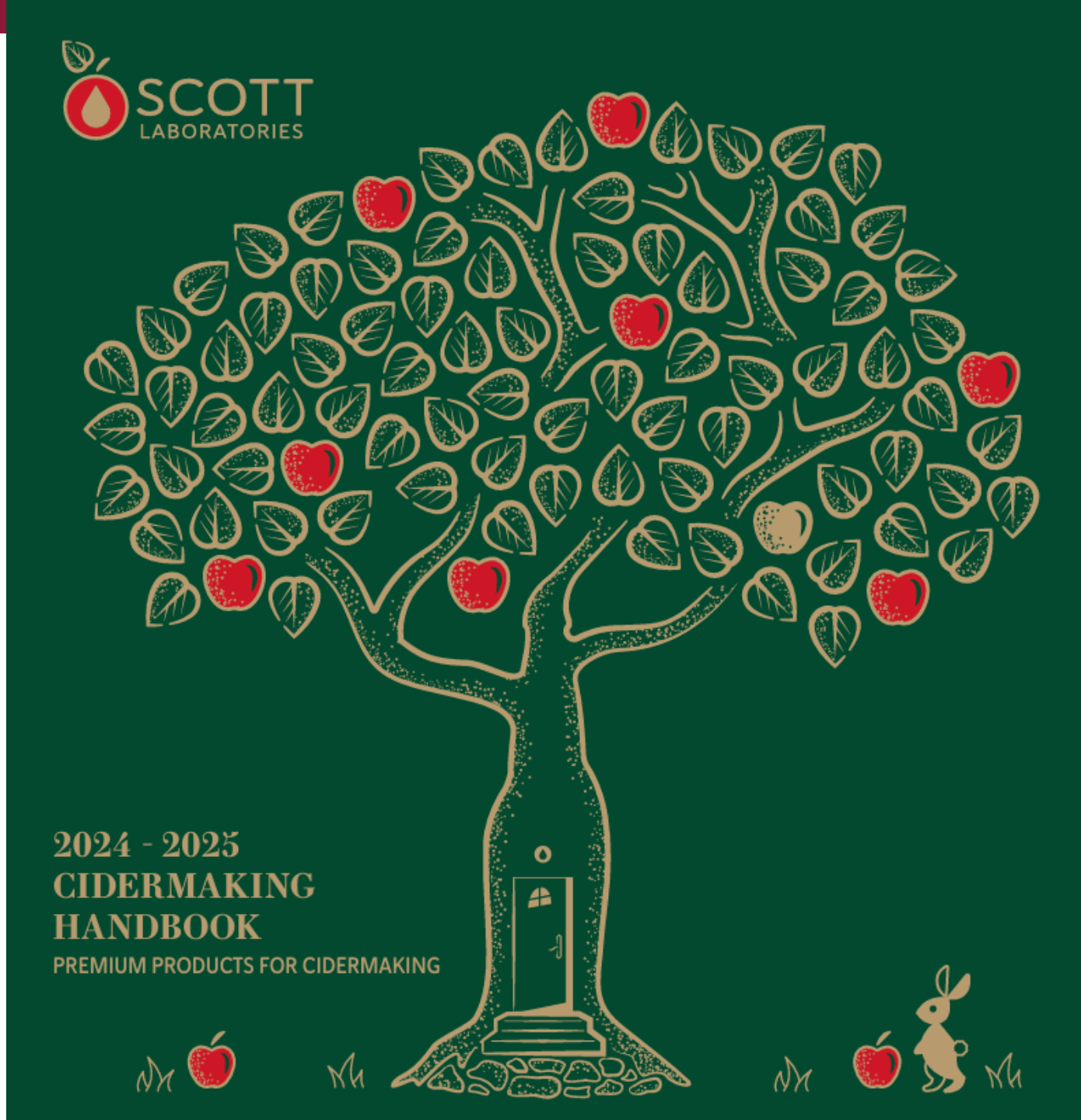
A CAN DO ATTITUDE: MAKING STABLE CIDER WITHOUT SO_2

Dr. Nichola Hall

January 19th, 2024

SCOTT LABORATORIES



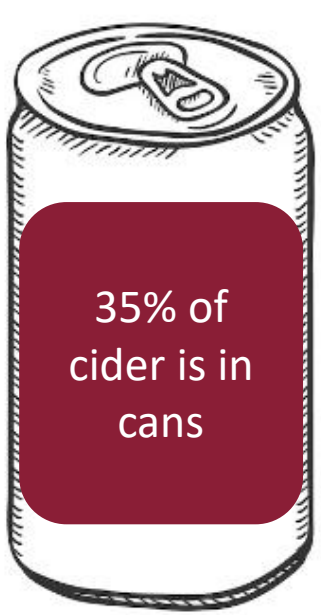
OVERVIEW

a.k.a. What are we going to talk about

- Factors for consideration when using cans
- Benefits and challenges of using SO_2
- Alternatives to SO_2
- Putting it into practice

CIDER AND PACKAGING OPTIONS?

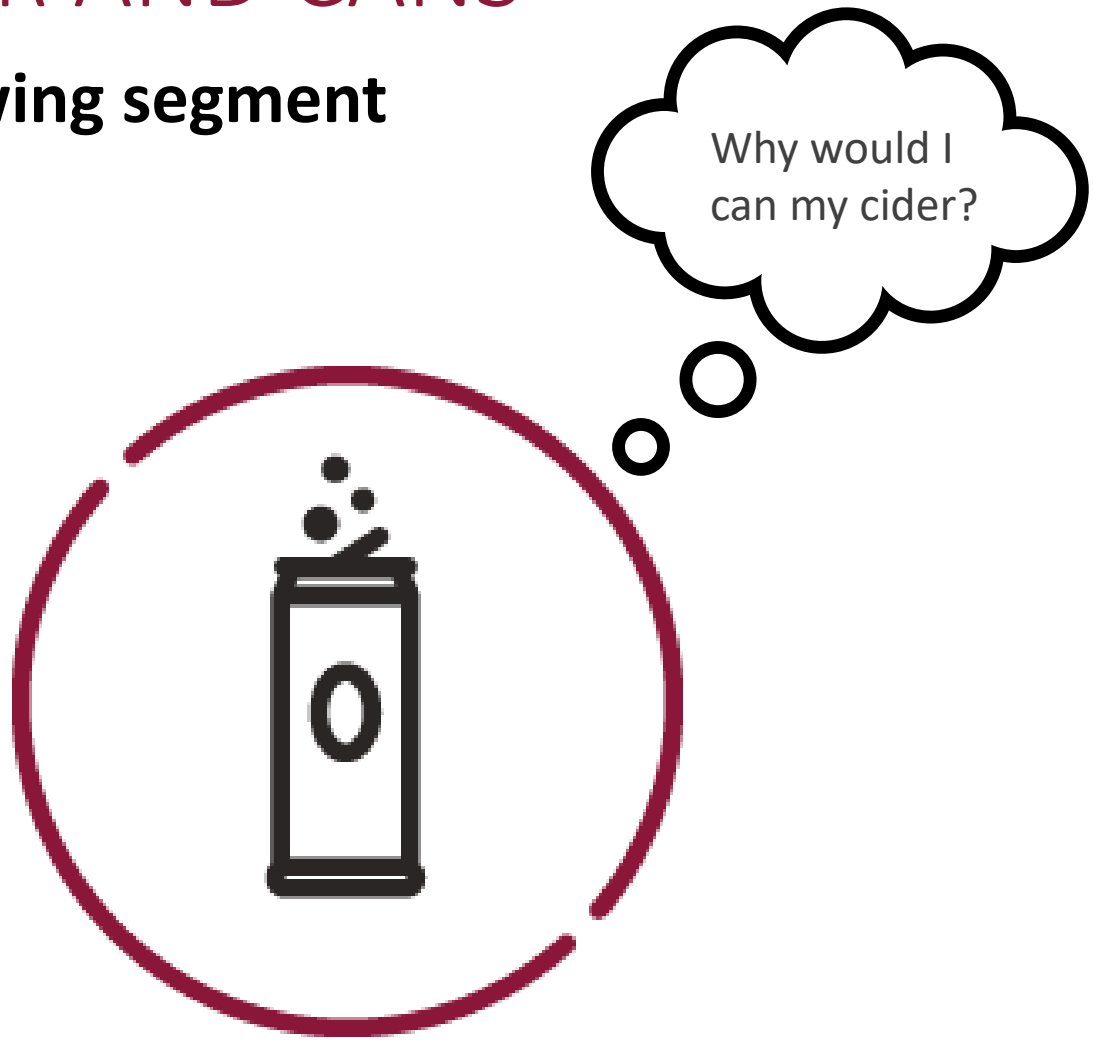
Cans are not a new package type but are an area of active growth in the packaging arena!



