For the purpose of wine characterization and study of changes resulting from technological processes, the variation of chemical composition may serve as useful parameters.

INTRODUCTION

THE CHEMICAL COMPOSITION of wines is known to be a function of the duration of fermentation, which in its turn, depends on the outside temperature, grape variety, type of wine being made (red or white), °Brix, pH, nitrogenous constituents (total nitrogen, free amino acids), glycerol content and other nutrients (Bell et al., 1978; Kain and Bandion, 1976; Kliewer, 1970; Mantashyan, 1977; Margheri et al., 1979; Ough and Amerine, 1966). Until recently, there has been very little enological information available on the content of Israel wines with regard to their chemical change during fermentation and post-fermentation.

Sediments and hazes are formed due to interaction between the minerals (Boulton, 1980; Goranov, 1979), polyphenols and tannins (Gorinstein, 1973; Gorinstein et al. (1980a; Heatherbell, 1976), amino acids (Oogh and Tabacman, 1979; Temperli and Kuensch, 1976; Yokotsuka et al., 1977), nitrogenous and sulfurous components (Moretti and Berg, 1965; Shol'tz et al., 1977) and especially by proteins which tended to form complexes with iron and copper (Bayly and Berg, 1967; Gorinstein, 1975; Gorinstein et al., 1971; Kiskovskii et al., 1976; Ratushnyi and Ratushnaya, 1973). Therefore wine stability constitutes one of the most important indices in the evaluation of wines. Some Israeli grape varieties were studied in previous work (Gorinstein et al., 1980c). The present investigation was performed in order to gain insight into the changes of Israeli grape juices during fermentation and post-fermentation periods.

Fermentation and post-fermentation studies were conducted to determine the relationship between must levels of the indicated parameters – total, amine and protein nitrogen, amino acids, calcium, glycerol, tartaric acid, and the levels present after fermentation, with a view to its significance for the stability of the final product.

Author Gorinstein is presently on sabbatical leave at the Univ. of Zululand, Dept. of Chemistry, Private Bag X1001, KWA-DLANGEZWA, 3886, South Africa. Authors Goldblum, Kitov and Deutsch are affiliated with the Dept. of Pharmaceutical Chemistry, School of Pharmacy, The Hebrew Univ. of Jerusalem, Israel.

MATERIALS & METHODS

THE EXPERIMENTS were carried out with two varieties of Israeli grapes *V. vinifera*, *Carignane* and *Semillon*, used in the production of 90% of the red and 50% of the white wines in Israel, respectively. Wines made from Carignane and Semillon grapes at one Israeli winery and wine from Carignane grapes at another winery are identified in the text and tables as CR, SR, and CP respectively. Samples of these grapes were obtained from four consecutive vintages (1976–1980). The grapes were harvested manually and immediately were transported to the wineries without storage. The juices were fermented by natural yeast flora with the added use of a wine yeast strain (*Saccharomyces ellipsoideus*). The temperature during the fermentation was controlled for white wines from 15–20°C and for red wines 28–29°C. The contents of carbon, hydrogen, nitrogen, glycerol and metals, were determined 0, 8, 13, 21, 26, 52 and 78 days after pressing. Samples of musts and wines were subsampled at the indicated intervals during the fermentation, the number of these days corresponding to different stages of the vinification such as 0 (fresh grape juice); 8 (complete juice fermentation); 13 (first racking); 21 (second racking); 26 (last racking); 52 (post fermentation) and 78 days (complete post fermentation). SR was treated with bentonite, CR with gelatin, and CP with bentonite and gelatin during the cooling process. After this fining and cold stabilization, wines were filtered and left in bulk. For this investigation 10-liter samples of musts and wines were taken directly from the winery tanks and part of each sample was lyophilized. Lyophilized samples of musts and wines were used only for elemental, nitrogenous and fatty content, amino acid analysis and mass spectroscopy.

The musts and wines were analyzed for °Brix, alcohol by volume, total and volatile acidity, pH, total sulfur dioxide, malic, tartaric, succinic, citric and lactic acids, and total polyphenols by conventional methods and by procedure of Amerine and Ough (1980). Color of wines (optical density, OD_{520}, OD_{420}) was determined spectrophotometrically. Intensity is the total sum of OD_{520} and OD_{420}. Hue is the ratios of OD_{520} and OD_{420} at a 1:9 dilution.

Nitrogen was determined by Dumas analysis and also by the Kjeldahl method. Carbon, hydrogen and chloride were found by microanalysis, while sodium, potassium, calcium, iron and copper were determined by absorption spectrophotometry. Stability of wine was studied below 55°C and at –5°C after 48 hr.

As part of this study on the influence of the length of the fermentation period, chloroform and acetone extracts of lyophilized samples were used for glycerol determination by gas chromatography combined with mass spectrometry, NMR analyses, IR and UV spectroscopy (Gorinstein et al., 1980a, 1980b).

