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Analyses of Aroma Components of Chardonnay Wine Fermented by Different Yeast Strains

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Summary

The aim of this work was to evaluate the influence of selected wine yeasts on the quality of primary and secondary wine aromas using chemical and sensorial evaluation. Twenty-nine selected yeast strains were tested in 5 L samples of homogeneous pasteurized must of Chardonnay variety. Samples of young wine were analysed for 4 higher alcohols, 4 fatty acids and 14 esters immediately after fermentation. At the same time wines were sensorially evaluated. The results demonstrate that different yeast strains result in a significant variety of aroma compounds and final wine quality. The optimal yeast strain for the Chardonnay variety was evaluated according to chemical and sensorial analysis.

Key words: different yeast strains, *Saccharomyces cerevisiae*, chardonnay, wine aromas

Introduction

Alcohol fermentation is the most important process for formation of fine aroma compounds of each wine. Most of the aldehydes are formed in the first phase by unsuitable conditions such as extended prefermentation and oxygenation. Acetaldehyde is a typical product of this phase, as a consequence of absence of yeast alcohol-dehydrogenase, which reduces generated acetaldehyde to ethanol. Acetals, as well as various ketons, diketons and hydroxyketons are formed from acetaldehyde. The second phase is related to generation of acetals and ketals. This phase is strongly enforced by temperature and high acidity *(3).*

Higher alcohols in wine are results of transamination of aminoacids, decarboxylation and reduction of particular keto acids by the Ehrlich metabolic pathway *(4).* Higher alcohols are quantitatively the most present aromatic substances. In top quality wines, there is also present a high number of their fatty acids esters, present mostly in the first phase of alcohol fermentation. There are not many organic acids present in wine aroma. From the volatile acids in it, the most frequent are: acetic, propanoic, butanoic and lactic acid. While during the alcohol fermentation concentration of butanoic, hexanoic, octanoic and decanoic acids is incerasing, concentration of hexadecanoic and octadecanoic acid is decreasing.

High fatty acid ethyl esters and higher alcohol acetates are the most present esters in wine. Concentration of some volatile acid esters, as 3-methyl-butyl acetate, hexyl acetate, ethyl caprilate *etc.* are factors in corelation with the top quality of wine *(3).*

Killian and Ough *(5),* and Seeber *et al. (6)* have found that »fruity« esters 3-methyl-butyl acetate, isobutyl acetate, ethyl *i*-butyrate and hexyl acetate are gen-

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erated at lower fermentation temperature of 10 °C, while between 10 and 15 °C most of the main aromatic compounds of wine character are preserved.

Rapp *(3)* has found that for the generation of fermentation wine aroma and its high quality, concentration of nitrogen, aminoacids and reductive sugars as well as pH, fermentation temperature and yeast strain are the most relevant factors.

On the other side, Seeber *et al. (6)* are more convinced that the physiology of various yeast strains is a more important parameter.

In comprehensive wine technology much attention was focused on studies on wine aroma compounds, Henning and Villforth *(1)* being among the pioneers. Motivated by the idea that wine aroma is mostly due to a single compound, they concentrated huge quantities of wine. Using the available equipment and classical analytical technique they already discovered a few compounds present in wine aroma. Applying gas chromatography Bayer and Bassler *(2)* showed the presence of higher alcohols (HA) and esters (E) as the major aroma compounds of wine distillates. The appearance of capillary columns finally enabled distinguishing up to 40–60 peaks of recognized aroma compounds. This technique is nowadays widely used in wine aroma compound determination. By employing a suitable capillary column and conditions in GC (split, carrier gas, flow, temperature) 600–800 aromatic components could be successfully determined. By employing bidimensional gas chromatography with a high pressure separation column connected to an elution capillary column, numerous possibilities are offered for determination of aromatic compounds.

It seems that GC-FTIR (gas chromatography – Fourier transform infra red detection), combined with GC-MS (gas chromatography-mass spectrometry) is reasonable and usefull combination for determination of the structure of specific aromatic compounds and their isomers *(3).*

SIM (selected ion monitoring) is used in routine analyses. Quantitative analyses of aromatic compounds are based on total separation of their mass fragments *(3).* Suitable accuracy is achieved by evaluating at least three mass fragments, as well as their intensity. A new analytical approach is based on ^{13}C-nuclear magnetic resonance (NMR). According to Rapp *(3)*, this is also the most relevant analytical technique to determine the structure of particular aroma compounds.

The aim of this work was to recognize the influence of the strain and its physiology on generation and oscilation of aromatic compounds at alcohol fermentation in chardonnay must.

