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AWRI Australian Wine Research Institute

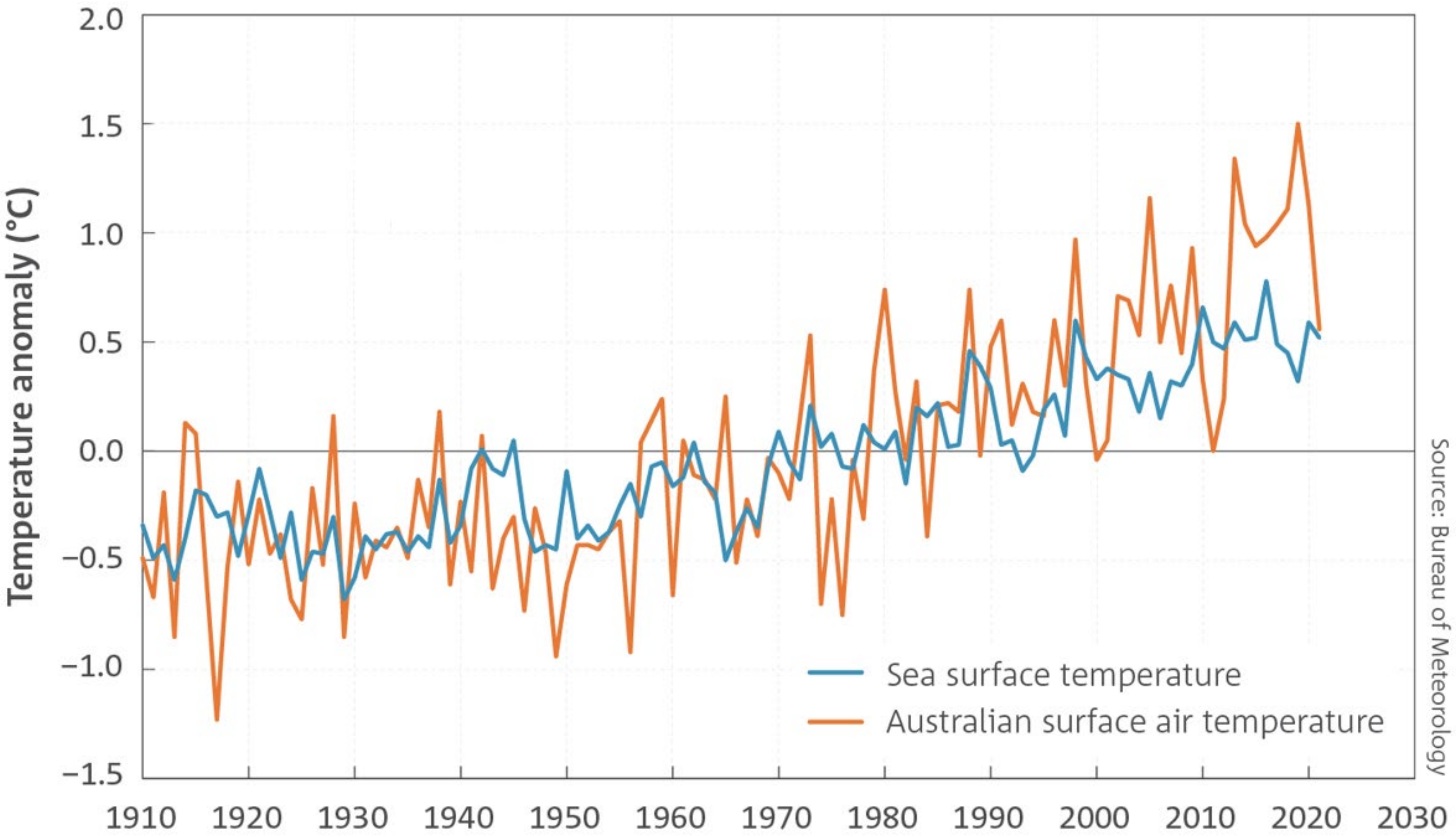
Adapting to difficult (hot) vintages

Bureau of Meteorology – State of the Climate 2022

Surface temperature

Australia's climate has warmed by an average of 1.47 ± 0.24 °C since national records began in 1910

This has led to an increase in the frequency of extreme heat events over land and sea.