Amino acid composition in bound and free forms was determined according to Fantozzi and Montedoro (1974). Correlation analyses were performed by a computer program that also calculated the squared correlation coefficients between all the variables. For each wine type, five variables were used: number of days (DAYS), glycerol in g/L (GLYC), total nitrogen in mg/L (N TOT), calcium in mg/L (CALC), and tartaric acid in g/L (TART).

RESULTS & DISCUSSION

THE OBSERVED CHANGES in chemical composition of the samples are presented in Tables 1–5 as an average of four vintages. An analysis of juices is given in Table 1, referring to 0 days of fermentation. All parameters for musts and wines are presented in Tables 2 and 3.

The pH levels, the accumulation of titratable acidity and volatile acidity stemming from bacterial spoilage, and levels of sulphur dioxide, free and bound, were in the range nor-

Table 1—Analysis of juices from white and red grapes

Parameters		SR[a]	CR[a]	CP[a]
°Brix		20.4	19.7	22.4
Total acidity, tartaric acid, g/L		5.55	5.10	5.15
pH		3.59	3.66	3.84
Malic acid, g/L		1.5	2.5	1.5
Tartaric acid, g/L		4.0	3.5	3.5
Citric acid, g/L		0.5	0.5	0.5
C, %		7.8	7.6	8.0
H, %		7.06	6.96	6.79
C/H		1.10	1.09	1.18
Nitrogen, mg/L	Total	324.5	351.2	405.6
	Amine	157	181	194
Metals, mg/L	Na	45.0	50.0	62.5
	K	1600	2000	1860
	Ca	256	416	320
	Fe	6.0	4.0	8.0
	Cu	0.20	0.80	0.50
Glycerol, g/L		1.6	0.5	0.5
Total polyphenols tan. ac., mg/L		925	1800	575
Color: Intensity		0.255	0.485	0.312
Hue		2.64	0.94	0.95

[a] SR = Semillon, Rishon-le-Zion; CR = Carignane, Rishon-le-Zion; CP = Carignane, Petach-Tikwa

mally encountered in grape musts (Robertson and Rush, 1979; Rush, 1979). In Table 2 is shown the total amount of sulphur dioxide (bound and free). Some sulphur dioxide was added to the juices after crushing grapes.

Under the climatic conditions, and conditions of fermentation which were set-up and controlled by the two Israeli wineries, the juice fermentation for white and red grapes was completed in 8 days. More than 95% of sugar was fermented; therefore, there was not a large change in composition even after 78 days of storage.

Tartaric acid was the predominant, and most widely varying, acid in the juices. The amount of this acid slightly decreased as the alcohol concentration increased during fermentation because of the precipitation of some potassium bitartrate. Malic and lactic acids, which are indicators of malolactic fermentation, appeared at levels normally found (Castino, 1980; Hara and Mizuno, 1981; Temperli and Kuensch, 1976).

Fermentation of the musts and further treatment of wines changed the amount of carbon from 1.10 in juices to 0.50 in wines as can be seen from the relation C/H (Table 3). During fermentation, the nitrogenous content dropped significantly during the first stage of fermentation because it was used as nutrient for yeast growth; after this, a slight increase was noted, which was followed by a decrease at the end of the fermentation. The level of residual nitrogen varied according to the initial nitrogen content of the grapes. The musts with low initial nitrogen contents (under 500 mg/L) are recommended (Pallotti et al., 1976), because they require fewer fermentations. In this study, according to the data of Table 2, the highest amount of nitrogen encountered in musts was about 400 mg/L.

Assimilation of total nitrogen during fermentation was between 30 and 46% of the initial must total nitrogen. The amount of amine nitrogen was halved at the first stage of juice fermentation (Table 3).

Table 2—Some indices of white and red musts and wines

Type of wine[a]	Stages in Process, Days	°Brix	Alcohol % vol.	Total acidity, tartaric acid, g/L	Volatile acidity, acetic acid, g/L	pH	Total SO_2, mg/L	Malic acid, g/L	Tartaric acid, g/L	Citric acid, g/L	Lactic & SUCC. acids, g/L
SR	8	0.9952	11.1	6.30	0.22	3.51	96	0	3.5	0	3.0
	13	0.9950	11.0	6.20	0.22	3.53	99	0	3.0	0	3.0
	21	0.9946	11.0	6.12	0.33	3.54	101	0	3.0	0	3.0
	26	0.9945	11.2	6.00	0.23	3.56	44	0	3.0	0	3.0
	52	0.9946	10.9	5.63	0.26	3.60	124	0	2.0	0	3.0
	78	0.9945	10.9	5.62	0.27	3.60	127	0	1.5	0	3.0
CR	8	0.9972	10.5	6.07	0.33	3.68	32	0	2.0	0	3.5
	13	0.9970	10.4	6.00	0.29	3.67	34	0	2.0	0	3.5
	21	0.9965	10.4	5.87	0.30	3.71	28	0	2.0	0	3.5
	26	0.9963	10.5	5.70	0.26	3.71	28	0	2.0	0	3.5
	52	0.9957	10.5	5.55	0.44	3.69	32	0	2.0	0	3.5
	78	0.9956	10.5	5.52	0.46	3.68	33	0	1.5	0	3.5
CP	8	0.9970	11.0	5.49	0.33	3.79	70	1.5	2.5	<0.5	0
	13	0.9971	11.3	5.77	0.43	3.76	76	1.5	2.0	<0.5	1.5
	21	0.9972	11.2	6.00	0.45	3.81	80	1.3	2.0	<0.5	1.5
	26	0.9973	11.3	6.15	0.45	3.80	83	1.5	2.0	<0.5	1.5
	52	0.9973	11.2	6.28	0.47	3.69	85	1.5	2.5	<0.5	1.5
	78	0.9973	11.2	6.40	0.51	3.60	85	1.5	2.0	<0.5	1.5

