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ORGANIC ACIDS CONCENTRATION IN WINE STOCKS AFTER *Saccharomyces cerevisiae* FERMENTATION

V. N. Bayraktar Odesa Mechnikov National University, Ukraine

E-mail: vogadro2007@rambler.ru

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The biochemical constituents in wine stocks that influence the flavor and quality of wine are investigated in the paper. The tested parameters consist of volume fraction of ethanol, residual sugar, phenolic compounds, tartaric, malic, citric, lactic, acetic acids, titratable acidity and volatile acids. The wine stocks that were received from white and red grape varieties Tairov`s selection were tested. There was a correlation between titratable acidity and volatile acids in the wine stocks from white and red grape varieties. High correlation was also found between lactic and acetic acids, between volatile acids, acetic acid and sugar. It was determined that wine stocks with a high concentration of ethanol originated from those yeast strains of *Saccharomyces cerevisiae*, in a fermented grape must of high speed of enzyme activity. The taste of wine stocks correlated with the ratio of tartaric to malic acid. Analysis showed significant differences between the varieties of white and red wine stocks in concentrations of organic acids, phenolic compounds, residual sugar, and volume fraction of ethanol. Positive correlation was indicated for both studied groups for volatile acids and acetic acid, tartaric, malic, lactic acids and total sugar. Prospective yeast cultures with high productivity of alcohol (ethanol) were selected for winemaking biotechnology.

Key words: organic acids, grape varieties, *Saccharomyces cerevisiae*.

Organic acids play an important role in wine biotechnology because of the taste imparted by the concentration, of the different organic acids. Organic acids in wine include tartaric, malic, citric, lactic, acetic, succinic and others. Concentration of organic acids varies depending on different factors such as temperature, pH, concentration of oxygen and carbon dioxide.

Wine taste depends mainly on the ratio of tartaric acid to malic one. If the ratio of these acids is about 2 or less, the wine will not be harmonious and will have a sour aftertaste. On the contrary, wine stock with the best flavor and bouquet will be obtained at a ratio of tartaric to malic acid equal coefficient 3 and more.

Some organic acids have their own specific taste and aroma. For example citric acid gives freshness to wine, succinic acid has salty-bitter taste, and malic acid gives the taste of green apples. However, malic acid may exhibit different flavours depending on the concentrations of ethanol, tannic acids, sugar, aromatic and mineral substances. Making quantitative changes in the ratio of these compounds makes it possible to achieve the tastes of different harmonious acidity [1, 2].

Buffering also plays an important role in formation of taste that results mostly from potassium ions in malic acid and, to a lesser extent, from small ions of Ca^{2+}, Mg^{2+}, and Na^{+}. In sparkling wines, acidic harmony is controlled by concentrations of sugar and carbon dioxide, but in dry wines it is controlled by concentrations of organic acids [3, 4].

Interaction of organic acids and alcohol, with their degradation products (example of tartaric acid degradation) play an important role in forming of organoleptic properties of wine stocks, which is very important in wine biotechnology.

Organic acids commence to be accumulated in the grapes at the moment when grapes begin to accumulate and concentrate sugar. At the moment of reduced accumulation of organic acids, titratable acidity decreases sharply [5, 6].

During fermentation of grape must with high titratable acidity, decreasing acidity indicates the completion of fermentation. The amount of tartaric and malic acids decrease, however the amount of citric and succinic acids increase, which is natural. Lactic acid is formed, which is impossible to find in the ripe grapes. Wine stocks at a high pH have a sour taste. Therefore, strict adherence to deadlines in harvesting grapes will be a key to successful formation of optimal concentration of organic acids for preparation of high-quality wines with excellent taste and aroma.

Organic acids in wine are of technological importance and have different dissociation constants. Most of strong organic acids in grapes and wine is tartaric acid — (K_{dis}=1.3× 10^{-3}), next is citric acid (K_{dis}=8.4×10^{-4}), malic acid (K_{dis}=3.95×10^{-4}) , lactic acid (K_{dis}=1.4 ×10^{-4}), succinic acid (K_{dis}=7.4×10^{-5}), acetic acid (K_{dis}=1.8×10^{-5}) [7, 8]. Organic acids in wine play an important role in the taste and quality of wines. Because a low content of organic acids resulting in insufficient acidity, wine loses its fullness and roundness of taste and becomes characterless and expressionless [9–11].

Each type of wine must correspond to its optimum acidity. Tingling acidity typical of sparkling wines, up to incompletely fermented or freshly fermented grapes must contain carbon dioxide, which is produced during fermentation. Organic acids preserve the wine from bacterial diseases. Under acidic conditions the redox processes proceed slower, slowing down the maturation of wine, and prevents iron or iron-phosphate turbidity as well. Organic acids influence the bouquet of wine, and form complex esters with alcohols. A special role in the maturation of wines belongs to tartaric acid, which is converted to dioxy-fumaric acid and restores the taste of wine [12, 13].

