



Ethanol Removal from Wine: Making More with Less

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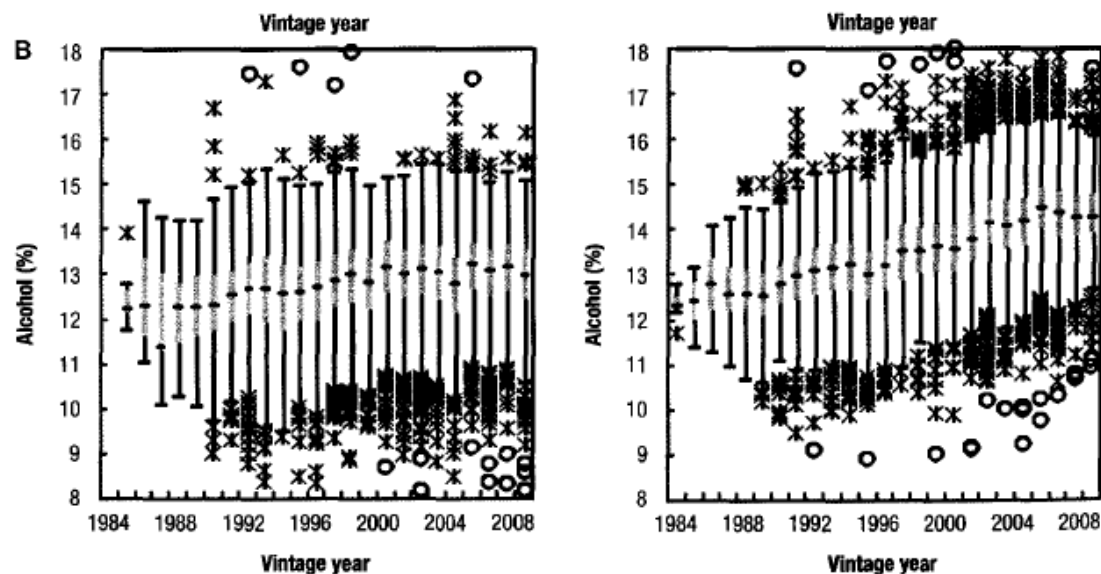
**School of Agricultural and Wine Sciences and
National Wine and Grape Industry Centre
Charles Sturt University**

The National Wine and Grape Industry Centre is a research centre within Charles Sturt University in alliance with the Department of Primary Industries NSW and the NSW Wine Industry Association

www.csu.edu.au/nwgic

Alcohol Levels Going Up

- Australia
 - Red wines: 12.4% (1984) to 14.4% (2008)
 - White wines: 12.5% (1985) to 12.9% (2008)



Why Remove Alcohol ?

- Wine style
- Health – disease, injury
- Social impacts – drink driving, violence
- Financial impacts – some jurisdictions tax according to alcohol content
- Pressure to reduce alcohol consumption
 - International – WHO: Global strategy to reduce harmful use of alcohol (2010) http://www.who.int/substance_abuse/activities/gsrhua/en/
 - State / national government <http://www.alcohol.gov.au/internet/alcohol/publishing.nsf/Content/home>
 - Non-government e.g. Australian Medical Association <https://ama.com.au/youthhealth/alcohol>

Overview

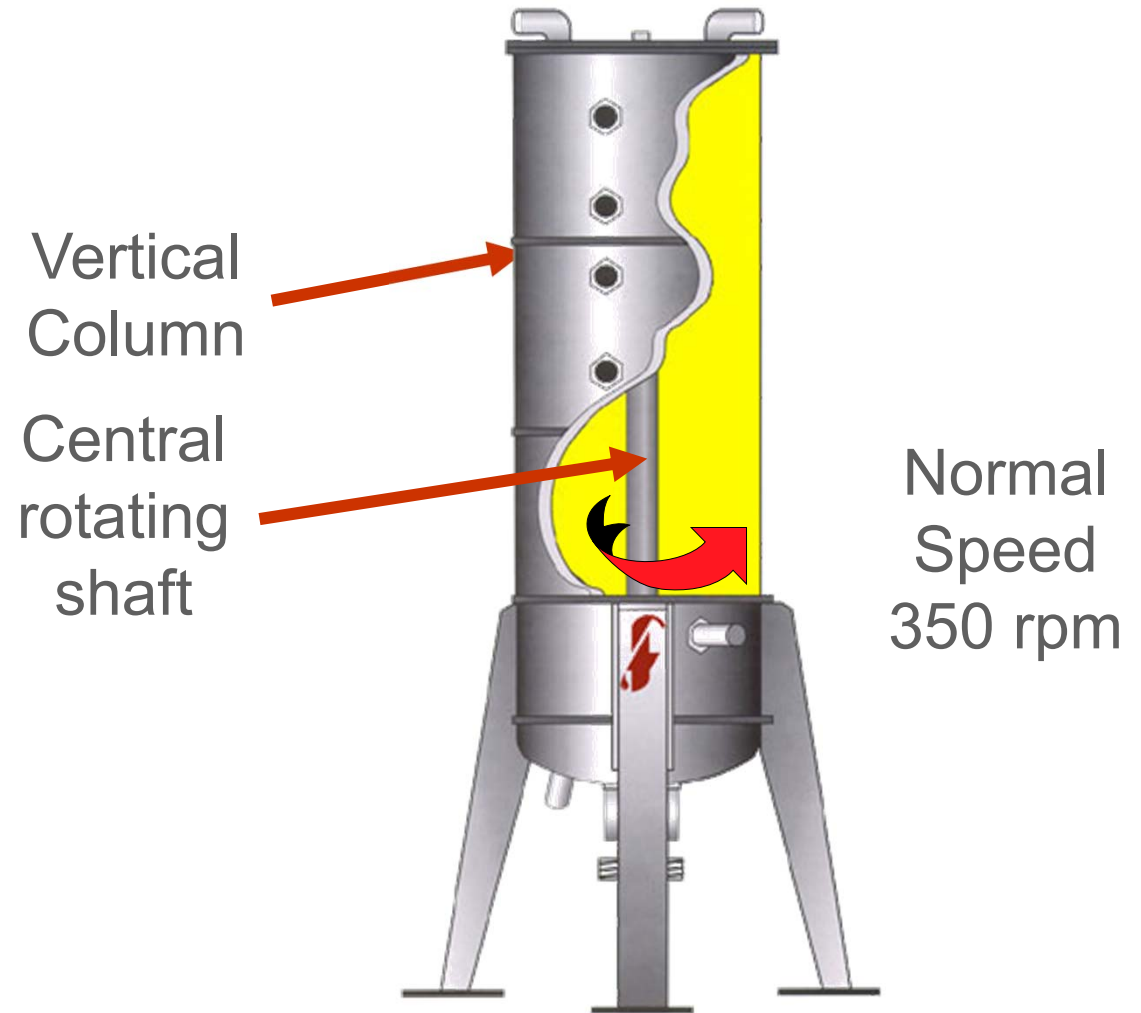
- Commercial ethanol removal techniques
 - SPP versus membrane
- Compositional analysis of wines
- Sensory comparisons

