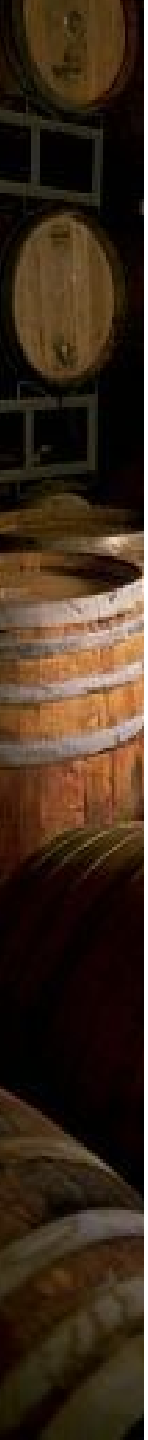
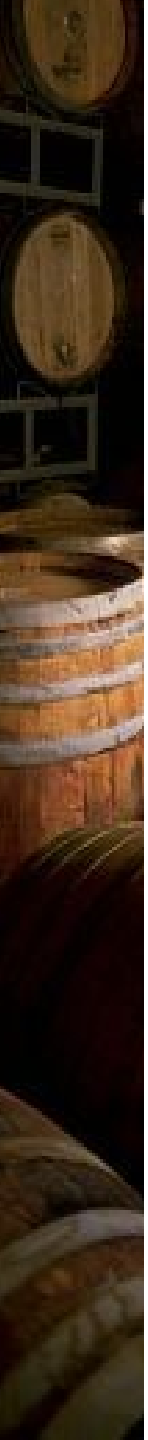


Alternatives to oak barrel maturation
&
Flavour potential of reclaimed oak

Kerry L. Wilkinson

The University of Adelaide



The Origin of Oak Cooperage

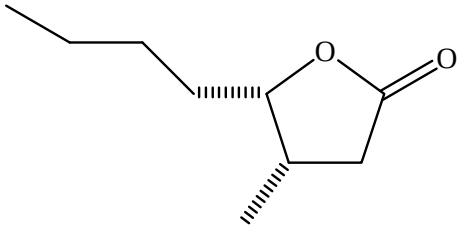
Oak cooperage dates back over 2000 years to the Roman Empire
Wooden barrels replaced clay and earthenware pots (more robust, less cumbersome)

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)

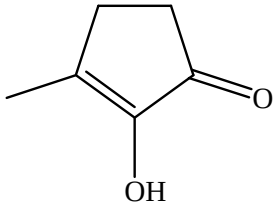
However, oak also improved quality of wine and spirits
- improves flavour, colour and stability
- reduces astringency
- enhances character and complexity
- (slow evaporation, controlled oxidation, flavour extraction)

The Chemical Composition of Oak Wood

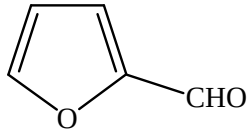
Structural formula of some oak components and their aroma descriptors



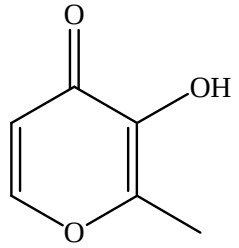
***cis*-oak lactone**
coconut, vanilla



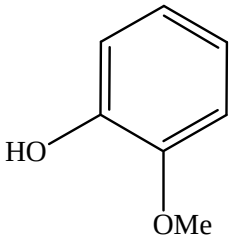
2-hydroxy-3-methyl cyclopent-2-enone
caramel, sweet, toasty