Per Nielsen scan data

CIDER AND CANS

A growing segment

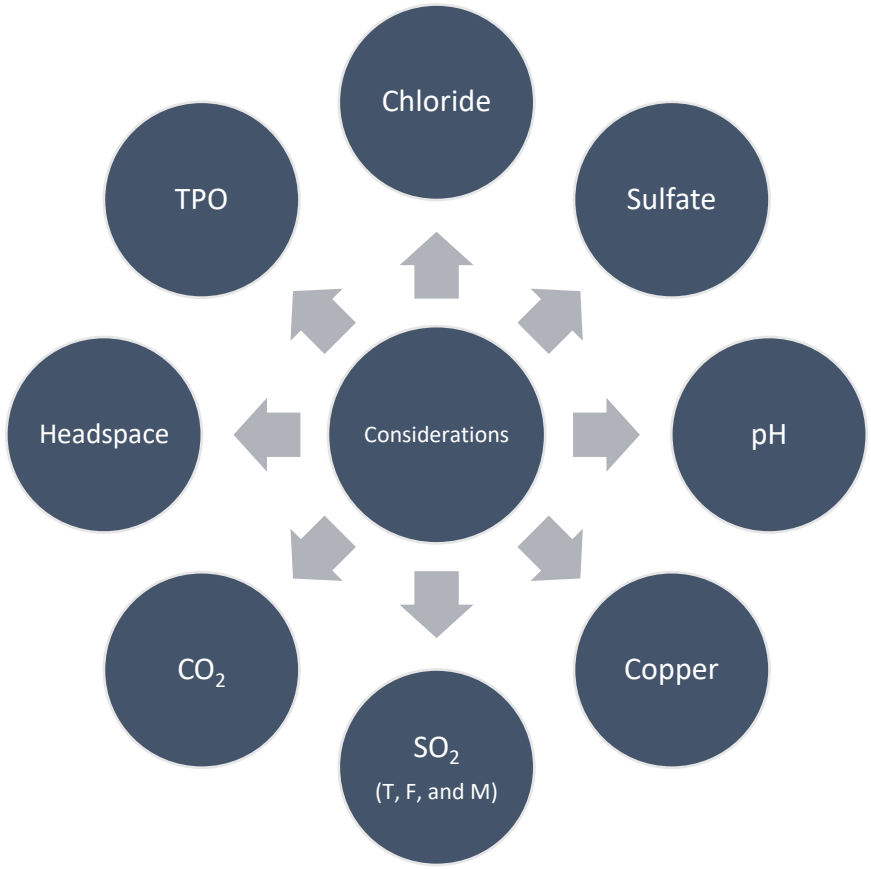


- Recyclable
- Convenient and portable
- Chill quickly
- Customizable
- Protect product integrity

Versari A. et al (2023) AJEV, Vol 74

CIDER AND CANS

Risk factors for consideration when using Aluminum cans



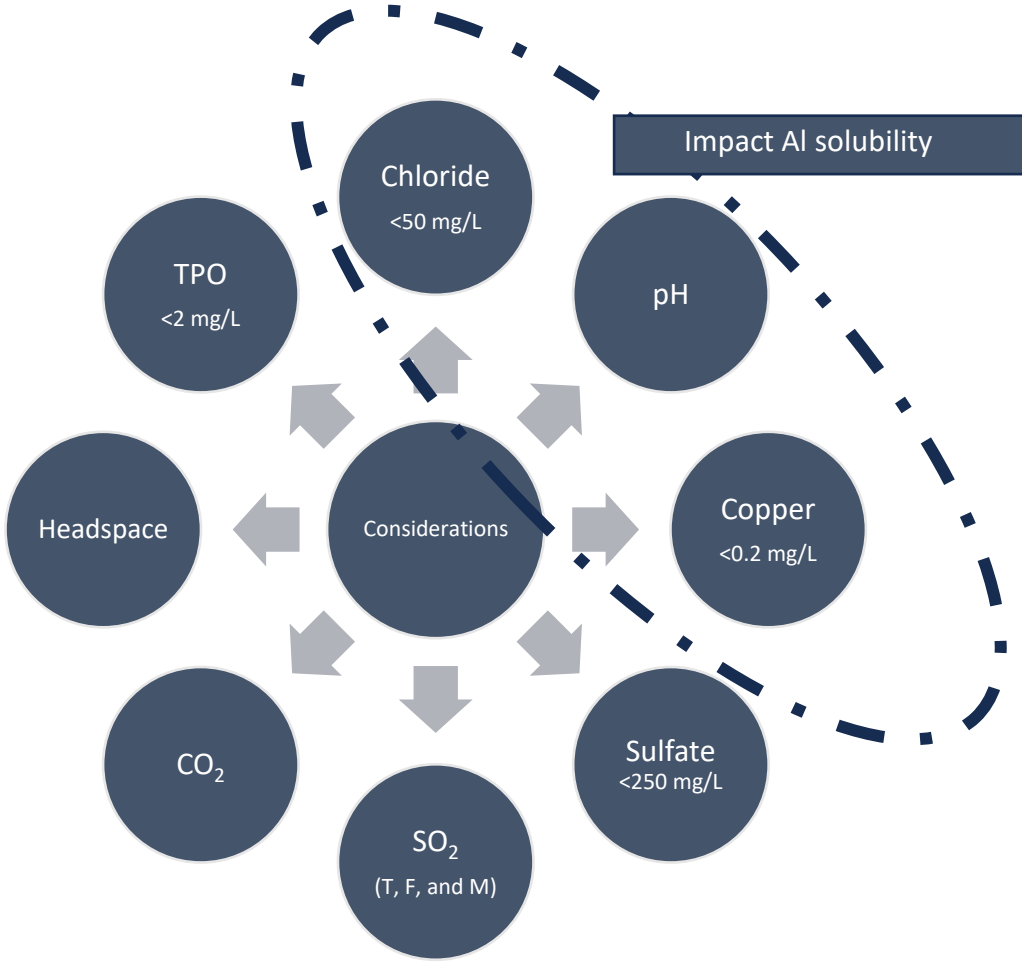
Why are these risk factors?

- Can material is aluminum (Al)
  - Al forms a protective layer with oxygen
  - If this layer is compromised
  - Al is exposed

Image adapted from AWRI webinar on canning wines
Montgomery A. et.al., (2022) AJEV, Vol 74
Versari A. et al (2023) AJEV, Vol 74

CIDER AND CANS

Risk factors for consideration when using Aluminum cans



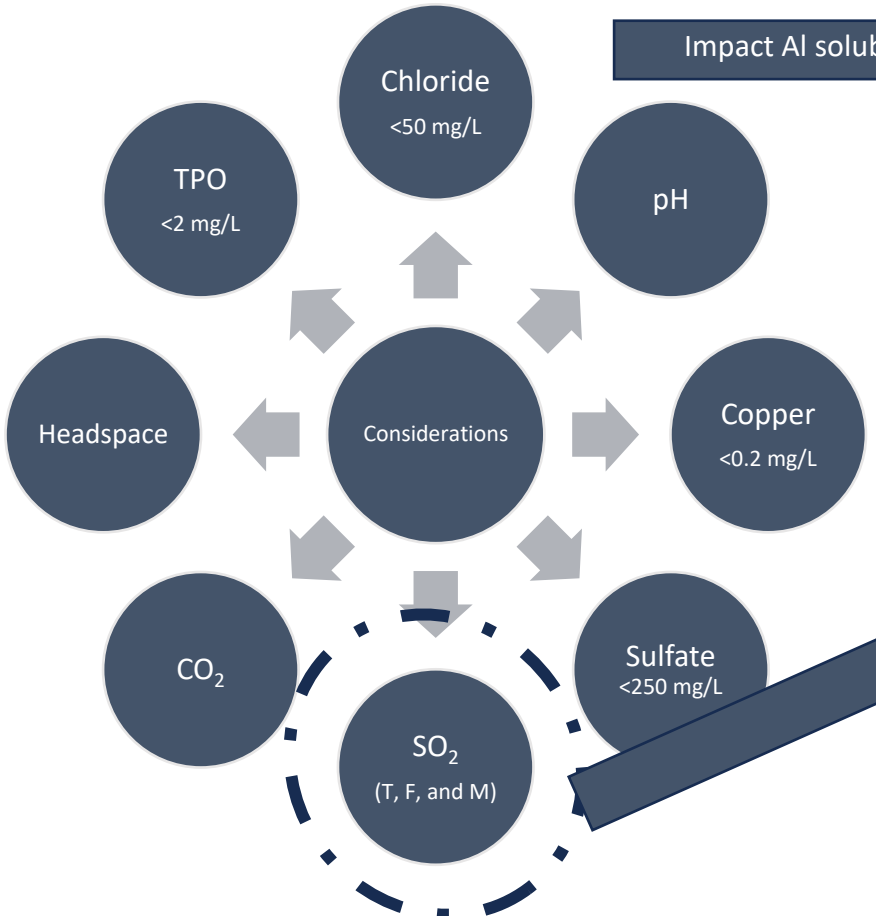
Impact Al solubility

Al migrates into beverage

Image adapted from AWRI webinar on canning wines
Montgomery A. et.al., (2022) AJEV, Vol 74
Versari A. et al (2023) AJEV, Vol 74