Spinning Cone

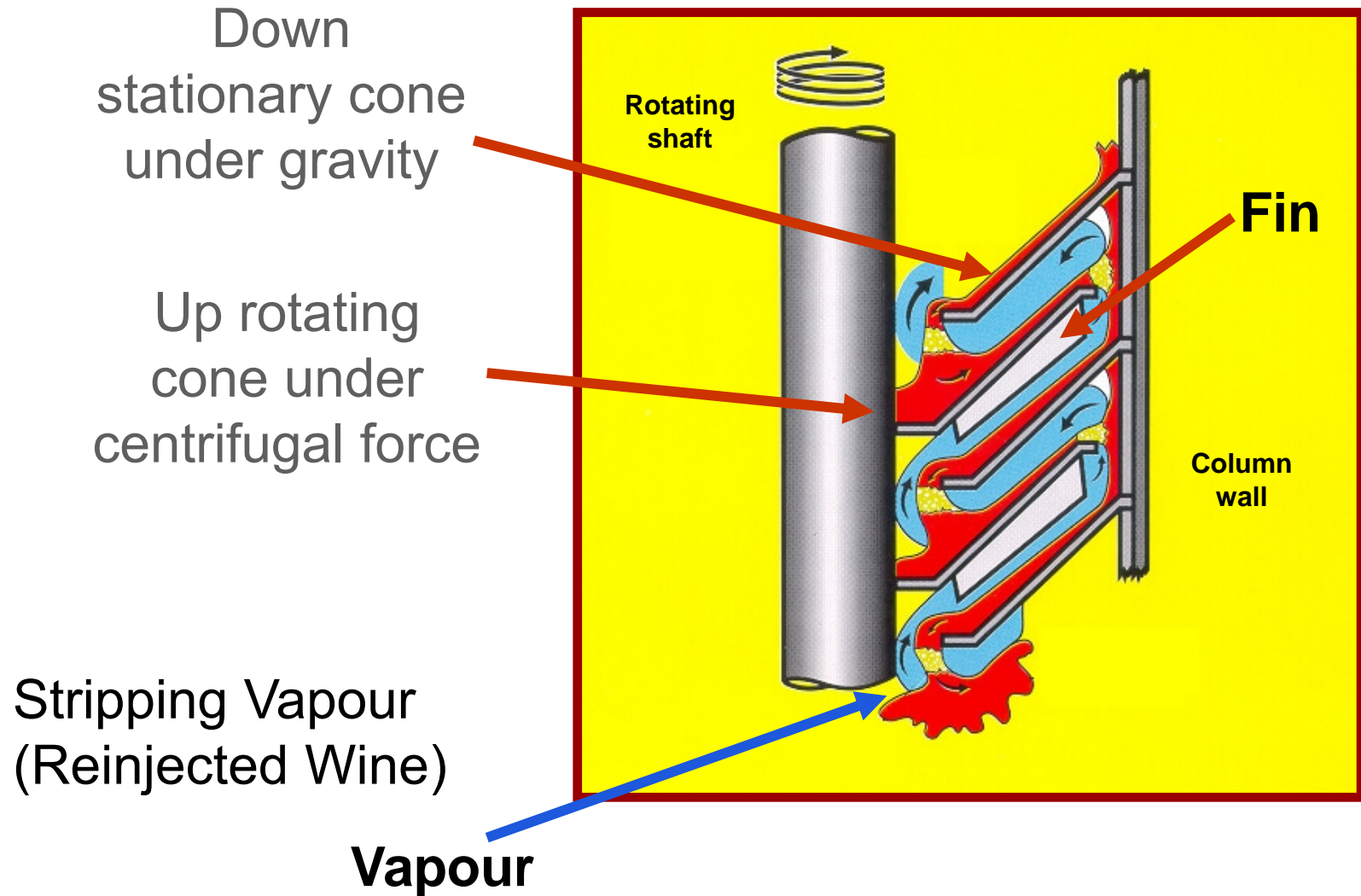
System Design

Stripping column

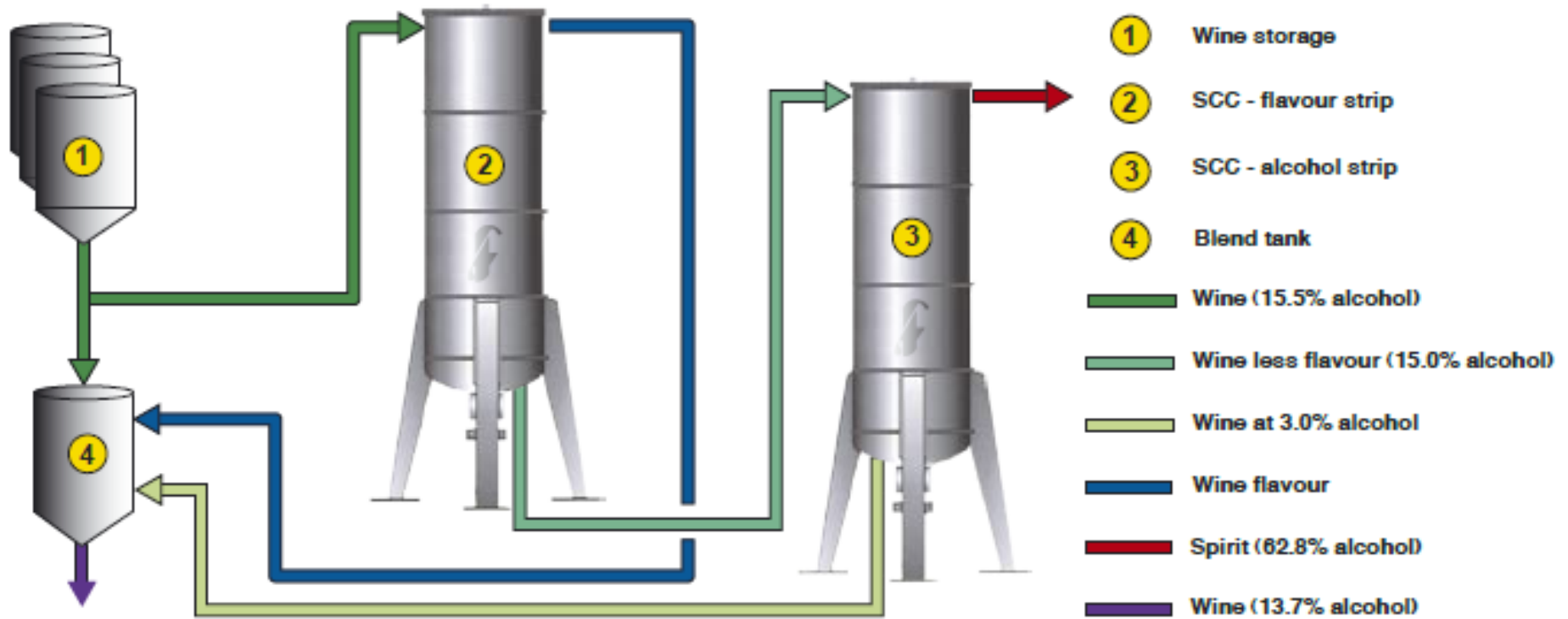
- Vacuum
- Low temperature
- High solids ok
 - Juice conc.
 - De-sulfuring