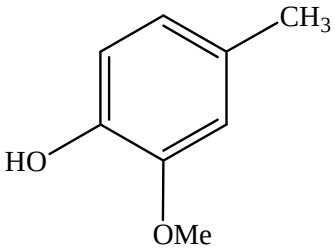
2-furfural
caramel, vanilla-like



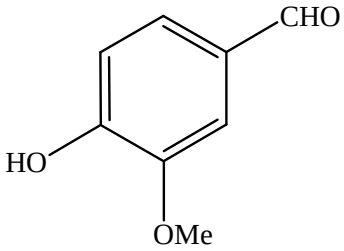
maltol
caramel, sweet, toasty



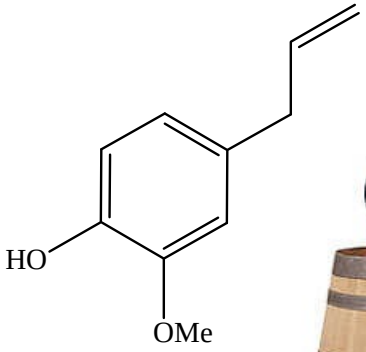
guaiacol
smoky, burnt bacon



4-methylguaiacol
smoky



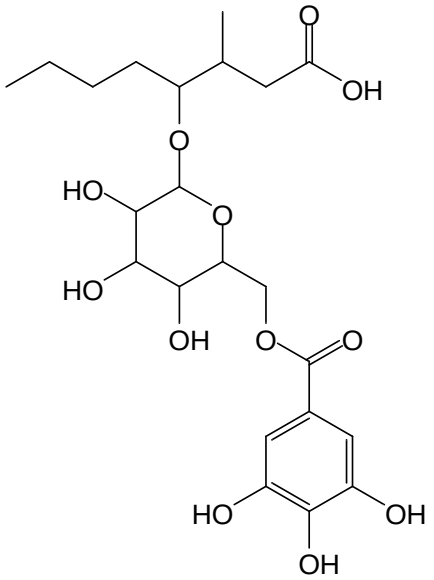
vanillin
vanilla



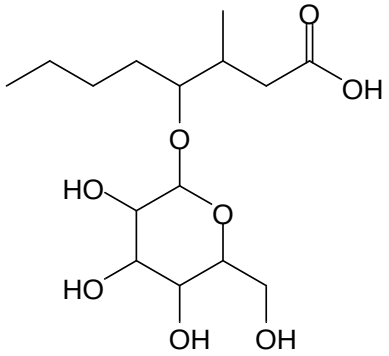
eugenol
spicy, clove-like

The Chemical Composition of Oak Wood

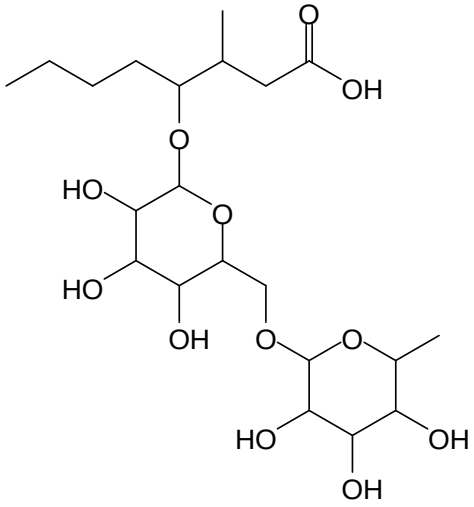
Oak lactone also extracted in glycoconjugate forms (precursors)



ring-opened oak lactone gallateglucoside



ring-opened oak lactone glucoside



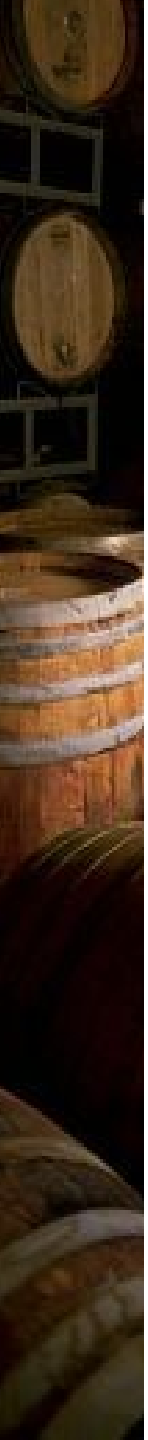
ring-opened oak lactone rutinoside

Variability in Oak Composition

Oak type	Toasting conditions	Concentration (µg/L)				
		cis-oak lactone	*trans*-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

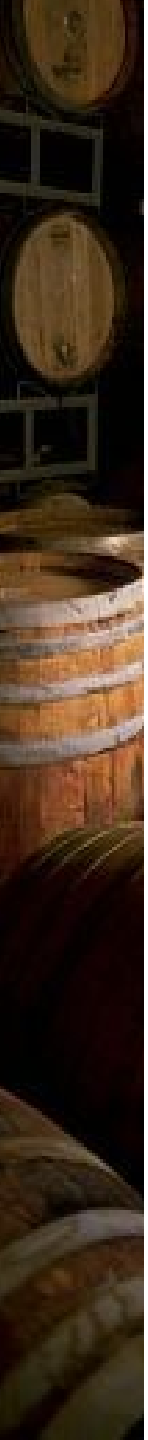
As more rapid and economical methods of oak maturation

