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Amino Acid Composition of Grape Cultivars (*Vitis* Spp.) in Japan

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The concentration of free amino acids and other chemical constituents in 75 grape cultivars at maturity were examined. The amino acid concentrations were found to be in decreasing order of arginine, proline, threonine and alanine in *Vitis vinifera* cultivars and alanine, arginine, threonine and proline in *Vitis labrusca* cultivars.

The concentration of total amino acid was 5,083 μmol in 'Campbell Early' and 3,391 μmol in 'Yates', both *Vitis labrusca* and table grapes. The amounts of total amino acids in *vinifera* and wine grape cultivars were low while those of table grape cultivars were high in organoleptic sweet amino acids such as threonine, serine, proline, glycine, alanine, etc.

INTRODUCTION

The amino acids in table grapes are important as a source of the good taste contributors. The importance of amino acids in contributing to the taste of foodstuffs was first recognized by Ikeda who discovered that monodium L-glutamate was the essential component of the taste-imparting ingredients of traditional Japanese food seasoners such as sea tangle. The taste of traditional Japanese foods such as soy sauce was presumed to be due to the amino acids which were released from the natural proteins during the course of fermentation (Kirimura et al. 1969).

Amino acids are used in food processing not only to enhance the nutritive value, but also to enhance or improve the taste of natural characteristics of foodstuffs. The taste of amino acids and their relative stuffs. The taste of amino acids and their relative contribution to the taste of foods have been the topic of extensive investigations ; studies have been undertaken on the distribution, isolation, and elucidation of the chemical structures of amino acids and some of their properties in foods.

The amino acid contents in *Vitis vinifera* (Castor et al. 1953, 1956 ; Kliewer 1968, 1970 ; Ough 1968, 1969) and *V. labrusca* (Gallander 1974 ; Kliewer 1969 ; Kluba et al.) grapes were reported.

This paper presents the data on the composition of the free amino acids in many *vinifera* and *labrusca* cultivars cultivated in Japan.

MATERIALS AND METHODS

About 50 g of ripe berries were sampled from ten clusters in the center portion of the randomly selected vines in the experimental vineyards of Fukuoka Horticulture Experiment Station, Fukuoka, and the Akitsu Branch of the Fruit Tree Research Station Akitsu in 1977 and 1978. After removing the seeds, 50 g samples were ground with quartz sand in a triturator, 200 ml of deionized water was added to the macerate

and then clarified by centrifugation at 10,000 G and 10 min. The supernatant was decanted, and the residue was reextracted several times with deionized water and filtered through Toyo No. 5B filter paper. Preparation and determination for amino acid content were examined by the ion exchange column chromatography, and the analyses of sugars and organic acids were done through the procedure described by Shiraishi *et al.* (1980 ; 1986).

RESULTS AND DISCUSSION

Table 1 shows the concentrations of the free amino acid compositions in the ripe grapes. The total sugars, total and free acids of the grape cultivars examined are presented in Table 2.

The most abundant free amino acids in all 75 grape cultivars at maturity were alanine, arginine, and proline, constituting 20.9, 27.7 and 15.3% of the total free amino acids, respectively. Amounts ranged from 9 to 2.482 μmol per 100 g fresh berries for alanine, 34 to 1,045 μmol for arginine, and 14 to 1,037 μmol for proline. Threonine, serine, and glutamic acid values ranged between 1 and 110 μmol , and their amount varied with cultivars.

The most abundant free amino acids in *Vitis vinifera* cultivars were arginine, proline, threonine and alanine with the average percentages of 35.4, 21.2, 11.7 and 9.7, respectively (Table 3). The average amounts of these amino acids were 295.2, 176.0, 97.1 and 81.2 μmol per 100 g fresh berries, respectively.

Likewise, the most abundant free amino acids in *labrusca* cultivars were alanine, arginine, threonine and proline with the average percentages of 31.7, 18.2, 17.7 and 9.0, and amounts of 549.5, 269.8, 261.8 and 132.9 μmol per 100 g fresh berries, respectively.

Labrusca grape 'Campbell Early' had the highest content of total amino acids (5,083 μmol per 100 g fresh berries), followed by same *labrusca* 'Yates' (3,391 μmol). Average total free amino acid levels in *labrusca* and *vinifera* grapes were 1,479 and 833 μmol , respectively.