[a] SR = Semillon, Rishon-le-Zion; CR = Carignane, Rishon-le-Zion; CP = Carignane, Petach-Tikwa

During fermentation and wine formation, the amount of proteins decreased, which could affect the colloid protein stability of wine at 55°C (Table 3). The presence of Na, K and Ca may lead to cloudiness. The amount of Na increased, resulting from the use of bentonite, which contains large amounts of this cation. Only in the case of CP the amount of Na decreased slightly. K changed only slightly, with all values being in the range normally found in grape musts and wines. Tables 1 and 3 show that the content of Ca, Fe and Cu were approximately halved from juice to wine. This suggests that attention must be devoted to the Ca content during the fermentation step because it influences the tartrate stability of the final product at −5°C (Table 3).

It was interesting to follow the changes in pigments and tannins because of their important role in the sensory evaluation of wine, particularly of red wine. From the changes in color it can be seen, that bentonite reduced the wine color to a higher degree than the gelatin (Table 3, sample CP). It was observed also (Table 3), that gelatin alone was as efficient as a gelatin-bentonite mixture in absorbing the polyphenols in red wines.

The most notable changes (Table 4) were in the contents of total SO_2, color, polyphenols, and metals, depending on the method of vinification. The soil in different areas affected the chloride content in wines. A strong change appeared also in °Brix and carbon with area and year of collection.

The GC-MS profile showed 5 peaks (Fig. 1). The two most prominent ones (1 and 3) were identified by mass spectrometry as glycerol and a pentose respectively. Glycerol is one of the final products, whereas the pentose is an intermediate which almost disappeared after the main juice fermentation. The structure of peaks 2, 4 and 5 were not determined. GC-MS profiles of different samples of wines during fermentation revealed small differences in the content of the glycerol and pentose, which may be due to variations in raw materials composition.

The correlation matrix (Table 5) presents some interesting features. The highest correlations were found between the calcium content and glycerol, clearly indicative of the interdependence of those variables. The calcium content was highly correlated also with tartaric acid, which is important for the tartrate stability of wine. The acid and glycerol were well correlated only for the CR and CP. Some correlation was also found between the nitrogen content and glycerol, whereas dependence on the number of days was found only for tartaric acid in SR. The lower correlation of the acid, calcium and glycerol content of CR, CP and SR with the number of days, seems to be more than just chance correlation and agrees with the literature (Ratushnyi and Ratushnaya, 1973; Shimizi et al., 1979). The equations calculated for the correlation with $r^2 > 0.80$ are presented in Table 6.

The confidence limits for intercept values in Eq. 4 and 8 (Table 6) nearly overlap and both equations agree very closely on the relation between calcium and glycerol. The agreement is even better between Eq. 6 and 10, while their counterpart for SR has different values for both the slope and the intercept. Eq. 5 and 7, relating the tartaric acid and

Table 3—Elemental, nitrogenous and fatty content, metals and stability in samples during winemaking