Materials and Methods

The fermentative aroma of young wines formed during wine fermentation was studied. Five litres of homogenous pasteurised must of the Chardonnay variety from Ljutomer – Ormož wine growing region was used in all the experiments. It was inoculated with 29 different isolates of *Saccharomyces cerevisiae*, strains ZIM 0628 to ZIM 0692, from the Microbial Collection of the Department of Food Technology, Biotechnical Faculty, University of Ljubljana. The samples of *Saccharomyces cerevisiae* were isolated from Slovenian vineyards. The plates were incubated at 25 °C. Strain identification was carried out according to standard methods *(7).* A volume of 75 mL of inoculum was used in all the experiments. Fermentation proceeded 21 days at the temperature of 15 °C.

Aromatic compounds were extracted according to the 'kaltron' method by liquid-liquid extraction with 1,1,2-trichloro-trifluoroethane *(8).* 10 mL of sample were extracted by shaking for 15 min with 1 μL of internal standard and 150 μL of 1,1,2-trichloro-trifluoroethane. The mixture was centrifuged for 5 min at 3000 rpm, and the supernatant was injected on the GC. This technique enables a suitable separation, has a low boiling point, negligible ethanol solubility, robustness and low toxicity. All samples were analyzed in triplicate and average results are presented in all tables. Statistical analysis of variances and the Tukey test were applied.

Twenty four different aromatic compounds formed during fermentation were detected using Siemens (Germany) GC L 350 gas chromatograph *(3,4).*

Chromatography conditions: detector: FID, split: 1:18, injector temperature: 210 °C, detector temperature: 210 °C, temperature interval: 50–200 °C, DT °C^{-1} min^{-1}: 5, column: DB-5, 60 m ×0.247 mm, carrier gas: N_2, 30 mL min^{-1}, internal standard: 2-ethyl-1-hexanol, injection volume: 1 μL.

Analyzed samples were compared with standards by GC and their identity was confirmed by mass spectrometry (MS 455 Siemens, Germany) *(3,4).*

Results and Discussion

Chemical analysis

Fourteen higher alcohols, four higher fatty acids and fourteen esters were identified (Tables 1 a,b,c).

Significant differences exist between the concentrations of total determined aromatic compounds. The highest concentration of 1175.7 mg L^{-1} was detected in sample 7 and the lowest of 897 mg L^{-1} in sample 26. Practically this means a reduction of almost 50 %. For comparison the analysis of a control sample of wine must showed only 56.0 mg L^{-1}.

Differences between the wines were statistically significant in samples 9, 27, 12, 4, 25, 23, 22, 2, 24, 17, 10, 1 and 3 containing higher concentrations, while 29 and 15 had the lowest concentrations of total determined aromatic compounds. In the remaining samples differences between the concentrations of total aromatic compounds were negligible.

The highest concentration of HA (738.4 mg L^{-1}) was detected in the sample 9 and the lowest 263.5 mg L^{-1}, in the sample 29. Significant differences were obvious in samples 9, 25, 27, 22 and 23 with higher concentrations of HA and in samples 26, 11, 5, 6, 14, 15, 8, 10, 13 and 1 with lower HA concentrations. In the remaining samples statistical differences were not obvious. Wine must analysis showed just 25.2 mg L^{-1} of HA.

Table 1a. Maximal and minimal concentrations of aromatic compounds (mg L^{-1}) in young wines fermented with different yeast strains

