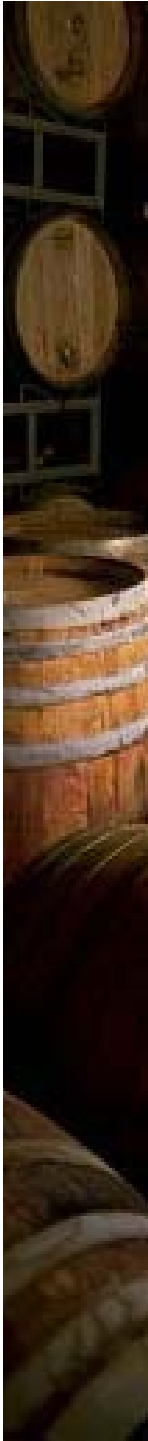


Oak alternatives:  
a balance between science and finance

Kerry L. Wilkinson  
The University of Adelaide

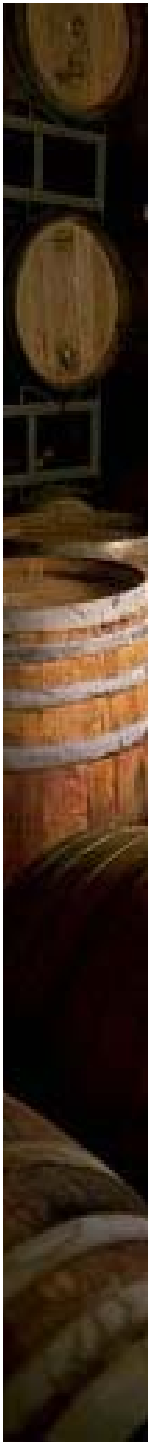


# The Origin of Oak Cooperage

Oak cooperage dates back over 2000 years to the Roman Empire  
Wooden barrels replaced clay and earthenware pots (more robust, less cumbersome)

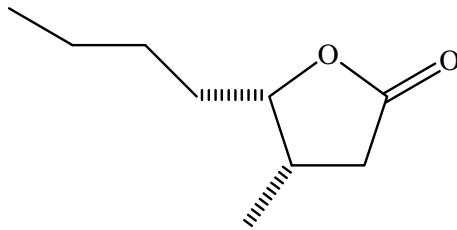
Initially, oak wood used to manufacture wine barrels because:  
readily available in wine producing parts of the world  
possessed desirable mechanical properties  
(strength, durability, workability and low leakage rates)

However, oak also improved quality of wine and spirits  
improves flavour, colour and stability  
reduces astringency  
enhances character and complexity  
(slow evaporation, controlled oxidation, flavour extraction)

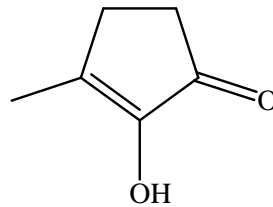


# The Chemical Composition of Oak Wood

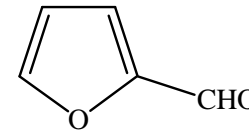
Structural formula of some oak components and their aroma descriptors



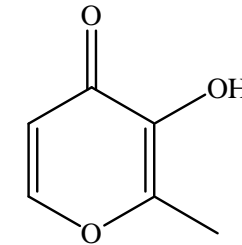
**cis-oak lactone**  
*coconut, vanilla*



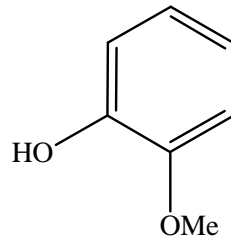
**2-hydroxy-3-methyl  
cyclopent-2-enone**  
*caramel, sweet, toasty*



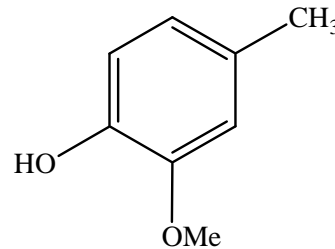
**2-furfural**  
*caramel, vanilla-like*