The aim of this work is to establish correlations between quantitative contents of organic acids and the quality of the resulting wine fermented on yeast culture isolated from different industrial varieties in the Tairov`s selection. To achieve this goal, the following tasks were undertaken.

To determine the concentrations of the organic acids in wines made from different industrial varieties of Tairov`s selection it was needed to determine among them tartaric, citric, malic, lactic and acetic acids. Based on these determinations it would be easier to determine the quality of investigated wines using the ratio between tartaric and malic acids.

Materials and methods

Samples of wine from different industrial grape varieties were collected after completing fermentation with different yeast cultures of *Saccharmyces cerevisiae* during the vintage season from the vineyard of the Ukrainian Tairov`s Research Institute of Viticulture and Oenology, located in the Odessa region of Ukraine. The total number of the species selected for the research was thirteen. The following industrial grape varieties were selected for the research:

– **white wine grape varieties:** Aromatic, Odessa`s Muscat, Opalovy (Opaline), Ovidiopolskij, Selena, Sukholimansky, Zagrey.

– **red wine grape varieties:** Charivny (Magic), Illychevsky Early, Odessa`s Black, Odessa`s Pearl, Ruby Jubilee, Tairov`s Ruby.

Yeast strains:

I. Laboratory yeast cultures isolated from grape must from the vineyard of the Ukrainian Tairov`s Research Institute of Viticulture and Oenology.

Yeast culture isolated from white wine grape varieties:

*Y-3444; *MAFF-230106. *Saccharomyces cerevisiae* isolated from grape must of the variety Aromatic;

Y-3445; MAFF-230107. *Saccharomyces cerevisiae* isolated from grape must of the variety Odessa`s Muskat;

Y-3441; MAFF-230103. *Saccharomyces cerevisiae* isolated from grape must of the variety Opalovy (Opaline);

Y-3442; MAFF-230104. *Saccharomyces cerevisiae* isolated from grape must of the variety Ovidiopolskij;

Y-3439; MAFF-230101. *Saccharomyces cerevisiae* isolated from grape must of the variety Selena;

Y-3440; MAFF-230102. *Saccharomyces cerevisiae* isolated from grape must of the variety Sukholimansky;

Y-3443; MAFF-230105. *Saccharomyces cerevisiae* isolated from grape must of the variety Zagrey.

The designated yeast culture numbers were derived from those deposited in the MAFF Collection, National Institute of Agrobiological Sciences, Genbank of Japan.

* MAFF — Culture Collection of microorganisms Ministry of Agriculture, Forestry and Fisheries, Tsukuba, Ibaraki, Japan.

Yeast culture isolated from red wine grape varieties:

Y-3438; MAFF-230100. *Saccharomyces cerevisiae* isolated from grape must of the variety Charivny (Magic);

Y-3448; MAFF-230110. *Saccharomyces cerevisiae* isolated from grape must of the variety Illychevsky Early;

Y-3447; MAFF-230109. *Saccharomyces cerevisiae* isolated from grape must of the variety Odessa`s Black;

Y-3446; MAFF-230108. *Saccharomyces cerevisiae* isolated from grape must of the variety Odessa`s Pearl;

Y-3437; MAFF-230099. *Saccharomyces cerevisiae* isolated from grape must of the variety Ruby Jubilee;

Y-3436; MAFF-230098. *Saccharomyces cerevisiae* isolated from grape must of the variety Tairov`s Ruby.

Pure yeast cultures were isolated from grapes and followed by fermentation by using traditional microbiological methods consisting of inoculation of a sample into a Petri dish with a few modifications of nutrient selective agar for yeast isolation and cultivation. Primary yeast isolation was carried out using Inhibitory Mold Agar medium (IMA) (Becton Dickinson Company, USA). Morphological properties of the yeast culture were analyzed after the primary yeast culture isolation. Yeasts were identified by polymerase chain reaction (PCR) using universal yeast primers. Then yeast cultures were cultivated on a Wort Agar medium (Becton Dickinson Company, USA). Each isolated, yeast culture was deposited in the NRRL Culture Collection (National Regional Research Laboratory), Peoria, USA, in the British National Collection of Yeast Culture (NCYC), Norwich, UK and Genbank of Japan.

All biochemical parameters were tested in the wine stocks followed by fermentation of the white and red grape varieties Tairov`s selection.

The volume fraction of ethanol, total sugar (glucose/fructose), and pH were determined by the spectroscopy method using the Bacchus-II spectrometer (Microdom Company, France).