- less oak wood rejected
- increased surface area gives greater rates of extraction
- micro-oxygenation enables introduction of oxygen

But, potential for ‘over-oaking’

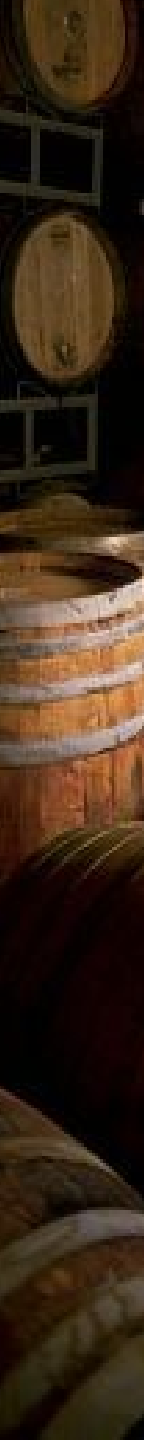
Introduction to Oak Alternatives

Oak alternatives used in conjunction with ‘barrel alternatives’



Trial 1: Evaluation of Barrel Alternatives

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



Trial 1: Evaluation of Barrel Alternatives

Various analyses performed on wines post-maturation

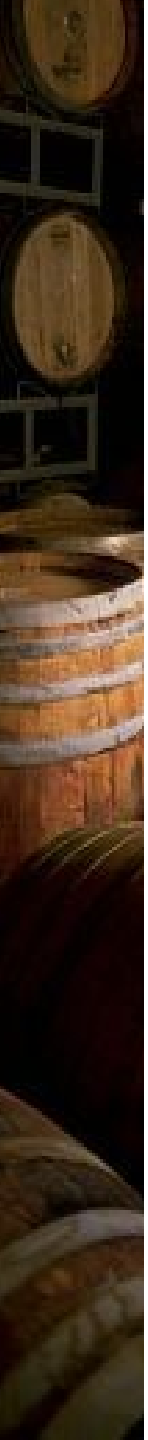
Compositional analysis (including quantification of oak volatiles by GC-MS)

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 Cabernet Sauvignon	mean	12.6	0.84	61	14.6	3.43	6.1
	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 Cabernet Sauvignon	mean	9.9	0.77	53	14.2	3.51	6.4
	range	9.7–10.2	0.76–0.80	51–57	14.1–14.3	3.50–3.53	6.4–6.6