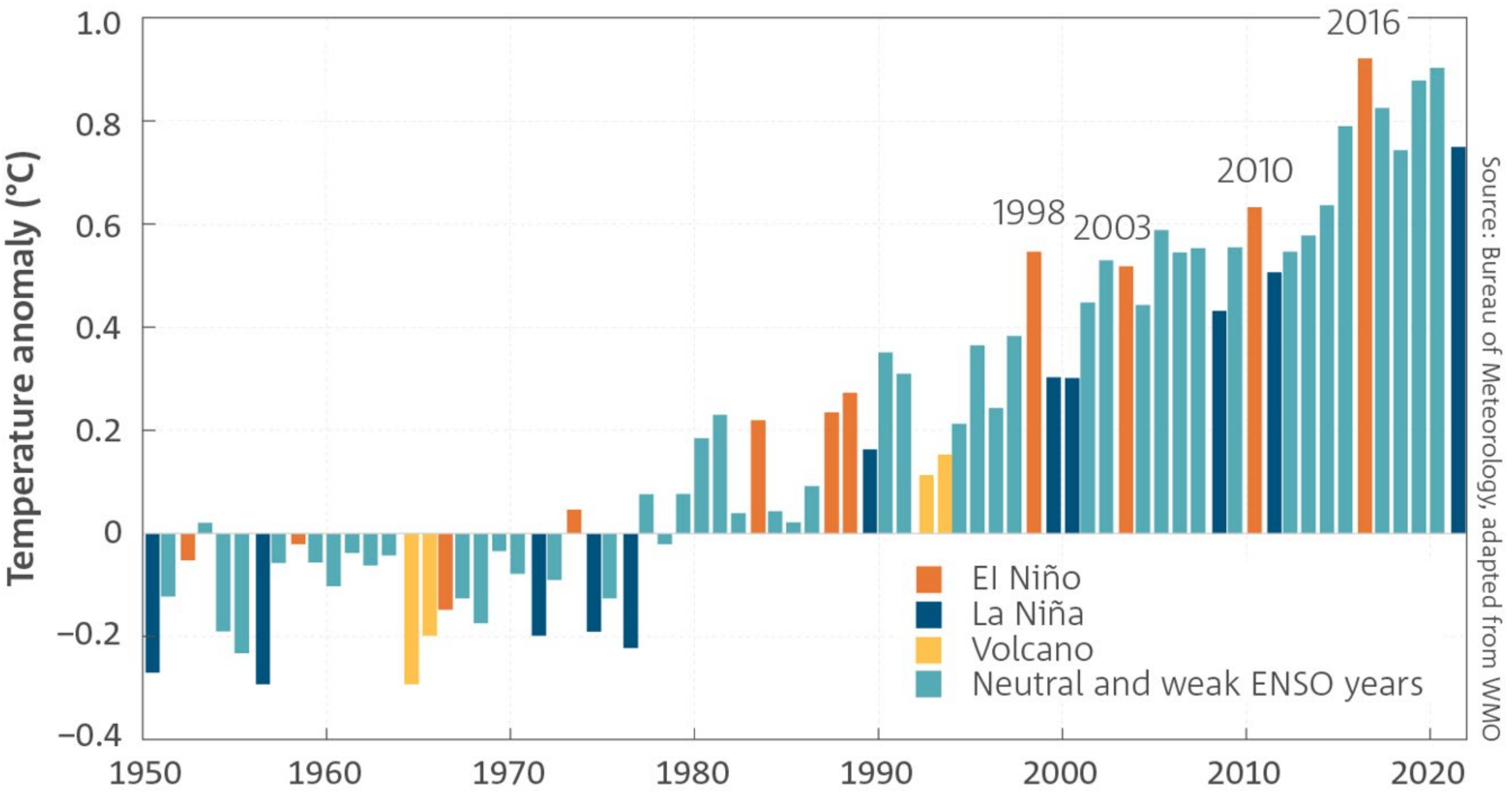
Anomalies in annual mean sea surface & land temperature in the Australian region.

Bureau of Meteorology – State of the Climate 2022

Global temperature

Increasing surface temperatures mean a La Niña year is now warmer than an El Niño year in the 1980s.

There has been an increase in extreme fire weather, and a longer fire season in Australia since the 1950s.



Annual global surface temperature anomalies of the Earth (land and ocean), 1950–2021.

Compressed Vintages

January → February → March → April → May

January	February	March	April	May
White harvest	White harvest	Red harvest	Red harvest	Red harvest
		Whites to barrel	Red pressed to barrel	

January → February → March → April

January	February	March	April
White harvest	White harvest		
	Red harvest	Red harvest	Red harvest
	Whites to barrel	Red pressed to barrel	Red pressed to barrel

