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Original scientific paper

Amino acid composition of some grape juices (*Vitis vinifera* L.) from Croatia

Abstract

Free amino acids in grape juice are important as nitrogen source for yeast strains during alcoholic fermentation. The aim of this research was to determine amino acid profiles in musts from nine grapevine cultivars (six white and three red). The cultivars were located in a homogeneous soil and climatic zone of Bilogora growing hill (West continental region, Prigorje–bilogora subregion), grown on the same training system. The experiment was conducted in vintage 2015. The results showed significant influence of grape cultivar on the amino acids composition in musts of white and red grape cultivars. Arginine was dominant in most analyzed varieties of amino acids. The highest concentration of arginine in white cultivars was measured in Chardonnay must (470.18 mg/L) and in red cultivar must from Saint Laurent (280.65 mg/L). Statistically significant difference was also found in the total amino acid composition of white and red cultivars. The highest concentration of total amino acids in white cultivars was determined in Manzoni juice (1639.51 mg/L) and among the red cultivars in Pinot noir juice (1173.12 mg/L).

Keywords: *free amino acid, arginine, total amino acid, grape juice*

Introduction

Must in average contains 20 amino acids that together represent 30-40% of the total nitrogen. The concentration and the composition of amino acids vary between cultivars, type of soil, processing and climate (Moreno and Peinado, 2012). The concentration of amino acids in must varies between 65 and 1130 mg/L (Amerine *et al.*, 1998), mainly depending on the cultivar, region, time of harvest, the amount of nitrogen in the soil and fertilization (Bell *et al.*,1979). According to Shiraishi, (1991) the most presented free amino acids in the grapes of *Vitis vinifera* cultivars were arginine (295.2 mg/l) proline (176.0 mg/l), threonine (97.1 mg/l) and alanine (81.2 mg/L). According to Moreno and Peinado (2012) amino acids and amino salts are the main nitric components in the grape, although their content can vary significantly, from 300-5000 mg/L in must. According to Bell and Henschke (2005) and Spayd and Andersen-Bagge (1996) the predominant amino acids in must is proline, which can exist at concentrations up to 4000 mg/L, followed by arginine, valine and alanine. Cecchini et al.(2006) investigated the amino acid composition of musts from seven Italian cultivars and found significant differences in the total amino acids content between the cultivars and the authors suggest using this as a differentiation index between varieties from the same region. Significant differences in individual and the total amino acids between cultivars were also found by Umit Unal et al. (2015). The highest concentration was found for arginine, ranging from 910 to 955 mg/L. The research

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of amino acid profiles in clonal candidates of cv. Kraljevina (Puhelek et al., 2015) as well found the highest concentration of arginine among all clones in the range of 197.07- 438.36 mg/L. Garde-Cerdan et al. (2009) determined that arginine represents 20-50% of the total amino acid content in must, depending on the cultivar tested. The research conducted by Huang and Ough (1991) found that the prevailing amino acids in must are arginine and proline, followed by glutamine and alanine. According to Spayd and Andersen-Bagge (1996) arginine, proline, free amino acids, free amino nitrate and proline/arginine ratio were in weak correlation with the maturity level of grape expressed as the sugar content. Hernandez et al. (1999) in their studies on amino acids of the grapes, during the three years' period found that the content of arginine was always higher in comparisons to proline and other amino acids. Huang and Ough (1991) in their research found concentration of arginine of 200 mg/L in Cabernet Sauvignon up to 900 mg/L in Chardonnay, Sauvignon blanc and Pinot noir. Spayd and Andersen-Bagge (1996) indicate that the average concentration of the total amino acids in white grapevine cultivars vary in the range from 156 mg/L in Riesling (22 to 442 mg/L), 236 mg/L in Sauvignon blanc (ranging from 43 to 506 mg/L) and up to 400 mg/L in Gewürztraminer (90 to 1064 mg/L).

Lee and Schreiner (2010) state that the concentrations of amino acids in must depend on many factors, including grapevine variety, maturation stage, weather conditions, management practices, and Bouzas-Cid et al.(2018) state in their work that combination of these factors might have caused these differences with previous studies on other cultivars. Petrovic et al. (2019) investigated the amino acid profile of South African cultivars (738 musts) and found that the most abundant amino acids were proline and arginine, averaging 697.69 mg /L proline and 388.35 mg /L arginine regardless of year, region and cultivar. The aim of this research was to determine the amino acid composition of some grape varieties grown in Croatia.