γ(aromatic compound) mg L^{-1}	*Saccharomyces cerevisiae* strain										Control
	1	2	3	4	5	6	7	8	9	10	
HA											
3-methyl-1-butanol	323.00	353.00	384.80	359.30	262.50	261.00	399.20	299.30	536.80	284.80	13.00
2-methyl-1-butanol	76.00	88.80	91.50	92.80	51.50	78.00	113.30	77.00	115.50	93.00	7.60
2-methyl-1-pentanol	6.30	6.80	5.30	5.80	5.00	6.00	5.50	5.50	6.80	6.30	0.00
2-phenyl ethanol	50.50	62.80	58.80	43.80	54.80	34.30	85.80	42.80	79.30	50.80	4.60
Σ HA	**455.80**	**511.40**	**540.40**	**501.70**	**373.80**	**379.30**	**603.80**	**424.60**	**738.40**	**434.90**	**25.20**
LFA											
pyruvic acid	20.00	20.00	13.50	10.50	10.50	10.80	18.20	11.00	14.00	19.80	5.00
hexanoic acid	32.00	28.50	8.30	5.00	4.00	7.00	16.30	4.00	9.50	11.30	0.00
octanoic acid	158.00	167.30	148.80	142.30	141.80	142.80	192.00	120.30	150.30	157.00	4.80
decanoic acid	136.00	155.80	116.30	125.00	140.50	128.00	173.00	113.30	139.30	152.00	6.60
Σ LFA	**326.00**	**351.60**	**273.40**	**272.30**	**286.30**	**277.80**	**381.30**	**237.60**	**299.10**	**320.30**	**16.40**
ESTERS											
ethyl acetate	29.00	36.80	41.00	41.30	21.00	34.50	32.20	12.30	33.30	28.80	6.20
ethyl isobutirate	5.00	5.50	6.00	8.00	7.80	7.30	7.30	5.50	8.30	6.30	0.00
isobutyl acetate	12.80	11.50	8.80	16.50	11.00	13.80	19.30	7.50	9.00	12.50	0.00
ethyl lactate	15.30	15.80	12.30	18.80	14.80	15.80	18.80	11.00	16.30	16.50	0.00
ethyl isovalerate	1.30	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.30	1.00	0.00
3-methyl-butyl acetate	227.00	228.30	213.30	392.30	199.30	204.80	338.00	194.00	265.00	202.50	5.40
2-methyl-butyl acetate	18.50	18.50	17.80	33.50	19.80	22.00	36.00	17.80	21.50	22.50	1.00
ethyl capronate	85.80	78.50	62.00	66.50	65.50	64.30	92.30	57.00	65.00	79.80	0.00
hexyl acetate	16.30	14.80	13.00	17.30	19.00	15.00	16.00	12.80	12.00	17.00	1.80
diethyl succinate	5.80	7.00	7.50	6.80	7.00	6.30	7.80	7.80	8.30	9.00	0.00
ethyl caprilate	96.00	112.50	83.00	94.50	55.50	82.00	102.30	97.80	88.00	117.00	0.00
2-phenyl-ethyl acetate	42.00	46.80	41.00	47.50	64.80	33.50	79.00	33.30	51.80	46.30	0.00
diethyl malate	4.30	6.50	5.50	14.30	10.80	10.80	11.30	12.80	11.30	24.00	0.00
ethyl caprinate	22.00	43.50	26.80	30.00	28.50	22.00	28.80	22.00	27.00	34.50	0.00
Σ ESTERS	**581.10**	**627.00**	**539.00**	**788.30**	**525.80**	**533.10**	**790.60**	**492.60**	**618.10**	**617.70**	**14.40**
Σ aromat. comp.	**1362.90**	**1490.00**	**1352.80**	**1562.30**	**1185.90**	**1190.20**	**1775.70**	**1154.80**	**1655.60**	**1372.90**	**56.00**
methanol	2.30	2.80	2.30	2.80	2.00	3.00	3.00	3.00	3.00	3.30	2.00
acetaldehyde	14.00	10.00	8.30	8.50	11.30	11.30	28.80	10.50	9.00	12.00	0.00

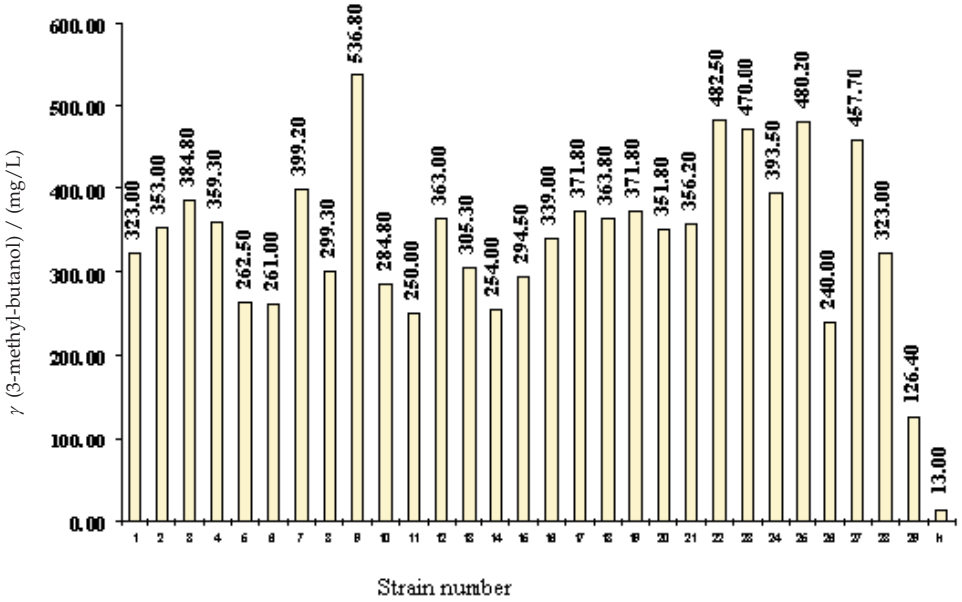

Fig. 1. Concentration of 3-methyl-1-butanol in young wines fermented with different yeast strains of *Sacharomyces cerevisiae* and in pasteurised must as control

Table 1b. Maximal and minimal concentrations of aromatic compounds (mg L^{-1}) in young wines fermented with different yeast strains