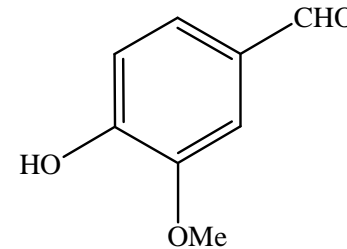
**maltol**  
*caramel, sweet, toasty*



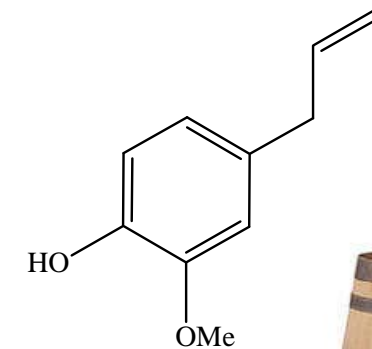
**guaiacol**  
*smoky, burnt bacon*



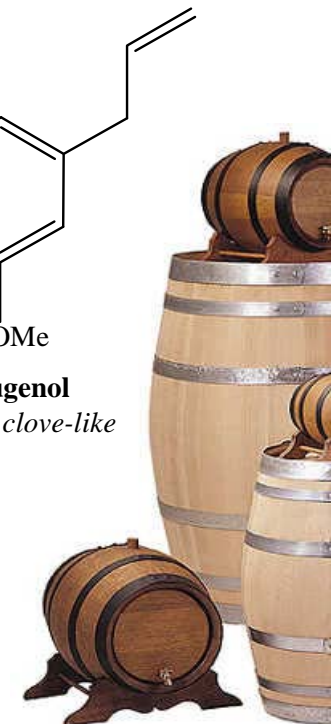
**4-methylguaiacol**  
*smoky*



**vanillin**  
*vanilla*

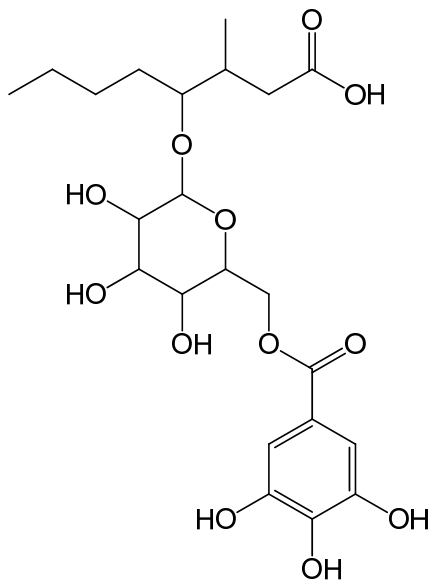


**eugenol**  
*spicy, clove-like*

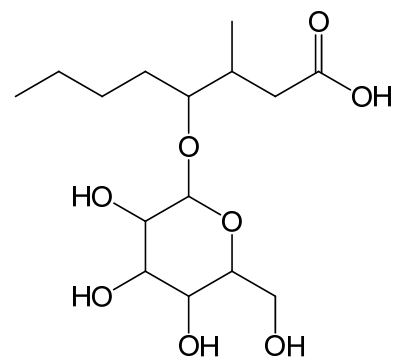


# The Chemical Composition of Oak Wood

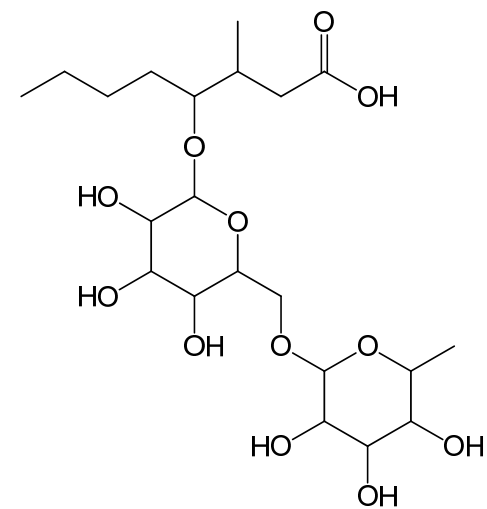
Oak lactone also extracted in glycoconjugate forms (precursors)



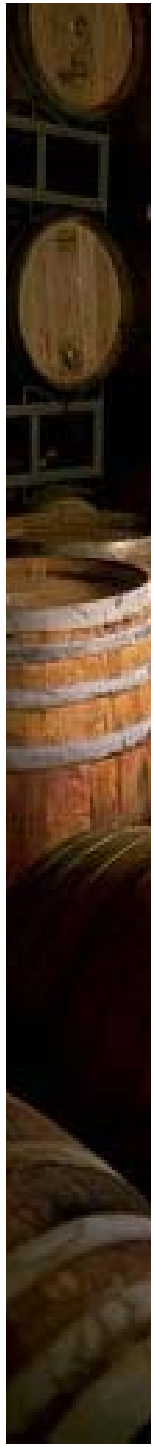
ring-opened oak lactone gallateglucoside