Concentrations of organic acids: tartaric, malic, citric, lactic, acetic and phenolic compounds were determined using a method of liquid chromatography (Ultimate 3000, Dionex Company, Germany).

Statistical deviation and significance were evaluated by the Student`s t-test with $P$ — value: $P < 0.1$; $P < 0.05$; $P < 0.01$. We calculated Spearman's rank correlation coefficient for the tested biochemical parameters between tested wine stocks from different white and red grape varieties of the Tairov`s selection. Each biochemical test was repeated three times to confirm the exact result. For the groups of white and red wine grape varieties, fermentation made with different *Saccharomyces cerevisiae* yeast cultures dispersion analysis (ANOVA) was done as well. The dispersion analysis (ANOVA) based on the Fisher`s test (unifactorial model) was applied, where F- criterion determined whether the relevant samples belong to one from general aggregate and then possible to pool them or not. Standard deviation was calculated, statistical significance of the difference was evaluated by the Student's t-test.

Results and discussion

The results of the organic acid study in wine stocks received from the white and red grape varieties had specific differences in concentrations of organic acids. Results of organic acids concentrations are given in table 1 for white grape varieties and in table 2 for red grape varieties. The normal ranges of tested parameters in wine stocks are given in Table 3.

The study showed that concentration of ethanol and residual sugar in wine stocks depends on enzymatic activity of *Saccharomyces cerevisiae* yeast strains which are used for winemaking. For example, the index of ethanol produced by yeast cultures in wine stocks received from white grape varieties has concentrations of ethanol compared with minimal amounts in: Odessa`s Muscat MAFF-230107 more than 125%, Opalovy (Opaline) MAFF-230103 more than 122%, Selena MAFF-230101 more than 112%.

Study of the morphology of *Saccharomyces cerevisiae* yeast followed by fermentation illustrate that between wine stocks of white and red grape varieties there exist some differences in level of ethanol production. It`s more for yeast cultures isolated from white grape varieties and less (moderate) for yeast cultures isolated from red grape varieties. All the yeast cells were stained by Gram method. Some cells of yeast are large and either rounded or oval shaped (Fig. 1–6).

In wines received from red grape varieties, the index of ethanol produced in wine stocks showed maximal concentration of ethanol, compared with minimal amounts in such

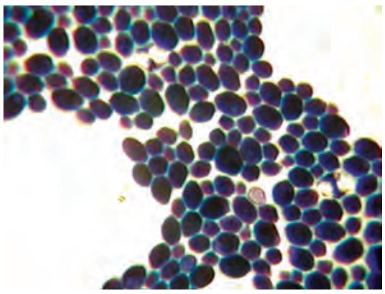

Fig. 1. **Morphology of *Saccharomyces cerevisiae* yeast culture isolated from white grape variety «Odessa`s Muscat» MAFF-230107:**
the volume fraction of alcohol (ethanol) production — 15.55 v/v%; stained by Gram method; magnification — ×720

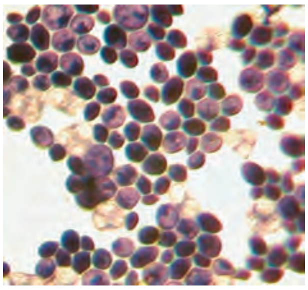

Fig. 2. **Morphology of *Saccharomyces cerevisiae* yeast culture isolated from white grape variety «Opalovy (Opaline)» MAFF-230103:**
the volume fraction of alcohol (ethanol) production — 14.94 v/v% ; stained by Gram method; magnification — ×720

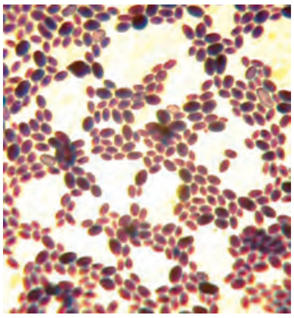

Fig. 3. **Morphology of *Saccharomyces cerevisiae* yeast culture isolated from white grape variety «Selena» MAFF-230101:**
the volume fraction of alcohol (ethanol) production — 14.15 v/v% ; stained by Gram method; magnification — ×720

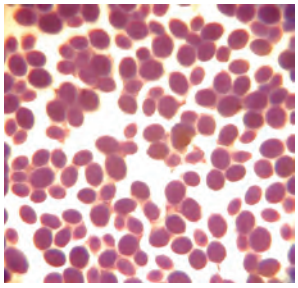

Fig. 4. **Morphology of *Saccharomyces cerevisiae* yeast culture isolated from red grape variety «Charivniy (Magic)» MAFF-230100:**
the volume fraction of alcohol (ethanol) production — 12.27 v/v% ; stained by Gram method; magnification — ×720