Wine & Stripping Flow



Alcohol removal in 2 stages



Alcohol adjustment using the SCC in a two pass process

De-aromatisation: 0.04 atm/26-28°C

Dealcoholisation: 36-38°C

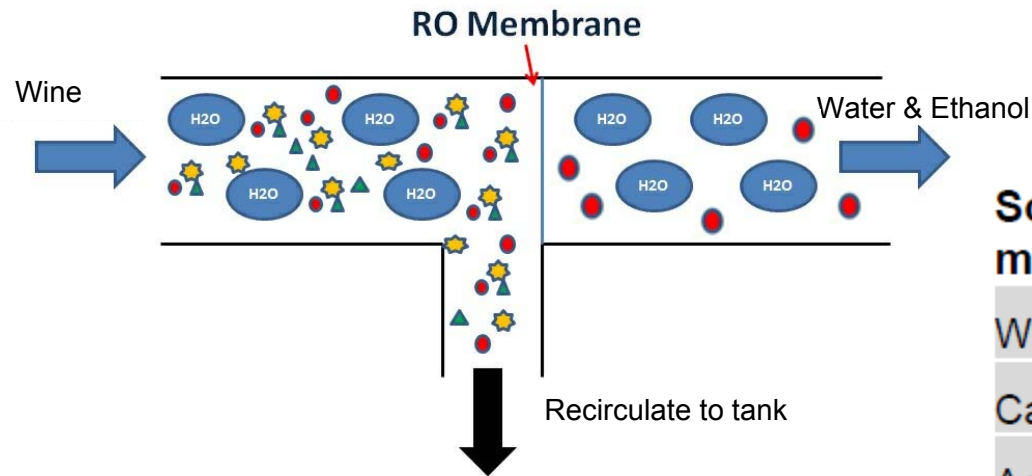
Ethanol base with aroma ~ 1% vol

Product strength > 50% v/v

Membrane Technologies

Process	Approx. size	Separation Mechanism	Driving Force	Application
Nanofiltration	0.5 – 5.0 nm	Sieving & charge effects	Pressure	Juice sugar removal
Reverse Osmosis	0.1 -1.0 nm	Semi-permeable membrane	Trans membrane pressure	Ethanol removal
Osmotic distillation (perstraction, membrane contactor)	0.03 – 0.5 μ m	Volatilisation & permeation	Vapour pressure gradient	Ethanol removal, aroma, water recovery
Pervaporation	Non-porous	Partial vaporization	Partial pressure differential	Ethanol removal, aroma recovery

Reverse Osmosis



Nominal molecular weight cut off

Aroma compound loss

Some wine components and their molecular weights:

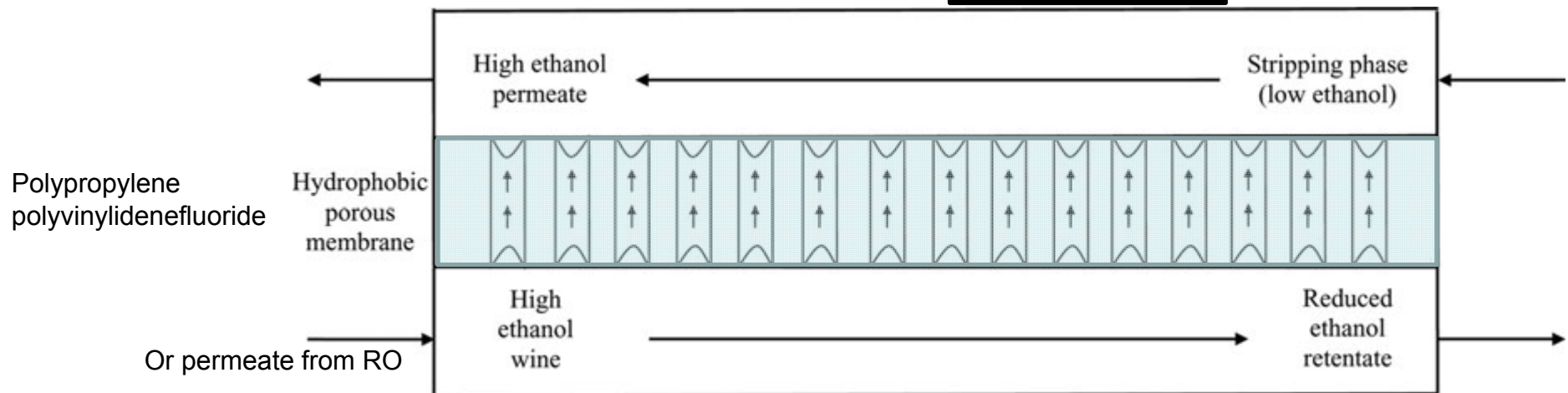
Water	18	
Carbon dioxide	44	
Acetaldehyde	44	
Ethanol	46	
Acetic acid	60	
Ethyl acetate	88	
Lactic acid	90	"tight" RO↑
Malic acid	134	
Tartaric acid	150	
Volatile phenols	120-150	"loose" RO↑
Glucose / Fructose	180	
Flavonoids	>300	

Osmotic Distillation

- Also known as
 - Isothermal membrane distillation
 - **Evaporative perstraction**
 - Membrane contactor