γ(aromatic compound) mg L^{-1}	*Saccharomyces cerevisiae* strain										Control
	11	12	13	14	15	16	17	18	19	20	
Higher alcohols											
3-methyl-1-butanol	250.00	363.00	305.30	254.00	294.50	339.00	371.80	363.80	371.80	351.80	13.00
2-methyl-1-butanol	48.00	91.50	84.50	80.30	78.00	79.30	104.00	91.80	94.80	97.80	7.60
2-methyl-1-pentanol	5.30	6.00	6.30	6.00	5.50	6.30	5.50	6.50	6.00	5.00	0.00
2-phenyl ethanol	47.50	44.30	53.80	43.00	42.80	70.80	53.30	56.50	62.00	45.80	4.60
Σ Higher alcohols	**350.80**	**504.80**	**449.90**	**383.30**	**420.80**	**495.40**	**534.60**	**518.60**	**534.60**	**500.40**	**25.20**
LFA											
pyruvic acid	9.00	12.30	12.00	9.00	7.50	12.30	11.50	10.00	7.50	6.50	5.00
hexanoic acid	7.30	19.00	25.00	3.30	6.50	6.80	16.30	5.00	1.00	2.30	0.00
octanoic acid	111.30	144.80	112.30	137.50	107.80	138.80	124.50	127.30	119.50	106.00	4.80
decanoic acid	119.00	125.50	111.30	89.80	79.30	87.00	108.30	94.50	95.50	98.80	6.60
Σ LFA	**237.60**	**289.30**	**248.60**	**230.60**	**193.60**	**232.60**	**249.10**	**226.80**	**216.00**	**207.10**	**16.40**
ESTERS											
ethyl acetate	28.00	38.30	46.00	23.30	36.00	23.50	39.00	41.50	32.80	47.00	6.20
ethyl isobutyrate	9.50	7.50	3.00	5.50	8.00	5.50	10.50	6.30	6.00	3.50	0.00
isobutyl acetate	17.30	16.80	11.50	7.00	10.80	7.50	16.30	16.30	7.00	12.50	0.00
ethyl lactate	13.00	16.50	11.30	17.00	11.50	16.00	17.50	16.30	13.30	11.80	0.00
ethyl isovalerate	1.00	1.30	1.80	1.30	1.00	1.80	1.50	2.00	2.00	1.00	0.00
3-methyl-butyl acetate	233.00	364.50	149.30	185.50	196.80	191.00	256.50	152.00	204.30	135.80	5.40
2-methyl-butyl acetate	14.00	31.50	14.30	15.50	19.30	14.80	25.50	12.80	14.50	14.80	1.00
ethyl capronate	54.50	72.80	59.00	63.30	51.50	78.30	66.00	77.30	58.80	53.80	0.00
hexyl acetate	18.00	18.00	13.30	11.00	12.00	11.50	13.50	8.80	9.80	11.30	1.80
diethyl succinate	4.80	7.00	5.80	8.00	7.50	7.00	8.50	7.30	8.00	6.50	0.00
ethyl caprilate	81.30	118.80	78.30	89.80	63.00	117.30	100.80	83.00	57.00	48.30	0.00
2-phenyl-ethyl acetate	58.00	49.00	36.30	33.80	39.30	57.50	42.00	38.80	53.30	32.80	0.00
diethyl malate	6.30	6.30	6.80	2.00	1.00	1.50	2.30	6.30	2.50	5.50	0.00
ethyl caprinate	33.00	36.50	25.50	26.80	16.30	28.50	33.30	22.00	12.50	9.50	0.00
Σ ESTERS	**571.70**	**784.80**	**462.20**	**489.80**	**474.00**	**561.70**	**633.20**	**490.70**	**481.80**	**394.10**	**14.40**
Σ aromat. compounds	**1160.10**	**1578.90**	**1160.70**	**1103.70**	**1088.40**	**1289.70**	**1416.90**	**1236.10**	**1232.40**	**1101.60**	**56.00**
methanol	2.50	3.00	3.30	2.50	2.50	2.80	2.80	3.00	3.00	2.00	2.00
acetaldehyde	11.80	20.00	11.30	10.00	10.00	11.00	12.30	10.80	10.00	207.00	0.00