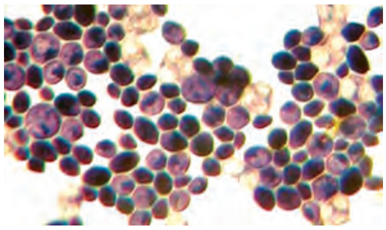

Fig. 5. **Morphology of *Saccharomyces cerevisiae* yeast culture isolated from red grape variety «Odessa`s Black» MAFF-230109:**
the volume fraction of alcohol (ethanol) production — 11.22 v/v% ; stained by Gram method; magnification — ×720

Table 1. **Organic acid content (g/L) after fermentation and formation of wine stocks from grape varieties of Tairov`s selection (white wine grape varieties)**

Wine stocks from white grape varieties	MAFF Collection number in Genbank of Japan	Titratable acidity in terms of tartaric acid (g/L)	volatile acids in terms to acetic acid (g/L)	Tartaric acid (g/L)	Malic acid (g/L)	The ratio of tartaric acid to malic acid	Citric acid(g/L)	Lactic acid (g/L)	Acetic acid (g/L)	Common sugar glucose/fructose (g/L)	The volume fraction of the ethanol (% v/v)	Concentration of total phenolic compounds, (mg/L)
Aromatic	230106	5.67± 0.35	**0.53 ±0.02	2.9± 0.24	**0.98 ±0.02	*2.95± 0.1	**0.09 ±0.02	**1.21 ±0.03	0.39± 0.08	**1.14 ±0.04	13.79± 1.08	270.0± 30.41
Odessa`s Muscat	230107	*4.80± 0.1	*1.15± 0.1	**1.41 ±0.02	**1.29 ±0.04	*1.09± 0.1	**0.10 ±0.01	*0.85± 0.1	1.20± 0.2	1.07± 0.08	15.55± 0.8	279.0± 22.4
Opalovy (Opaline)	230103	5.19± 0.1	0.69± 0.05	**1.11 ±0.03	1.70± 0.2	0.65± 0.07	**0.23 ±0.02	**0.67 ±0.03	**0.25 ±0.03	*1.61± 0.1	14.94± 1.6	248.8± 16.43
Ovidiopolskij	230104	6.67± 0.2	0.43± 0.09	5.04± 0.3	1.94± 0.06	*2.59± 0.1	**0.09 ±0.02	1.45± 0.06	**0.23 ±0.02	2.3± 0.2	*7.02± 0.1	147.0± 13.2
Selena	230101	*6.21± 0.1	*0.85± 0.1	3.27± 0.2	1.55± 0.2	2.10± 0.2	***0.08±0.01	**0.69 ±0.04	**0.42 ±0.02	*1.53± 0.1	*14.15 ±0.1	841.8± 11.0
Sukholimansky	230102	5.8± 0.5	*0.68± 0.1	*3.01± 0.1	*1.84± 0.1	*1.63± 0.1	***0.07 ±0.01	**0.76 ±0.02	***0.12±0.01	1.83± 0.07	13.4± 0.4	384.6± 11.0
Zagrey	230105	6.47± 0.2	**0.90 ±0.05	*4.2± 0.1	*2.24± 0.1	1.87± 0.09	***0.06 ±0.007	**0.41 ±0.04	**0.54 ±003	**1.05 ±0.05	9.92± 0.4	282.1± 13.0

Note: P–value * $P \le 0.1$; ** $P \le 0.05$; *** $P \le 0.01$.

Table 2. **Organic acid content (g/L) after fermentation and formation of wine stocks from grape varieties of Tairov`s selection. (red wine grape varieties)**