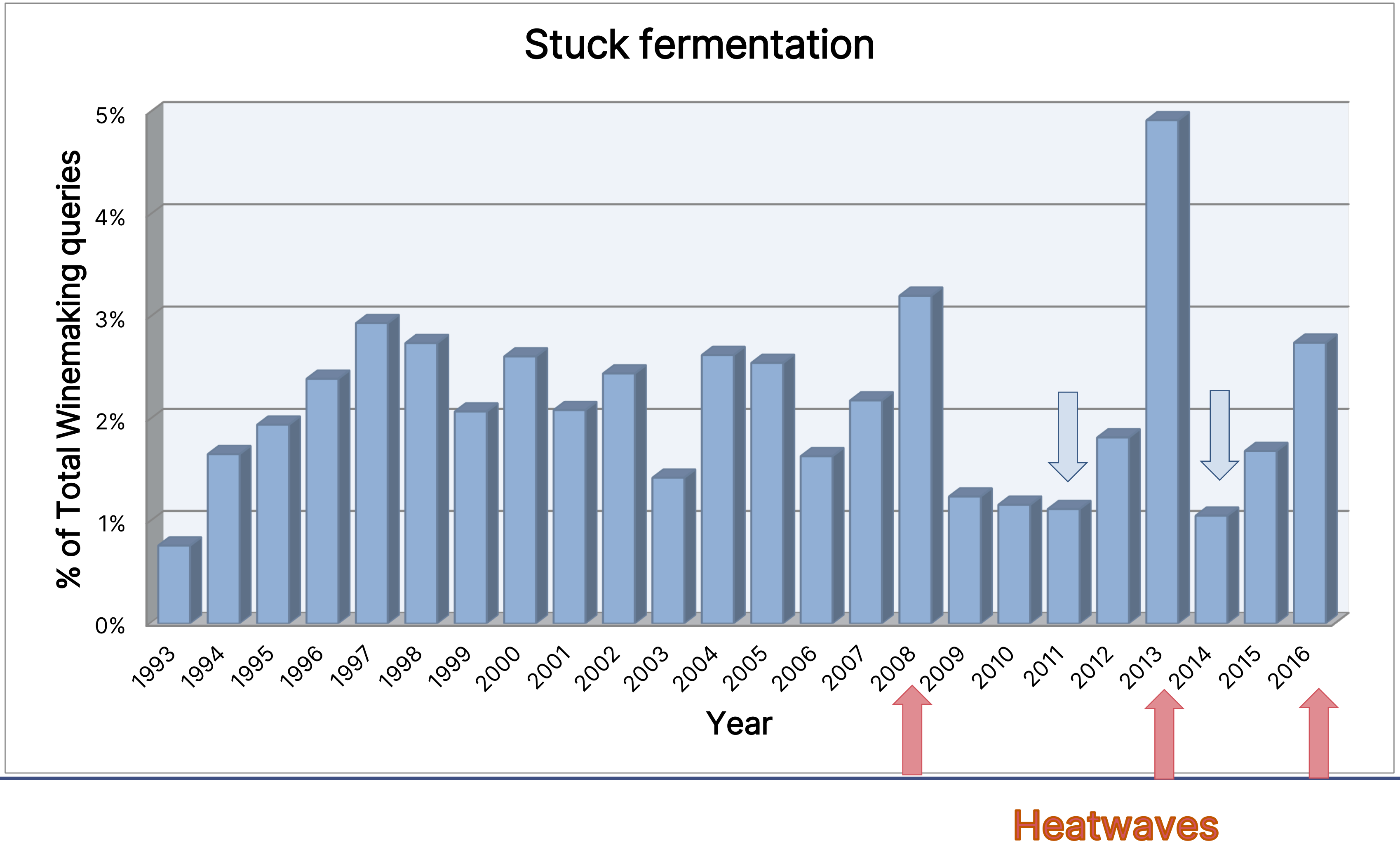
Compressed Vintage impacts

- Dry conditions will exacerbate variation within a vineyard
- Maturity increase can be rapid
- Period during which fruit will be at optimum ripeness is likely to be shorter than usual

$\Rightarrow$ increase maturity testing to 2-3 times/week

Heat waves are associated with stuck fermentations

AWRI helpdesk winemaking queries 1993 – 2016 (~25,000 queries)



Factors that contribute to fermentation issues during heatwaves

- High temperature and microbial growth
- High fruit temperature and capacity of winery cooling systems
- High Bé fruit (leads to high alcohol wine)
- Fermentation temperature
- Yeast assimilable nitrogen (YAN) concentration
- Yeast – bacteria interaction (high VA)
- Inhibitory substances – residual agrochemicals

❖ Cumulative impacts (can occur individually without consequence)

High temperature and microbial growth

Damaged berries

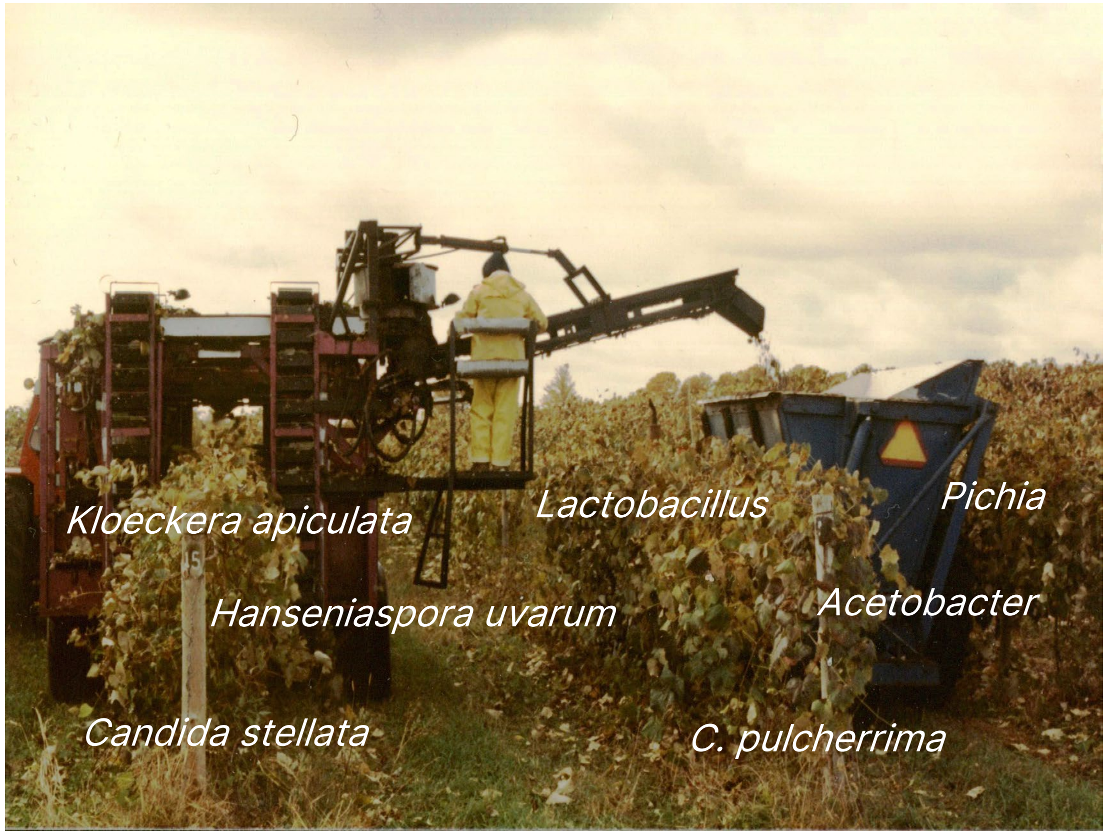
- berries split due to dehydration, or leakage of sugar from the berries due to loss of turgidity