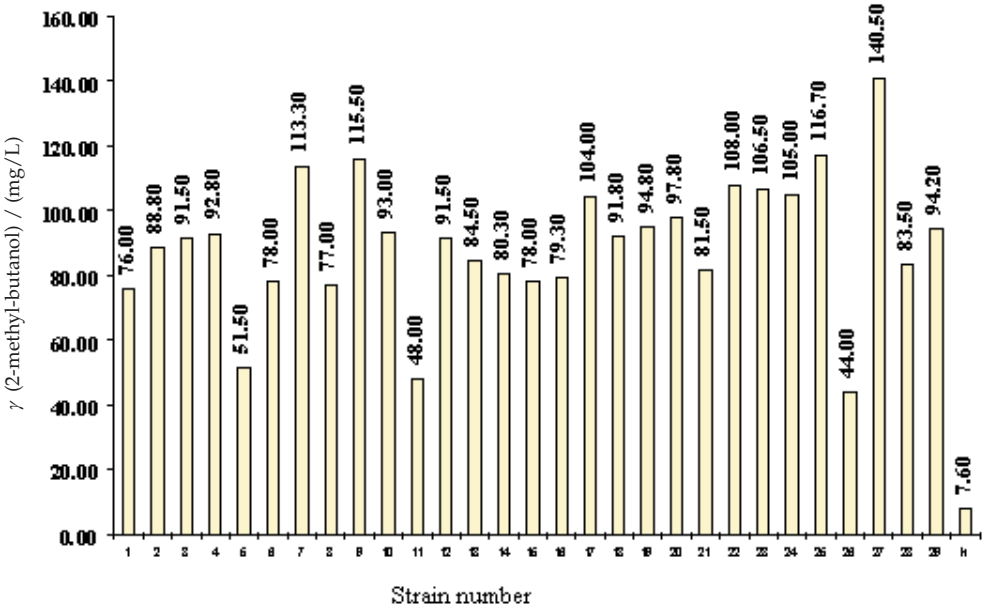

Fig. 2. Concentration of 2-methyl-1-butanol in young wines fermented with different yeast strains of *Sacharomyces cerevisiae* and in pasteurised must as control

Table 1c. Maximal and minimal concentrations of aromatic compounds (mg L^{-1}) in young wines fermented with different yeast strains

γ(aromatic compound)	*Saccharomyces cerevisiae* strain									Control
mg L^{-1}	21	22	23	24	25	26	27	28	29	
HA										
3-methyl-1-butanol	356.20	482.50	470.00	393.50	480.20	240.00	457.70	323.00	126.40	13.00
2-methyl-1-butanol	81.50	108.00	106.50	105.00	116.70	44.00	140.50	83.50	94.20	7.60
2-methyl-1-pentanol	6.00	7.00	6.20	5.70	4.00	5.30	5.50	4.00	3.70	0.00
2-phenyl ethanol	46.50	68.00	56.20	47.00	71.70	35.50	67.20	62.50	39.20	4.60
Σ HA	**490.20**	**665.50**	**638.90**	**551.20**	**672.60**	**324.80**	**670.90**	**473.00**	**263.50**	**25.20**
LFA										
pyruvic acid	7.80	11.00	10.00	6.80	9.50	6.30	9.30	8.70	6.80	0.00
hexanoic acid	7.80	18.00	5.20	2.50	2.50	4.00	7.50	3.50	3.30	5.00
octanoic acid	132.80	130.80	140.50	105.20	116.00	87.00	126.70	125.20	89.20	4.80
decanoic acid	98.80	120.80	108.00	82.70	114.20	77.80	120.20	96.00	73.00	6.60
Σ LFA	**239.40**	**269.60**	**253.70**	**190.40**	**232.70**	**168.80**	**254.40**	**224.70**	**165.50**	**16.40**
ESTERS										
ethyl acetate	30.30	35.00	49.00	42.70	58.50	14.20	73.70	34.70	62.30	6.20
ethyl isobutirate	7.00	7.50	10.50	9.20	10.70	5.00	11.00	6.50	7.70	0.00
isobutyl acetate	6.30	10.50	14.00	18.70	16.70	6.00	21.20	7.50	27.50	0.00
ethyl lactate	14.80	14.00	17.50	13.20	12.70	11.20	12.00	11.70	10.00	0.00
ethyl isovalerate	1.00	1.00	1.70	1.00	2.00	1.50	1.00	2.20	1.50	0.00
3-methyl-butyl acetate	162.50	245.50	259.70	352.20	278.20	166.50	290.70	153.00	174.20	5.40
2-methyl-butyl acetate	12.80	19.00	20.70	34.00	24.00	13.50	28.50	14.50	25.70	1.00
ethyl capronate	74.50	62.50	68.70	48.70	59.20	55.70	59.20	52.00	59.80	0.00
hexyl acetate	9.50	13.30	13.70	15.00	8.50	13.70	13.00	8.20	9.50	1.80
diethyl succinate	7.80	6.30	9.20	5.50	7.70	4.50	7.00	6.50	5.50	0.00
ethyl caprilate	93.50	90.00	114.00	71.70	73.50	45.50	70.00	64.00	54.50	0.00
2-phenyl-ethyl acetate	37.30	40.30	39.00	51.70	59.50	38.50	46.20	44.50	56.20	0.00
diethyl malate	5.00	12.50	11.00	11.00	16.50	12.20	2.20	3.50	8.20	0.00
ethyl caprinate	17.50	26.50	28.20	18.50	21.00	15.50	20.20	14.50	13.00	0.00
Σ ESTERS	**479.80**	**583.90**	**656.90**	**693.10**	**648.70**	**403.50**	**655.90**	**423.30**	**515.60**	**14.40**
Σ aromat. compounds	**1209.40**	**1519.00**	**1549.50**	**1434.70**	**1554.00**	**897.10**	**1581.20**	**1121.00**	**944.60**	**56.00**
methanol	3.00	3.00	3.00	2.20	2.70	2.00	1.50	3.00	2.00	2.00
acetaldehyde	61.00	12.80	11.00	18.00	11.20	11.70	11.20	12.50	22.00	0.00

Figs. 1 and 2 show concentrations of 3-methyl-1-butanol and 2-methyl-1-butanol in young wines, respectively. Both higher alcohols are responsible for the fine fruity character of wine.