Wine stocks from white grape varieties	MAFF Collection number in Genbank of Japan	Titratable acidity in terms of tartaric acid (g/L)	volatile acids in terms to acetic acid (g/L)	Tartaric acid (g/L)	Malic acid (g/L)	The ratio of tartaric acid to malic acid	Citric acid (g/L)	Lactic acid (g/L)	Acetic acid (g/L)	Common sugar glucose/fructose (g/L)	The volume fraction of the ethanol (% v/v)	Concentration of total phenolic compounds, (mg/L)
Charivny (Magic)	230100	6.0±0.2	*0.69±0.1	2.74±0.2	*1.45±0.1	*1.88±0.1	0.09±0.03	0.72±0.06	0.24±0.02	*1.55±0.1	12.27±0.5	675.9±13.8
Illychevsky Early	230110	*10.71±0.1	*1.49±0.1	2.27±0.2	0	–	0.09±0.04	6.71±0.2	3.60±0.2	5.38±0.2	*10.54±0.1	1004.2±19.5
Odessa`s Black	230109	7.28±0.2	***0.18±0.01	5.81±0.2	**1.36±0.05	4.27±0.04	0.19±0.04	**0.49±0.05	***0.02±0.005	*1.62±0.1	11.22±0.3	543.6±11.0
Odessa Pearl	230108	11.89±0.2	1.6±0.2	2.76±0.2	0	–	***0.17±0.01	*7.51±0.1	3.1±0.3	8.25±0.2	8.11±0.3	1123.4±43.7
Ruby Jubilee	230099	7.49±0.2	0.44±0.04	4.21±0.2	*1.09±0.1	3.86±0.02	0.07±0.02	0.45±0.04	**0.23 ± 0.05	4.15±0.3	7.2±0.3	654.3±18.7
Tairov`s Ruby	230098	*6.05±0.1	**0.76±0.05	2.84±0.2	*1.75±0.1	*1.62±0.1	0.11±0.02	0.59±0.04	0.45±0.03	6.23±0.2	12.27±0.5	645.4±15.3

Note: P–value * $P \le 0.1$; ** $P \le 0.05$; *** $P \le 0.01$.

Table 3. **Normal range of organic acid content (g/L) after grape must fermentation and formation of wine stocks from grapes**

Group of wine stock	Titratable acidity in terms of tartaric acid (g/L)	volatile acids in terms to acetic acid (g/L)	Tartaric acid (g/L)	Malic acid (g/L)	The ratio of tartaric acid to malic acid	Citric acid (g/L)	Lactic acid (g/L)	Acetic acid (g/L)	Common sugar glucose/fructose (g/L)	The volume fraction of the ethanol (% v/v)	Concentration of total phenolic compounds, (mg/L)	pH
For white dry wines	not less than 3.5	1.20	1.5–5	From traces up to 5	3 and more	no more than 0.8	from traces up to 0.5–5	0.4–1.5	less than 4.0	8.5–15	1200–1500	2.8–3.8
For red dry wines	5.0-7.0	1.50	1.5-5	0-5	3 and more	no more than 1.0	1–5	0.4–1.5	less than 4.0	10–15	1800–3700	3.0–4.6

Note: There are no strict standards of content for the concentration of organic acids in dry grape wines. However research Laboratories established their own standards based on grape growing regions.

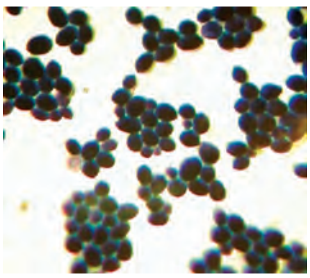

Fig. 6. **Morphology of *Saccharomyces cerevisiae* yeast culture isolated from red grape variety «Tairov`s Ruby» MAFF-230098:**
the volume fraction of alcohol (ethanol) production — 12.27 v/v% : stained by Gram method; magnification — ×720

Table 4. **Dispersion analysis (ANOVA) represents parameters of organic acid concentration and other components in the wine stocks made from white and red grape varieties of the Tairov`s selection**

Tested parameters	White dry wine stocks			Red dry wine stocks		
	F	P	r	F	P	r
Titratable acidity/ volatile acids	349.09	<0.0001	-0.47	50.47	<0.0001	0.82
Titratable acidity/tartaric acid	23.27	0.0004	0.95	17.44	0.001	-0.32
Volatile acids/ acetic acid	3.3	0.09	0.82	0.35	0.56	0.94
Tartaric acid/ acetic acid	21.6	0.0005	-0.38	6.38	0.03	-0.60
Tartaric acid/ malic acid	5.9	0.031	0.51	15.88	0.002	0.39
Tartaric acid/ citric acid	29.69	0.0001	-0.65	37.1	0.0001	0.48
Tartaric acid/ phenolic compounds	16.33	0.0016	-0.02	66.38	< 0.0001	-0.64
Tartaric acid/ sugar	7.11	0.02	0.41	2.22	0.16	-0.60
Tartaric acid/ ethanol	57.41	< 0.0001	-0.90	43.79	< 0.0001	-0.10
Tartaric acid/ lactic acid	15.18	0.002	0.32	0.22	0.64	-0.54
Acetic acid/ sugar	22.76	0.0004	-0.65	4.04	0.07	0.67
Acetic acid/ ethanol	108.93	< 0.0001	0.35	67.01	< 0.0001	-0.18
Citric acid/ lactic acid	31.58	0.0001	-0.07	3.59	0.08	0.19
Citric acid/ acetic acid	6.39	0.026	-0.13	3.03	0.11	0.06
Citric acid/ sugar	63.52	< 0.0001	0.1	5.38	0.04	0.07
Citric acid/ ethanol	116.73	< 0.0001	0.37	153.88	< 0.0001	0.04
Lactic acid/ acetic acid	4.71	0.05	-0.16	0.92	0.36	0.98
Lactic acid/ sugar	8.53	0.01	0.50	2.51	0.14	0.68
Lactic acid/ ethanol	101.75	< 0.0001	-0.38	21.07	0.0009	-0.34
Malic acid/ citric acid	92.98	< 0.0001	-0.11	7.0	0.02	-0.11
Malic acid/ total Phenolics	16.46	0.001	-0.11	66.82	< 0.0001	-0.92
Malic acid/ sugar	0.37	0.55	0.36	4.46	0.06	-0.56
Malic acid/ ethanol	88.19	< 0.0001	-0.63	100.5	< 0.0001	0.53
Malic acid/ lactic acid	14.35	0.002	-0.37	1.62	0.23	-0.95
Malic acid/ acetic acid	32.94	< 0.0001	-0.34	0.21	0.65	-0.93
Sugar/ ethanol	90.17	< 0.0001	-0.51	0.03	0.86	-0.42