⇒ can expect higher than usual microbial load

High temperature and microbial growth

Indigenous Microbiological growth

- Mechanical harvesting causes further damage of the fruit
- stimulates further growth of indigenous microorganisms during transport
- Uncontrolled micro growth can lead to serious losses of grape berry nutrients
- Non-*Saccharomyces* yeasts such as *Kloeckera apiculata, Candida stellata*, and *C. pulcherrima* (typically present on grapes) are far more demanding of vitamins than S. cerevisiae

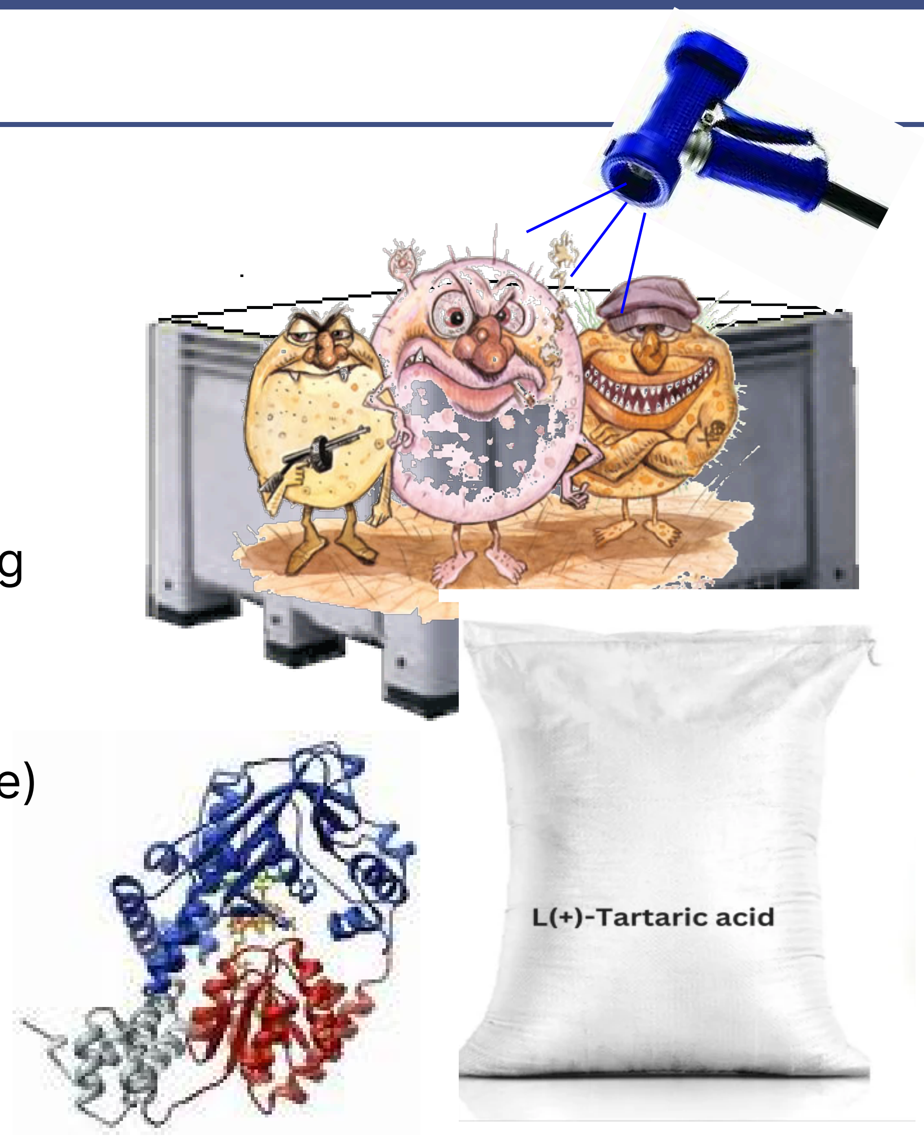


High temperature and microbial growth

- Picking bins used several times, not washed out properly or sanitised, build up a large population of wild yeast.
- Amount of toxins excreted by those yeast could potentially be enough to inhibit fermentation
- high populations of well established native yeasts can compromise the ability of the inoculated yeast to dominate the microflora, leading to depletion of essential nutrients

Minimising the micro inoculum

- Use more SO_2 (2X usual to help prevent microbial growth and oxidation)
- Sanitation: grape bins between loads, receival bins, crushers, presses, must pumps and lines
- Cover grape bins during transport to reduce further heating by exposure to direct sunlight.
- Add acid as soon as must tanks are mixed and the acidity parameters are known (lower pH makes SO_2 more effective)
- Lysozyme addition to must or ferments to control LAB has also been suggested (but not effective against yeast or AAB)