The grape cultivars were arbitrarily grouped into low-, medium-and high-amino acid groups with total amino acids of 2,139 and 1,000 μmol as thresholds. The high-amino acid group included *labrusca* cultivars and high quality table grapes. The medium-amino acid group included many hybrid cultivars and table grapes. The low-amino acid group included *vinifera* cultivars and many wine grapes.

Amino acids were also divided into 4 groups by their chemical constructions : The first group was the monoamino monocarboxylic acid which included glycine, alanine, serine, cystine, threonine, methionine, valine, leucine isoleucine, phenylalanine and tyrosine. The second group was the polyamino monocarboxylic acid which included arginine, histidine and lysine. The third group was the monoamino dicarboxylic acid which included aspartic acid and glutamic acid. The fourth group was the iminocarboxylic acid which included proline and hydroxyproline. Hydroxyproline was rarely present in the grape cultivars examined in this study.

The amino acid compositions divided into 4 groups with the 75 cultivars are shown in Table 2. Higher concentration of monoamino monocarboxylic acids seemed to be responsible for the high content of total amino acids in some grape cultivars. Polyamino monocarboxylic among which arginine is the major component, are basic

Table 1. Comparison of amino acid composition in the 75 cultivars* of grapes (*²: *vinifera*, ³: *labrusca*)