ring-opened oak lactone glucoside



ring-opened oak lactone rutinoside

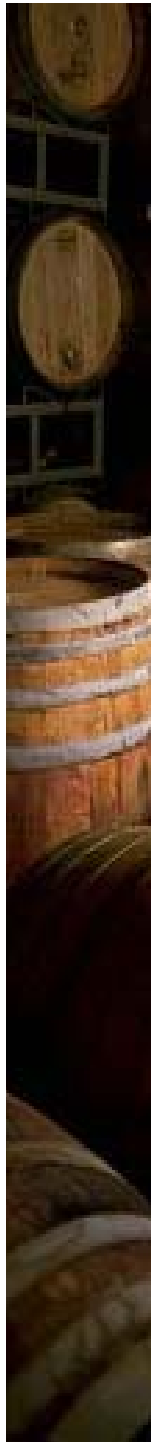


# Variability in Oak Composition

Oak type	Toasting conditions	Concentration ( $\mu\text{g/L}$ )				
		<i>cis</i> -oak lactone	<i>trans</i> -oak lactone	guaiacol	4-methyl guaiacol	vanillin
French oak	unheated	115	68	<1	nd	79
	200 °C	114	68	3	8	392
	235 °C	65	34	129	102	1900
American oak	unheated	492	47	<1	nd	95
	200 °C	479	47	5	5	325
	235 °C	423	49	92	79	1400

(Campbell et al. 2005)

Challenge: to optimise oak expression to winemakers' goals and desired wine style – i.e. to control variability!



# The Cost of Oak Maturation

Traditionally, wine is matured in oak barrels, but oak is an expensive raw material

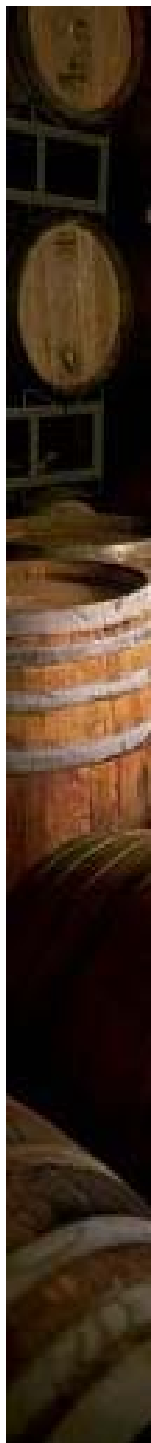
Barrels contribute significantly to production costs (both capital and labour)

Finite pool of extractable volatiles, thus barrels decommissioned after 3-5 years

Wine Australia: Directions to 2025 Case Study: Cost of Wine Maturation

Table 1: Cost effect of maturation

Description	Cost to make \$/per case	Cost increase compared to no Oak %	Retail price to achieve 50% gross margin \$ per 750ml bottle
No oak	99.97	-	40.00
One year in new French oak	160.32	60.4	64.00
Two years in new French oak	204.43	104.5	82.00
Two years in new French oak and 1 year in bottle	237.74	137.8	95.00
Two years in new French oak and 2 years in bottle	274.39	174.5	110.00



# Introduction to Oak Alternatives

While barrel maturation is still preferred for production of premium wines...

The range and application of oak alternatives (staves, chips, powders) has increased



As more rapid and economical methods of oak maturation

less oak wood rejected

increased surface area gives greater rates of extraction

micro-oxygenation enables introduction of oxygen

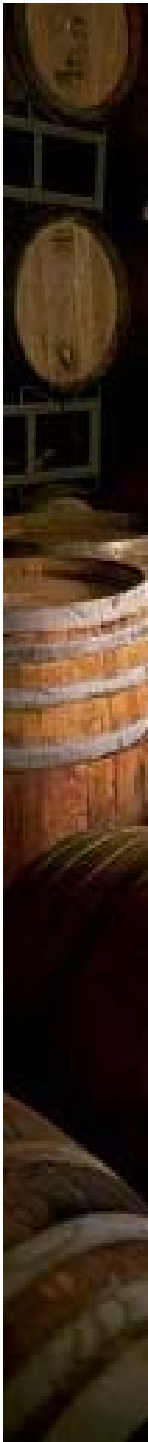
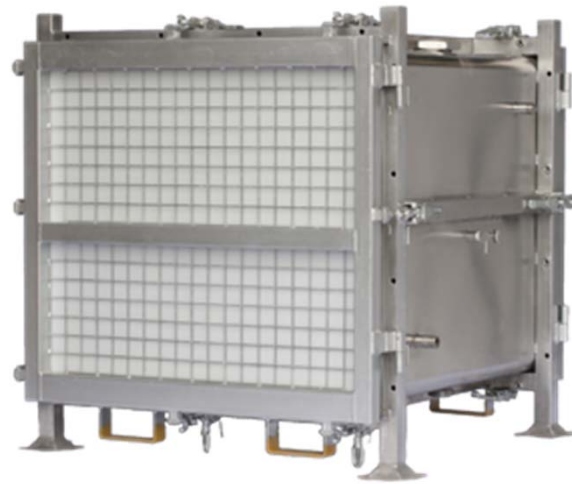
But, potential for 'over-oaking'