CIDER AND CANS

Risk factors for consideration when using Aluminum cans



Impact Al solubility

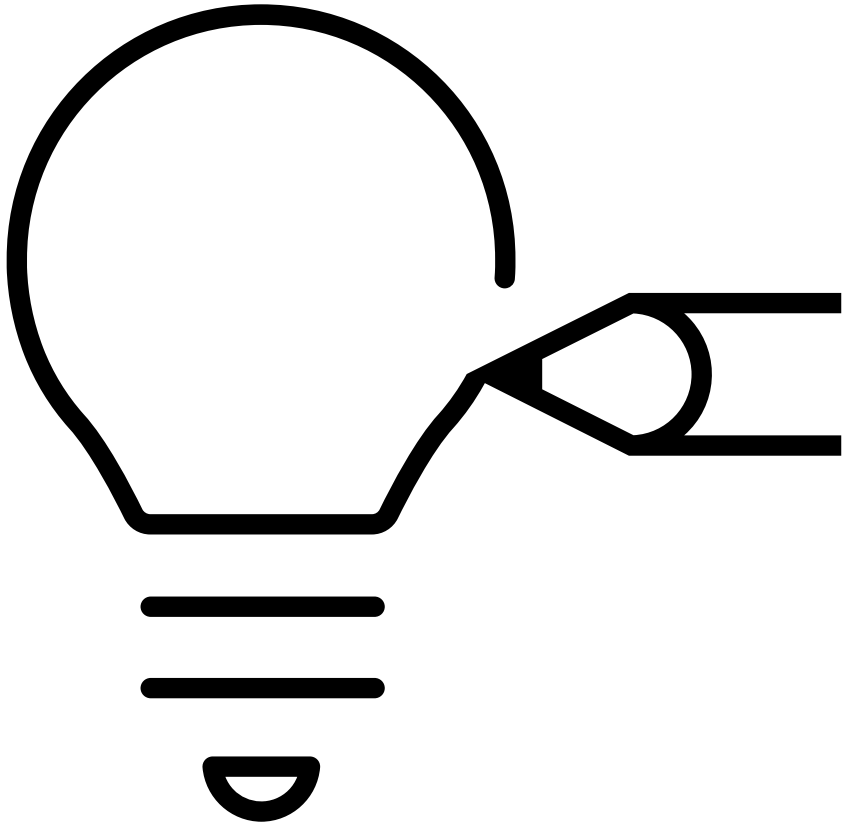
Al migrates into beverage

$Al + SO_2 \Rightarrow \mathbf{H_2S}$

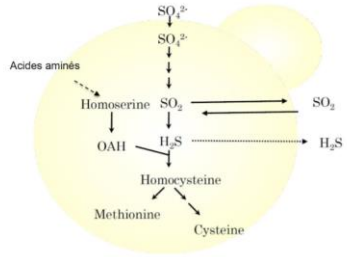
$$2Al_{(s)} + SO_{2\,(aq)} + 6H^+_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + H_2S_{(g)} + 2H_2O$$
$$(Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-;\ E_h = -166\ mV)$$

Image adapted from AWRI webinar on canning wines
Montgomery A. et.al., (2022) AJEV, Vol 74
Versari A. et al (2023) AJEV, Vol 74

HOW MUCH SO_2 IS IN YOUR CIDER?



- Deliberate addition
  - Salt form (e.g. potassium metabisulfite)
  - Liquid form
  - Effervescent form (e.g., Inodose tablets)
- Normal constituents of fermented beverages
  - Cider, Beer, Wine…
  - 10-65mg/L can be present as a by product of yeast metabolism



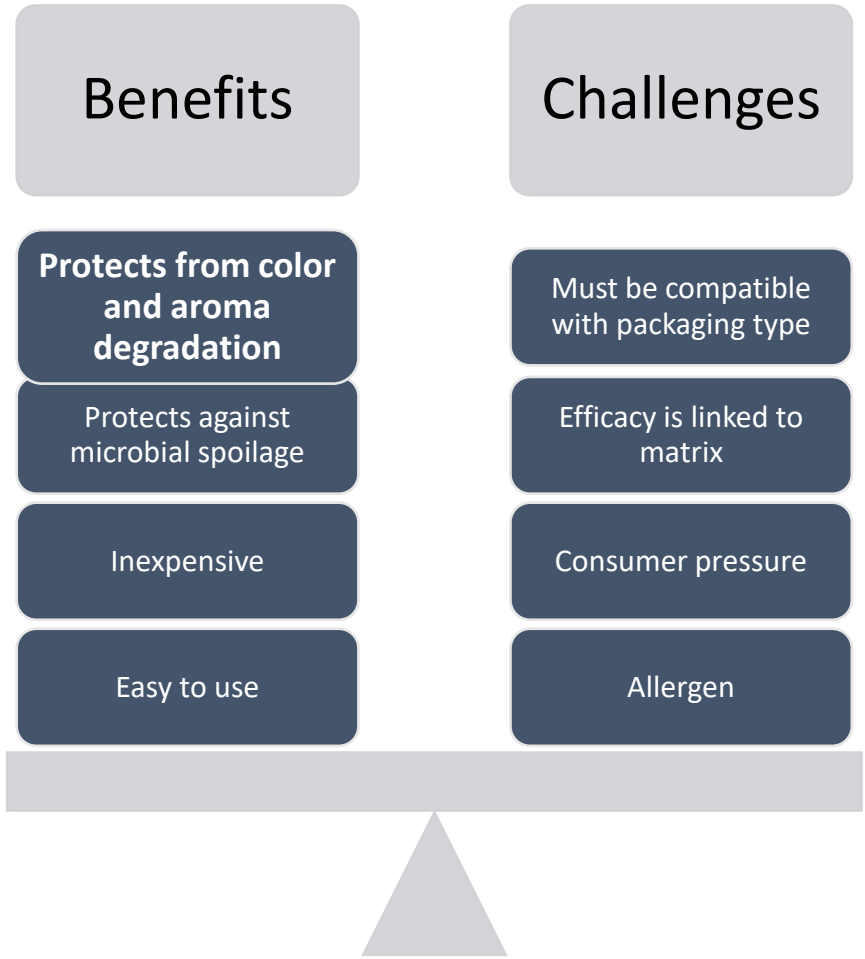
HOW MUCH SO_2 IS IN YOUR CIDER?

- Deliberate additio
  - Sal
- lfite)
- ets)
- erages

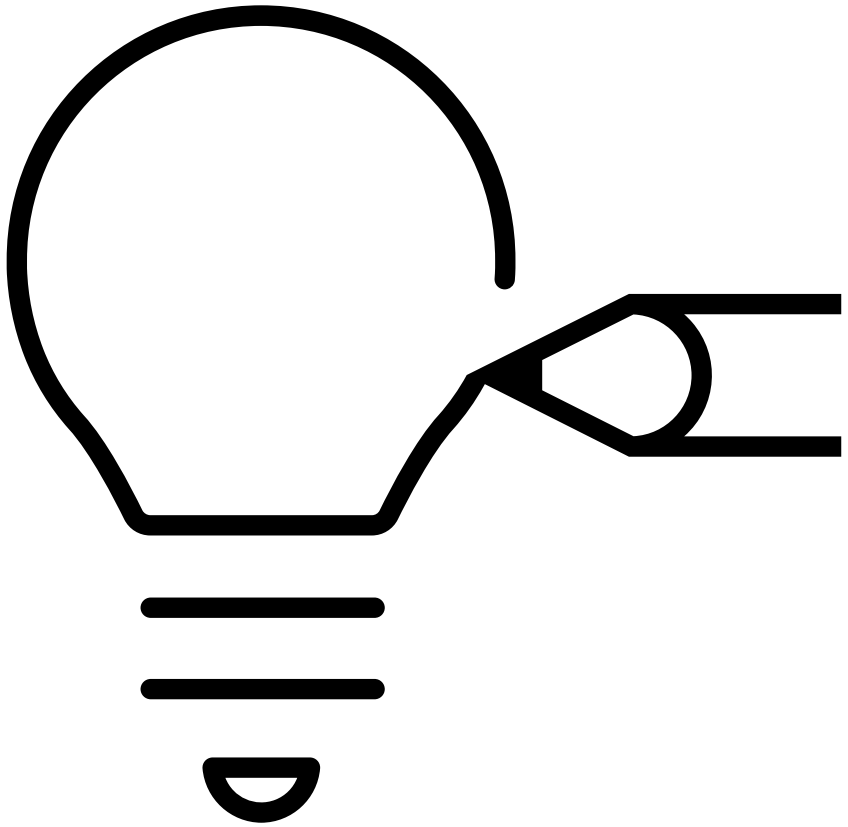
an be present as a by
duct of yeast metabolism

SULFUR DIOXIDE (SO_2)

What are the benefits and challenges of SO_2?