Note: F — Fisher`s criterion. Dispersion analysis (ANOVA) (unifactorial model);
P — value of differences between the investigated groups;
r — Spearman`s rank correlation coefficient.

samples fermented using yeast cultures: Charivny (Magic) MAFF-230100 more than 85% and Tairov`s Ruby MAFF-230098 more than 85%. Comparative assessment shows that some white wine grape varieties produce much more ethanol compared to red wine grape varieties. This indicates that fermentation activity and ethanol forming capacity of tested wine stocks increases when using yeast strains MAFF-230100 and MAFF-230098. In both white and red grape varieties there exist 2–3 yeast strains which produce maximal amount of ethanol over other yeast strains. Those strains with high enzymatic activity could be used in the alcohol industry to produce ethanol for the pharmaceutical and food industries. Maximal concentration of tartaric acid in wines received from white grape varieties in Ovidiopolskij MAFF-230104 was more than 480%. For red wine grape varieties maximal concentration in Odessa`s Black MAFF-230109 was more than 548%. The maximal level of malic acid concentration in white wine grape varieties for Ovidiopolskij MAFF-230104 was more than 120% and Zagrey MAFF-230105 was more than 260%.

Red wine grape varieties showed maximal concentration of malic acid using yeast culture Charivny (Magic) MAFF-230100 and was more than 45%, Tairov`s Ruby MAFF-230098 was more than 75%. Such red wine grape varieties as Illychevsky Early MAFF-230110 and Odessa`s Pearl MAFF-230108 did not containe malic acid. This means that spontaneous malolactic fermentation was completed in these wines.

Rating quality of wines by the ratio of tartaric to malic acid was maximal and perfect for white wine grape varieties Aromatic MAFF-230106, the ratio was 2.95 for Ovidiopolskij MAFF-230104. We found that quality of wine depends upon the ratio between tartaric and malic acids. We found that due to a high ratio, of dry wine received using yeast culture Odessa`s Black MAFF-230109 in perfect quality, where ratio was 4.27. Quality of dry wine received using yeast culture Ruby Jubilee MAFF-230099 is excellent quality, where ratio was 3.86. Parameters of titratable organic acids provide an information of the balance between assimilated and produced organic acids for separate *Saccharomyces cerevisiae* yeast culture. For acidity, an important role is played by malolactic fermentation. Wines from red grape varieties were bright and lively ruby-red color, with a clear aroma and notes of wild berries, ripe and dried plums with accents of dry vegetable mass. Taste for red wine grape varieties was well structured, dense, soft and rounded, with delicate acids and almost without bitterness. Such wine stock samples were received with *Saccharomyces cerevisiae* yeast strains and produced high level of ethanol: white wine grape varieties Ovidiopolskij MAFF-230104 and Zagrey MAFF-230105. Samples of wine stock received using *Saccharomyces cerevisiae* yeast strains, Odessa`s Black MAFF-230109 and Ruby Jubilee MAFF-230099 obtained from red grape varieties contained a high volume fraction of ethanol production. The strains which produced high amounts of alcohol (ethanol) are going to be proposed for use in wine biotechnology, pharmaceutical industry, and food industry.

Information given in Table 4 shows positive, moderate and negative correlations, P-value, Fisher-Snedecor test (unifactorial model) frequency in the null distribution in the analysis of variance between tested parameters in both groups of white and red wine stocks (F). Existing high correlation between tested parameters of titratable acidity and volatile acids for wine stocks of red grape varieties (r = 0.82; P = 0.0001). It is natural because between titratable acidity and volatile acids there exists normal correlation and interdependence.