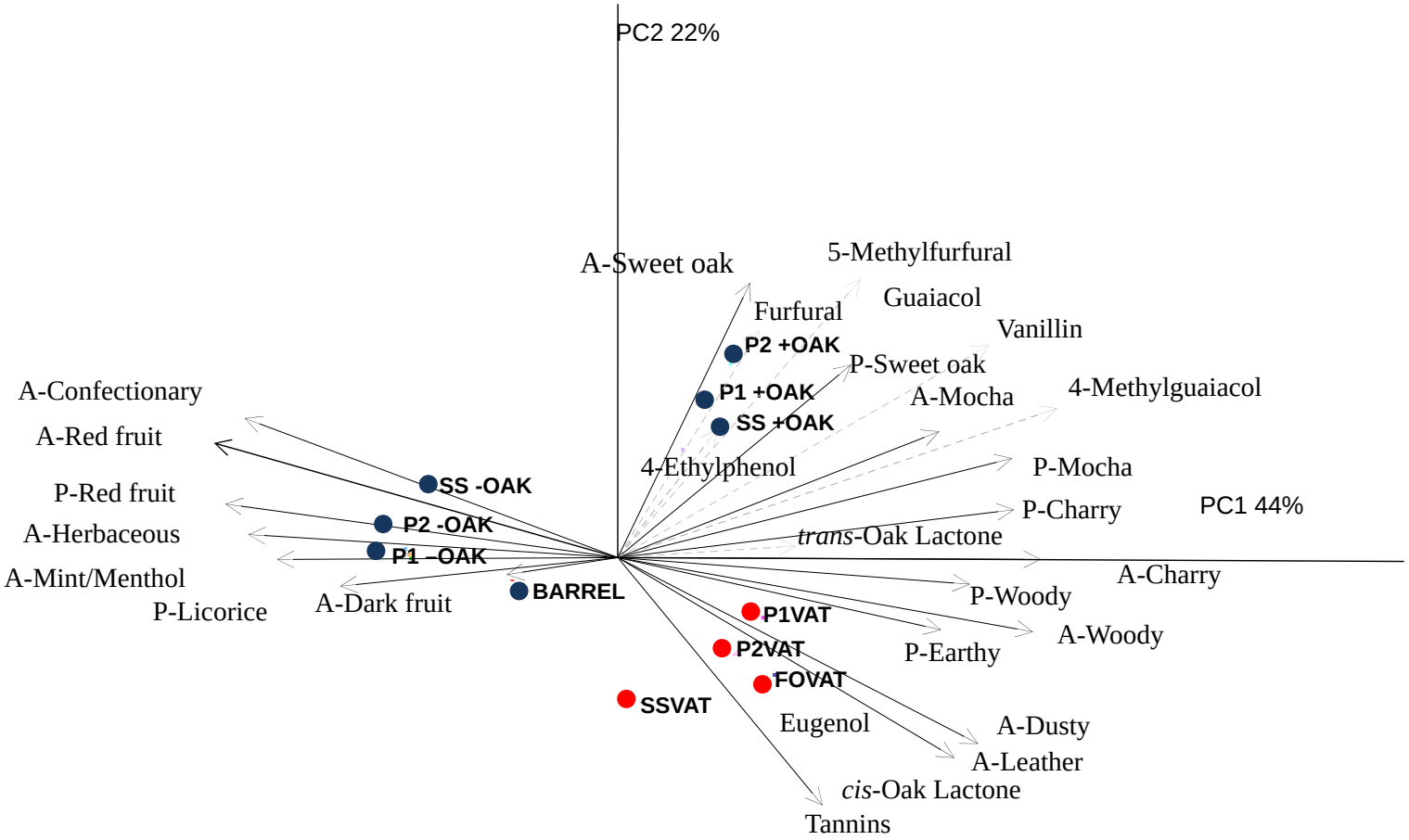


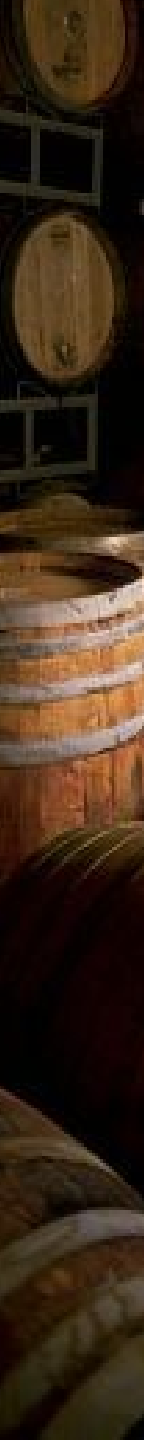
Trial 1: Evaluation of Barrel Alternatives

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

nd = not detected

Trial 1: Evaluation of Barrel Alternatives



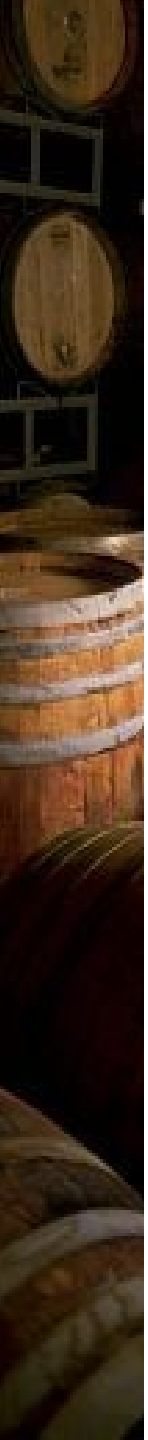


Trial 1: Evaluation of Barrel Alternatives

	hedonic ratings[a]				quality ratings[b]
	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

[a] 9-point scale, where 1 = strongly dislike and 9 = strongly like

[b] 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)
Enjoy drinking oaked wines						
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
Prefer French or American oak						
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
Able to tell the difference between wine made in barrel or with alternative						
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?