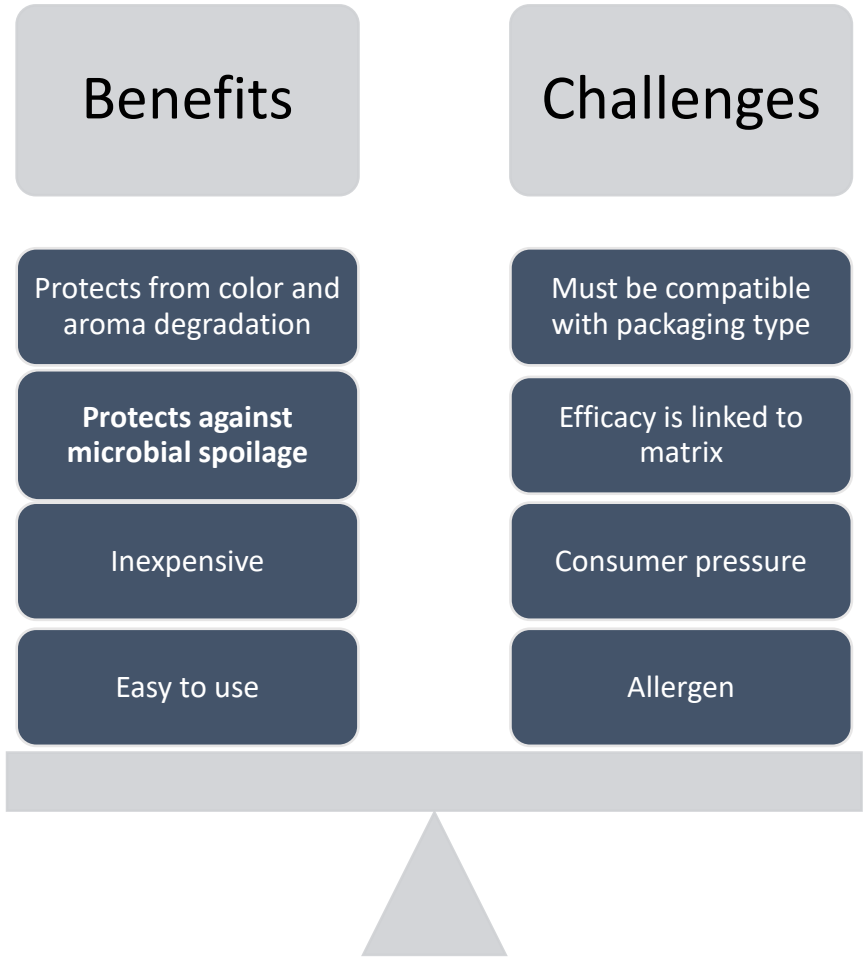


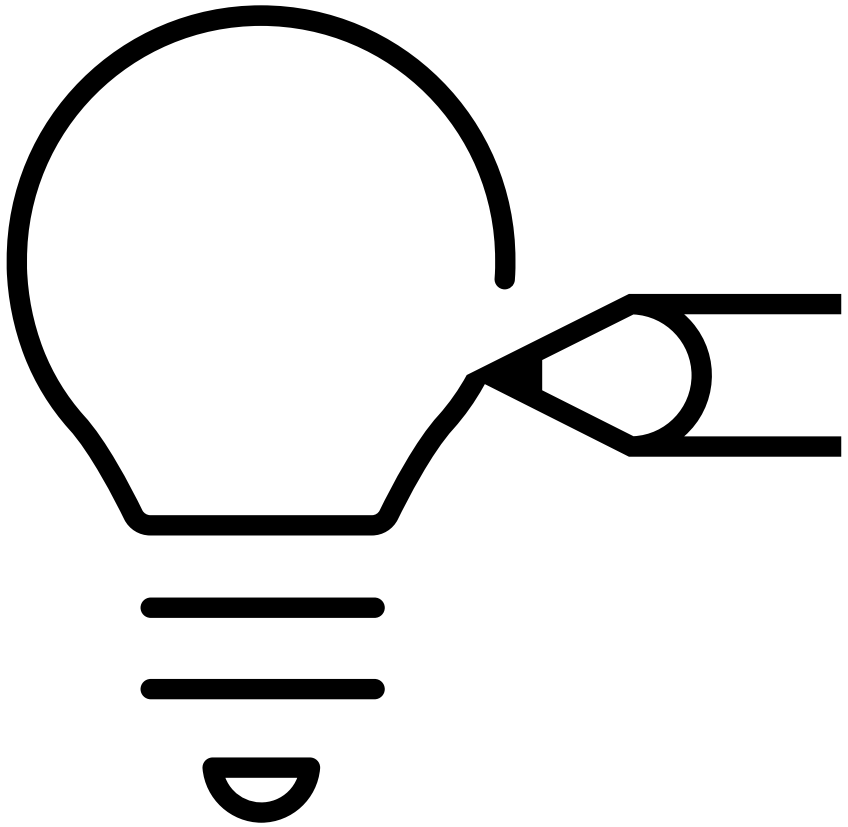
SCOTT LABORATORIES



SULFUR DIOXIDE (SO_2)

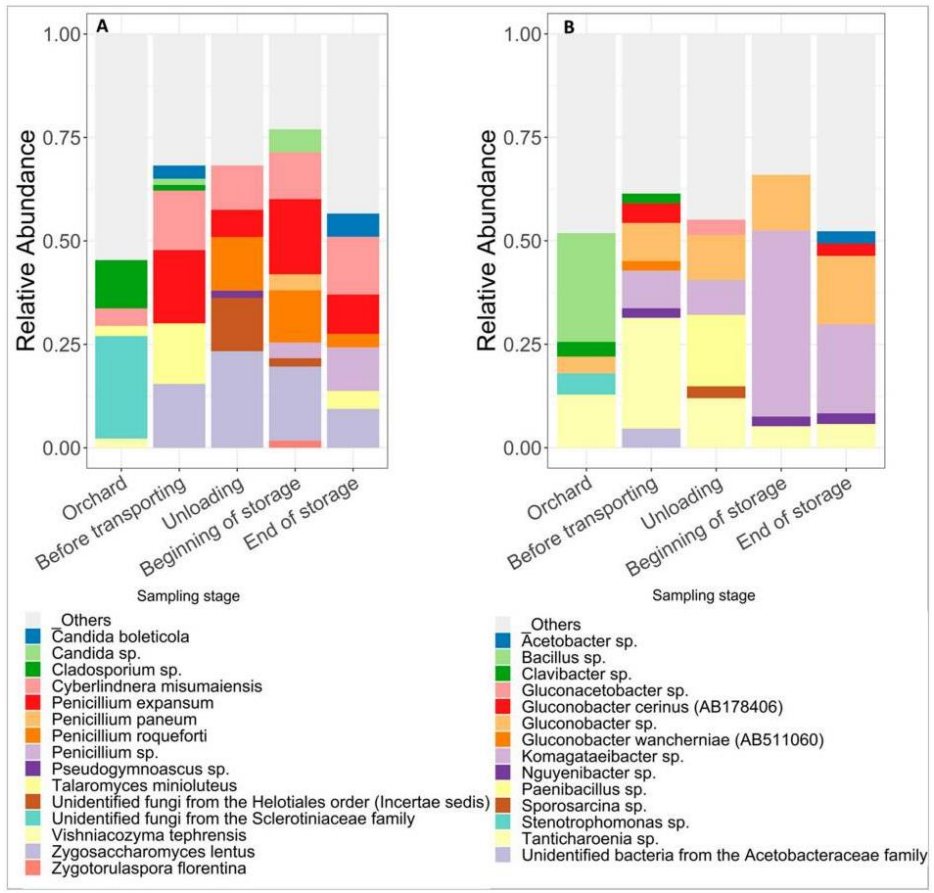
What are the benefits and challenges of SO_2?





WHAT ORGANISMS DOES CIDER NEED PROTECTING FROM?

WHAT SPOILAGE ORGANISMS ARE WE TRYING TO MANAGE?