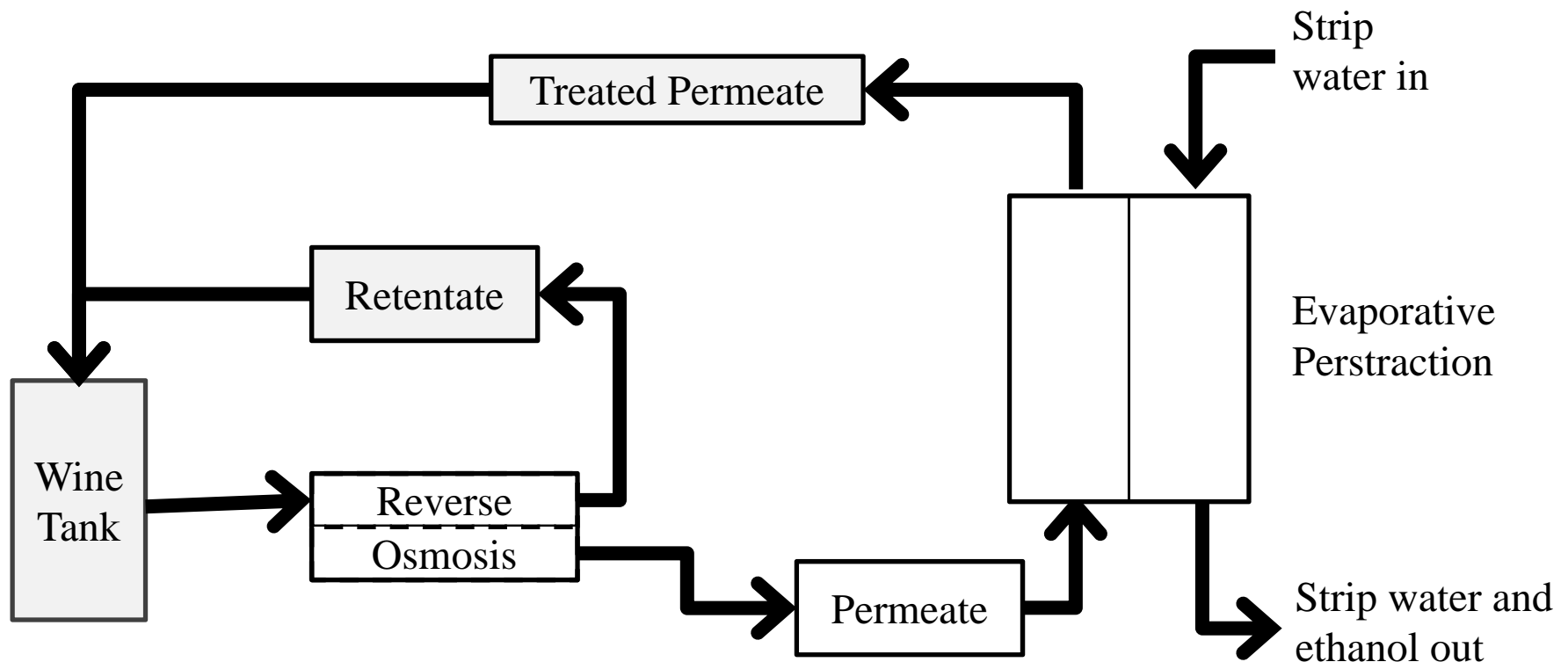
Higher temp.
favours
ethanol
permeation

Degassed water
Operation at 40°C

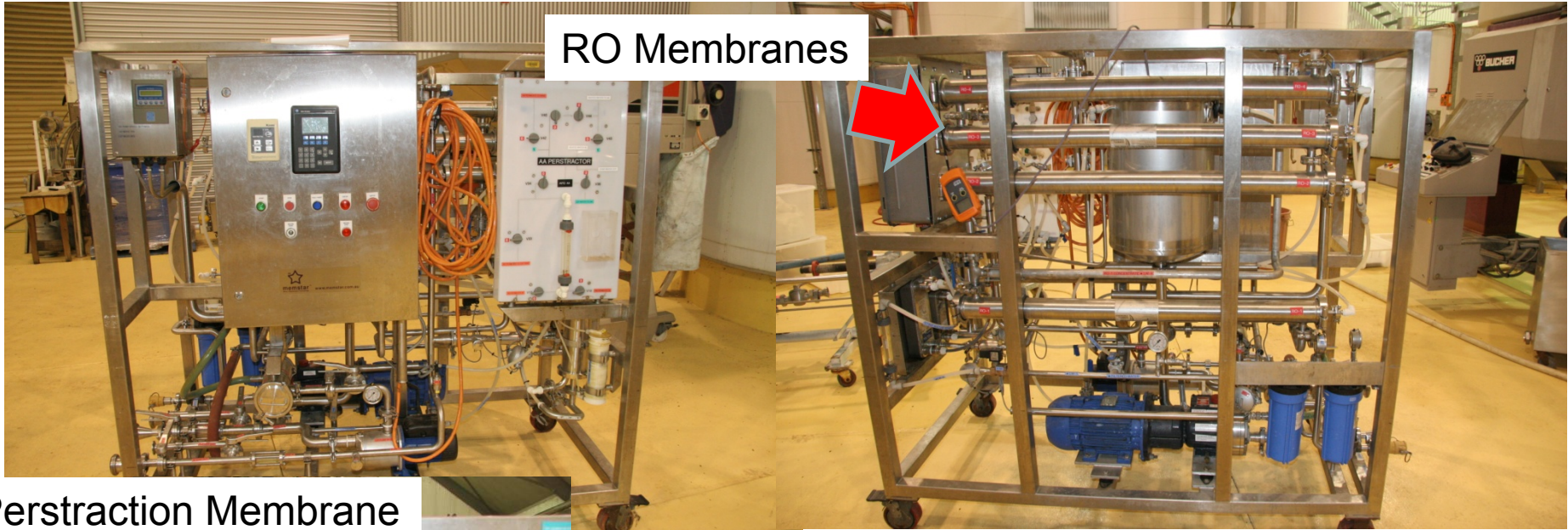


Alcohol Adjustment (AA) Process

- Combination of two processes:
- Reverse Osmosis and Evaporative Perstraction



	Membrane (RO + Perstraction)	Spinning Cone
Wine requirements	Heat & cold stable Pectin & glucan free NTU < 50	Unstable wines ok High solids ok
Number of passes	Multiple	Two (Flavour, ethanol)
Strip ethanol conc.	<10% v/v (batch)	> 50% v/v (65% typical)
Potential ethanol removal/pass	0.7 – 1.5% v/v	0.5 – 15% v/v
Residence time	Minutes	10-20 seconds per pass
Process time	Hours/days	Hours
Flavour Impact	Some compounds pass through membranes	Recovered aroma in 1% vol added back to BW
Operating Temperature	20-22°C (RO) ~40°C (Perstraction)	~28°C (flavour) ~36°C (ethanol)
Water removal	High – but reclaimed	Negligible
Water consumption	Moderate (Perstraction)	Minor
Consumables	Membranes	N/A
Capital	\$\$	\$\$\$



Perstraction Membrane



Wine must be **VERY** clean
Temperature 18-20°C (tank cooling)
Permeate rate ~ 60 L/hour
Strip water ~ 180 L/hr