Type of wine[a]	Stages in Process, days	C, %	H, %	C/H	Nitrogen, mg/L Total	Nitrogen, mg/L Amine	Metals, mg/L Na	K	Ca	Fe	Cu	Glycerol g/L	Total Polyphenols, tan. ac., mg/L	Color: Intensity / Hue	Stability −5°C	Stability 55°C
SR	8	3.53	6.21	0.57	160.1	99	42.5	1520	200	6.5	0.30	6.3	155	0.255 / 2.64	–	–
	13	3.47	6.25	0.56	165.3	90	47.2	1500	185	6.8	0.35	6.7	155	0.255 / 2.64	–	–
	21	3.39	6.47	0.52	171.4	86	50.0	1400	180	6.5	0.35	6.0	155	0.200 / 2.63	–	–
	26	3.31	6.32	0.54	172.3	82	55.0	1420	175	6.0	0.35	6.0	150	0.200 / 2.63	–	–
	52	3.01	6.53	0.46	209.1	79	52.0	1400	145	4.0	0.20	6.0	150	0.160 / 3.0	Stab.	Non. St.
	78	2.87	6.95	0.41	218.7	72	50.0	1380	135	3.5	0.10	6.0	120	0.155 / 3.43	stab.	stab.
CR	8	3.41	6.54	0.52	131.8	101	74.5	1720	220	5.0	0.90	4.9	1800	0.485 / 0.94	–	–
	13	3.29	6.14	0.54	150.7	100	48.5	1700	200	5.0	0.90	5.0	1800	0.485 / 0.94	–	–
	21	3.18	6.04	0.53	164.2	94	50.0	1600	185	5.5	0.80	5.8	1850	0.482 / 0.91	–	–
	26	3.00	6.43	0.47	172.1	96	55.0	1620	175	5.5	0.70	5.0	1800	0.482 / 0.90	–	–
	52	2.71	6.70	0.40	173.1	93	60.0	1640	130	3.5	0.30	5.0	1400	0.480 / 0.85	stab.	stab.
	78	2.65	6.63	0.40	191.4	91	60.0	1620	85	3.5	0.30	5.0	1040	0.480 / 0.85	stab.	stab.
CP	8	3.92	6.53	0.60	202.4	123	60.0	1800	94	8.0	0.50	5.8	925	0.312 / 0.95	–	–
	13	3.86	6.69	0.58	225.3	118	55.0	1740	96	8.5	0.60	6.3	930	0.312 / 0.95	–	–
	21	3.77	6.89	0.55	241.4	100	54.0	1710	92	8.2	0.60	6.7	938	0.235 / 0.95	–	–
	26	3.53	6.84	0.52	253.8	98	51.0	1700	90	8.0	0.60	6.2	930	0.235 / 0.95	–	–
	52	3.40	6.71	0.51	261.5	97	50.0	1640	90	8.0	0.35	6.0	775	0.196 / 1.22	stab.	stab.
	78	3.14	6.23	0.50	273.6	97	47.0	1600	90	6.0	0.30	6.5	725	0.190 / 1.11	stab.	stab.

[a] SR = Semillon, Rishon-le-Zion; CR = Carignane, Rishon-le-Zion; CP = Carignane, Petach-Tikwa

calcium content for the CR and CP, are practically identical. The intercept of Eq. 3 has no physical meaning, unless one considers the 95% confidence limits.

The relations between amino acid composition in bound and free forms during fermentation and post-fermentation are shown in Figs. 2-4. There were no dramatic effects on amino acid composition after 13 and 21 days. Therefore, only the changes in amino acid composition after 0, 8, 26 and 78 days are shown.

Most of the amino acids in bound and free forms were assimilated during fermentation. However, proline, cystine, lysine, methionine and glycine were not assimilated (Ough and Stashak, 1974). The concentrations of ammonia were significantly greater in CR and CP wines than in the SR. CR and CP wines contained more histidine than SR. Therefore, ammonium –N increased the histidine content and also increased the lysine, arginine and leucine contents. The hydrolyzed samples of CR, CP and SR were rich in proline, glutamic acid, aspartic acid and arginine, but poor in basic, aromatic, S-containing, and heterocyclic amino acids. Free amino acids in these types of wine were found in concentrations similar to those reported in the literature (Fantozzi and Montedoro, 1974; Kliewer, 1970; Mantashyan, 1977; Ough and Tabacman, 1979; Temperli and Kuensch, 1976).

CONCLUSIONS

THE CHANGES in the minerals (Na, K, Ca), heavy metals (Cu, Fe), total, amine N, free and bound amino acids, color (OD_{420}, OD_{520}), five organic acids and glycerol were followed during fermentation and post-fermentation in wines. These changes as well as mass spectral identification and gas-liquid chromatographic profiles can be used as possible indicators of fermentation rate and stability of wines. In the wines significant correlations were found between the Ca and glycerol, Ca and tartaric acid. However, the lower correlation was computed between tartaric acid, Ca and glycerol and the number of days, with the exception

Table 4—Variation of some components in wines with area, year of collection and method of vinification