Riachy R A. et. al. (2021) J. Fungi; 7 (4)

Yeast

- *Candida spp.*
- *Hanseniaspora spp./ Kloeckera spp.*
- *Brettanomyces spp.*
- *Saccharomyces spp.*
- *Metschnikowia spp.*

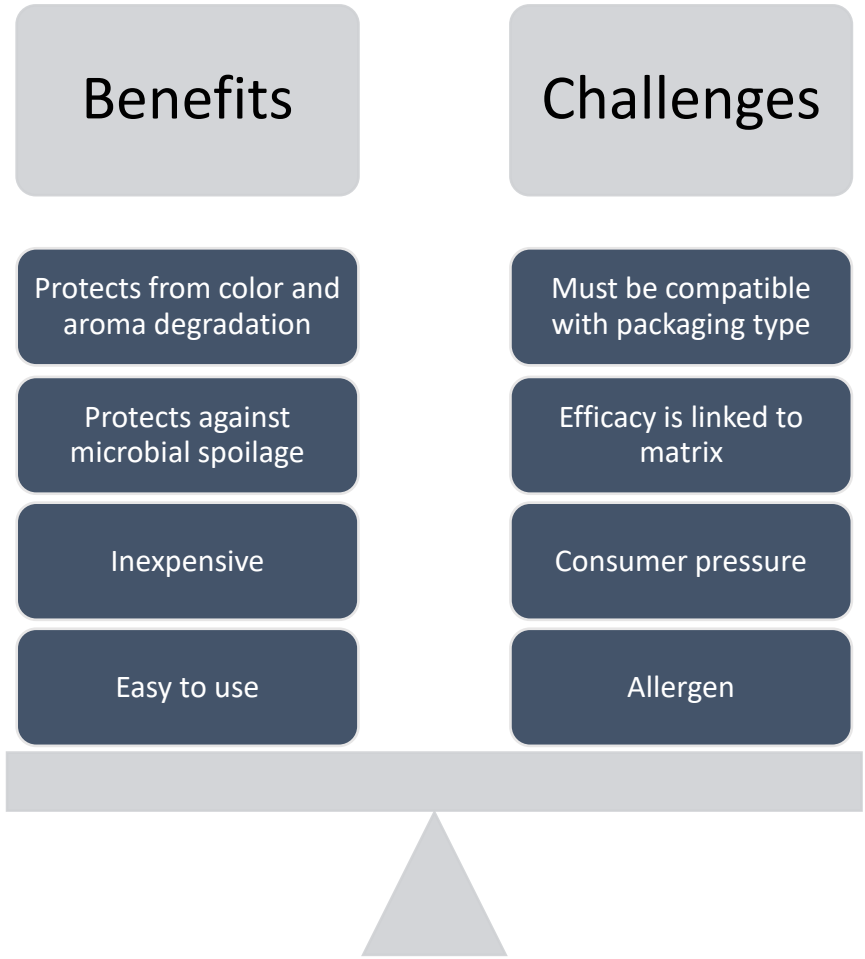
Bacteria

- Lactic acid bacteria
- Acetic acid bacteria

There are organisms associated with all stage the process, however the type and number of microbes differ

SULFUR DIOXIDE (SO_2)

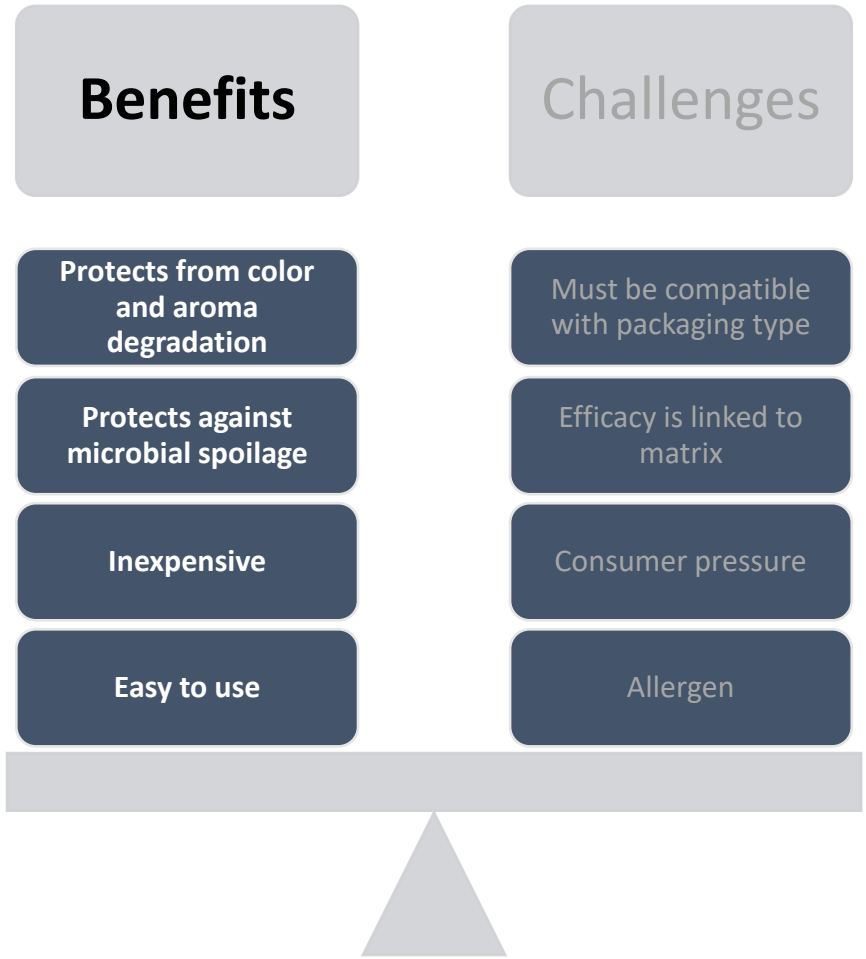
What are the benefits and challenges of SO_2?



SULFUR DIOXIDE (SO_2)

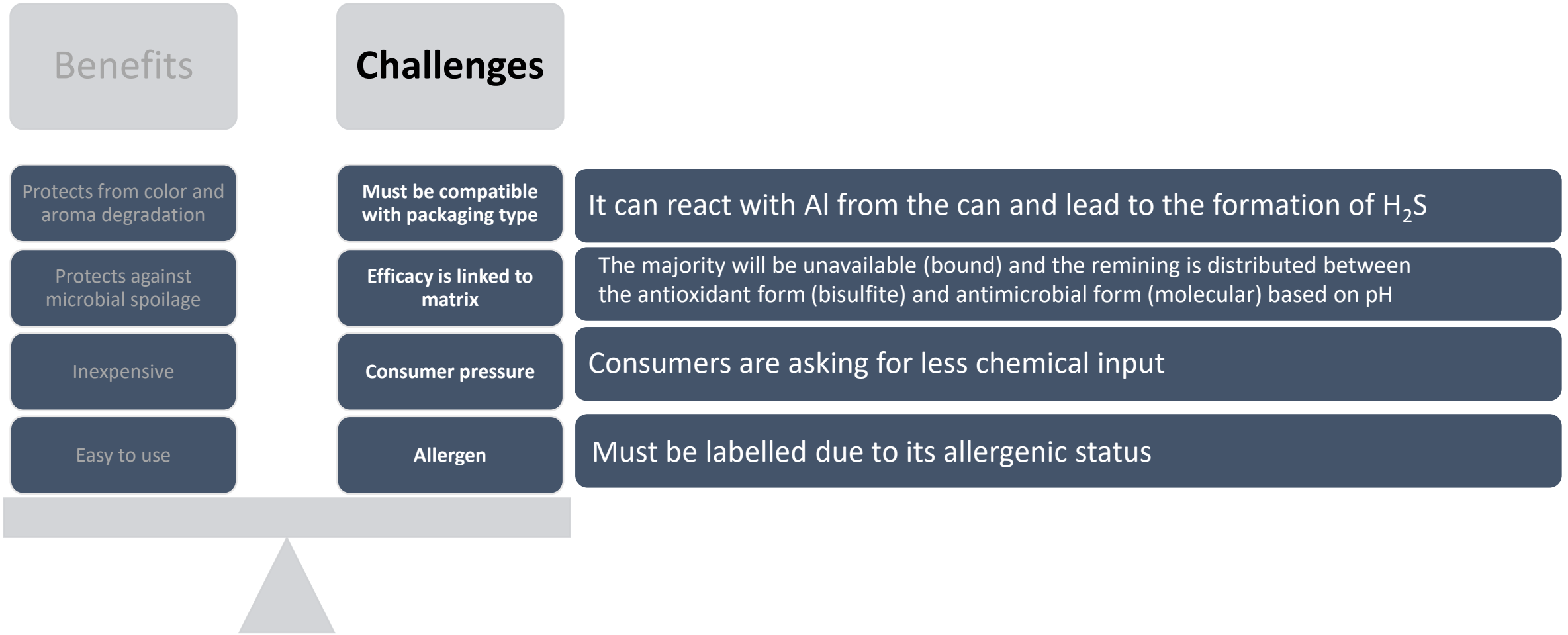
What are the benefits and challenges of SO_2?

- Can inhibit or delay the oxidation process: protects from browning and aldehyde (bruised apple/sherry) aroma formation
- Dissociates (based on the pH) into the active form (MSO_2) which diffuses into yeast and bacteria cell resulting in cell inhibition or cell death
- 1kg KMBS (576g SO_2) costs <$8
- Comes in standard powder, liquid, effervescent pre-dosed packs of potassium metabisulfite; generally, all are 57% active SO_2



SULFUR DIOXIDE (SO_2)

What are the benefits and challenges of SO_2?



IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)

BIOLOGICAL & DERIVATIVES

- Selected cultures
  - Non-Sacc.
  - *Saccharomyces*
  - Malolactic bacteria
  - Chitin derivatives

CHEMICAL

- ~~SO_2~~
- CO_2
- pH mgmt.
- Lysozyme
- Ethanol
- Residual sugar
- Delle Units
- Sorbic Acid
- Velcorin® (DMDC)

PHYSICAL

- Clarification
- Filtration
- Centrifugation
- Thermal
- Hydrostatic pressure
- Electric current
- Ultrasound

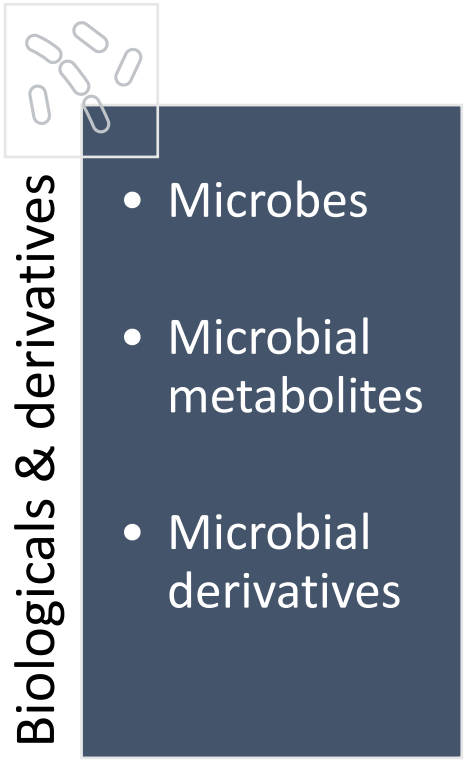
ENVIRONMENTAL

- Temperature control
- Humidity
- Headspace
- Facility hygiene

- On the horizon: Natural plant extracts (polyphenolic compounds, almond skins, herb oil, stilbenes, olive)
https://www.jmbfs.org/wp-content/uploads/2020/01/jmbfs_1646_Y%C4%B1ld%C4%B1r%C4%B1m.pdf

IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)



- These are general use- check with your regulatory body to determine if permitted

IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)

Biologicals & derivatives

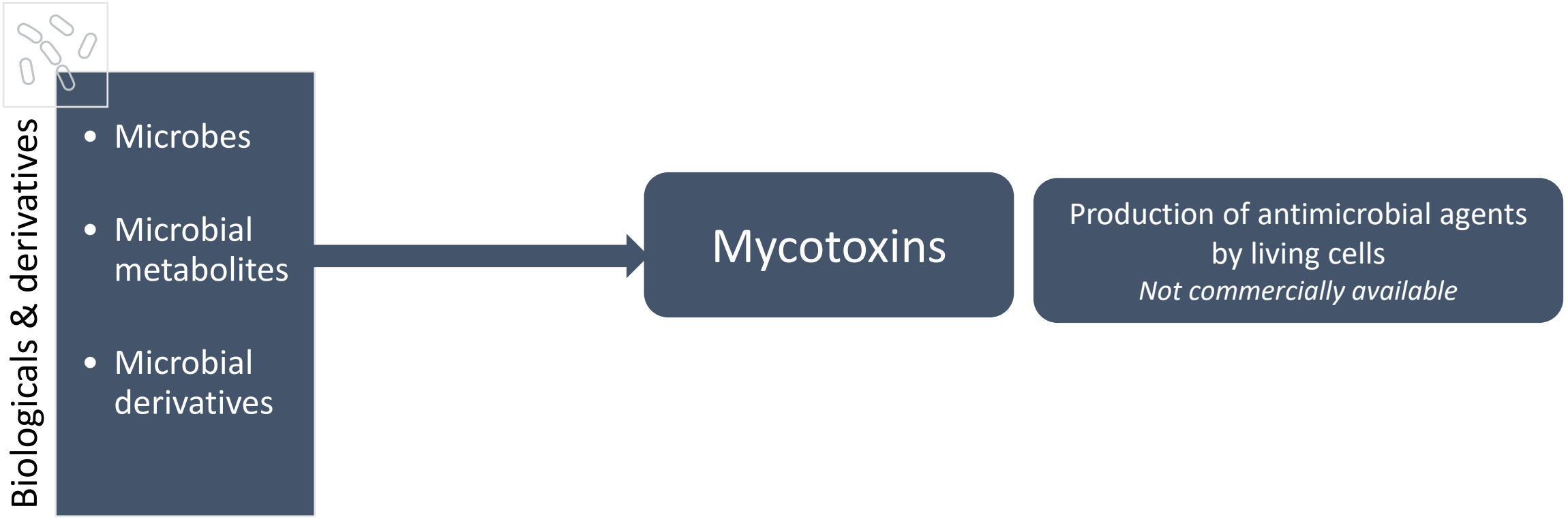
- Microbes
- Microbial metabolites
- Microbial derivatives

Non-Saccharomyces yeast
Saccharomyces yeast

Act as bioprotectants
Take over the juice become dominant organisms and/or remove essential elements from the juice

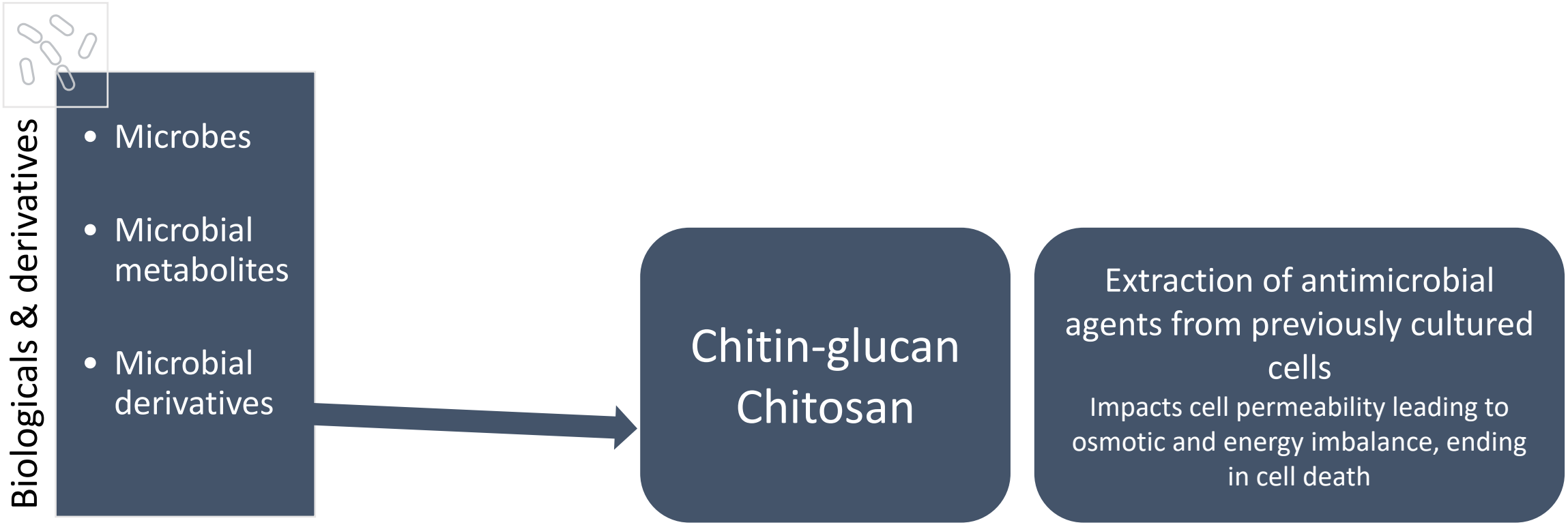
IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)



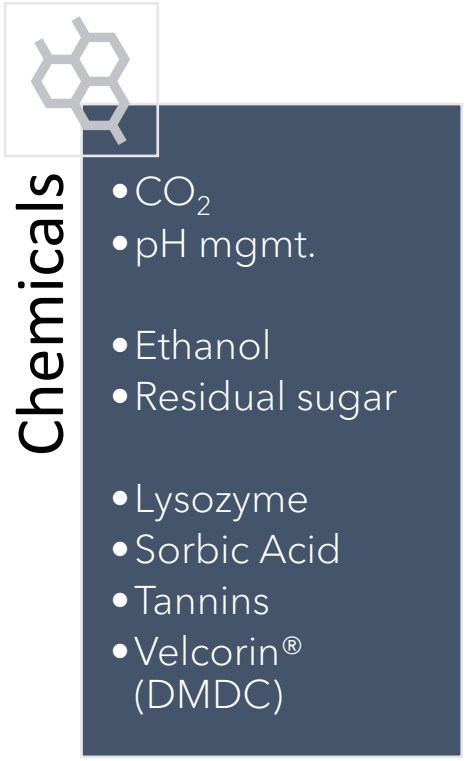
IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)



IF SO_2 IS UNAVAILABLE, WHAT IS?

