

# Sensory evaluation and some acetate esters of bottle aged Chardonnay wines

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## ABSTRACT

A five-year study was conducted to study the correlations between chemical analyses and sensory properties of wine during bottle aging. Chardonnay grapes were harvested as a normal and late harvest. After separate vinification, bottles were put in an underground cellar at 12°C and 75% of humidity. Chemical and sensory analyses were carried out after bottling (0), after 12, 24 and 36 months of bottle aging. The results of chemical and sensory evaluation show a strong correlation between a young wine bouquet and decrease in the concentration of isoamyl and 2-phenethyl acetates, and between an increase in diethyl succinate and bottle bouquet.

**Keywords:** esters; sensory analysis; bottle aging; white wine; Chardonnay

It is a well-known fact that wines do not all age well (Rapp and Mandrey 1986, Bartoshuk and Beauchamp 1994, Axel 1995). Especially white wines are very sensitive (Amerine and Roessler 1983, Noble and Bursick 1984). The period between bottling and attainment of the desired character can differ drastically from wine to wine, even though they are stored under identical conditions (Kantz and Singleton 1991, Kinnamon 1996).

Esters are an important facet of wine quality and flavour. The hydrolysis of esters is accelerated by acids (Boulton et al. 1996). This reaction is expected to take place in wines during the aging period (Boulton et al. 1996).

Chemical analysis gives us quantities of analysed substances, but without sensory evaluation of wines there is no final judgement of wine quality.

The history of wine quality evaluation is longer than for any other food product. With an increasing consumer demand for better wines, keen competition of wine producers, and development of appropriate statistical procedures for the analysis of sensory data, many wine experts have concluded that it is unsound to rely on the quality and standards-of-identity judgements of only one or two individuals (Thorngate 1997).

Chardonnay is a grapevine variety that is distributed all over the world unlike other white varieties of *Vitis vinifera* L. It is known that all great wines like those from Chablis are produced from this cultivar (Marić 1999).

This study was conducted to try to answer a question: how to determine the optimum period of bottle aging for wines of different harvest dates in definite production conditions?

## MATERIAL AND METHODS

**Harvest.** Chardonnay grapes from the vineyards Veto-vo in Kutjevo d.d. in Slavonia, a continental region of Croatia, were harvested normally when the concentration

of sugar stopped rising and the concentration of acids was not falling. The rest of Chardonnay grapes were harvested when the concentration of sugar was high enough for late-harvest wines.

**Vinification.** The grapes of normal and late harvest were separately vinified in Kutjevo d.d. winery. After fermentation, settlement and clarification, young wines were bottled. Normal harvest was bottled in January and wines of late harvest in April–May. The bottles were stored in an underground cellar at 12°C and 75% of humidity in Kutjevo.

**Analytical methods.** Volatile esters were analysed from volatile extracts. Wine (500 ml) was extracted for 10 hours with dichloromethane in a liquid-liquid upward displacement apparatus. The extract was dried to 10 ml over anhydrous sodium sulphate and stored prior to gas chromatography analysis. For that purpose GC Hewlett Packard 5890, series 2, with HP-FFAP column wines was used under these temperature conditions: 5 min isothermal at 60°C followed by a linear rise in temperature for 2.5°C/min to 190°C and 20 min isothermal at 190°C. Determination of volatile esters was done by the method of internal standards. All results were analysed by an electronic integrator.

**Sensory protocol.** Sensory evaluation was carried out four times (after bottling, after 12, 24 and 36 months of bottle aging) in 1996 and 1997 (Tables 1–3). Chardonnay wines were evaluated by three sensory methods and all

Table 1. Terms of sensory evaluation

Harvest	1993	1994	1995
Terms	months of bottle aging		
1996	24	12	0
1997	36	24	12

the results were statistically analysed (Amerine and Roessler 1983).

**Paired sample test.** In this test the judge is presented with two samples and asked to identify the one with well-defined characteristics. The test was run twice with a group of judges.

**Rank total test.** In the ranking procedure the judges are asked to arrange a series of more samples in decreasing order with respect to the characteristics. The test was run twice with a group of judges.

**Buxbaum method.** It is a 20-point method that requires detailed evaluation of each wine. In this test the judge gives scores for colour 0–2, appearance 0–2, aroma 0–4 and taste 0–12.