Material and methods

Chemicals

Amino acids standards, iodoacetic acid, propionic acid and o-phtaldialdehyde were obtained from Sigma Aldrich (St. Louis, MO, USA). Boric acid and sodium hydroxide were purchased from Kemika (Zagreb, Hrvatska). Dimethylsulfoxide, methanol and acetonitrile were obtained from J.T. Baker (Derventer, Netherlands).

Grapes and vineyard

The research was conducted in a 12-year-old vineyard, located in West continental region, subregion Prigorje-Bilogora. Subregion Prigorje-Bilogora, with regard to its geographical position and horizontal and vertical relief, has a temperate continental climate with an average annual temperature of 10-12° C (Zdunić, 1995). The amount of precipitation is well distributed during the year, given that more than 55% falls during the growing season (Product specification, 2013). According to DHMZ (State Hydrometeorological Institute Zagreb) data, the average annual temperature for 2015, measured at the meteorological station Bilogora, for the area of Bilogora was 12.3 °C, and the amount of precipitation for the same year was 907.4 mm. The cultivation form in the investigated vineyard is single Gyot with 8-10 buds. The planting distance in the vineyard is 0.80 * 1.40 m. The soil of the experimental vineyard belongs to pseudogley, which is characteristic of humid and semi-humid climatic areas. The study included three red cultivars Pinot noir, Saint Laurent, Zweigelt and six white cultivars Chardonnay, Rheinriesling, Manzoni, Sauvignon blanc, Traminer and Moscato giallo.

Grapes were harvested at technological maturation. Ten kg of grapes of each cultivar, in

three replicates (25 vines was one repetition) were crushed and pressed using a basket press. Grape juice samples were collected immediately after pressing, shipped cold to the laboratory and analyzed for amino acids.

Chemical analysis of musts

Sugar content in must was determined by refractometer and expressed in Oechsle degrees (°Oe). The total acidity of must was expressed as g/L as tartaric acid, determined by the sample neutralization with 0.1 M NaOH with bromothymol blue as indicator (O.I.V., 2001). pH values were determined by MP220 pH meter (Mettler Toledo, Germany). Amino acids in grape juice were determined according to Pripis-Nicolau et al. (2001) with some modifications. An Agilent 1100 binary gradient HPLC, equipped with an automatic sampling system, and 1200 Agilent fluorescence detector were used. The excitation and emission wavelengths were 356 nm and 445 nm, respectively. Separation of amino acids derivates was carried out using Lichrosher (Merck) RP 18 (125 mm × 4 mm × 5 µm). Amino acid derivatization by o-phtaldialdehyde (OPA) and iodoacetic acid (IDA) was performed automatically by the high-performance liquid chromatography autosampler right before injection. Total free amino acids (without proline) concentration was calculated as the sum of all free amino acids measured (proline wasn't measured since it is not used by yeasts during fermentation).

Statistical analysis

Statistical analysis was done with software tool Statistica 8.0 (StatSoft, Tulsa, Oklahoma, USA), at significance level $p = 0.05$. After testing normality of the data distribution (Kolmogorov-Smirnov test) discriminant analysis was applied to the data, and they are shown as mean and standard deviation or median and interquartile range. For the comparison of multiple variables based on a categorical data Kruskal-Wallis test was used, and Spearman's test of correlations was used to calculate correlations between numerical data.

Results and discussion

Table 1 shows concentrations of sugar, total acididity (TA), real acidity (pH), free and total amino acids in red grapevine cultivars musts. Concentrations of sugar, total acidity and pH were expected, considering the climate conditions and cultivars involved. Composition of analyzed musts did not differ significantly regarding the sugar, TA or pH values. Concentrations of the individual amino acids (cysteine, serine, threonine, phenylalanine and isoleucine) in red grapevine musts were significantly different. The most abundant free amino acids in all red musts were arginine and threonine. Amounts of arginine ranged from 233.54 to 280.65 mg/L and threonine from 98 to 240 mg/L. The highest concentration of arginine was measured in Saint Laurent (280.65 mg/L). In Pinot noir, threonine was amino acid measured in the highest amount, followed by arginine, glycine and cysteine. In Saint Laurent and Zweigelt must arginine was amino acid with the highest concentration (280.65 mg/L and 211.04 mg/L). This results are in agreement with the results Shiraishi (1991). The total amino acids concentration ranged from 782.62 in Zweigelt to 1173.12 in Pinot noir and differed significantly.