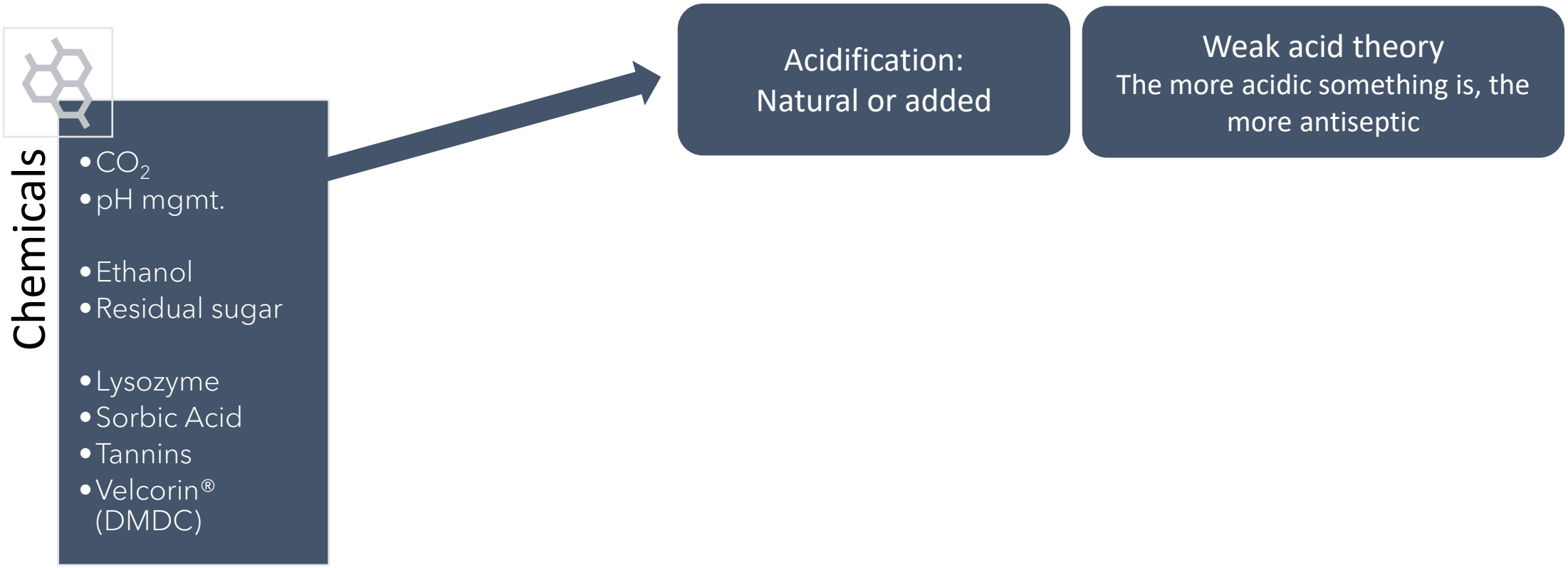
To prevent spoilage (antimicrobial)



- These are general use- check with your regulatory body to determine if permitted

IF SO_2 IS UNAVAILABLE, WHAT IS?

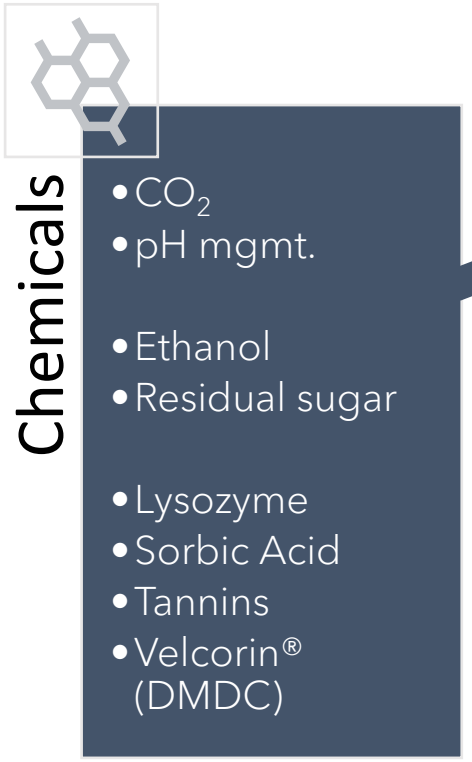
To prevent spoilage (antimicrobial)



- These are general use- check with your regulatory body to determine if permitted

IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)



Exploit natural chemistry

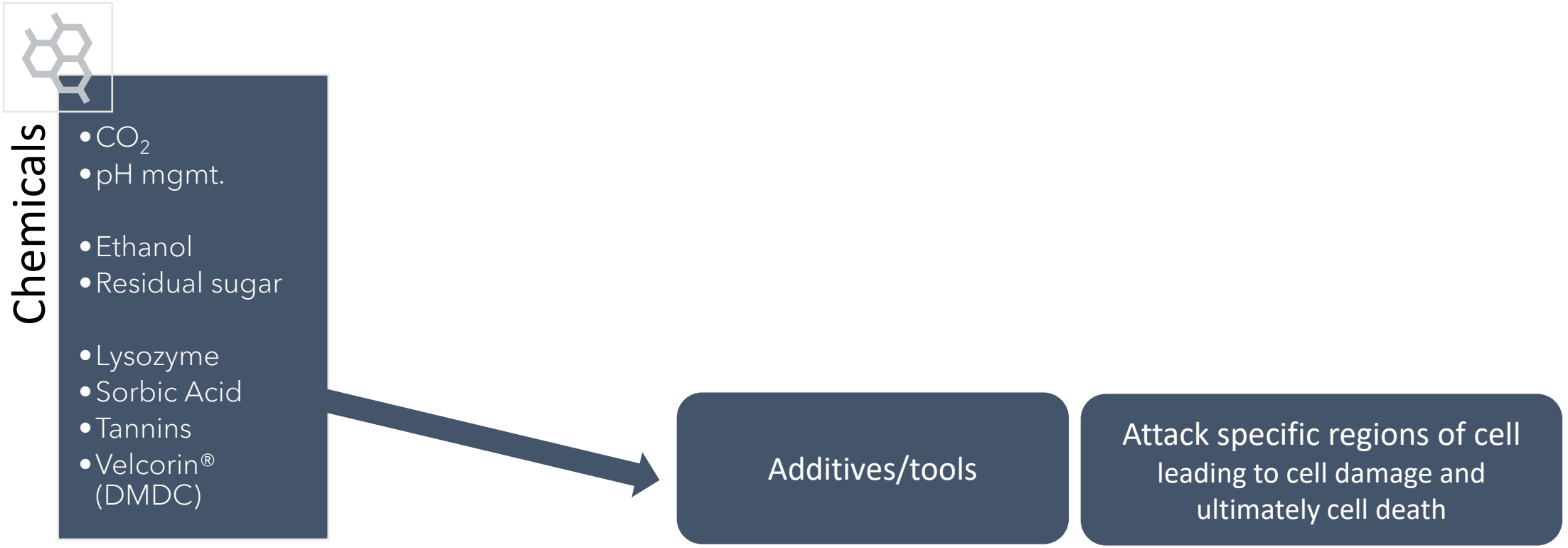
In late harvest/ice-ciders
The combination of ethanol and residual sugar in combination can be lethal (Delle Units)

- Assumptions made:
  - A sugar concentration >80% has an equivalent anti-microbial activity of ~18% ethanol
  - Assume that sugar >780g/L is microbiologically stable
  - Assume that ethanol >17.5% is microbiologically stable
- In theory DU≥78 then the cider should be microbiologically stable
- In actuality ≥75 should confer stability due to other hurdles

$$Delle\ Units = \frac{Residual\ Sugar(g\ per\ L)}{10} + (4.5\ x\ ethanol(\%)\ )$$

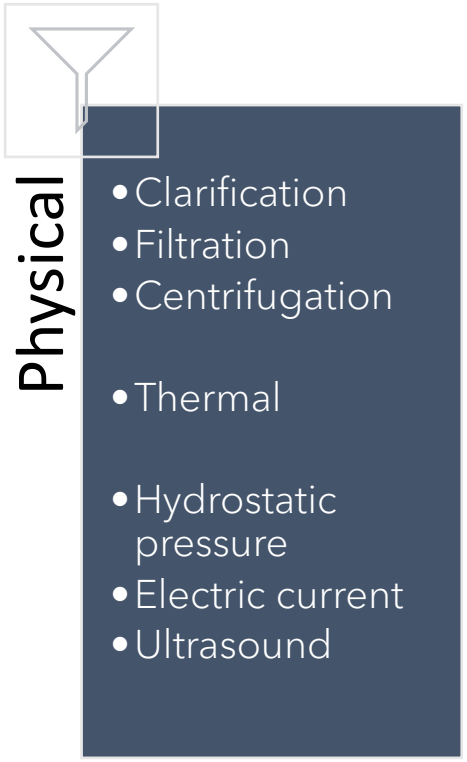
IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)



IF SO_2 IS UNAVAILABLE, WHAT IS?