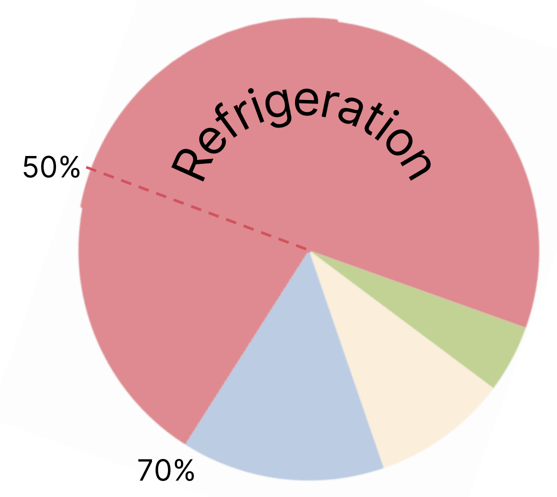


Capacity of winery cooling systems

- Fruit can arrive at the crusher at 30°C to 35°C (ambient temp. can be >40°)
- Increased load on refrigeration
- Rapid ripening of fruit compresses intake period, further exacerbating this problem

Inability to chill musts efficiently and quickly

- allows further growth of the indigenous yeasts and bacteria
- further loss of essential nutrients
- increases the risk of stuck fermentations.



Refrigeration consumes between 50 - 70% of electricity used (SAWIA)

Processing dehydrated and shrivelled fruit

- lower juice volume
- blockages of must lines and heat exchangers
- processing delays & increased oxidation risks

⇒ isolate free run, use to push grapes through hopper
⇒ avoid long distance pumping
⇒ chill in tank
⇒ add larger amounts of SO_2

High Bé fruit leads to high alcohol wine

Ethanol:

- is the most important inhibitor of growth of *Saccharomyces cerevisiae*
- inhibits the transport into the cell of many nutrients and substrates such as glucose, ammonium and amino acids
- increases the toxicity of other compounds, such as the medium chain length fatty acids

Explains why some compounds might not be problematic early in fermentation, but might interfere in the latter stages

Water addition

Historically, maximum 70mL/L permitted for incorporating permitted additives or processing aids (Winemaking Production guidelines Std 4.5.1)

Water may be added to juice or must to reduce the sugar level to no less than 13.5°Baumé (Bé) (equivalent to 24.3 °Brix).

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Water addition

- Ensure the tank has the capacity to take extra volume post-addition
- Water can be added by measuring the tank dip pre- and post-water addition or by flow meters if available
- Ameliorated must should be mixed thoroughly
- re-analyse to obtain a starting Bé/Brix, pH and titratable acidity
- Make any adjustments on this data not the initial juice parameters
- Take correct records for auditing purposes

Water addition - Compositional changes

- pH — no change

- Tartaric acid
- Malic acid
- YAN
- Colour and tannin

↓ Proportionally with the % dilution

- Hard water – adds calcium and magnesium (calcium instabilities)
- Soft water – adds sodium and chloride (saltiness)
- Chlorinated water → Chlorophenols