Table 1. Analysis of sugar, acid, acidity (given as pH) and total and separate amino acids of three tested varieties of red grapevine cultivars

Tablica 1. Analiza šećera, kiselina, kiselosti (pH) i ukupnih i pojedinačnih aminokiselina triju istraživanih crnih sorti vinove loze

Variable	PINOT NOIR		SAINT LAURENT		ZWEIGELT		p
	mean[P]	SD[P]	mean	SD[P]	mean[P]	SD[P]	
Sugar	83	8	77	6	77	77-80	0.272
Acid	6.9	1.9	7.5	1.6	6.6	1.2	0.296
pH	3.7	0.5	3.6	0.3	3.6	0.2	0.935
ASP	27.82	26.53-44.26	31.26	6.76	12.33	7.95-36.21	0.066
GLU	84.74	14.22	58.79	57.64-91.12	89.69	61.41	0.156
CYS	113.35	28.11	97.88	20.20	77.81	17.29	*0.018**
SER	109.20	29.17	52.04	11.28	55.78	13.43	*<0.001**
HIS	2.73	0.00-233.36	2.67	0.00-44.97	0.00	0.00-5.26	0.324
GLY	197.82	161.58	221.56	60.87	155.70	97.91-167.07	0.156
THR	233.54	103.20	240.06	68.23	98.92	27.09	*<0.001**
ARG	231.41	36.74	280.65	188.62-300.01	211.04	201.57-355.31	0.368
ALA	7.51	7.60	2.66	1.72-17.22	5.04	3.19	0.997
TYR	2.97	2.88	5.33	2.52	3.32	1.42	0.071
MET	37.09	21.32	29.80	13.25	19.46	6.54	0.102
PHE	25.29	18.13	15.56	9.48	9.14	4.43	*0.028**
ILE	12.08	6.88-36.72	12.00	8.29	6.57	4.38	*0.046**
Total aminoacids	1173.12	338.74	1054.52	239.18	782.62	212.18	*0.005**

ASP=aspartate, GLU=glutamate, CYS=cysteine, SER=serine, HIS=histidine, GLY=glycine, THR=threonine, ARG=arginine, ALA=alanine, TYR=tyrosine, MET=methionine, PHE=phenylalanine, ILE=isoleucine

Results are given as mean ±SD or median 25th-75th percentile depending on the distribution normality

*marks statistical significance at $p<0.05$, Kruskal-Walis test between three varieties of red wine grape

Table 3 shows concentrations of sugar, total acidity, free and total amino acids and pH values in white grapevine musts. Concentrations of sugar, total acidity and pH were expected considering the cultivars and the growing conditions. The exception is the low concentration of sugar in Rheinriesling which associate with the data of the manufacturer stating that he had to consciously go picking in conditions of low sugar concentration because of the appearance of gray mold. This may be associated with a higher amount of precipitation at the time of grape ripening. According to DHMZ (State Hydrometeorological Institute Zagreb) data, the average amount of precipitation measured for the Bilogora station was 907.4 mm, and only in the 9th and 10th month it was measured 287.7 mm (Table 2).

Table 2. Mean air temperature (°C) and total monthly rainfall (mm), Bilogora, 2015 year

Tablica 2. Srednja temperature zraka (°C) i ukupna količina oborina (mm), Bilogora, 2015.godina

Month	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	God.
Temperature	2,9	1,9	7,2	12	16,5	20,2	24,2	23,4	16,9	10,3	8,8	3,5	12,3
Mean vegetation temperature						17,6							
Rainfall	102,3	74	25,2	49	173,3	51,8	50,4	44,2	118,4	169,3	44,8	4,7	907,4
Total vegetation rainfall						**656,4**							