# Introduction to Oak Alternatives

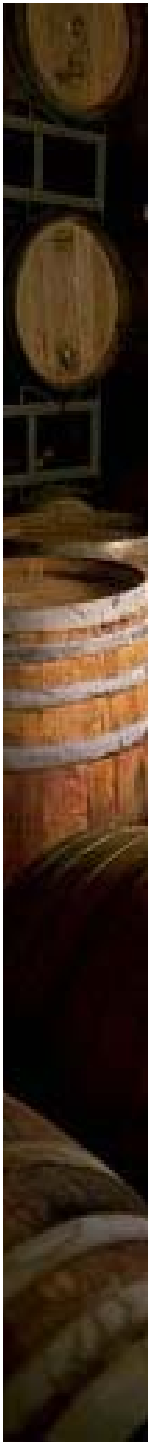
Oak alternatives used in conjunction with 'barrel alternatives'





# Trial 1: Evaluation of Barrel Alternatives

wine	code	maturations vessel	volume (L)	oak regime
2009	SSVAT	stainless steel vat	900	2 g/L chips
Padthaway	P1VAT	ss vat, 2 x 4.5mm plastic panels	900	2 g/L chips
Cabernet	P2VAT	ss vat, 2 x 1.5mm plastic panels	900	2 g/L chips
Sauvignon (12 months)	FOVAT	ss vat, 2 x oak panels	900	1.6 m <sup>2</sup> panels
	Barrel	barrels	225-300	various
2011	SS +OAK	stainless steel tank	4550	staves (1.4 m <sup>2</sup> /KL)
Eden Valley	SS -OAK	stainless steel tank	4550	no oak
Cabernet	P1 +OAK	plastic tank	1000	staves (1.4 m <sup>2</sup> /KL)
Sauvignon	P1 -OAK	plastic tank	1000	no oak
(4 months)	P2 +OAK	plastic tank	1000	staves (1.4 m <sup>2</sup> /KL)
	P2 -OAK	plastic tank	1000	no oak



# Trial 1: Evaluation of Barrel Alternatives

Various analyses performed on wines post-maturation

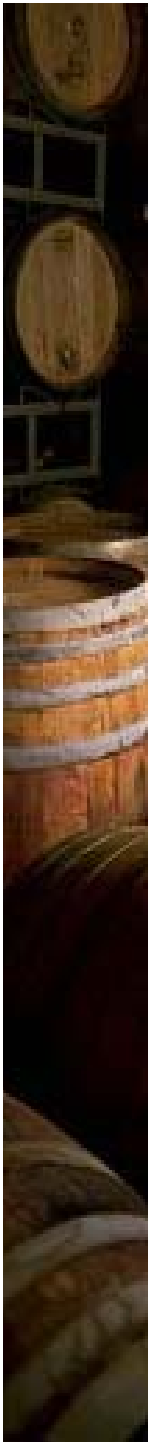
Compositional analysis (including quantification of oak volatiles by GC-MS)

Descriptive sensory analysis (trained panel)

Quality ratings (expert panel)

Consumer liking trials

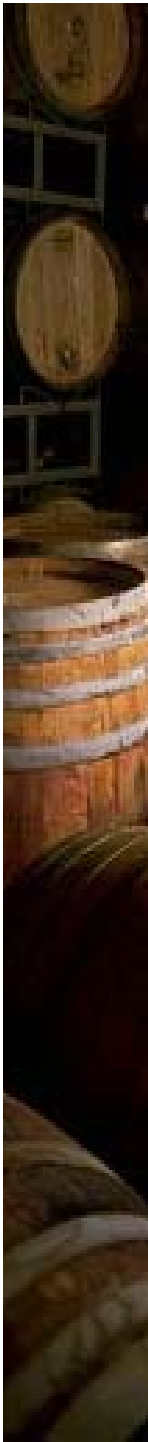
		colour density	wine hue	phenolics (au)	alcohol (% v/v)	pH	TA (g/L)
2009 Padthaway	mean	12.6	0.84	61	14.6	3.43	6.1
Cabernet Sauvignon	range	12.4–12.8	0.83–0.86	60–62	14.5–14.6	3.43–3.45	6.0–6.2
2011 Eden Valley	mean	9.9	0.77	53	14.2	3.51	6.4
Cabernet Sauvignon	range	9.7–10.2	0.76–0.80	51–57	14.1–14.3	3.50–3.53	6.4–6.6