Fermentation temperature

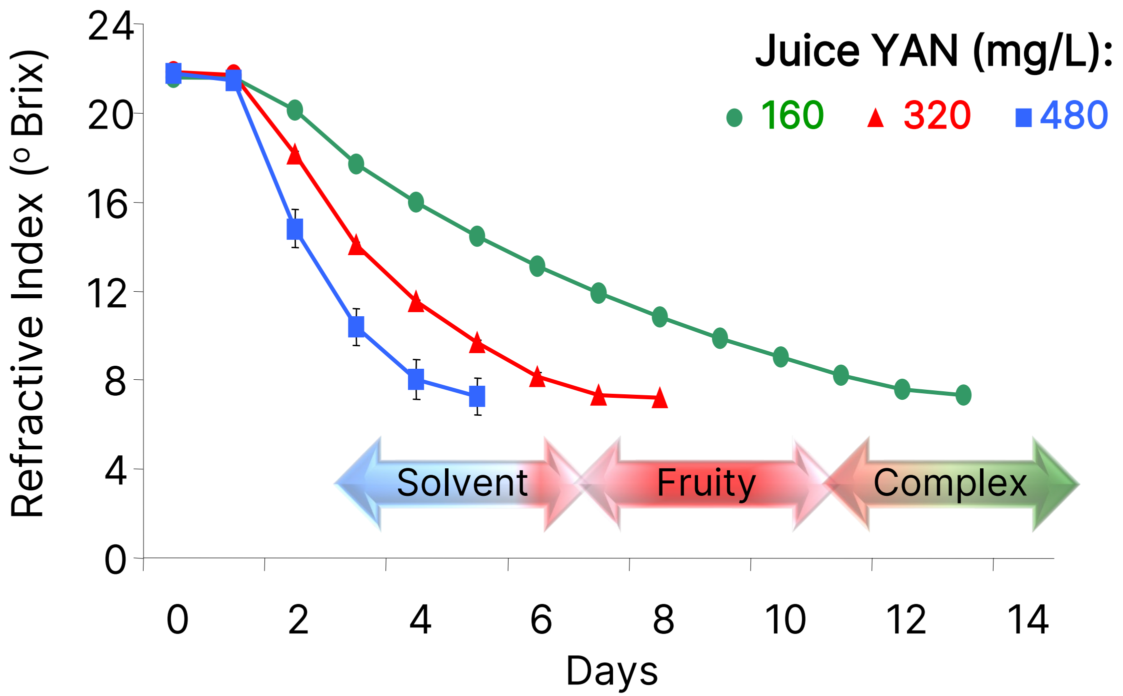
↑ fermentation temperature ⇒

↑ yeast consumption of nitrogen

Heat wave: ⇒ availability of YAN can be limited due to prior microbial growth

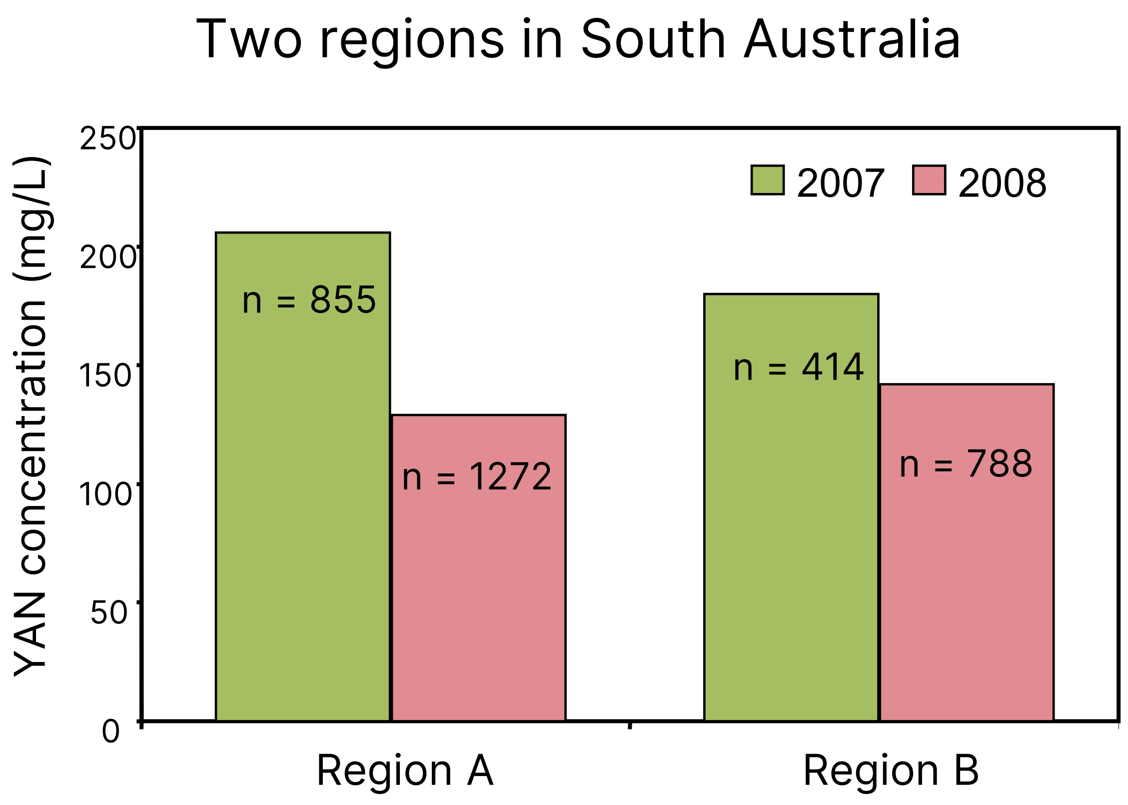
Drought: ⇒ YAN can be low due to prevailing drought conditions.

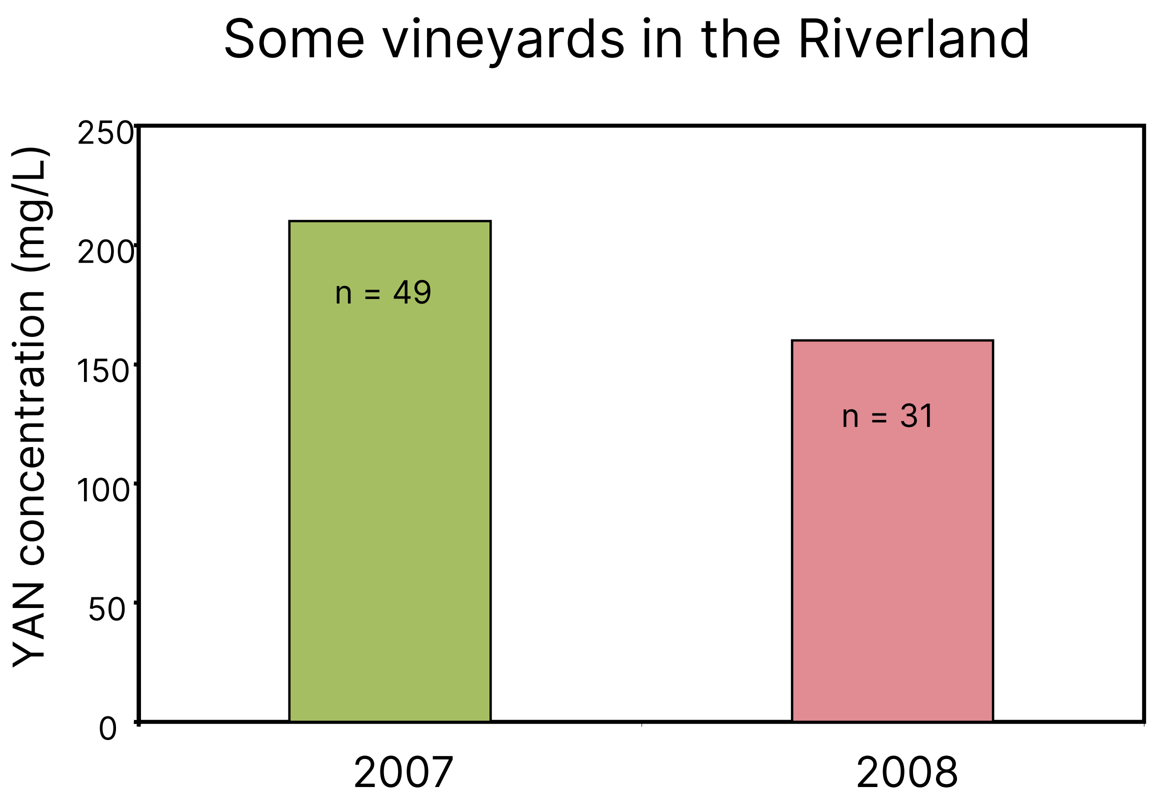
Chardonnay (filtered), Yeast: AWRI 796, 18°C