There is very high correlation between titratable acidity and malic acid in white grape varieties (r = 0.95; P = 0.0004). There was high correlation between volatile acids and acetic acid in wine stocks received from white grape varieties (r = 0.82; P = 0.09). We found very high correlations in wine stocks received from red grape varieties (r = 0.94; P = 0.56). Such indices are natural because between volatile acids and acetic acid in wine stocks there exists normal correlation and interdependence. We found moderate correlation between tartaric acid and malic acid in wine stocks received from white grape varieties (r = 0.51; P = 0.03) and there was specified low, but statistically reliable correlation in wine stocks received from red grape varieties (r = 0.39; P = 0.002). We found moderate correlation between lactic acid and sugar in wine stocks received from white grape varieties (r = 0.50; P = 0.01), also moderate correlation was found for wine stocks received from red grape varieties (r = 0.68; P = 0.1). We found very high correlation between lactic and acetic acids in wine stocks received from red grape cultivars (r = 0.98; P = 0.3). We found low correlation between malic acid and sugar in wine stocks received from white grape varieties (r = 0.36; P = 0.5). We noticed moderate correlation between malic acid and ethanol in wine stocks received from red grape varieties ($r = 0.53$; $P = < .0001$). We found low correlations between citric acid and ethanol in wine stocks received from white grape varieties ($r = 0.37$; $P = < 0.0001$).

We found moderate correlation between acetic acid and sugar in wine stocks received from red grape varieties ($r = 0.67$; $P = 0.07$). We noticed low correlations between tartaric and lactic acids in wine stocks received from white grape varieties ($r = 0.32$; $P = 0.02$). We found low correlations between tartaric acid and sugar in wine stocks received from white grape varieties ($r = 0.41$; $P = 0.02$) and also low correlation between tartaric and citric acids in wine stocks received from red grape varieties ($r = 0.48$; $P = 0.0001$).

We found very high correlations between titratable acidity and tartaric acid in wine stocks received from white grape varieties ($r= 0.95$; $P = 0.0004$). We found high correlations between titratable acidity and volatile acids in wine stocks received from red grape varieties ($r = 0.82$; $P = < 0.0001$).

We noted negative correlation between tartaric and acetic acids for wine stocks received from white grape varieties ($r = 0.38$; $P = 0.0005$) and for wine stocks received from red grape varieties ($r = -0.60$; $P = 0.03$). In both groups there were negative, but pretty reliable connections.

Negative correlations between tartaric acid and phenolic compounds in wine stocks received from white grape varieties ($r = -0.02$; $P =0.001$) and in wine stocks received from red grape varieties ($r = -0.64$; $P = < 0.0001$) were observed. In both investigated groups there were negative, but pretty reliable connections. However, between the investigated groups of wine stocks received from white and red grape varieties there was appreciable difference. Negative correlations also existed between the content of tartaric acid and ethanol for wine stocks received from white grape varieties ($r = -0.90$; $P = < 0.0001$) and for wine stocks received from red grape varieties ($r = -0.10$; $P = < 0.0001$).

There is a high correlation between titratable acidity and volatile acids in wine stocks received from red grape varieties ($r = 0.82$; $P = <0.0001$). However, the same parameters in white wine stocks received from white grape varieties are absolutely different, because correlation is negative ($r = -0.47$; $P = <0.0001$). Such great differences results in opposite correlations between white and red stocks. It could be explained by the fact that red wine stocks contained different ingredients including pigments, anthocyanins, and high phenolic and tannine contents. Therefore, red wine stocks have a high correlation compared with the same in white wine stocks. Very high correlation was indicated between titratable acidity and tartaric acid in white wine stocks that were received from white grape varieties ($r = 0.95$; $P = 0.0004$). However, the same parameters in red wine stocks received from red grape varieties are absolutely different, and correlation showed a negative result ($r = -0.32$; $P = 0.001$).