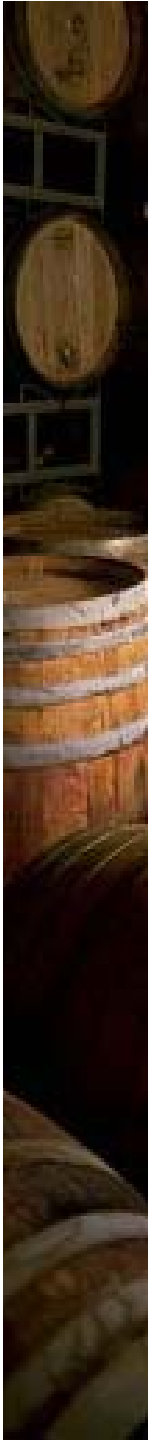
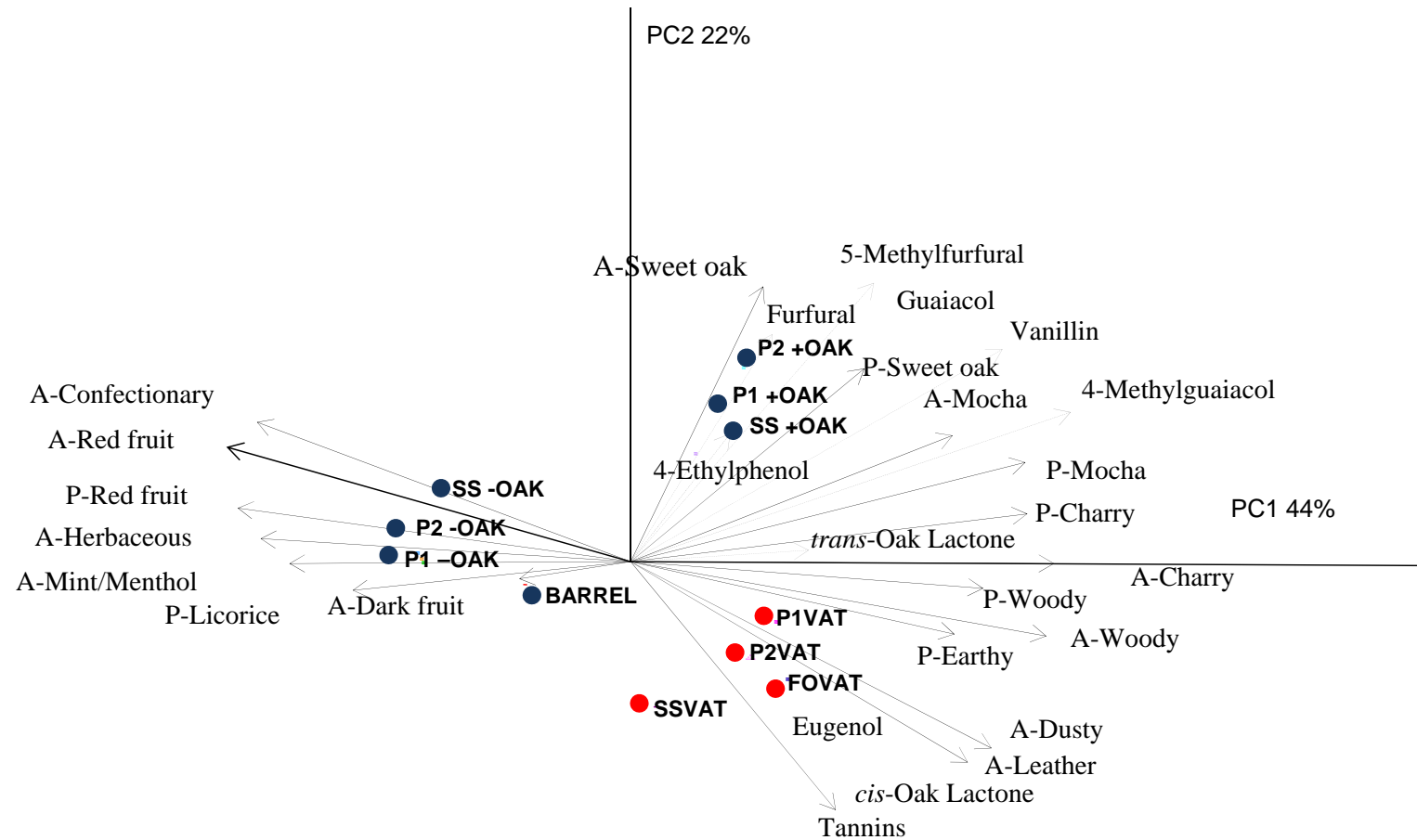
# Trial 1: Evaluation of Barrel Alternatives