Statistically significant difference was found in the sugar and the TA concentration among all white cultivars. Statistically significant difference was noticed among all individual amino acids except aspartate and histidine. Chardonnay must had the highest concentration of arginine (470 mg/L) which was also the most abundant amino acid in white grapevine musts. (Shiraishi, 1991; Bouzas-Cid, et al.,2018, Petrovic, et al. 2019). Arginine concentration significantly differed between studied white cultivars. In other white cultivars, these concentrations were not as high and ranged between 56 mg/L in Manzoni to 198 mg/L in Sauvignon. According to the obtained results for individual amino acids in the white cultivars, it was not possible to specify the most abundant amino acid common for all cultivars. For Chardonnay and Sauvignon, it was arginine, for Rheinriesling threonine, for Manzoni, Traminer and Moscato it was glycine. Significant number of amino acids were detected in concentrations below 25 mg/L, like histidine, alanine, tyrosine, phenylalanine, isoleucine and leucine in Chardonnay, Sauvignon and Traminer, asparagine, histidine, tyrosine, methionine, phenylalanine and isoleucine, in Rheinriesling, histidine and leucine in Manzoni and alanine, histidine, tyrosine, methionine, phenylalanine and isoleucine in Moscato. Concentrations of amino acids in this research differed significantly between cultivars, which are in accordance to previous findings by Bonzas-Cid et al. (2015). These authors reported the amount of arginine in white cultivars to contribute to the total amino acid concentration with 25%, which was confirmed in our research. Our results showed that the concentration of histidine was below 10 mg/L while Unala et al. (2015) listed histidine as the second amino acid according to its abundance, ranging from 156.73 to 268.43 mg/L. Also, the concentration of glycine was found to be substantial in our cultivars (79.44 – 244.61 mg/L), and already mentioned study of Turkish white grapevine cultivars found low concentration of glycine (6.64 – 15.5 mg/L). Glycine was the most abundant amino acid in Traminer, followed by threonine and arginine. These findings are opposite from the ones reported by Premužić i Dominez (1976). According to their research, the most abundant amino acid in Traminer was arginine. The highest concentration of the total amino acids was in Manzoni must (1639.51 mg/L) and the lowest of in Rheinriesling must (470.73 mg/L). Statistically significant difference was found between the total amino acid concentrations. Table 1 and Table 3 show, in some cases, the range for SD which is consequence of the non-representativeness of the sample (grapes).

There was no statistically significant correlation found between white and red cultivars in terms of the total amino acid concentration (Table 4). For analyzed varieties of red grapes total acid content had significant negative correlation on total amino acids content. Also, the total content of acids had strong negative correlation on all individual amino acids (except glutamate, serine, threonine) and positive effect on aspartate and histidine. For white grapevine cultivars statistically significant correlation was found between the content of sugar and pH (r=0.709), and amino acids serine, glycine, threonine, arginine, alanine, tyrosine, methionine and isoleucine (Table 5). On the other hand, the total acid content in white musts significantly correlates only with the content of glutamate (r=0.426) and histidine (r=0.429).

Table 3. Analysis of sugar, acid, acidity (given as pH) and the total and separate amino acids of six tested white grapevine cultivars
Tablica 3. Analiza šećera, kiselina, kiselosti (pH) i ukupnih i pojedinačnih aminokiselina šest istraživanih bijelih sorti vinove loze