According to our investigation there were determined the following: a high and very high correlation between volatile acids and acetic acid in white wine stocks received from white grape varieties ($r = 0.82$; $P = 0.09$) and in red wine stocks received from red grape varieties ($r = 0.94$; $P = 0.56$); a high correlation between lactic and acetic acid in red wine stocks received from red grape varieties ($r = 0.98$; $P = 0.36$). However, the same parameters in white wine stocks received from white grape varieties were absolutely different, where correlation showed a negative result ($r = -0.16$; $P = 0.05$); a moderate correlation was found between lactic acid and residual sugar for white wine stocks received from white grape varieties ($r = 0.50$; $P = 0.01$) and for red wine stocks received from red grape varieties ($r = 0.68$; $P = 0.14$); a moderate correlation between malic acid and ethanol. For wine stocks received from red grape varieties ($r = 0.53$; $P = <0.0001$) and for white wine stocks received from white grape varieties correlation was negative ($r = -0.63$; $P = <0.0001$); prospective yeast cultures of *Saccharomyces cerevisiae* for wine biotechnology produced a high volume fraction of ethanol isolated from white grape varieties: Odessa`s Muscat MAFF-230107, Opalovy (Opaline) MAFF-230103, Selena MAFF-230101 and yeast culture *Saccharomyces cerevisiae* isolated from red grape varieties: Charivny (Magic) MAFF-230100, Odessa`s Black MAFF-230109, Tairov`s Ruby MAFF — 230098.

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КОНЦЕНТРАЦІЯ ОРГАНІЧНИХ КИСЛОТ У ВИНОМАТЕРІАЛАХ ПІСЛЯ ФЕРМЕНТАЦІЇ ДРІЖДЖІВ *Saccharomyces cerevisiae*

В. М. Байрактар

Одеський національний університет
ім. І. І. Мечникова, Україна

E-mail: vogadro2007@rambler.ru

Досліджували біохімічні показники виноматеріалів, що впливають на смак і якість вина: об'ємну частку етанолу, концентрації залишкових цукрів, фенольних сполук, винної, яблучної, лимонної, молочної, оцтової кислот, титрувальну та летючу кислотність. Використовували виноматеріали, отримані з білих і червоних сортів винограду Таїровської селекції. Відзначено кореляцію в обох групах між показниками титрувальної та летючої кислотності у виноматеріалах із білих та червоних сортів винограду. Високу кореляцію спостерігали між концентраціями молочної та оцтової кислот, летючою кислотністю і концентраціями оцтової кислоти та загальних цукрів. Встановлено, що виноматеріали з високою концентрацією етанолу отримано з використанням штамів дріжджів *Saccharomyces cerevisiae*, що ферментували виноградне сусло з високою швидкістю й активністю бродіння. Смак виноматеріалів залежить від показників відношення винної кислоти до яблучної кислоти. Показано значні відмінності між виноматеріалами, що їх одержано з білих і червоних сортів винограду: у концентраціях органічних кислот, фенольних сполук, залишкових цукрів, а також об'ємної частки етанолу. Для обох досліджуваних груп відзначено позитивну кореляцію між показниками летючої кислотності та концентраціями оцтової, винної, яблучної, молочної кислот і загальних цукрів. Відібрано найбільш перспективні культури дріжджів з високою продуктивністю синтезу етанолу, які можуть бути використані у біотехнології виноробства.

Ключові слова: органічні кислоти, виноградні сорти, *Saccharomyces cerevisiae*.

КОНЦЕНТРАЦИЯ ОРГАНИЧЕСКИХ КИСЛОТ В ВИНОМАТЕРИАЛАХ ПОСЛЕ ФЕРМЕНТАЦИИ ДРОЖЖЕЙ *Saccharomyces cerevisiae*

В. Н. Байрактар

Одесский национальный университет
им. И. И. Мечникова, Украина

E-mail: vogadro2007@rambler.ru

Исследовали биохимические показатели виноматериалов, влияющие на вкус и качество вина: объемную долю этанола, концентрации остаточных сахаров, фенольных соединений, винной, яблочной, лимонной, молочной, уксусной кислот, титруемую и летучую кислотность. Использовали виноматериалы, полученные из белых и красных сортов винограда Таировской селекции. Отмечена корреляция между показателями титруемой и летучей кислотности в виноматериалах из белых и красных сортов винограда. Высокая корреляция наблюдалась между концентрациями молочной и уксусной кислот, летучей кислотностью и концентрациями уксусной кислоты и общих сахаров. Установлено, что виноматериалы с высокой концентрацией этанола получены с использованием штаммов дрожжей *Saccharomyces cerevisiae*, которые ферментировали виноградное сусло с высокой скоростью и высокой активностью брожения. Вкус виноматериалов зависит от показателей отношения винной кислоты к яблочной кислоте. Показаны значительные различия между виноматериалами из белых и красных сортов винограда: в концентрациях органических кислот, фенольных соединений, остаточных сахаров, а также объемной доли этанола. Для обеих исследуемых групп отмечена положительная корреляция между показателями летучей кислотности и концентрациями уксусной, винной, яблочной, молочной кислот и общих сахаров. Отобраны наиболее перспективные культуры дрожжей с высокой продуктивностью синтеза этанола, которые могут быть использованы в биотехнологии виноделия.

Ключевые слова: органические кислоты, виноградные сорта, *Saccharomyces cerevisiae*.