	SR*			CR			CP		
Parameters	Area	Year of collection	Method of vinification	Area	Year of collection	Method of vinification	Area	Year of collection	Method of vinification
°Brix	0.9929–0.9950	0.9928–0.9952	0.9945–0.9950	0.9940–0.9965	0.9940–0.9962	0.9953–0.9957	1.0009–1.0016	1.0004–1.0017	0.9971–0.9973
Alcohol, 20°C % Vol.	10.7–10.8	10.8–11.0	10.9–11.1	10.4–10.8	10.4–10.9	10.4–10.5	10.8–11.3	10.8–11.3	11.2–11.3
Total acidity, Tartaric acid, g/L	4.83–4.86	4.86–5.80	5.62–6.00	5.50–5.60	5.45–5.62	5.52–5.70	4.82–6.17	4.90–6.30	6.28–6.40
Volatile acidity, acetic acid, g/L	0.34–0.38	0.30–0.35	0.27–0.33	0.43–0.52	0.40–0.50	0.46–0.48	0.49–0.84	0.40–0.90	0.47–0.51
pH	3.40–3.60	3.40–3.50	3.56–3.60	3.60–3.70	3.62–3.75	3.68–3.72	3.61–3.70	3.58–3.72	3.60–3.69
Total SO_2, mg/L	100–110	104–110	104–127	25–30	30–32	20–34	100–130	80–135	70–100
Malic acid, g/L	0	0	0	0	0	0	0.5–1.0	0.5–1.0	0.5–1.5
Tartaric acid, g/L	1.0–2.0	1.5–2.0	1.5–3.0	1.0–1.5	1.0–1.5	1.5–2.0	1.0–2.0	1.0–2.0	1.5–3.0
Citric acid, g/L	0	0	0	0	0	0	<0.5	<0.5	<0.5
Lactic and suc. acids, g/L	2.0–2.5	2.0–2.5	2.5–3.0	3.5	3.5	3.5	1.5–2.0	1.5–2.0	1.5–2.0
C1, %	0.85–1.63	0.80–1.34	1.34–1.63	0.84–1.69	0.90–1.70	0.80–1.70	0.57–2.23	0.45–2.35	0.45–2.35
C, %	2.40–3.50	2.70–3.20	2.80–3.40	2.42–3.50	2.40–3.00	2.42–2.70	3.92–4.00	3.64–3.85	3.86–3.14
H, %	6.14–6.94	6.00–6.70	6.80–7.20	6.20–6.70	6.30–6.60	6.50–6.70	6.30–6.70	6.40–6.80	6.23–6.71
Nitrogen, mg/L	100–300	100–300	200–400	100–200	100–200	140–220	150–250	150–150	200–300
Metals, mg/L Ca	160–190	160–190	80–135	170–185	165–190	85–138	150–170	140–180	70–90
Metals, mg/L Fe	6.0–7.5	6.5–8.0	3.5–4.0	6.0–8.0	5.5–8.5	3.0–5.5	5.0–8.0	5.5–7.8	6.0–7.0
Metals, mg/L Cu	0.20–0.40	0.25–0.50	0.10–0.20	0.80–0.90	0.65–0.90	0.10–0.30	0.50–0.60	0.45–0.75	0.20–0.30
Total polyphenols, mg/L	170–180	150–190	140–120	1600–1800	1400–1900	1000–1400	600–900	540–1000	600–800
Color: Intensity	0.155 0.150	0.180 0.160	0.155 0.125	0.485 0.480	0.482 0.480	0.482 0.480	0.235 0.212	0.220 0.218	0.195 0.190
Color: Hue	2.83 2.75	2.60 3.0	3.43 4.0	0.94 0.85	0.91 0.85	0.90 0.85	0.96 1.08	1.09 1.08	1.17 1.11
Glycerol, g/l	5.0–7.0	5.0–7.0	4.0–6.0	4.0–5.0	4.5–5.0	4.5–5.0	5.0–6.0	5.5–6.5	5.0–6.0

* SR = Semillon, Rishon-le-Zion; CR = Carignane, Rishon-le-Zion; CP = Carignane, Petach-Tikwa

Table 5—Square correlation coefficient (r^2) matrix for all variables

	DAYS			GLYC			NTOT			CALC			TART		
	SR[a]	CR[a]	CP[a]	SR	CR	CP	SR	CR	CP	SR	CR	CP	SR	CR	CP
DAYS	1.0	1.0	1.0	0.46	0.52	0.40	0.01	0.06	0.02	0.76	0.63	0.22	0.95	0.42	0.43
GLYC				1.0	1.0	1.0	0.60	0.70	0.61	0.89	0.99	0.91	0.61	0.95	0.95
NTOT							1.0	1.0	1.0	0.29	0.59	0.86	0.06	0.76	0.51
CALC										1.1	1.1	1.1	0.89	0.93	0.84
TART													1.1	1.1	1.1

[a] SR = Semillon, Rishon-le-Zion; CR = Carignane, Rishon-le-Zion; CP = Carignane, Petach-Tikwa