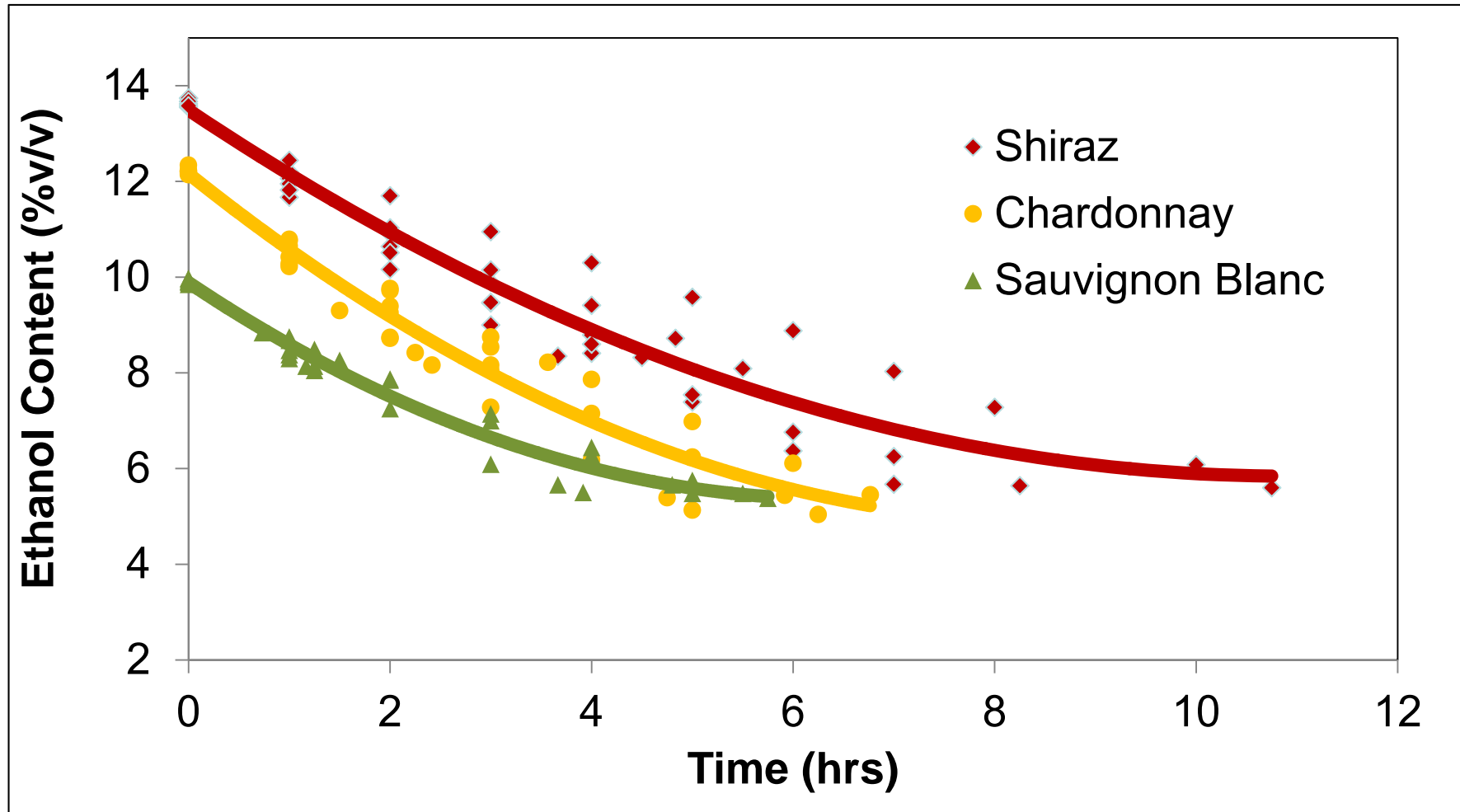
Approx 40 hours to reduce 2% v/v in 10kL

Experiment 1 - Alcohol Adjustment

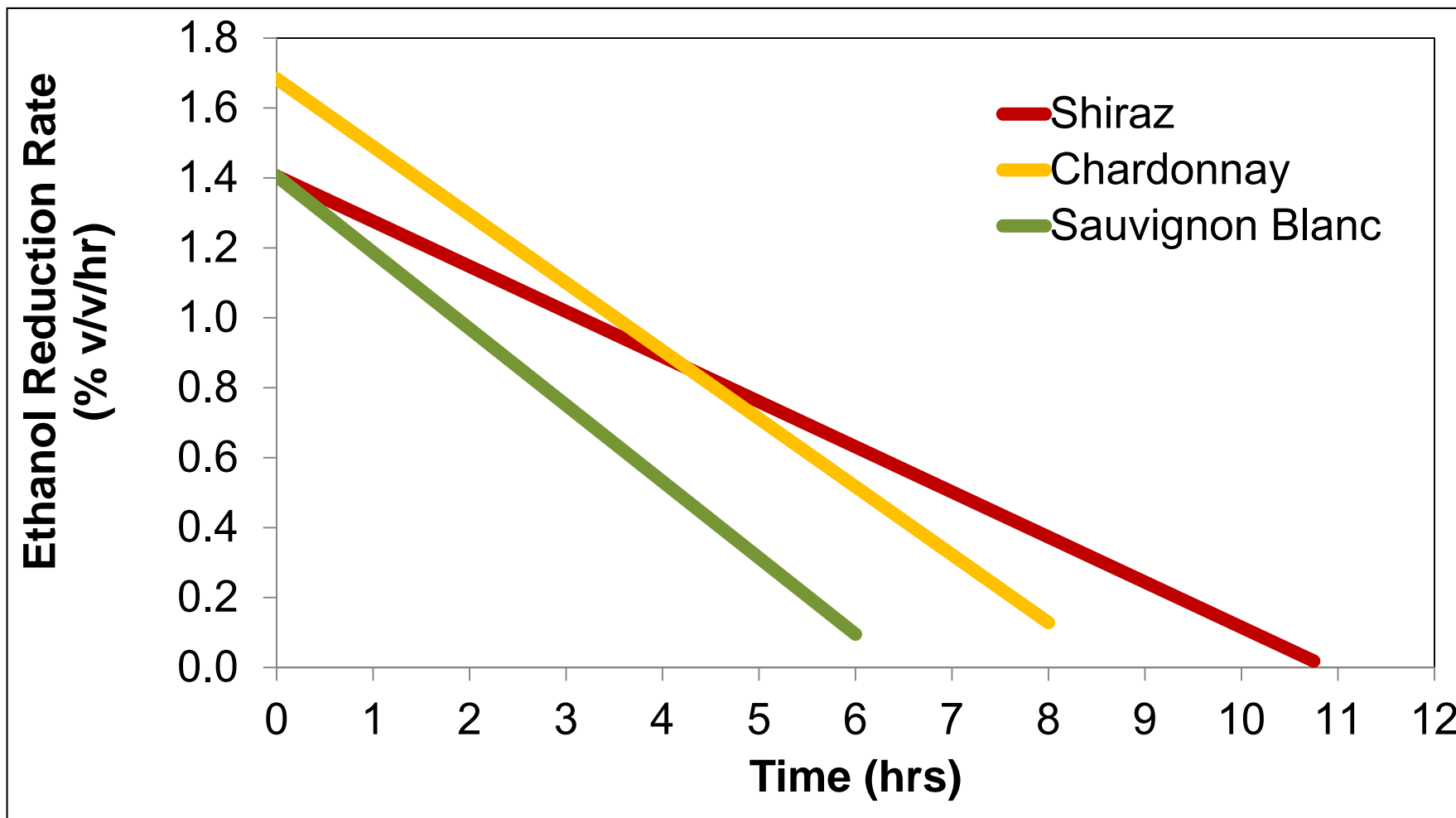
- Varieties
 - Chardonnay
 - Sauvignon Blanc
 - Shiraz
- Initial Alcohol
 - 12.2%
 - 9.9%
 - 13.7%
- Adjusted to:
 - 10% alcohol
 - 8% alcohol
 - 5% alcohol