Both of these higher alcohols are formed from the coresponding amino acids, mainly from leucine and iso-leucine and partly from some other amino acids, according to the Ehrlich and Ribereau-Gayon metabolic pathways. The concentrations of both HA were high in all wine samples. Together with their esters, they contribute to the dry fruit aroma of wine. The highest concentration of 3-methyl-1-butanol (536.8 mg L^{-1}) was present in sample 9, while the lowest content of 126.4 mg L^{-1} was found in sample 29.

Statistically, differences between the wines were significant in samples 9, 22, 25, 23 and 27 with higher concentrations, in comparison to lower concentrations in samples: 29, 26, 11, 14, 6 and 5. In the remaining samples the differences were not significant.

A similar picture is shown in the Fig. 2, where the highest concentration (140.5 mg L^{-1}) of 2-methyl-1-butanol is present in sample 27, and the lowest of 44.0 mg L^{-1} in sample 26. Significant differences in 3-methyl-1-butanol and 2-methyl-1-butanol are present in the same samples, which means that biosynthesis of both HA is in linear relation. All the yeast strains applied produced significant amounts of alcohols. 3-methyl-1-butanol and 2-methyl-1-butanol together represent 18 to 30 % of all the aromatic compounds produced in wine fermentation.

In pasteurized must the concentration of 3-methyl-1-butanol was 13.0 mg L^{-1}, and 2-methyl-1-butanol 7.6 mg L^{-1}, representing 35.0 % of all aromatic compounds in wine must.

2-phenyl ethanol is an aromatic alcohol whose bouquet resembles to roses. Its oxidation transforms the aroma from a rose to a hyacinth bouquet. Further oxidation leads esters with a fine honey nose. 2-phenyl ethanol is a carrier of wine aroma. Noble yeast produces more of this compound than the acidulate strains. A low concentration of 2-phenyl ethanol, 4.6 mg L^{-1}, was already detected in pasteurised wine must. The yeast strains included in the study showed differing ability to synthesize 2-phenyl ethanol. The highest amount of 85.7

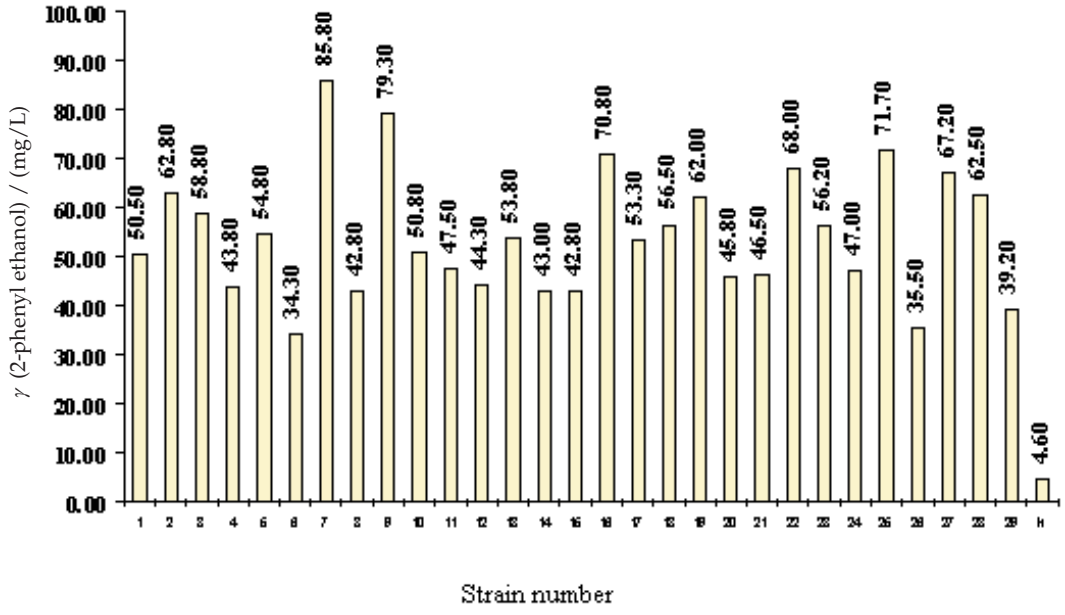

Fig. 3. 2-phenyl ethanol in young wines fermented with different yeast strains of *Sacharomyces cerevisiae* and in pasteurised must as control