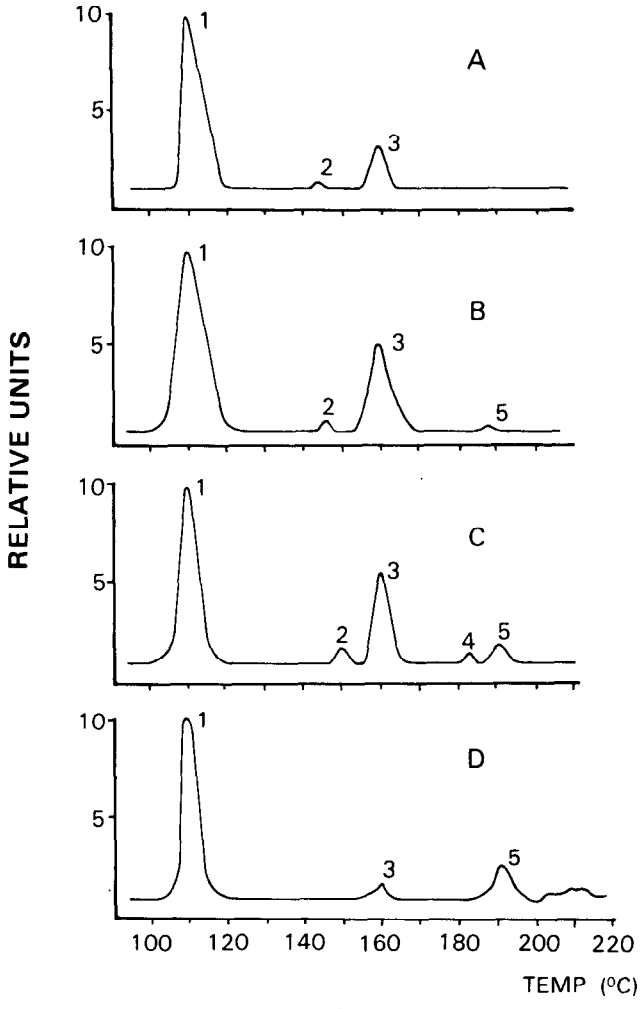

Fig. 1—Gas chromatographic profiles of acetone extractable fractions: A, B, C and D — samples after 0, 8, 26 and 78 days of fermentation, respectively. Peaks: 1 — MW308; 2 — MW282; 3 — MW-366; 4 — MW 428; 5 — MW 436.

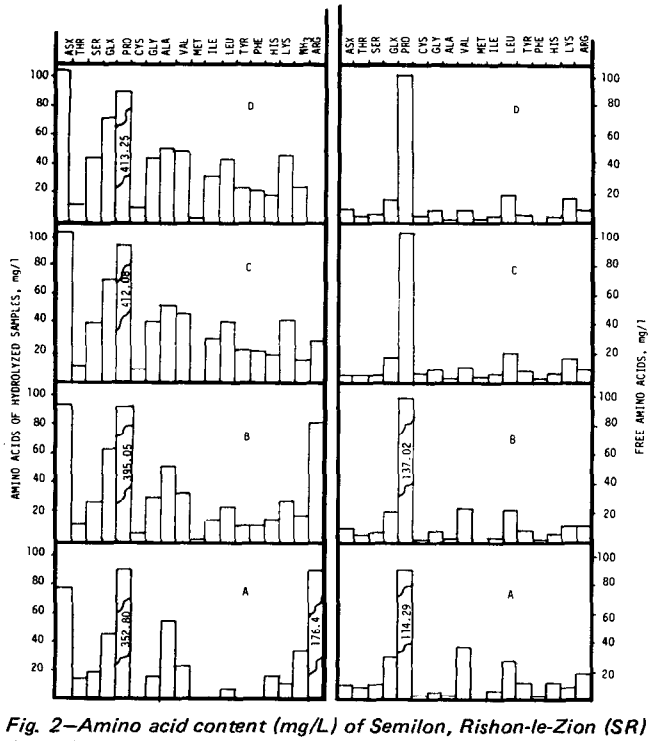

Fig. 2—Amino acid content (mg/L) of Semilon, Rishon-le-Zion (SR) A, B, C and D — samples after 0, 8, 26 and 78 days of fermentation, respectively.

of SR. The wines were rich in proline, glutamic and aspartic acids and arginine in their free and bound forms.

REFERENCES

Amerine, M.A. and Ough, C.S. 1980. "Methods for Analysis of Musts and Wines." J. Wiley and Sons, New York.

Bayley, F.C. and Berg, H.W. 1967. Grape and wine proteins of white wine varietals. Amer. J. Enol. Vitic. 18: 18.

Bell, A.A. Ough, C.S., and Liewer, W.M. 1978. Effects on must and wine composition, rates of fermentation and wine quality of nitrogen fertilization of Vitis vinifera var. Thompson seedless grapevines. Am. J. Enol. Vit. 30(2): 124.

Boulton, R. 1980. The general relationship between potassium, sodium and pH in grape juice and wine. Am. J. Enol. Vitic 31(2): 182.

Castino, M. 1980. Malo-lactic fermentation of white wines. Riv. Vitic. Enol. 33(9): 425.

Fantozzi, P. and Montedoro, G. 1974. Determination of five amino acids in musts and wines by gas-liquid chromatography. Am. J. Enol. Vitic. 25: 151.

Table 6—Equations calculated for the correlation with $r^2 > 0.80$

A		SR	
1	TART (g/L)	=	3.709 (±0.317) − 0.030 (±0.008) X DAYS
		s = 0.218;	r = 0.972
2	CALC (mg/L)	=	275.22 (±39.640) − 7.244 (±2.895) X GLYC
		s = 14.261;	r = 0.945
3	TART (g/L)	=	−0.827 (±1.558) + 0.020 (±0.008) X CALC
		s = 0.317	r = 0.941
B		CR	
4	CALC (mg/L)	=	470.521 (±40.531) − 17.068 (±2.421) X GLYC
		s = 14.066;	r = 0.993
5	TART (g/L)	=	3.721 (±0.442) − 0.100 (±0.026) X GLYC
		s = 0.153;	r = 0.975
6	TART (g/L)	=	0.983 (±0.414) + 0.006 (±0.002) X CALC
		s = 0.185;	r = 0.963
C		CP	
7	TART (g/L)	=	3.720 (±0.382) − 0.093 (±0.024) X GLYC
		s = 0.136;	r = 0.975
8	CALC (mg/L)	=	331.596 (±78.414) − 14.107 (±5.010) X GLYC
		s = 27.882;	r = 0.956
9	N TOT (mg/L)	=	178.314 (±49.170) + 0.707 (±0.333) X CALC
		s = 27.322;	r = 0.926
10	TART (g/L)	=	1.623 (±0.443) + 0.006 (±0.003) X CALC
		s = 0.246;	r = 0.915.