- Low nitrogen contributes to sluggish fermentation
- Can contribute to the production of H_2S (but too much can lead to ethyl acetate!)

The average YAN concentration in juices in 2008





Juice tank samples after crushing

Measure YAN and adjust as necessary

YAN requirements of yeast:

Maximum YAN demand:

Mean = 400 mg/L

Range = 330 – 470 mg/L

Minimum YAN requirement

Whites – approx. 150 mg/L

Reds – approx. 100 mg/L

Optimum flavour/prevent H_2S

Whites – approx. 250–350 mg/L

Reds – approx. 250 mg/L

Nutrient strategy for reinvigorating fermentation

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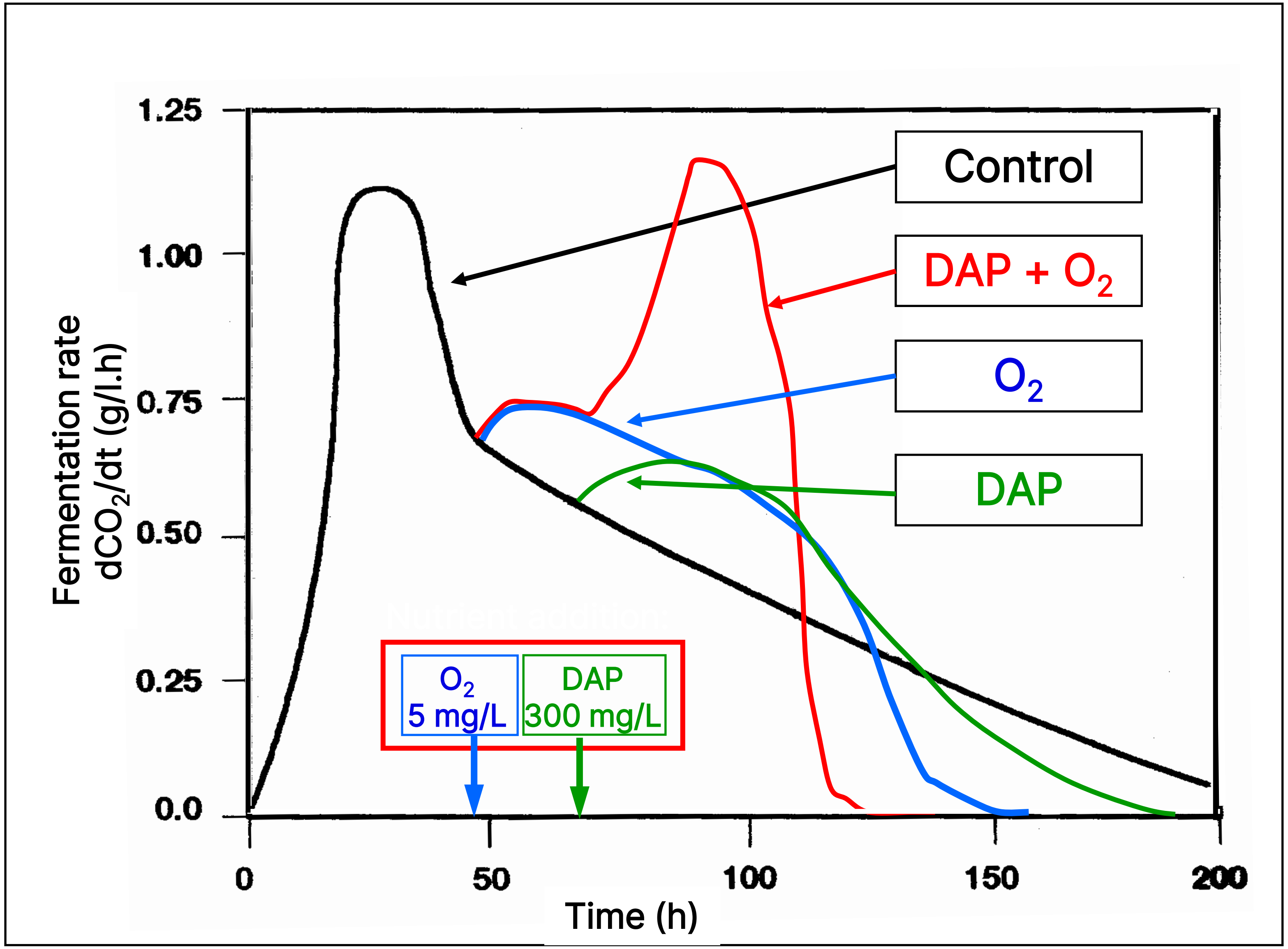
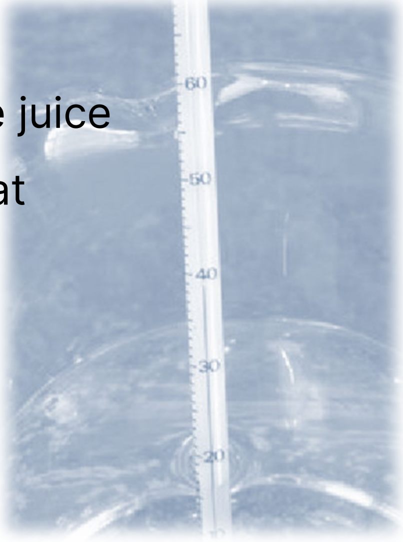