		concentration ( $\mu\text{g/L}$ )					
		<i>cis</i> -oak lactone	<i>trans</i> -oak lactone	guaiacol	eugenol	vanillin	furfural
2009 Padthaway Cabernet Sauvignon (12 months)	SSVAT	128 $\pm$ 1 a	23 $\pm$ 0	7 $\pm$ 0 b	12 $\pm$ 1	54 $\pm$ 1 b	121 $\pm$ 0
	P1VAT	121 $\pm$ 1 b	27 $\pm$ 3	8 $\pm$ 0 a	5 $\pm$ 7	153 $\pm$ 12 a	123 $\pm$ 1
	P2VAT	121 $\pm$ 1 b	29 $\pm$ 0	8 $\pm$ 0 a	nd	128 $\pm$ 42 ab	119 $\pm$ 3
	FOVAT	122 $\pm$ 4 b	29 $\pm$ 3	8 $\pm$ 0 a	10 $\pm$ 0	131 $\pm$ 19 ab	119 $\pm$ 2
	Barrel	99 $\pm$ 1 a	79 $\pm$ 4 a	4 $\pm$ 1 c	6 $\pm$ 9	123 $\pm$ 3 b	261 $\pm$ 24 c
2011 Eden Valley Cabernet Sauvignon (4 months)	SS +OAK	39 $\pm$ 1 c	30 $\pm$ 1 c	28 $\pm$ 1 b	nd	242 $\pm$ 5 a	1877 $\pm$ 2 b
	SS -OAK	nd	nd	4 $\pm$ 1 c	nd	18 $\pm$ 7 c	173 $\pm$ 1 cd
	P1 +OAK	30 $\pm$ 1 d	46 $\pm$ 2 b	27 $\pm$ 1 b	nd	281 $\pm$ 64 a	32 $\pm$ 1 e
	P1 -OAK	nd	nd	4 $\pm$ 1 c	nd	6 $\pm$ 8 c	121 $\pm$ 4 de
	P2 +OAK	47 $\pm$ 1b	24 $\pm$ 2 d	33 $\pm$ 1 a	6 $\pm$ 8	313 $\pm$ 98 a	2633 $\pm$ 141 a
	P2 -OAK	nd	nd	3 $\pm$ 0 c	nd	20 $\pm$ 11 c	116 $\pm$ 4 de

nd = not detected



# Trial 1: Evaluation of Barrel Alternatives

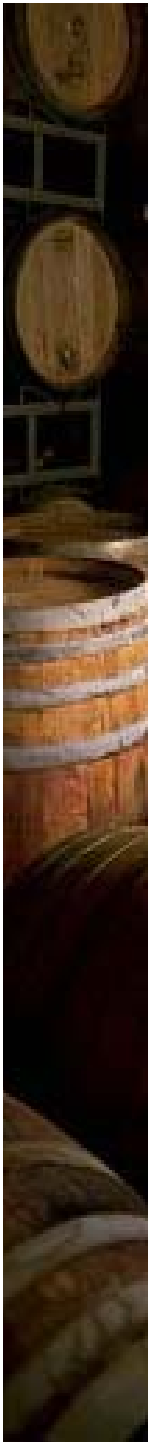


# Trial 1: Evaluation of Barrel Alternatives

	hedonic ratings <sup>a</sup>				quality ratings <sup>b</sup>
	total sample (n=116)	cluster 1 (n=35)	cluster 2 (n=55)	cluster 3 (n=26)	wine experts (n=10)
Barrel	5.7	5.11 b	6.35 a	4.85 b	13.8
SS +OAK	5.8	4.49 b	6.45 a	6.12 a	14.4
P1 +OAK	5.9	4.31 b	6.60 a	6.23 a	14.8
P1 -OAK	5.9	3.91 b	6.73 a	6.58 a	13.9
P2VAT	5.9	5.80 b	7.00 a	3.42 c	14.7

<sup>a</sup> 9-point scale, where 1 = strongly dislike and 9 = strongly like

<sup>b</sup> 20 point wine show judging system



## Trial 2: Evaluation of Consumer Attitudes

	total sample (n=1015)	oaked wine consumer segment (n=847)	hedonic ratings			
			cluster 1 (n=461)	cluster 2 (n=133)	cluster 3 (n=141)	cluster 4 (n=112)
<i>Enjoy drinking oaked wines</i>						
No	16.6	-	-	-	-	-
Yes	44.4	-	47.3	55.6	58.2	68.8
Sometimes	39.0	-	52.7	44.4	41.8	31.3
<i>Prefer French or American oak</i>						
Not sure/no preference	-	81.0	92.6	75.9	79.5	41.1
French	-	17.1	6.5	21.1	17.0	56.3
American	-	1.9	0.9	3.0	3.5	2.7
<i>Able to tell the difference between wine made in barrel or with alternative</i>						
No	-	78.3	90.9	78.9	78.00	25.9
Yes	-	21.7	9.1	21.1	22.0	74.1