Cultivar	μmol of amino acid/100 g of fresh weight ^r																	Arg	Total
	Asp	Thr	Ser	Glu	Pro	Gln	Ala	Cys	Val	Met	Ile	Leu	Tyr	Phe	Lys	His			
Campbell early ³	52	583	85	125	238	80	2,482	6	82	12	45	75	12	35	38	88	1,045	5,083	
Yates ³	31	906	120	136	128	25	1,499	0	46	2	20	35	3	20	9	19	392	3,391	
Pusa seedless ¹	90	640	110	215	440	9	411	9	50	6	21	69	0	34	10	45	560	2,719	
Neo Muscat ¹	32	593	71	78	476	19	240	0	62	16	39	46	8	31	73	75	735	2,591	
Bath ¹	60	740	90	89	35	11	923	1	28	7	10	12	5	5	8	24	408	2,456	
Pione ²	26	696	106	91	70	20	530	2	56	11	25	40	6	36	1	45	518	2,287	
Cannon Hall Muscat ²	15	190	106	68	620	20	175	1	60	6	39	73	4	25	27	54	736	2,221	
Kokuho ³	40	313	156	63	618	28	634	0	44	6	26	28	4	19	4	14	191	2,188	
Kyohō ³	20	188	106	64	134	24	548	2	110	15	60	79	20	40	30	44	655	2,139	
Buffalo ¹	24	243	74	84	427	19	617	0	4%	2	12	33	2	16	11	20	275	1,901	
Himrod seedless ¹	30	480	98	78	178	15	445	0	46	6	27	33	6	20	10	33	330	1,835	
Ruski Concord ²	56	204	71	68	1,037	10	122	1	35	6	23	29	1	1	7	20	88	1,779	
Kendaia ³	13	197	16	40	58	24	1,115	0	35	1	15	25	10	10	8	10	60	1,637	
Nehelescol ²	18	124	45	45	844	6	98	0	15	10	12	15	0	15	5	17	337	1,606	
Red Millennium ¹	16	165	66	70	350	17	500	0	35	1	11	22	1	19	15	25	293	1,606	
Romulus ²	30	181	83	125	175	10	405	0	31	0	14	30	0	10	6	22	4x2	1,604	
Schyle ²	22	177	51	57	392	15	318	0	29	1	8	24	0	8	8	17	393	1,518	
Tachikawa No. 3 ¹	25	280	35	63	70	Y	425	0	15	0	6	13	0	10	6	19	470	1,446	
Violet Uehara ²	41	332	91	42	26	9	541	0	20	1	8	17	0	9	5	14	264	1,420	
Italia ²	30	256	35	60	94	12	107	1	32	8	20	32	9	20	39	36	615	1,406	
Interlaken seedless ¹	15	120	44	104	733	9	115	0	65	0	10	16	0	6	8	15	145	1,405	
Delaware ²	11	201	47	72	86	21	467	0	23	1	8	21	8	14	11	12	392	1,395	
Kōshū ²	15	83	62	27	531	15	138	1	15	1	9	19	1	1	9	16	424	1,367	
Black Olympia ¹	30	247	78	61	100	10	455	0	16	0	9	15	4	10	10	20	295	1,360	
Coma Neagra ²	13	177	52	51	251	12	230	0	30	4	10	19	3	8	7	20	465	1,352	
Alden ³	24	355	41	70	66	10	388	0	21	1	7	18	3	10	6	19	285	1,324	
Cabernet blanc ²	8	14	45	35	594	9	174	0	20	0	8	15	0	8	6	17	300	1,313	
Tachikawa No. 5 ¹	31	275	90	60	55	15	373	6	35	0	20	25	8	24	10	23	220	1,270	
Pierce ²	27	268	62	45	23	15	54.5	0	31	1	11	23	8	19	8	20	139	1,245	
Urbana ¹	11	225	62	67	66	8	398	0	26	2	5	15	5	23	5	17	241	1,176	
Mase No. 5 ³	10	182	34	34	156	31	265	0	6	0	5	10	0	6	12	15	405	1,171	
Keuka ³	70	48	10	15	0	300	0	40	2	14	31	11	16	15	19	435	1,051		
Ilro Hamburg ¹	10	30	70	98	58	10	115	0	38	6	21	46	2	1	16	36	490	1,047	
Anab-e shahi ²	25	250	59	44	105	10	140	0	28	5	15	15	2	15	7	20	281	1,021	
Concord ¹	28	223	52	42	37	7	410	0	18	3	8	9	1	12	2	11	150	1,013	