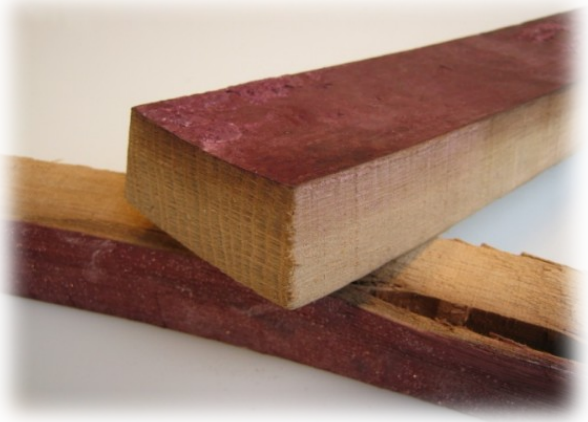
Oak battens prepared from oak wood recovered from old French and American barrels

1. barrel disassembled into individual staves

2. staves split laterally, wine-affected oak wood discarded

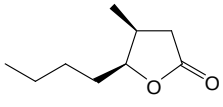
3. ‘reclaimed’ oak battens planed to expose fresh grain

4. oak battens toasted to release volatiles

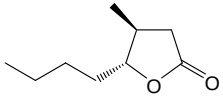


Trial 3: Flavour Potential of Oak from Old Barrels

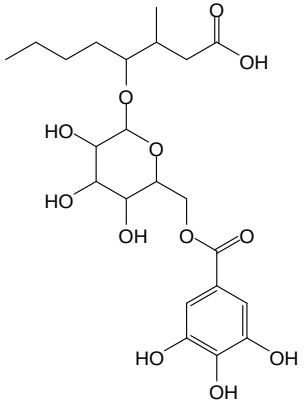
Quantification of glycoconjugate precursors of oak lactone in ***untoasted reclaimed oak***



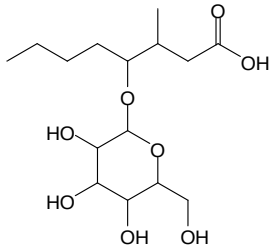
cis-oak lactone



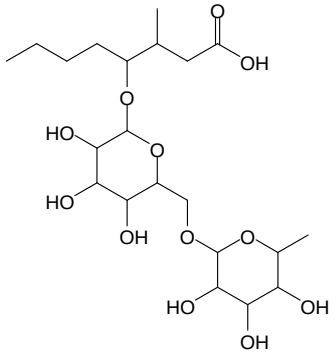
trans-oak lactone



galloylglucoside



glucoside

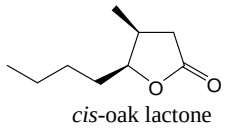


rutinoside

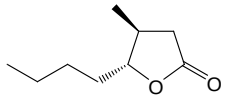
Oak Samples		Concentration (µg/g)		
		galloylglucoside	glucoside	rutinoside
new French oak		6.7-353.9	1.0-26.2	0.2-20.2
reclaimed French oak	mean	129.6	13.4	8.4
	range	0.5-283.7	0.2-37.6	0.1-82.6
new American oak		-	4.9-42.0	-
reclaimed American oak	mean	239.4	25.0	58.3
	range	0.18-402.5	0.03-51.4	0.02-169.9

Trial 3: Flavour Potential of Oak from Old Barrels

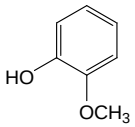
Quantification of oak volatiles in ***toasted reclaimed oak***



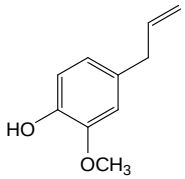
cis-oak lactone



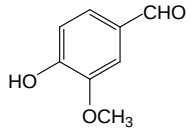
trans-oak lactone



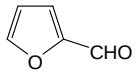
guaiacol



eugenol



vanillin



furfural

Oak Samples	Concentration (µg/g)					
	cis-OL	*trans*-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

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 oak barrels

Acknowledgements

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Peter Warren, Ausvat

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