Variable	CHARDONAY		RHEINRIESLING		MANZONI		SAUVIGNON BLANC		TRAMINER		MOSCATO GIALLO		p
	mean[p]	SD[p]	mean	SD[p]	mean[p]	SD[p]	mean[p]	SD[p]	mean[p]	SD[p]	mean[p]	SD[p]	
Sugar	82	9	67	6	85	12	81	10	81	13	81	8	*0.022**
Acid	8.4	1.0	8.1	0.8	9.9	1.7	9.6	0.9	8.6	2.0	5.0	0.7	*<0.001**
Ph	3.6	0.2	3.5	0.3	3.5	0.3	3.4	0.3	3.4	0.2	3.6	0.1	0.279
ASP	45.14	20.58	22.82	8.26	65.69	6.79-76.77	43.58	14.73-43.88	32.39	17.33	18.70	9.06	0.059
GLU	108.82	57.65-116.00	33.94	9.16	117.87	31.31-129.18	78.79	9.48	58.48	54.86-111.05	52.60	52.08-62.33	*<0.001**
CYS	259.08	13.07	55.17	11.23	319.82	45.87-347.15	79.11	72.92-141.33	100.67	31.63	69.27	10.55	*<0.001**
SER	291.51	39.03	61.47	29.85	76.31	11.88-557.27	67.96	59.71-154.00	99.77	79.76-266.37	44.45	43.02-71.35	*<0.001**
HIS	7.20	0.00-7.25	4.34	4.21	5.56	0.00-365.97	1.65	0.00-28.49	6.28	4.77	1.39	0.00-9.16	0.893
GLY	244.61	20.50	79.44	25.55	323.71	272.45	185.81	53.86	218.62	55.54	131.74	23.44	*<0.001**
THR	98.34	95.55-150.56	104.80	50.77	267.22	203.78	146.97	70.99	201.79	131.77-204.78	83.85	83.12-125.78	*0.030**
ARG	470.18	12.25	75.30	21.90	56.32	0.89-414.88	198.54	63.21	162.40	47.24	85.95	83.11-106.04	*<0.001**
ALA	3.95	3.20-13.35	0.00	0.00-3.34	77.45	11.42	3.36	3.90	0.070	0.00-2.98	0.00	0.00-2.31	*0.003**
TYR	7.19	1.73	0.54	0.00-3.07	0.00	0.00-16.64	0.51	0.00-3.20	2.78	1.97	2.50	2.50	*0.003**
MET	33.46	32.81-52.12	8.78	7.42-24.38	66.27	47.62	25.16	13.10	26.93	6.55	13.89	4.49	*<0.001**
PHE	18.50	17.87-26.90	5.67	5.15-20.30	55.00	40.63	9.47	7.70-27.53	19.81	7.39	7.86	3.18	*<0.001**
ILE	11.09	4.03	3.47	1.95-15.23	31.65	25.40	7.76	6.07	10.28	3.00	2.17	1.91-5.23	*<0.001**
LEU	1.10	0.53	0.00	0.00	1.75	1.33	0.03	0.03	0.05	0.00-2.38	0.00	0.00-0.10	*0.003**
Total aminoacids	1611.38	70.59	470.73	158.64	1639.51	1138.83	745.06	646.26-1304.99	984.89	306.77	549.56	73.63	*<0.001**

ASP=aspartate, GLU=glutamate, CYS=cysteine, SER=serine, HIS=histidine, GLY=glycine, THR=threonine, ARG=arginine, ALA=alanine, TYR=tyrosine, MET=methionine, PHE=phenylalanine, ILE=isoleucine

Results are given as mean ±SD or median 25th-75th percentile depending on the distribution normality

*marks statistical significance at $p<0.05$, Kruskal-Walis test between six varieties of white wine grapes

Table 4. Spearman's rank order correlations between all observed variables for three tested red grapevine cultivars (Note: only significant correlations are shown)

Tablica 4. Spearmanove usporedne korelacije između svih promatranih varijabli za tri ispitivane crne sorte (Napomena: prikazane su samo značajne korelacije)

Variables	Sugar	Acid	pH	ASP	GLU	CYS	SER	HIS	GLY	THR	ARG	ALA	TYR	MET	PHE	ILE	Total aminoacids
Sugar	1,000																
Acid	-0,794	1,000															
PH	0,853	-0,823	1,000														
ASP	-0,691	0,665	-0,792	1,000													
GLU			-0,410	0,545	1,000												
CYS	0,568	-0,519	0,512	-0,015		1,000											
SER					0,697	0,544	1,000										
HIS	-0,487	0,519	-0,551	0,610	0,792	0,098	0,328	1,000									
GLY	0,378	-0,537	0,354			0,728		-0,307	1,000								
THR	0,436		0,467			0,837			0,627	1,000							
ARG	0,363	-0,590	0,414		0,314	0,663			0,427	0,312	1,000						
ALA	0,818	-0,844	0,845	-0,572		0,662		-0,345	0,446	0,513	0,680	1,000					
TYR	0,472	-0,703	0,620	-0,302		0,692			0,714	0,577	0,781	0,771	1,000				
MET	0,790	-0,684	0,750	-0,342		0,860	0,397		0,532	0,762	0,545	0,861	0,637	1,000			
PHE	0,791	-0,626	0,717	-0,310		0,847	0,416		0,543	0,793	0,415	0,785	0,547	0,975	1,000		
ILE	0,780	-0,616	0,709	-0,353	-0,314	0,718			0,551	0,760		0,743	0,516	0,905	0,940	1,000	
Total aminoacids	0,469	-0,404	0,424			0,977	0,532		0,715	0,872	0,629	0,595	0,675	0,798	0,777	0,657	1,000

Spearman Rank Order Correlation at $p<0.05$

ASP=aspartate, GLU=glutamate, CYS=cysteine, SER=serine, HIS=histidine, GLY=glycine, THR=threonine, ARG=arginine, ALA=alanine, TYR=tyrosine, MET=methionine, PHE=phenylalanine, ILE=isoleucine