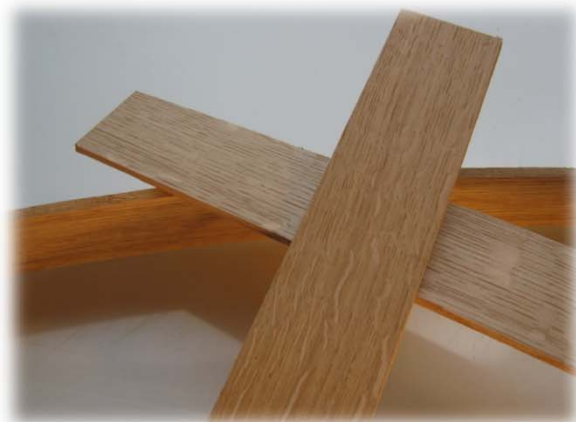


# Trial 3: Flavour Potential of Oak from Old Barrels

Are decommissioned barrels an untapped source of high quality oak?

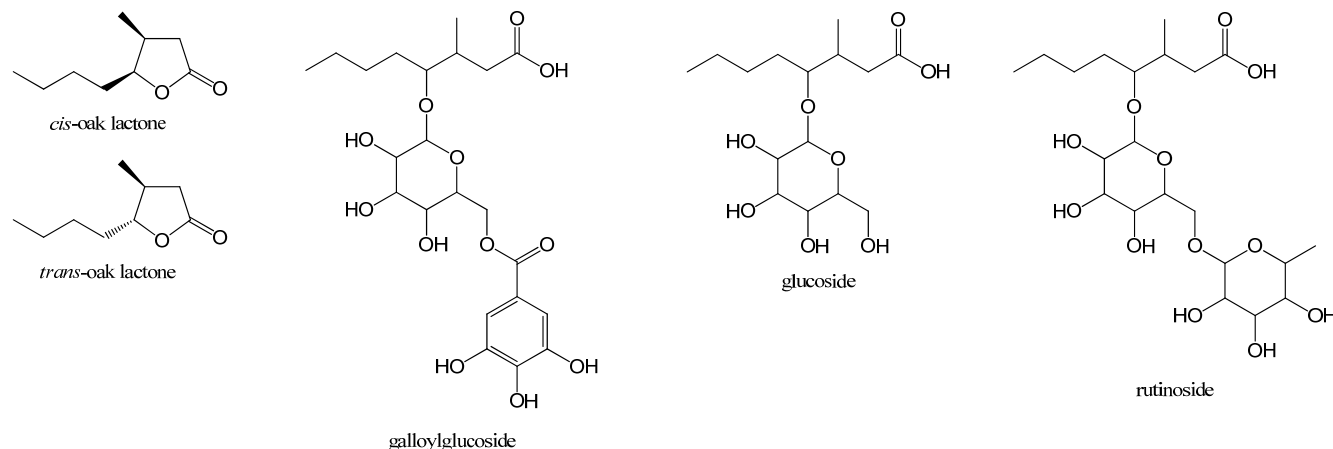
Oak battens prepared from oak wood recovered from old French and American barrels

1. barrel disassembled into individual staves
2. staves split laterally, wine-affected oak wood discarded
3. 'reclaimed' oak battens planed to expose fresh grain
4. oak battens toasted to release volatiles



# Trial 3: Flavour Potential of Oak from Old Barrels

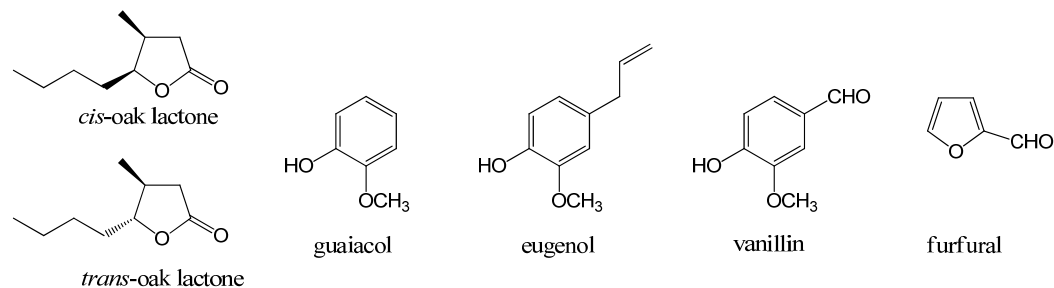
Quantification of glycoconjugate precursors of oak lactone in *untoasted reclaimed oak*