[a] Values in parentheses are 95% confidence limits.

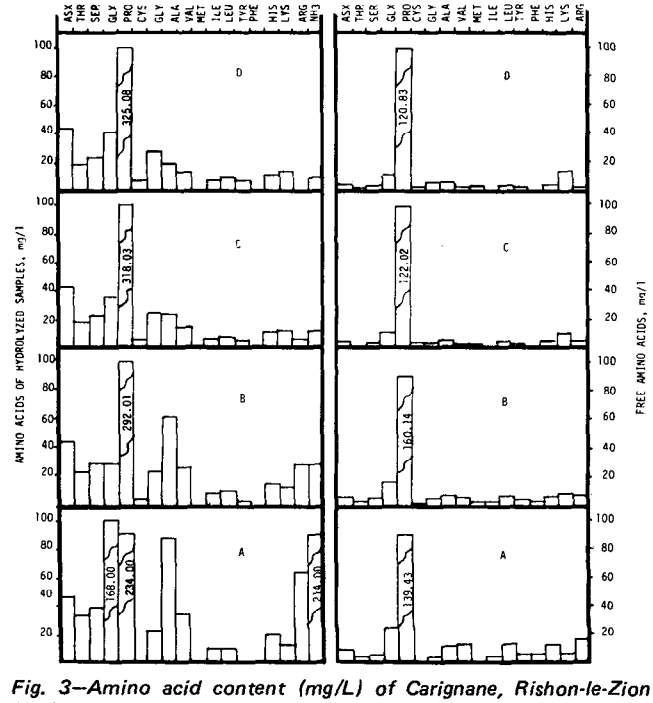

Fig. 3—Amino acid content (mg/L) of Carignane, Rishon-le-Zion (CR), A, B, C and D — samples after 0, 8, 26 and 78 days of the fermentation, respectively.

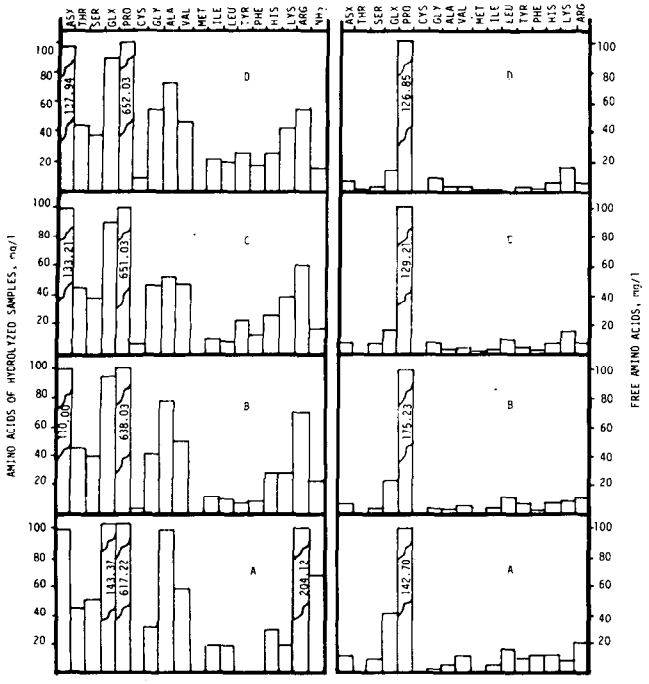

Fig. 4—Amino acid content (mg/L) of Carignane, Petach-Tikwa (CP), A, B, C and D — samples after 0, 8, 26 and 78 days of the fermentation, respectively.

Goranov, W. 1979. Calcium content and stability of wines. Mitt. Klosterneuburg 29(6): 241.

Gorinstein, S. 1973. Dependence of fruit-berry wines stability on the content of mineral and nitrogenous components. J. Food Sci. 38(7): 1264.

Gorinstein, S. 1975: A thermogravimetric study of the stability under heat of iron-protein complexes. J. Agr. Food Chem. 23(1): 45.

Gorinstein, S., Deutsch, J., Kitov, S., Sarel, S., Berman, O., Berliner, M., and Popovich, G. 1980a. Changes in nitrogen, polyphenol and fatty content in beer following enzymatic action. MBAA, Technical Quarterly 17(2): 98.