Table 5. Spearman's rank order correlations between all observed variables for six tested white grapevine cultivars (Note: only significant correlations are shown)

Tablica 5. Spearmanove usporedne korelacije između svih promatranih varijabli za šest ispitivanih bijelih sorata (Napomena: prikazane su samo značajne korelacije)

Variables	Sugar	Acid	pH	ASP	GLU	CYS	SER	HIS	GLY	THR	ARG	ALA	TYR	MET	PHE	ILE	LEU	Total aminoacids
Sugar	1,000																	
Acid	-0,385	1,000																
pH	0,709	-0,525	1,000															
ASP				1,000														
GLU		0,426		0,722	1,000													
CYS				0,717	0,834	1,000												
SER	0,410		0,458			0,499	1,000											
HIS		0,429						1,000										
GLY	0,452			0,619	0,743	0,887	0,717		1,000									
THR	0,484		0,416	0,481	0,459	0,691	0,443		0,742	1,000								
ARG	0,447		0,379		0,487	0,627	0,821		0,813	0,404	1,000							
ALA	0,592		0,531	0,469	0,417	0,782	0,491		0,688	0,757	0,531	1,000						
TYR	0,510		0,646			0,598	0,710		0,722	0,524	0,797	0,622	1,000					
MET	0,476		0,360	0,614	0,652	0,913	0,618		0,892	0,816	0,616	0,871	0,629	1,000				
PHE	0,396			0,624	0,530	0,790	0,601		0,815	0,880	0,469	0,784	0,555	0,935	1,000			
ILE	0,452		0,431	0,542	0,432	0,748	0,605		0,748	0,874	0,456	0,848	0,562	0,924	0,964	1,000		
LEU				0,815	0,838	0,840	0,542		0,775	0,481	0,490	0,478	0,402	0,733	0,684	0,596	1,000	
Total aminoacids				0,657	0,750	0,926	0,714		0,923	0,724	0,775	0,814	0,704	0,928	0,826	0,819	0,789	1,000

Spearman Rank Order Correlation at $p<0.05$

ASP=aspartate, GLU=glutamate, CYS=cysteine, SER=serine, HIS=histidine, GLY=glycine, THR=threonine, ARG=arginine, ALA=alanine, TYR=tyrosine, MET=methionine, PHE=phenylalanine, ILE=isoleucine

Conclusion

The results obtained show the difference in amino acid profile in white and red grapevine musts from Croatia, growing hill Bilogora. Red musts differed significantly in concentration of individual amino acids (cysteine, serine, threonine, phenylalanine, and isoleucine). White musts showed statistically significant difference in concentration of all analyzed amino acids except histamine and asparagine. In the majority of musts from studied grapevine cultivars, arginine was the most abundant amino acid. Statistically significant difference was found in the composition of total amino acids in both, white and red grapevine musts.

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Aminokiselinski sastav mošta nekih sorata vinove loze (Vitis vinifera L.) Hrvatske

Sažetak

Slobodne aminokiseline u moštu su važan izvor dušika za kvasce tijekom alkoholne fermentacije. Cilj ovog istraživanja bio je odrediti aminokiselinski profil mošteva devet sorata vinove loze (šest bijelih i tri crne). Sorte vinove loze zasađene su u ujednačenim uvjetima tla i klime vinogorja Bilogora (Regija Kontinentalne Hrvatske, podregija Prigorje-bilogora) te su imale iste agrotehničke uvjete uzgoja. Pokus je postavljen 2015. godine. Rezultati su pokazali signifikantan utjecaj sorte na aminokiselinski sastav u moštevima bijelih i crnih sorti. Najzastupljenija aminokiselina u moštevima devet sorata vinove loze bila je arginin. Najveća koncentracija arginina kod bijelih sorata bila je u moštu Chardonnay (470,18 mg/l), a kod crnih sorata u moštu Lovrijenca (280,65 mg/l). Statistički značajne razlike nađene su između koncentracije ukupnih aminokiselina bijelih i crnih sorata. Najveća koncentracija ukupnih aminokiselina kod bijelih sorata bila je u moštu sorte Manzoni (1639,51 mg/l), a kod crnih sorata u moštu sorte Pinot crni (1173,12 mg/l)

Ključne riječi: *slobodne aminokiseline, arginin, ukupne aminokiseline, mošt*