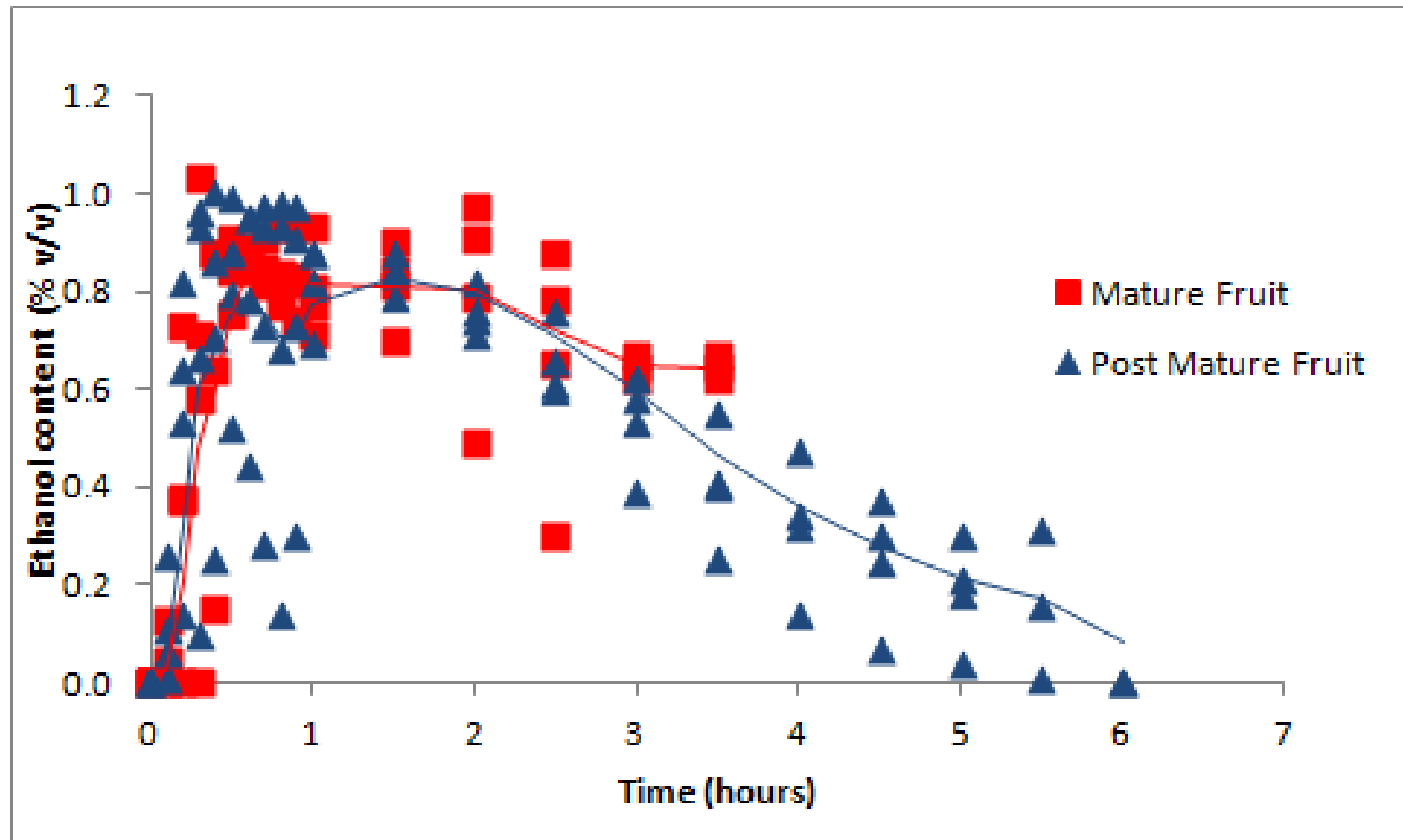
Ethanol Content During Operation



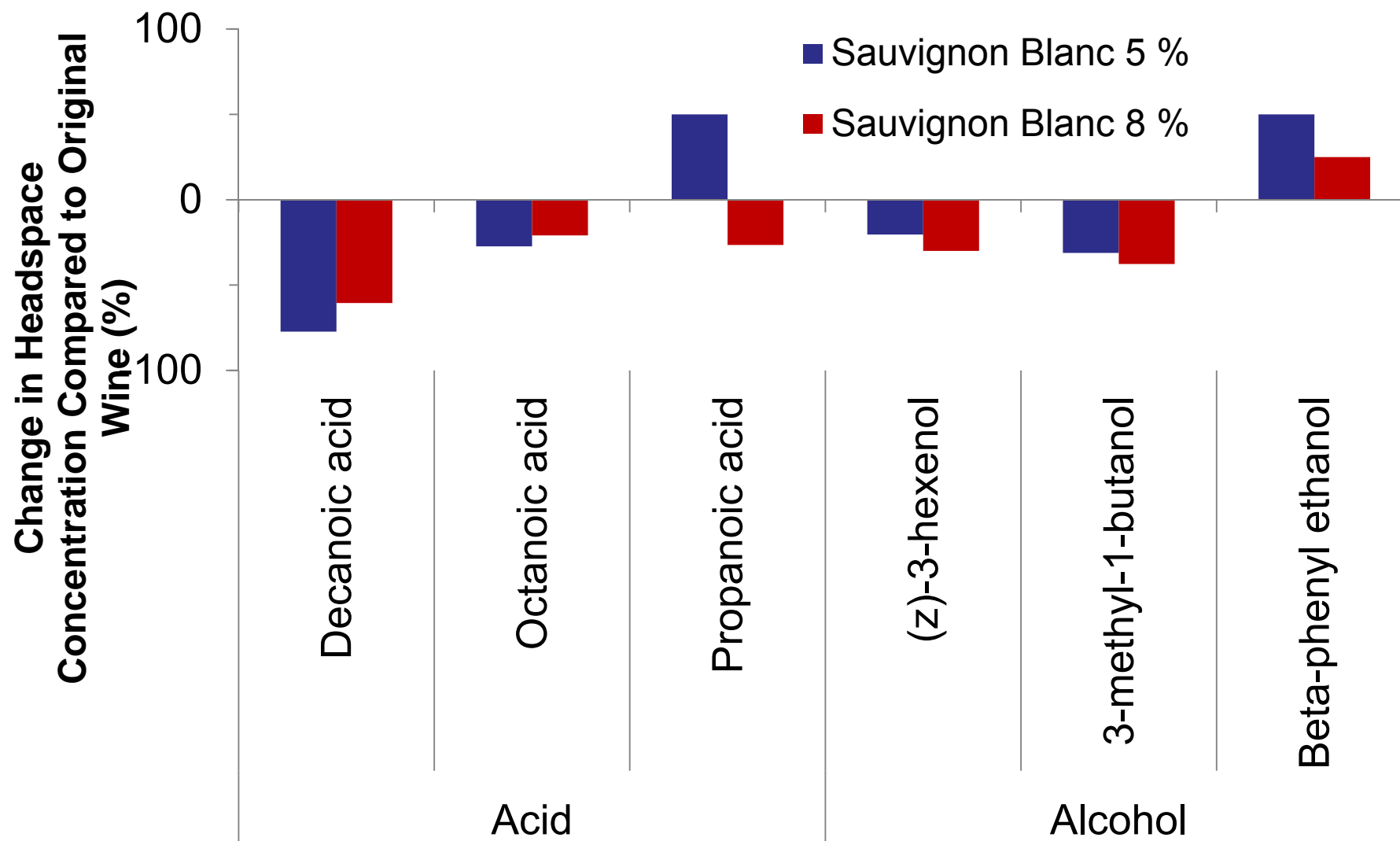
Rate of Ethanol Reduction



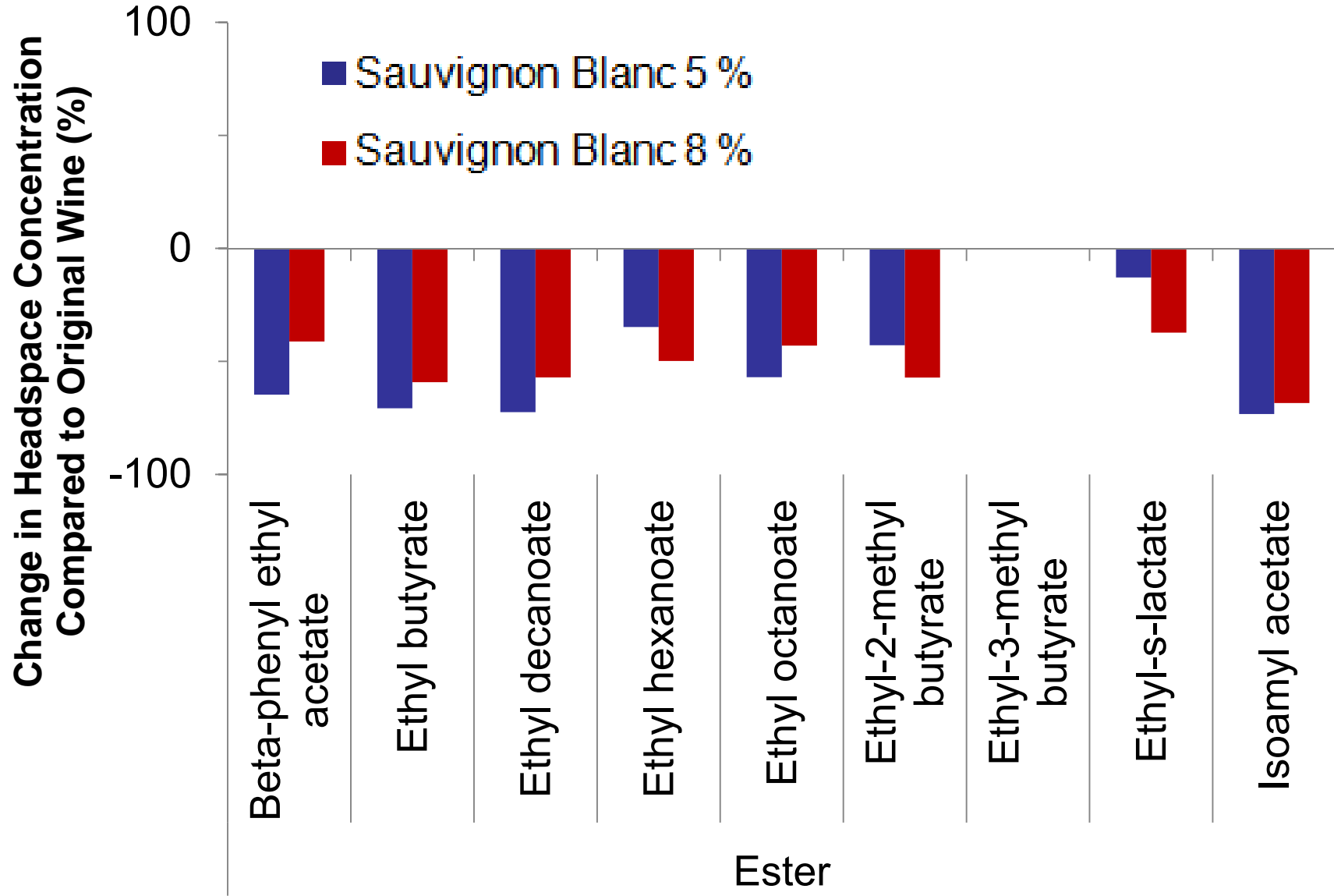
Ethanol conc. in strip water



Sauvignon Blanc Headspace Composition



Sauvignon Blanc Headspace Composition



		Chardonnay		Shiraz		Sauvignon Blanc	
		5%	8%	5%	8%	5%	8%
Acid	Decanoic acid	- - -	- - -	- - -	- - -	- - -	- - -
	Octanoic acid	-	+	-	-	-	-
	Propanoic acid	+	++	+++	+	+++	-
Alcohol	(z)-3-hexenol	-	-	-	-	-	-
	3-methyl-1-butanol	-	-	-	-	-	-
	Beta-phenyl ethanol	+++	+++	+	++	+++	++
Ester	Beta-phenyl ethyl acetate	-	0	-	-	- - -	-
	Ethyl butyrate	- - -	-	- - -	-	- - -	- - -
	Ethyl decanoate	- - -	- - -	-	-	- - -	- - -
	Ethyl hexanoate	- - -	- - -	- - -	- - -	-	-
	Ethyl octanoate	- - -	- - -	- - -	-	- - -	-
	Ethyl-3-methyl butyrate	- - -	-	-	0	0	0
	Ethyl-2-methyl butyrate	- - -	-	-	-	-	- - -
	Ethyl-s-lactate	-	-	-	-	-	-
	Isoamyl acetate	- - -	+	- - -	-	- - -	- - -