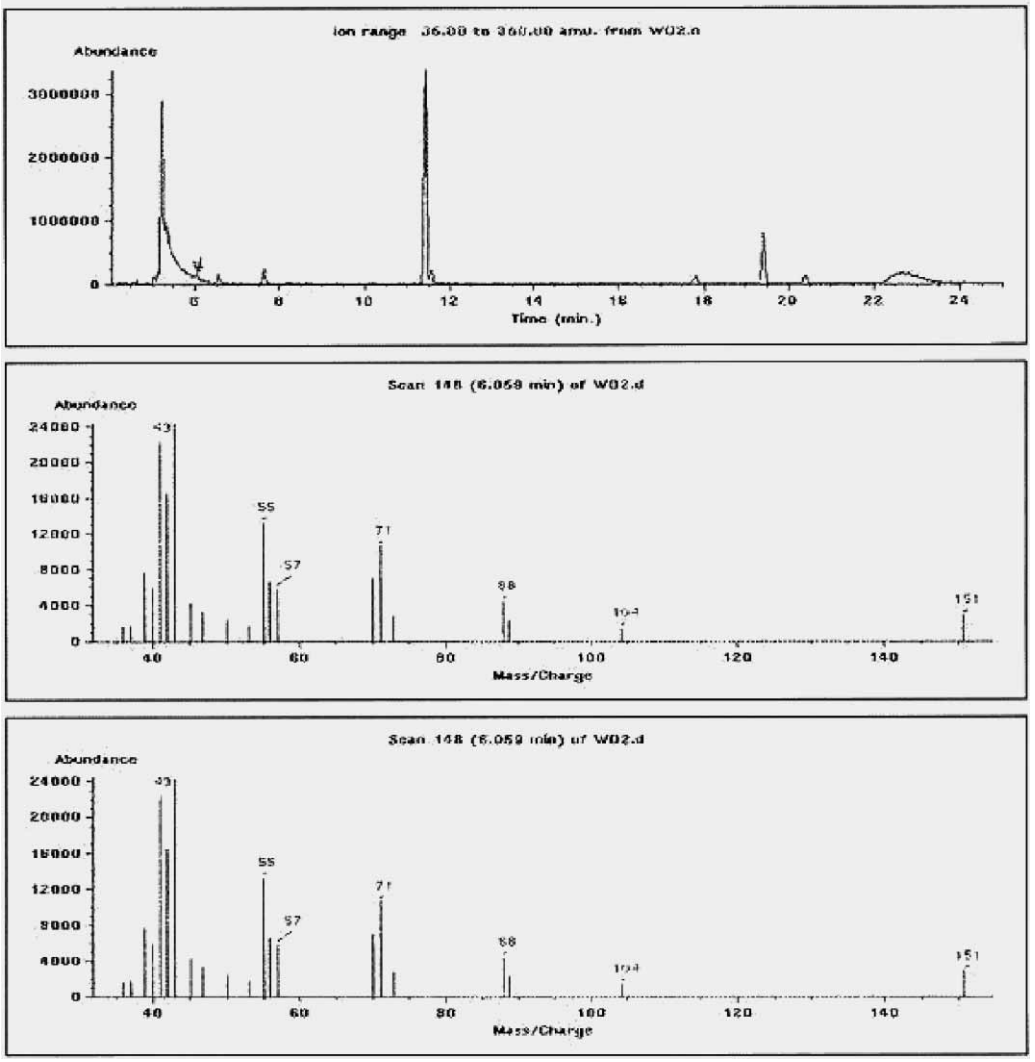

Fig. 4. Aromagram of young wine fermented with different yeast strains, based on gas chromatography and mass spectrometry, SIM technique *(8)*

mg L^{-1} was present in sample 7, and the lowest of 34.3 mg L^{-1} in sample 6.

Statistically, differences in phenyl ethanol content between the wines are significant in samples 9, 25, 16, 22, 27, 2, 28 with higher contents and in samples 6, 26, 29, 8, 15, 14, 4 with lower contents. In the remaining samples the differences were not significant.

The concentration of 381.3 mg L^{-1} of LFA was the highest in sample 7 and the lowest of 165.5 mg L^{-1} in sample 29. Statistically significant differences existed in samples 2, 1, 10, 9, 12, 5, 6, 3, 4, 22 and 27 with higher concentrations and in samples 26, 14, 15 with lower concentrations of LFA. In the remaining 12 samples there were no significant differences.

Large differences are also obvious in the case of the 14 esters detected. The largest total ester content of 790.6 mg L^{-1} was present in sample 7, and the lowest of 394.1 mg L^{-1} in sample 20. Statistically significant differences were obvious in samples 4, 12, 24, 23, 27, 25, 17, 2, 9, 10, 1, 11 with higher concentrations and in samples 26 and 18 with lower concentrations. The remaining samples showed little difference. In wine must analysis as a control, a total ester concentration of 14.4 mg L^{-1} was detected.