## RESULTS

The results of sensory evaluation of **normal harvest** (Tables 4–6) for Chardonnay wines by means of:

### Paired sample test

Question: Which of the two presented wines is better evaluated?

Answer (1996): All judges chose wines after bottling (harvest year 1995).

Answer (1997): All judges chose wines bottled for 12 months (harvest year 1995).

The sessions were performed twice. The significance of the answers in all sessions was on the level of 1%.

### Rank total test (line up from 1<sup>st</sup> to 3<sup>rd</sup> place)

Question: Line up the presented wines from 1<sup>st</sup> (the best) to 3<sup>rd</sup> place!

Answer (1996): All judges lined up the wines in this order:

1<sup>st</sup> = wines after bottling

2<sup>nd</sup> = wines after 12 months of bottle aging

3<sup>rd</sup> = wines after 36 months of bottle aging

Answer (1997): All judges lined up the wines in this order:

1<sup>st</sup> = wines after 12 months of bottle aging

2<sup>nd</sup> = wines after 24 months of bottle aging

3<sup>rd</sup> = wines after 36 months of bottle aging

According to Kramera citation by Amerine and Roessler (1983) the values in the intervals from 6 to 14 are not significant on the level of 5%. The values in the interval

Table 2. Concentration of some esters in Chardonnay wines during aging period

Ester (mg/l)	Harvest year	Harvest	Months in bottle			
			0	12	24	36
Ethyl butyrate	1993	A	0.36	0.36	0.23	0.12
		B	0.40	0.36	0.27	0.15
	1994	A	0.41	0.34	0.20	0.10
		B	0.44	0.23	0.19	0.00
	1995	A	0.52	0.30	0.10	–
		B	0.50	0.32	0.20	–
Isoamyl acetate	1993	A	1.57	1.31	0.90	0.10
		B	0.90	0.60	0.40	0.20
	1994	A	1.50	1.00	0.70	0.20
		B	0.69	0.48	0.30	0.25
	1995	A	1.80	1.00	0.30	–
		B	2.40	1.60	0.40	–
2-Phenethyl acetate	1993	A	0.20	0.00	0.00	0.00
		B	0.10	0.00	0.00	0.00
	1994	A	0.80	0.40	0.20	0.00
		B	0.60	0.20	0.10	0.00
	1995	A	0.63	0.30	0.10	–
		B	1.60	1.00	0.20	–
Diethyl succinate	1993	A	0.12	0.34	0.78	1.60
		B	0.60	0.70	0.82	1.50
	1994	A	0.00	0.75	1.06	1.90
		B	0.20	0.62	0.78	0.90
	1995	A	0.10	0.58	0.90	–
		B	0.20	0.40	0.60	–

A = normal harvest, B = late harvest

Table 3. Correlation coefficients of some esters

Ester	Normal harvest	Late harvest	LSD	
			$P \geq 5\%^*$	$P \geq 1\%^{**}$
Isoamyl acetate	0.6923**	0.7235**		
2-Phenethyl acetate	0.6852**	0.7221**	0.5529	0.6835
Ethyl butyrate	0.6922**	0.7252**		
Diethyl succinate	0.6843**	0.7136**		

from 6 to 19 are not significant on the level of 1%. All the results between these values are significant.

Putting the points in normal scores the results are as shown below:

Normal vintage 1995: 0.864

Normal vintage 1994: 0.346

Normal vintage 1993: -0.518

LSD 5% = 0.54, 1% = 0.76

The underlined values are not significant.

The session was performed twice. The significance of the answers in all sessions was on the level of 1%.

### Buxbaum method

Question: Give the following scores to each item: colour 0–2, appearance 0–2, aroma 0–4, taste 0–12, the best wine gets up to 20 scores.

Answer (1996): All the judges agreed that the best wine was after bottling harvested in the year 1995.

Answer (1997): All the judges agreed that the best wine was after 12 months of bottle aging (harvest year 1995).

The session was performed twice. The significance of the answers in all sessions was on the level of 0.1%.

The results of sensory evaluation of **late harvest** (Tables 7–9) for Chardonnay wines by means of:

### Paired sample test

Question: Which of the two presented wines is better evaluated?

Answer (1996): All judges chose wines bottled for 24 months (harvest 1993).

Answer (1997): All judges chose wines bottled for 36 months (harvest 1993).