Captivor ¹	18	122	23	19	195	24	167	0	45	5	14	35	17	66	12	32	206	1,000	
Ishihara wase ³	18	174	20	28	34	10	523	0	19	6	6	11	6	10	5	9	110	989	
Sheridan ³	32	149	39	59	40	7	394	0	24	4	8	15	6	8	6	11	121	96X	
Nyora ²	15	140	35	30	255	9	130	0	25	2	10	10	0	6	9	8	245	929	
Kōshū sanjaku ²	14	159	42	44	305	6	82	0	10	1	6	11	0	9	7	15	204	915	
Olympia ¹	3Y	137	96	49	130	10	260	0	29	3	13	25	3	16	2	7	96	913	
Katta Kurgan ²	15	148	20	34	58	6	46	0	11	2	6	16	2	20	11	20	475	890	
Purple Damascus ²	20	104	29	30	315	9	110	0	25	2	8	13	2	6	8	13	173	867	
Hanover ²	20	156	45	28	60	11	370	0	15	2	7	16	6	20	7	12	78	853	
Black queen ²	40	101	41	29	151	5	182	0	15	2	11	25	1	6	4	7	231	851	
Rose queen ¹	19	122	50	37	55	a	195	11	20	2	8	16	5	10	6	15	265	838	
Pecocede Marengre ²	31	66	41	22	23	7	56	0	13	0	8	20	0	0	6	9	514	X18	
Naples ³	14	95	45	16	35	9	360	2	12	2	10	20	2	14	2	11	117	766	
Muscat Hamburg ²	15	78	30	36	68	1	95	0	16	1	12	18	6	8	9	16	355	764	
Black prince ¹	27	100	30	30	39	6	132	0	7	2	9	8	0	6	10	12	328	746	
Roode Hanepoot ²	17	112	71	47	58	5	134	0	21	2	16	20	2	7	6	13	188	713	
Gros Colman ¹	29	36	21	22	109	3	39	0	19	1	13	25	3	13	8	16	348	706	
Pinot blanc ²	2	56	9	5	195	2	16	0	16	0	6	11	2	6	11	11	333	681	
Rosaki ²	38	100	51	28	117	6	81	0	32	2	10	13	2	11	10	11	132	644	
Shasslas rose ¹	25	54	30	18	102	3	73	0	18	0	9	15	0	5	5	13	269	639	
Ontario	10	136	22	25	21	6	212	0	Y	0	2	9	2	3	2	10	158	627	
Niagara ³	10	141	24	15	24	10	220	0	12	0	7	11	10	22	5	10	100	621	
Monukka ²	23	71	23	35	215	6	70	0	11	2	8	16	0	9	6	14	111	620	
Merlot ²	8	40	28	45	338	8	11	0	16	11	6	9	0	0	5	5	34	619	
Golden Muscat ¹	7	128	21	31	30	10	145	0	11	0	8	17	0	11	10	15	160	604	
Canada Muscat ¹	11	101	43	21	44	Y	119	1	10	2	6	13	4	15	5	12	148	574	
Rizamat ²	25	57	18	5	50	3	54	0	11	0	3	8	0	5	6	12	289	548	
Athens ¹	16	62	16	41	41	11	145	2	12	0	6	11	9	14	6	10	115	517	
Gros Sémillon ²	5	44	29	16	119	6	65	0	13	0	6	9	0	6	6	8	142	474	
Riesling Italico ²	9	42	37	7	44	2	69	0	6	4	9	17	0	3	6	13	205	473	
Black Hamburg ²	6	24	13	6	24	6	20	2	13	2	11	20	1	Y	7	Y	282	457	
Flame Tokay ²	9	56	15	16	134	6	43	0	Y	0	3	6	0	5	4	8	124	438	
Pizzutello Bianco ³	15	41	19	16	37	1	36	0	14	1	8	15	0	15	7	9	193	427	
Black Cornichon ²	Y	31	14	14	81	6	27	0	7	0	5	9	0	4	6	5	181	399	
Ryugan ²	10	55	30	16	95	15	62	0	7	0	5	8	1	6	1	8	78	397	
Königin dr Weingarten ²	14	55	20	25	42	6	45	0	11	0	Y	8	0	10	6	6	112	369	
Centennial ²	20	65	58	15	25	5	45	0	6	0	4	4	1	5	4	8	75	340	
Chardonnay ²	10	28	14	6	65	5	9	0	10	0	6	10	0	4	6	5	150	328	
Grüner Sylvaner ²	17	24	25	10	23	8	23	0	17	0	28	42	0	15	3	5	40	280	
Olivette rose ²	15	30	12	11	14	5	21	0	6	1	5	5	0	3	6	8	135	277	