The results of young wine aroma analysis determined by gas chromatography and mass spectrometry are presented in Fig. 4.

Sensory evaluation

Sensory evaluation of the young fermented wines was carried out by five wine tasters. Their marks were classified into four categories:

Excellent: xxx strains: 1, 2, 7, 11, 14, 17, 18, 19, 24, 25, 27

Very good: xx strains: 3, 5, 8, 9, 10, 12, 15, 16, 22, 23, 28, 29

Good: x strains: 4, 6, 13, 21, 26

Non-specific strains: 20

Wine fermented with strain No. 20 gave a negative score due to its oxidized taste and organic smell. It contained increased amounts of acetaldehyde (207.0 mg) and volatile acids (0.63 g L^{-1}). The best wine (No. 7) contained the highest amount of aromatic compounds (1775.7 mg L^{-1}) comprising higher alcohols (603.8 mg L^{-1}), fatty acids (381.3 mg L^{-1}) and acetate and ethyl esters (790 mg L^{-1}).

Young wines, evaluated as excellent, contained higher amounts of aromatic HA (predominantly 2-phenyl ethanol), higher amounts of fatty acids (hexanoic, octanoic, decanoic) and higher amounts of esters (3-methyl-1-butyl acetate, 2-methyl-1-butyl acetate, 2-phenyl-ethyl-acetate, ethyl caprilate and ethyl caprinate).

Sensory evaluation of young wines gives final and also better indication of quality than chemical analyses. The combined wine constituents give a total olfactory impression perceived as harmony in taste and smell. Differences between young wines fermented with different yeast strains are better distinguished through sensory evaluation than by means of single chemical components. High quality wines should have a characteristic bouquet and taste which depends on the cultivar, maturity and phytosanitary conditions of the grapes, pedo--climatic conditions, and most importantly, on yeast fermentation physiology. Setting the chemical components of wine between minimal and maximal allowed limits does not guarantee wine quality, but it only facilitates marketing of wine.

Conclusions

The significant differences found in the concentrations of aromatic compounds show the important physiological role of the fermentation ability of yeast; yeast can produce different amounts of aromatic compounds.

The selected yeast strains, 1, 2, 11, 14, 17, 18, 19, 24, 25, 27, and especially strain 7, produced excellent wines and they could be usefully applied in further wine production. The presence of these yeast strains should be also indentified in the local vineyard microflora used in wine maker's practice. This article does not include the genesis of aromatic compounds generated by maturation and aging of wine in wine bottles, but no doubt that this would be a challenge for our next study.

Abreviations

HA	higher alcohol
LFA	lower fatty acid
E	esters
GC-FTIR	gas chromatography – Fourier transform infra red detection
GC-MS	gas chromatography-mass spectrometry
SIM	selected ion monitoring
NMR ^{13}C	^{13}C nuclear magnetic resonance
FID	flame ionization detector

References

1. K. Henning, F. Villforth, *Z. Lebensm.-Unters. Forsch. 5* (1942) 181–333.
2. E. Bayer, E. Bassler, *Z. Anal. Chem. 181* (1961) 418–424.
3. A. Rapp: Methods for the chemical analysis of the aroma in grapes and wines: Current experiences and future out look. In: *Procceding of the International Symposium on the Aromatic Substances in Grapes and Wines*, S. Michele all'Adige, Italy (1987).
4. M. Wondra, PhD Thesis, University of Ljubljana (1996).
5. E. Killian, C. S. Ough, *Am. J. Enol. Vitic. 30* (1979) 301–305.
6. R. Seeber, G. Sferiazo, R. Leardi, A. P. Serra, G. Versini, *Ind. bevande, 23* (1991) 561–564.
7. M. Wondra, *Master Thesis*, University of Ljubljana (1989).
8. A. Rapp, H. Franck, *Vitis, 9* (1971) 299–311.

Analiza aromatskih sastojaka tijekom vrenja u proizvodnji vina Chardonnay

Sažetak

U radu je utvrđen utjecaj odabranih vinskih kvasaca na kakvoću primarnih i sekundarnih aroma vina, primjenjujući kemijske i senzorske postupke. U pet litara pasteriziranoga grožđanog mošta sorte Chardonnay testirano je 29 odabranih sojeva kvasca izoliranih iz slovenskih vinograda. Nakon završena vrenja u mladom su vinu ispitivana 4 viša alkohola, 4 masne kiseline i 14 estera. Istodobno je obavljena i senzorska analiza vina. Rezultati analiza uzoraka prikazuju signifikantne razlike u sastavu sastojaka arome, a i konačne kakvoće vina. Kemijskom i senzorskom analizom odabran je optimalan soj vinskoga kvasca za vrenje vina sorte Chardonnay.