The session was performed twice. The significance of the answers in all sessions was on the level of 1%.

### Rank total test (line up from 1<sup>st</sup> to 3<sup>rd</sup> place)

Question: Line up the presented wines from 1<sup>st</sup> (the best) to 3<sup>rd</sup> place!

Answer (1996): All judges lined up the wines in this order:

1<sup>st</sup> = wines after 24 months of bottle aging

2<sup>nd</sup> = wines after 36 months of bottle aging

3<sup>rd</sup> = wines after bottling

Answer (1997): All judges lined up the wines in this order:

1<sup>st</sup> = wines after 36 months of bottle aging

2<sup>nd</sup> = wines after 24 months of bottle aging

3<sup>rd</sup> = wines after 12 months of bottle aging

According to Kramera citation by Amerine and Roessler (1983) the values in the intervals from 6 to 14 are not significant on the level of 5%. The values in the interval from 6 to 19 are not significant on the level of 1%. All the results between these values are significant.

Putting the points in normal scores the results are as shown below:

Normal vintage 1995: 0.864

Normal vintage 1994: 0.346

Normal vintage 1993: -0.518

LSD 5% = 0.54, 1% = 0.76

The underlined values are not significant.

The session was performed twice. The significance of the answers in all sessions was on the level of 1%.

### Buxbaum method

Question: Give the following scores to each item: colour 0–2, appearance 0–2, aroma 0–4, taste 0–12, the best wine gets up to 20 scores.

Answer (1996): All the judges agreed that the best wine was after 24 months of bottle aging.

Answer (1997): All the judges agreed that the best wine was after 36 months of bottle aging.

The session was performed twice. The significance of the answers in all sessions were on the level of 0.1%.

### DISCUSSION

Acetates, which were initially produced enzymatically, are slowly hydrolysed during storage time until an equilibrium is reached with the corresponding acids and higher alcohols. Isoamyl acetate has a banana like aroma and 2-phenethyl acetate rose like aroma. The concentration of isoamyl acetate and 2-phenethyl acetate was higher in normal harvest wines in 1993 and 1994. Wines of late harvest in 1995 had higher concentrations of these ace-

Table 4. Results of sensory evaluation in 1996 and 1997 (normal)

Judge No.	Harvest year					
	1995	1994	1995	1993	1994	1993
1	+	—	+	—	—	—
2	+	—	+	—	—	—
3	+	—	+	—	—	—
4	+	—	+	—	—	—
5	+	—	+	—	—	—
Total	5	0	5	0	0	0

*LSD* 5% = 5.19, *LSD* 1% = 5.89

Table 5. Results of sensory evaluation in 1996 and 1997 (normal)

Line	Vintages of wines	Sum
1	1995	5**
2	1994	12
3	1993	13

*LSD* 5% = 6–14, *LSD* 1% = 6–19

Table 6. Results of sensory evaluation (normal)

Sample No.	Harvest year	Score 1996	Score 1997
1	1995	18.5***	18.2***
2	1994	17.6	17.4
3	1993	16.2	15.2

Significant: 5%\*, 1%\*\*, 0.1%\*\*\* = 0.46, 0.64, 0.88

tate esters. A decrease in acetate concentration, isoamyl acetate and 2-phenethyl acetate (Table 2) could be responsible for the loss of fruitiness. Diethyl succinate, which was at a higher concentration in late harvest wines, increased during bottle aging, which was expected. The increase in diethyl succinate concentration could be responsible for an aging bouquet of Chardonnay wines. There is a good agreement between the sensory and chemical data for the analysed Chardonnay wines of normal and late harvest.

The loss of fruity aroma as measured by chemical methods together with the results of sensory evaluation suggests that Chardonnay wines of late harvest age more like Muscat type wines than Riesling wines. Rapp and Mandery (1986) reported that Muscat wines, which have an intense floral aroma, seldom improve with aging, whereas Riesling-like wines do not suffer any negative effects upon aging.