Change 0-25%: - or + 25-50%: -- or ++ >50%: --- or +++

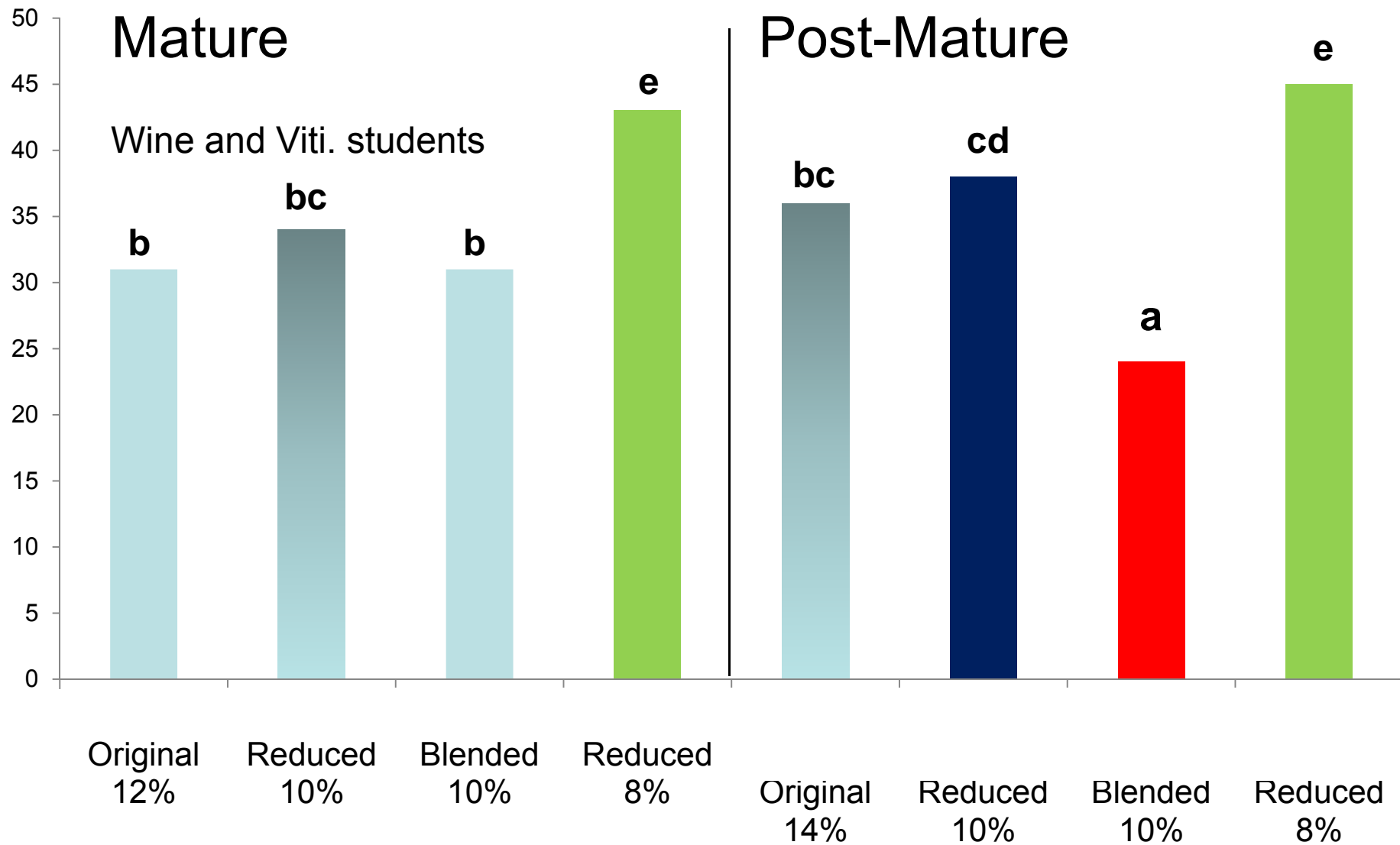
Change with Alcohol Concentration

- Decreasing alcohol concentration
 - Volatile HS conc. generally **decreased**
 - **All esters decreased**
 - Only a **few exceptions** (e.g. β -phenyl ethanol, propanoic acid)
- Alcohol Re-adjustment studies
 - Generally reduced conc. of all cmps
 - **Reduced** β -phenyl ethanol, propanoic acid
- Liquid Conc.
 - Generally **reduced** conc.

Experiment 2 - Alcohol Adjustment

- Shiraz
 - ‘Mature Fruit’
 - ‘Post Mature’
 - Adjusted to:
 - 10% alcohol
 - 8.0% alcohol
- Initial Alcohol
- 12.2%
- 14.0%
- Blended to:
10%
-
- ```
graph LR; A[12.2%] --- B[]; B --- C[14.0%]; C --- D[]; D --- E[10%];
```

# Rank sum pref. (lowest = most preferred)



# Difference Testing

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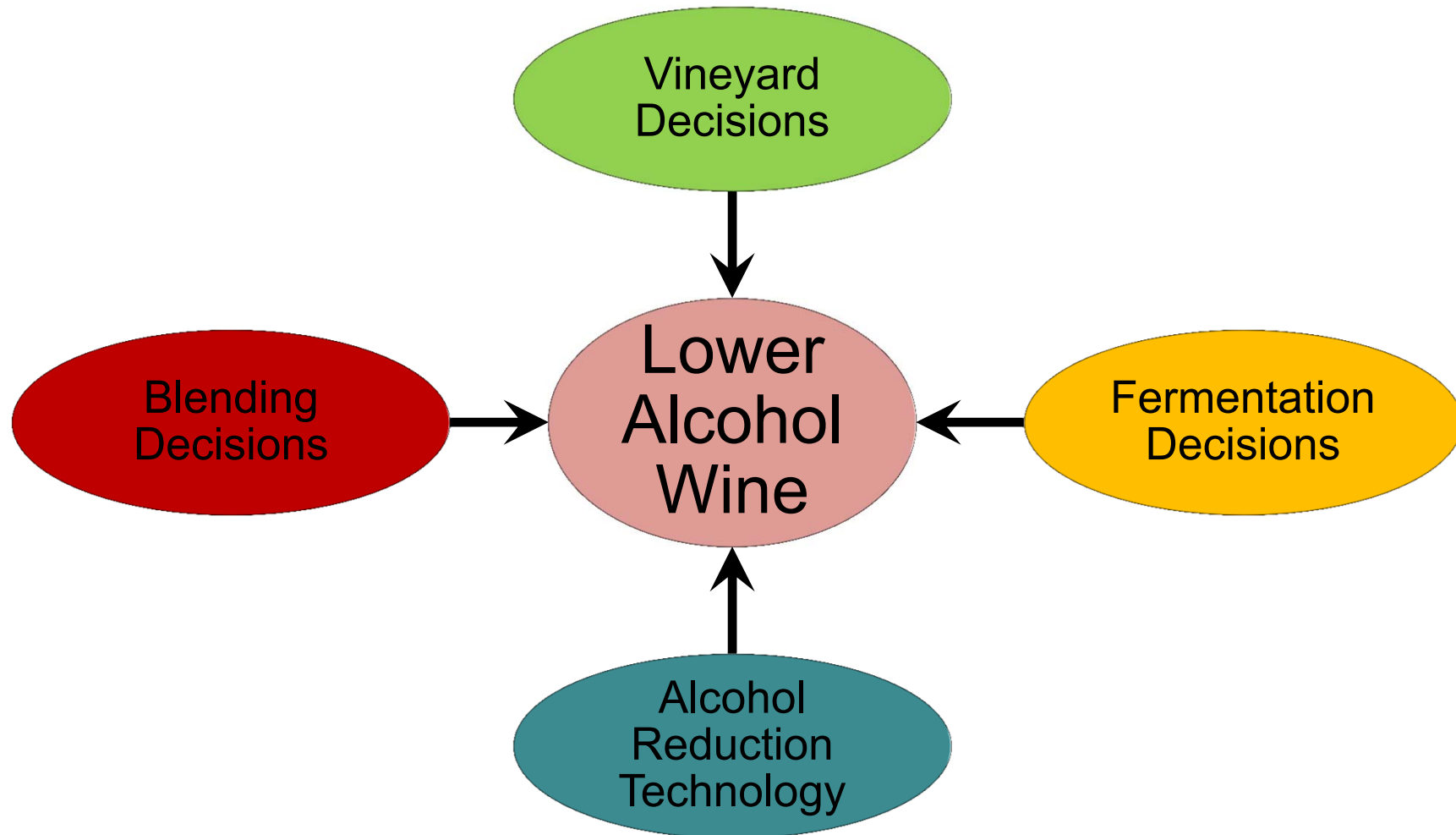
| Comparison            |                               | Significance |
|-----------------------|-------------------------------|--------------|
| 10% Mature Fruit      | 10% Post Mature Fruit         | NS           |
| 10% Mature Fruit      | 10% Blended Mature Fruit      | NS           |
| 10% Post Mature Fruit | 10% Blended Post Mature Fruit | NS           |
| 8% Mature Fruit       | 8% Post Mature Fruit          | Significant  |

Degree of grape berry ripeness will influence the perception of reduced alcoholic wines



# An Integrated Approach Required

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# Acknowledgements

- Grape Growers and Wine makers of Australia
  - Through their investment body the Australian Grape and Wine Authority



Australian Government

Australian Grape and Wine Authority

- Charles Sturt University &  
The National Wine and Grape Industry Centre