Table 2. Sugar and acid contents, and constructive distributions and organoleptic characteristics of amino acids in the 75 cultivars** of grapes ($\mu\text{mol}/100$ g of fresh weight) (**²: *vinifera*, ³: *labrusca*)

Cultivar	Total Sugar (g/100 g fresh weight)	Total Acid (g fresh weight)	Free Acid (g fresh weight)	* constructive distribution				* organoleptic characteristics		
				Mono. Mono.-amino	Poly. Mono.-carboxylic	Mono. Di-	Imino Acid	sweet Amino Acid	Sour Amino Acid	Bitter Amino Acid
Campbell early ³	13.0	1.082	0.570	3,557	1,171	117	238	3,524	1	7
Yates ³	13.X	1.159	0.616	2,676	420	167	128	2,690	167	534
Pusa seedless ¹	17.9	1.252	0.627	1,359	615	305	440	1,629	305	785
Neo Muscat ¹	13.8	1.043	0.357	1,122	883	110	476	1,477	110	1,004
Bath ³	9.2	1.051	0.672	1,832	440	149	35	1,813	149	494
Pione ²	13.5	0.879	0.360	1,645	572	117	70	1,437	117	733
Cannon Hall Muscat ²	14.2	1.020	0.582	701	817	X3	620	1,142	83	996
Kokuhō ³	19.2	0.929	0.478	1,258	209	103	618	1,757	103	328
Kyohō ³	16.2	1.015	0.480	1,192	729	X4	134	1,050	a4	1,005
Buffalo ³	20.5	0.991	0.449	1,060	306	108	427	966	108	827
Himrod seedless ¹	16.8	1.014	0.543	1,176	373	108	178	1,232	108	495
Ruski Concord ¹	17.4	1.552	0.706	503	115	124	1,037	1,453	124	202
Kendaia ¹	7.2	0.942	0.589	1,148	78	53	58	1,428	53	156
Nehelescol ²	16.7	1.364	0.682	340	359	63	844	1,122	63	421
Red Millennium ¹	12.7	1.073	0.539	837	333	86	350	1,114	86	406
Romulus ¹	14.6	0.963	0.468	764	510	155	175	860	155	589
Schuyler ¹	17.3	0.930	0.305	629	418	79	392	970	79	469
Tachikawa No. 3 ¹	11.2	0.720	0.329	793	495	XX	70	838	88	520
Violet Uehara ²	14.8	0.792	0.385	1,028	283	83	26	1,013	83	324
Italia ²	14.7	0.942	0.468	532	690	90	94	552	90	764
Interlaken seedless ¹	13.8	0.769	0.334	385	168	119	733	1,029	119	257
Delaware ³	15.8	1.387	0.489	811	415	83	86	841	83	471
Kōshū ²	14.4	1.089	0.872	345	449	42	531	840	42	485
Black Olympia ¹	13.6	0.734	0.458	844	325	91	100	904	91	365
Corna Neagra ²	12.6	1.086	0.638	545	492	64	251	732	64	556
Alden ³	15.X	0.7114	0.357	854	310	94	66	869	94	361
Cabernet flanc ²	16.0	1.704	0.649	353	323	43	594	902	43	368
Tachikawa No. 5 ¹	12.9	0.754	0.348	871	253	91	55	832	91	347
Pierce ¹	10.3	1.489	1.042	983	167	72	23	929	72	244
Urbana ¹	16.0	0.976	0.432	769	263	7X	66	769	78	329
Mase No. 5 ³	14.0	1.623	0.906	539	432	44	156	680	44	447
Keuka ³	13.3	0.919	0.523	555	469	12	15	459	12	580
Hiro Hamburg ²	16.5	1.015	0.480	339	542	108	58	301	108	638
Anab-e-shahi ²	10.6	0.884	0.482	539	308	69	105	573	69	379
Concord ¹	14.9	1.020	0.670	743	163	70	37	732	70	211
Captivator ¹	11.6	1.092	0.364	518	250	37	195	560	37	403
Ishihara wase ³	12.9	1.052	0.648	785	124	46	34	776	46	167
Sheridan ¹	13.2	1.232	0.814	699	138	91	40	641	91	236
Nyora ²	13.7	1.061	0.458	367	262	45	255	578	45	306
Kōshū sanjaku ²	12.9	1.327	0.723	326	226	58	305	601	58	256
Olympia ¹	14.1	0.772	0.360	592	105	88	130	638	88	189
Katta Kurgan ²	13.4	1.310	0.819	277	506	49	58	291	49	550
Purple Damascus ¹	7.7	1.030	0.564	308	194	50	315	577	50	240
Hanover ²	11.8	1.250	0.782	64X	97	48	60	655	48	150
Black queen ²	13.2	1.460	0.896	389	242	69	151	485	69	297
Rose queen ¹	14.7	1.052	0.673	436	286	56	55	441	56	336
Pecocede Marengre ²	12.2	1.109	0.468	213	529	53	23	199	53	566
Naples ¹	16.4	1.028	0.432	571	130	30	35	550	30	186
Muscat Hamburg ¹	12.8	0.920	0.412	265	380	51	68	287	51	426
Black prince ¹	11.0	0.904	0.449	300	350	57	39	317	57	372
Roodie Hanepoot ²	13.3	0.992	0.613	384	207	64	58	388	64	261
Gros Colman ¹	14.5	0.648	0.320	174	372	51	109	219	51	436
Pinot blanc ²	15.4	0.840	0.294	124	355	7	195	291	7	383
Rosaki ¹	16.4	0.812	0.345	308	153	66	117	367	66	211
Shasslas rose ²	14.1	0.862	0.389	207	287	43	102	267	43	329
Ontario ³	13.9	1.242	0.768	401	170	35	21	401	35	191
Niagara ³	9.9	1.208	0.771	457	115	23	24	434	23	162
Monukka ²	10.9	0.923	0.422	216	131	58	215	391	58	171
Merlot ³	12.8	1.259	0.676	184	44	53	338	496	53	70
Golden Muscat ¹	14.5	1.308	0.824	351	185	38	30	344	38	222
Canada Muscat ¹	14.7	1.129	0.683	323	165	42	44	326	42	206
Rizamat ²	14.8	0.688	0.368	161	307	30	50	188	30	330
Athens ¹	14.0	0.973	0.445	288	131	57	41	292	57	168
Gros Sémillon ²	16.1	1.263	0.678	178	156	21	119	269	21	184
Riesling Italico ²	14.4	1.233	0.780	189	224	16	44	200	16	257
Black Hamburg ²	14.2	0.744	0.288	123	298	12	24	97	12	348
Flame Tokay ²	16.7	1.364	0.678	143	136	25	134	258	25	155
Pizzutello Bianco ²	10.6	0.76 ¹	0.337	150	209	31	37	141	31	255
Black Cornichoho ¹	11.0	0.097	0.589	102	192	24	81	165	23	211
Ryugan ²	11.4	0.934	0.549	189	87	26	95	259	26	112
Königin der Weingarten ²	12.1	0.833	0.307	164	124	39	42	201	39	156
Centennial ¹	11.5	1.020	0.509	193	87	35	25	203	35	102
Chardonnay ²	7.4	1.004	0.568	86	161	16	65	127	16	186
Grüner Sylvaner ²	14.3	0.889	0.407	182	48	27	23	106	27	147
Olivette rose ²	9.9	1.000	0.568	88	149	26	14	XX	26	163