Gorinstein, S., Kitov, S., and Deutsch, J. 1980b: Spectroscopic determination of glycerol, polyphenols and nitrogenous compounds in beer and wine. MBAA, Technical Quarterly 17(3): 156.

Gorinstein, S., Kitov, S., Deutsch, J., Sarel, S., Loinger, C., Cohen, S., Tabacman, H., Stiller, A., and Zykerman, A. 1980c. Variation in the chemical content of grape juices during their fermentation. *Proceedings 18th Congress of the South African Society for Plant* Pathology and Microbiology, p. 22.

Gorinstein, S., Venskyavichus, J., and Makshtyalene, Z. 1971. The change of common and organic nitrogen in fruit-berry wines. Vinodel. Vinograd. Mold. 4: 33.

Hara, S., and Mizuno, A. 1981. Formation of L- or D-lactate on malolactic fermentation of red wine. Hakko Kogaku Kaishi 59(1): 17.

Heatherbell, D.A. 1976. Haze and sediment formation from starch degradation products in apple wine and clarified apple juice. Confructa 21(½): 36.

Kain, W. and Bandion, F. 1976. Zur Analytischen Beurteilung Beurteilung Osterreichischer Qualitatsweine Besonderer Reife und Leseart — Glyceringehalt. Mitt. Klosterneuburg 26: 159.

Kishkovskii, Z.N., Sakharova, T.A., and Kossobudskaya, N.S. 1976. Effect of different methods of processing must and wine on their quality and chemical composition. Vinodel. Vinograd. SSSR 2: 26. [Chem. Abstr. 85: 18944a.]

Kliewer, W.M. 1970. Free amino acids and other nitrogenous fractions in wine and must. J. Food Sci. 35: 17.

Mantashyan, E.A. 1977. Role of amino acids of glutamic acid family in the growth of wine yeasts. Biol. Zh. Arm. 30(2): 92. [Chem. Abstr. 87: 20561.]

Margheri, G., Versini, G., Sartori, G., Inama, S., Pellegrini, R., and Gianotti, L. 1979. The relationship between vinification procedures and the volatile components of the wine. "Pinot Bionco Trentino 79" Vini d'Italia 22: 275.

Moretti, R.H. and Berg, M.W. 1965. Variability among wines to protein clouding. Am. J. Enol. Vitic. 16: 69.

Ough, C.S. and Amerine, M.A. 1966: Fermentation rates of grape juice. 4. Compositional changes affecting prediction equations. Am. J. Enol. Vitic. 17: 163.

Ough, C.S. and Stashak, R.M. 1974. Further studies on proline concentration in grapes and wines. Am. J. Enol. Vitic. 25: 7.

Ough, C.S. and Tabacman, H. 1979. Gas chromatographic determinations of amino acid differences in Cabernet Sauvignon grapes and wines as affected by rootstocks. Am. J. Enol. Vitic. 30(4): 306.

Pallotti, G., Bencivenga, B., Brighina, G., and Palmioli, A. 1976. Nitrogen composition as a characterization index of Frascati wine. Riv. Soc. Ital. Sci. Aliment 5(9): 303.

Ratushnyi, G.D. and Ratushnaya, S.G. 1973. Role of organic acids during the formation and breakdown of complexed iron in wines. Sadovod. Vinograd. Vinodel. Mold. 28(7): 25 [Chem. Abstr. 80: 13597b.]

Robertson, J.M. and Rush, G.M. 1979. Chemical criteria for the detection of winemaking faults in red wines. Food Technol. in New Zealand 14(1): 3.

Rush, G.M. 1979. New Zealand white table wines, 1971 and 1977. Food Technol. in New Zealand. July: 3.

Shimizu, J., Shimazu, Y., and Watanabe, M. 1979. Relationship between some minerals and organic acids in table wine. Nippon Nogei Kagaku Kaishi 53(6): 203. [Chem. Abstr. 91: 138794x.]

Shol'ts, E.P., Ivanytina, A.I., Furkevich, V.A., Kreshenevskaya, R.G., and Polteva, L.I. 1977. Improved scheme for preparation of table semidry wines by biological lowering of nitrogen. Vinodel. Vinograd. SSSR 7: 21.

Temperli, A. and Kuensch, U. 1976. The variation in the content of free amino acid during vinification. Qual. Plant. Plant Foods Hum. Nutr. 26(1—3): 141. [Chem. Abstr. 86: 15171j.]

Yokotsuka, K., Yoshii, M. Aihara, T., and Kushida, T. 1979. Chemical studies on coloring and flavoring substances in Japanese grapes and wines. 6. Isolation and characterization of proteins from juices, musts and wines from Japanese grapes. J. Ferment. Technol. 55(5): 510.

Ms received 4/11/83; revised 6/17/83; accepted 7/5/83.

The authors acknowledge the analytical help of The Israeli Wine Institute, especially Dr. Tabacman and Mrs. M. Stevenson (University of Natal, South Africa). The Israeli wineries kindly provided the samples.

We thank Professor A. Kjaer, Technical Univ. of Denmark, for reviewing a prior draft of this manuscript.