Sablayrolles, Dubois, Manginot & Barre 1996 *J. Ferment. Bioeng.* 82:377-381

Yeast preparation is important

- Re-hydration medium:
  - Mineral water/rain water/clean tap water (remove Chlorine)
  - Mineral water with grape sugar
  - Diluted preservative-free (SO_2) grape juice (sterile)
  - Proprietary nutrients (inactive yeast) for difficult musts
- Temperature - 38-40°C
- Stand 15-20 min
- Lower temp/Add grape juice
- Stand 15-20 min, repeat
- Add to tank at similar temperature



Correct

Incorrect

Yeast storage ~4ºC

Yeast – bacteria interaction and high VA

Results of analysis of a typical ‘high VA’ heat-wave red ferment

Alcohol	12.0 % v/v
Acetic acid	1.94 g/L
G + F	47.0 g/L
Malic acid	<0.05 g/L
pH	3.81

Microbiological

Yeast: *Saccharomyces* sp., non-*Saccharomyces* sp.

Bacteria: *Lactobacillus* sp., *Acetobacter* sp.

Sensory: volatile, mousy off-flavour

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Acetic acid production

- Once the structure of the berry is damaged the native yeast and bacteria can multiply.
- Growth & formation of VA by acetic acid bacteria (AAB) is 2X as fast at 23°C as at 18°C, & 4X as fast at 28°C.
- Hot conditions can dramatically increase the rate of formation of acetic acid (we've had reports of VA of 0.8 g/L in juice!).
- Growth of lactic acid bacteria (LAB) such as the Lactobacilli and Pediococci is encouraged at higher (>3.5) pH
- Unless controlled by acid additions and use of SO_2, substantial populations of these microorganisms can develop, especially under warm (30°C to 35°C) conditions

Acetic acid production

- *Lactobacillus* sp. can produce acetic acid when growing on glucose.
- *Pediococcus* sp. can also produce acetic acid when growing on pentose sugars.
- When ethanol or acetaldehyde are present from fermentative yeast growth, the presence of grape sugars stimulates mousy compound formation by LAB.
- Apart from spoilage, acetic acid and associated products of LAB metabolism represent potent inhibitors to fermentatively growing Saccharomyces & can delay the onset of fermentation
- Potential for more acetic acid to be produced by LAB at pH >3.5, both during growth on grape sugars and during MLF

Summary

- A number of factors contribute to fermentation issues in heat wave and drought conditions
- However, high must sugar concentration is typically the most important factor in stuck or sluggish fermentations due to the higher ethanol produced.
- Persistent drought conditions contribute to a low YAN content, which is known to reduce yeast growth and fermentation power
- Furthermore, heat waves and drought conditions give rise to larger populations of indigenous microflora which remove nutrients from the juice at a greater rate than usual.

Summary

- Use more SO_2 (help prevent microbial growth and oxidation)
- Sanitation: grape bins between loads, receival bins, crushers, presses, must pumps and lines
- Cover grape bins during transport to reduce further heating by exposure to direct sunlight.
- Add tartaric as soon as must tanks are mixed and the acidity parameters are known
    - lowering the pH will improve the efficacy of SO_2 by increasing its antimicrobial and antioxidant properties and inhibit the growth of unwanted microorganisms (including LAB such as *Lactobacillus* and *Pediococcus* spp.).

Logistics - prioritisation of fruit parcels

- consider harvesting some batches of fruit earlier
- retains acid; under-ripe flavour can be blended away
- consider harvesting fruit most susceptible to heat first
- do you harvest? Consider additional cost of VA/alcohol removal by RO, or MOX

Logistics - access to services/equipment and capacity

Do you have easy access to:

- Harvesters?
- Trucks?
- Grape bins?

$\Rightarrow$ book in advance (if possible)

Capacity

- tank and fermenter space
  - decrease ferment length to increase tank turnaround
    - press reds before full dryness
  - contract winemaking option?
  - Can you use of other vessels for fermentation?

Hope for the best but prepare for the worst

Spread your vineyards and varieties over the region

- mitigate any localised rainfall, frost or heat effects

Red : white fruit ratio

- related impacts of a compressed vintage

Pre-vintage planning

- order winemaking materials for the whole vintage
- have rescue culture yeast in stock
- have enough hoses to do more than one operation at a time

Acknowledgements

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Wine Australia