Table 3. Amounts of the major free amino acids and percentages in *Vitis vinifera*. and *labrusca*. cultivar groups

Group	Alanine	Arginine	Proline	Threonine
<i>vinifera</i>	81.2*	295.2	176.0	97.1
	9.7**	35.4	21.2	11.7
<i>labrusca</i>	549.5	269.8	132.9	261.8
	31.7	18.2	9.0	17.7

* Amount : μmol per 100 g fresh berries

* * Percentage

amino acids, and are contained in many *vinifera* cultivars. 'Pusa seedless' had the highest content of monoamino dicarboxylic acids among 75 grape cultivars examined. Among grape cultivars with relatively high amounts of monoamino dicarboxylic acids were 'Yates'(167), 'Romulus'(155), 'Bath'(149), 'Russki concord'(124), 'Interlaken seedless'(119), 'Campbell Early' and 'Pione'(117), 'Neo Muscat'(110), 'Buffalo', 'Himrod seedless', and 'Hiro Hamburg'(108), and 'Kokuho'(103 μmol). Iminocarboxylic acid group contained only proline. There seemed no relationship among species in the concentration of proline. The proline contents were 1,037, 844, 733, 620 and 518 μmol per 100 g fresh berries in 'Russki Concord', 'Nehelescol', 'Interlaken seedless', 'Cannon Hall Muscat' and 'Kokuho' grapes, respectively.

Amino acids are classified into three types-sweet, sour, and bitter amino acids by their organoleptic characteristics. Table shows the concentration of them in 75 cultivars. Threonine, serine, proline, glycine, alanine, cystine, tyrosine and lysine are important sweet taste contributors. These amino acids were contained in many *labrusca* cultivars and table grapes in high quantity. Aspartic-and glutamic acid contribute to sour taste. Cultivars containing relatively abundant concentrations of sour amino acids are grapes with good taste. Valine, methionine, isoleucine, leucine phenylalanine, histidine and arginine have a bitter taste accompanied by slight sweetness. These amino acids were found to be contained more in the *vinifera* than in the *labrusca* cultivars, and the average percentages were 22.4 in the *labrusca* and 45.5 in the *vinifera* cultivars.

Amounts of total sugar contents ranged from 7.2 to 20.5 g per 100 g fresh berries. Higher total sugar contents of 20.5, 19.2, 17.9, 17.4 and 17.3 g per 100 g fresh berries were observed on 'Buffalo', 'Kokuho', 'Pusa seedless', 'Russki Concord' and 'Schuyler', respectively. 'Kendaia', 'Chardonnay', and 'Purple Damascus' contained only small amounts of total sugars with respective 7.2, 7.4, and 7.7 g. There seemed no relationship among species in the concentration of total sugar, showing the average content of 13.8 g for cultivars belonging to both species. Most abundant total acid contents of 1.704, 1.552, 1.489, 1.387 and 1.364 g per 100 g fresh berries were found in 'Cabernet franc', 'Russki Concord', 'Pierce', 'Delaware' and 'Nehelescol', respectively. Amounts of free acids ranged from 0.288 to 1.042 g fresh berries. There seemed no relationship among species in the concentration of free acid. The results presented here are in accordance with Kluba *et al.* (1978). and Shiraishi *et al.* (1980).

It was concluded that the grape berries have many different patterns in free amino acids, and the table grape cultivars have the abundant content of sweet amino acids according to organoleptic characteristics. These results will further provide some

meaningful suggestions for the improvement of the quality of grape products containing useful amino acids.

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