Oak Samples	Concentration (µg/g)		
	galloylglucoside	glucoside	rutinoides
<b>new French oak</b>	<b>6.7-353.9</b>	<b>1.0-26.2</b>	<b>0.2-20.2</b>
reclaimed French oak	mean	129.6	8.4
	range	0.5-283.7	0.1-82.6
<b>new American oak</b>	-	<b>4.9-42.0</b>	-
reclaimed American oak	mean	239.4	58.3
	range	0.18-402.5	0.02-169.9

# Trial 3: Flavour Potential of Oak from Old Barrels

Quantification of oak volatiles in *toasted reclaimed oak*



Oak Samples	Concentration ( $\mu\text{g/g}$ )					
	<i>cis</i> -OL	<i>trans</i> -OL	guaiacol	eugenol	vanillin	furfural
new French oak	nd-11.4	nd-6.8	2.3-18.5	0.7-2.3	53-190	108-963
reclaimed French oak	nd-33.4	nd-73.1	1.5-11.6	2.7-7.7	58-115	786-1376
new American oak	12.3-47.9	3.3-5.3	4.3-13.5	4.2-6.1	42-140	55-1539
reclaimed American oak	nd-65.5	nd-9.1	0.8-12.3	2.3-6.2	70-137	412-1134

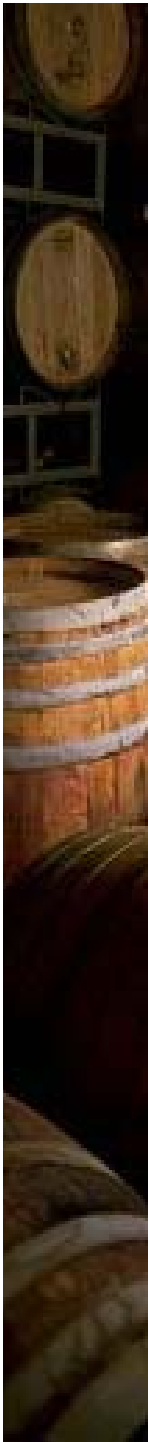
# Trial 3: Flavour Potential of Oak from Old Barrels

Barrel reclaim costs approximately \$150/barrel (or \$2.50 per stave)

Each barrel gives approximately 60 battens (~8 m<sup>2</sup> of extractable oak surface area)

Cost of oak maturation:

	1	2	3	4	5	6	7	8	9	Total	Cost
US oak barrel (300 x 300L @\$900 each)	270K	-	-	270K	-	-	270K	-	-	810K	\$1.00/L
Fr oak barrel (300 x 300L @\$1500 each)	450K	-	-	450K	-	-	450K	-	-	1,350K	\$1.67/L
Stakvat (100 x 900L @\$4730 each)	473K	-	-	-	-	-	-	-	-	581K	\$0.72/L
	12K	12K	12K	12K	12K	12K	12K	12K	12K		



# Conclusions

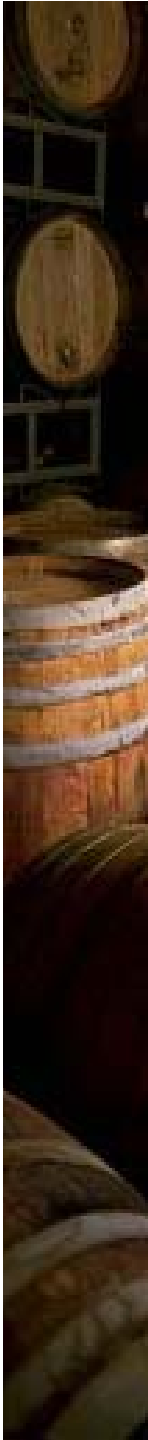
Oak/barrel alternatives certainly impart oak aroma and flavour

Provide winemakers a cost-effective method of oak maturation

Knowledgeable consumers appreciate/value traditional barrel maturation  
(for which they are willing to pay a price premium)

Less knowledgeable consumers were accepting of oak alternatives  
(which justifies their use by winemakers for wines at lower price points)

Potential for improved utility of cooperage oak - i.e. recycling old oak barrels







# Acknowledgements

Anna Crump, Sijing Li



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Peter Warren, Ausvat

**ausvat**<sup>o</sup>

wine, environmental and  
micro-climate technologies



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