## CONCLUSION

Chardonnay wines were harvested in 1993, 1994 and 1995 as a normal harvest and as late harvest wines. The

Table 7. Results of sensory evaluation in 1996 and 1997 (late)

Judge No.	Harvest year					
	1993	1994	1993	1995	1994	1993
1	+	—	+	—	—	—
2	+	—	+	—	—	—
3	+	—	+	—	—	—
4	+	—	+	—	—	—
5	+	—	+	—	—	—
Total	5	0	5	0	0	0

*LSD* 5% = 5.19, *LSD* 1% = 5.89

Table 8. Results of sensory evaluation in 1996 and 1997 (late)

Line	Vintages of wines	Sum
1	1993	5**
2	1994	11
3	1995	14

*LSD* 5% = 6–14, *LSD* 1% = 6–19

Table 9. Results of sensory evaluation (late)

Sample No.	Harvest year	Score 1996	Score 1997
1	1993	19.8***	19.9***
2	1994	18.7**	19.4
3	1995	17.9	18.7

Significant: 5%\*, 1%\*\*, 0.1%\*\*\* = 0.46, 0.64, 0.88

wines were bottled and stored in cellar at 12°C and 75% of humidity. After bottling, after 12, 24 and 36 months and by using different methods, wines were sensory evaluated and analysed for some esters. The obtained results allow us to conclude:

Wines from normal harvest achieve the best quality immediately after bottling and after 12 month aging, respectively, due to the concentration of acetate esters. The wines from normal harvest that age for a longer period (24 and 36 months), under reductive conditions in the bottle, lose in their quality. The concentration of acetate esters decreases and there is a strong correlation on the level  $P \geq 1\%$ .

Wines from late harvest achieve the best quality after 24 and 36 months of bottle aging, respectively. The decrease in diethyl succinate gives the wines nobility and improves the late harvest note in them. All other wines (immediately after bottling and after 12 months of aging, respectively) do not achieve the harmony of complexity and nobility of late harvest that is required for those wines. Those wines are too young. Justifiability of the obtained results is on the level of  $P \geq 1\%$  and  $P \geq 0.1\%$ . The obtained results imply that bottle-aging of wines must be controlled with great care to obtain great white wines.

## REFERENCES

- Amerine M.A., Roessler A.B. (1983): Wines and their sensory evaluation. Freeman W.H., New York.
- Axel R. (1995): The molecular logic of smell. *Sci. Am.*, 273: 154–159.
- Bartoshuk L.M., Beauchamp G.K. (1994): Chemical senses. *Ann. Psych.*, 45: 419–449.
- Boulton R.B., Singleton V.L., Bisson L.F., Kunkee R.E. (1996): Principles and practice of winemaking. Chapman & Hall Enol. Libr., New York.
- Kantz K., Singleton V.L. (1991): Isolation and determination of polymeric polyphenols in wines using Sephadex LH-20. *Am. J. Enol. Vitic.*, 42: 309–316.
- Kinamon S.C. (1996): A bitter-sweet beginning. *Nature*, 381: 737–738.
- Marić J. (1999): Changes in chemical and sensory characteristics in Chardonnay wines during bottle aging. [Ph.D. Thesis.] Fac. Agric. Univ. Zagreb, Croatia.
- Noble A.C., Bursick G.F. (1984): The contribution of glycerol to perceived viscosity and sweetness in white wine. *Am. J. Enol. Vitic.*, 35: 110–112.
- Rapp A., Mandery A. (1986): Wine aroma. *Experientia*, 42: 873–884.
- Thorngate J.H. (1997): The physiology of human sensory response to wine: A Review. *Am. J. Enol. Vitic.*, 48: 271–280.

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## ABSTRAKT

### Senzorické hodnocení a některé acetát estery ve vínech Chardonnay stárnoucích v lahvích

V průběhu pěti let jsme se zaměřili na zjištění korelací mezi chemickými analýzami a senzorickými vlastnostmi vína během jeho stárnutí v lahvích. Hrozny odrůdy Chardonnay jsme sklídili v normálním a pozdním sklizňovém termínu. Po odděleném vinném kvašení jsme lahve uložili do podzemního sklepa při teplotě 12 °C a 75% vlhkosti. Chemické a senzorické analýzy jsme prováděli po naplnění lahví (0) a dále po 12, 24 a 36 měsících stárnutí vína v lahvích. Výsledky chemického a senzorického hodnocení ukazují na silnou korelaci mezi buketem mladého vína a snížením koncentrace izoamyl a 2-fenetyl acetátů a mezi zvýšením obsahu dietyljantarátu a buketem vína v lahvích.

**Klíčová slova:** estery; senzorická analýza; stárnutí v lahvích; bílé víno; Chardonnay

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