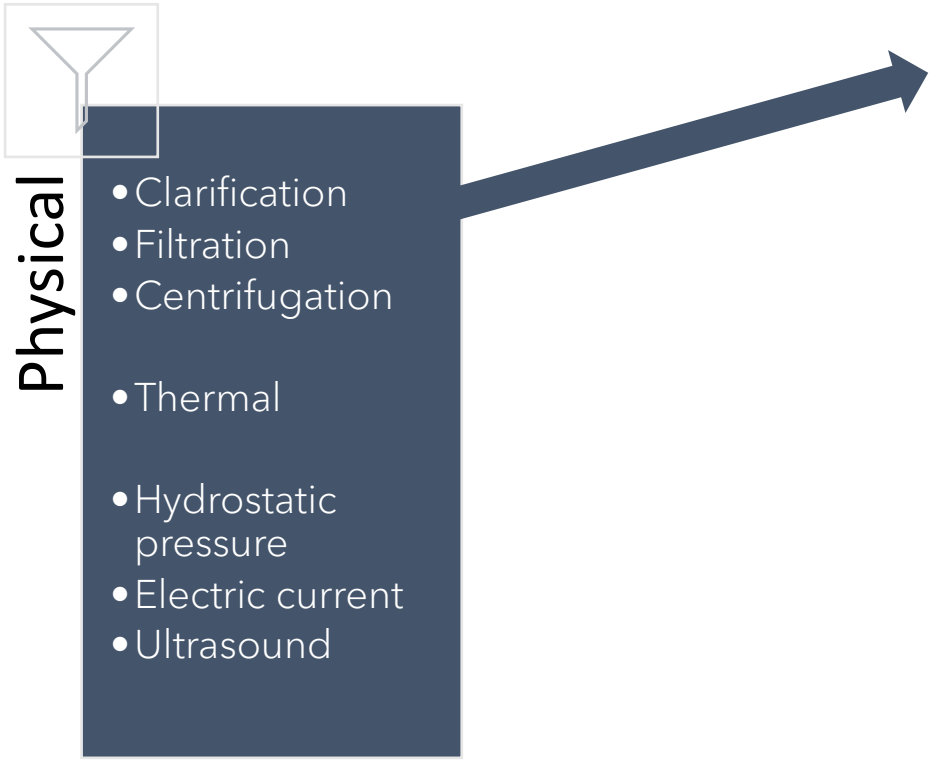
To prevent spoilage (antimicrobial)



- These are general use- check with your regulatory body to determine if permitted

IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)

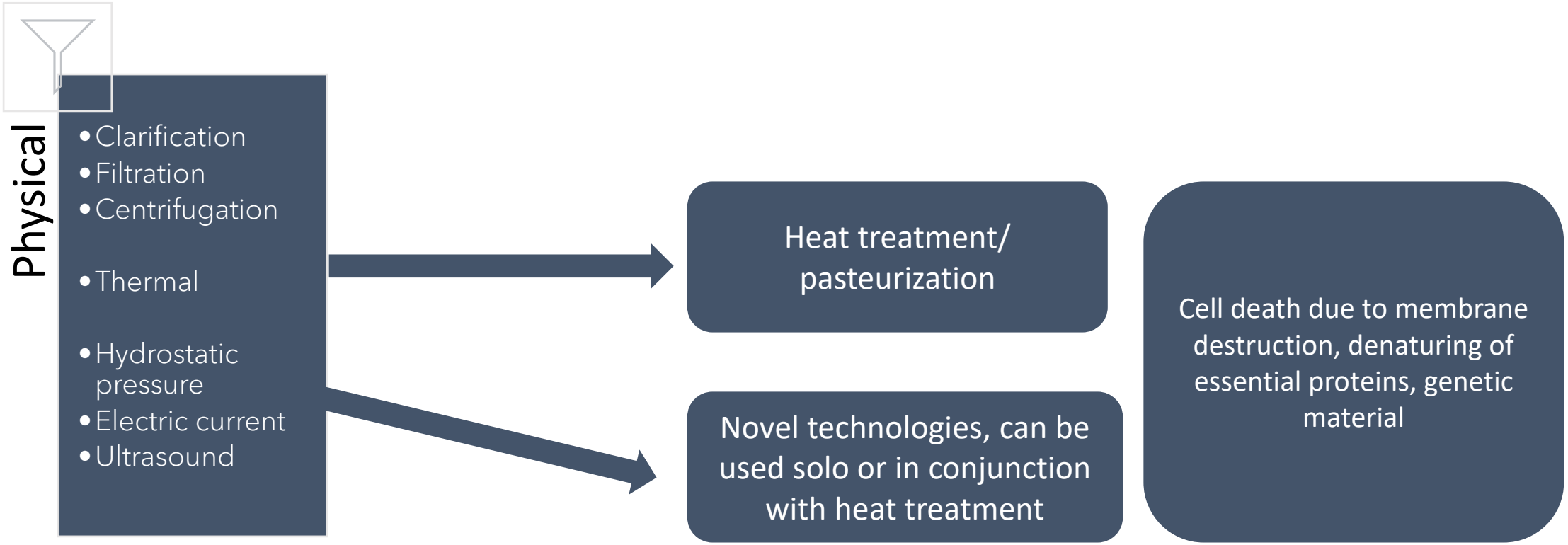


Separation techniques

Physically remove the organisms from the juice/cider

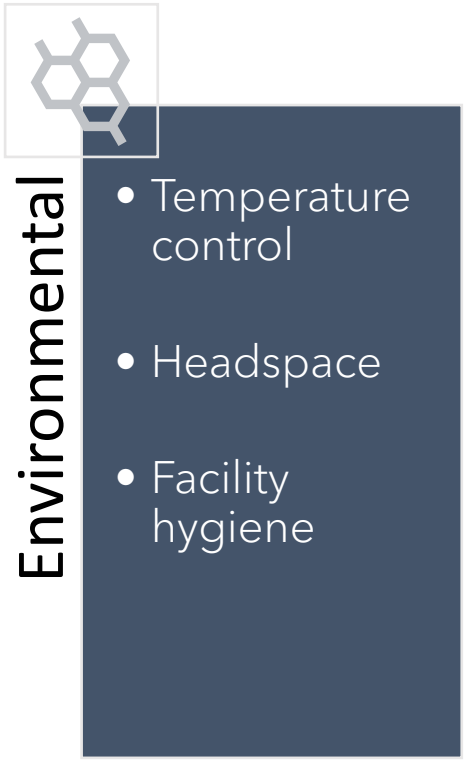
IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)



IF SO_2 IS UNAVAILABLE, WHAT IS?

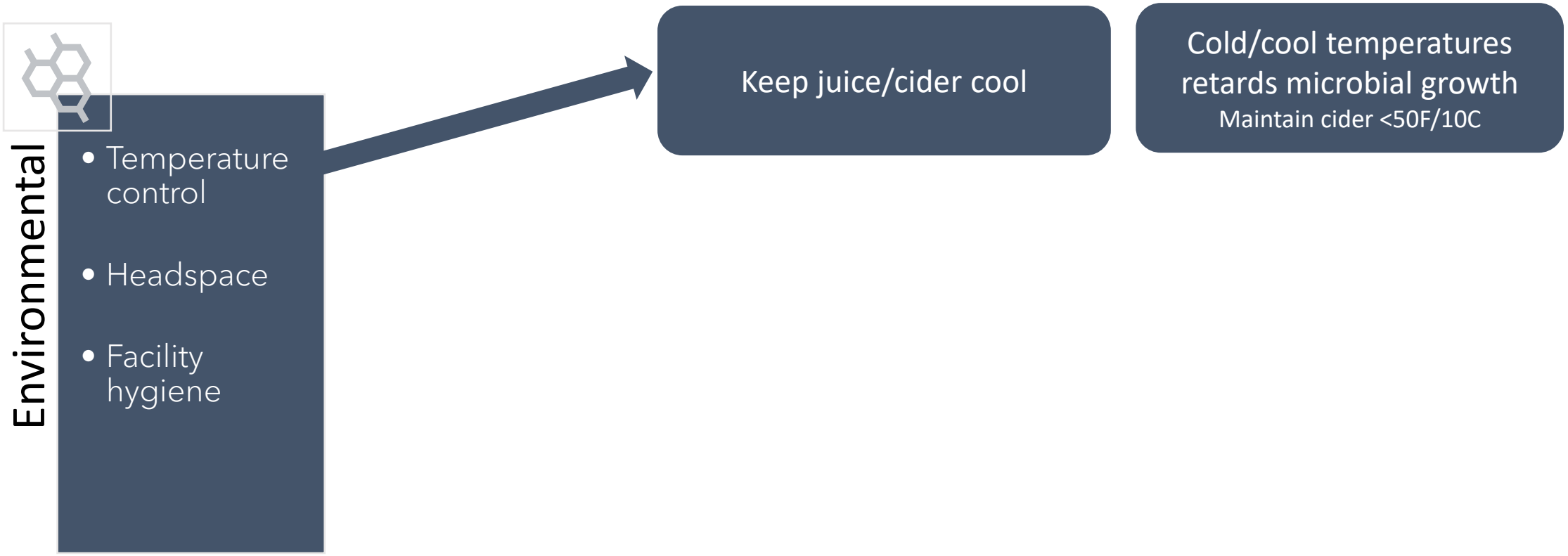
To prevent spoilage (antimicrobial)



- These are general use- check with your regulatory body to determine if permitted

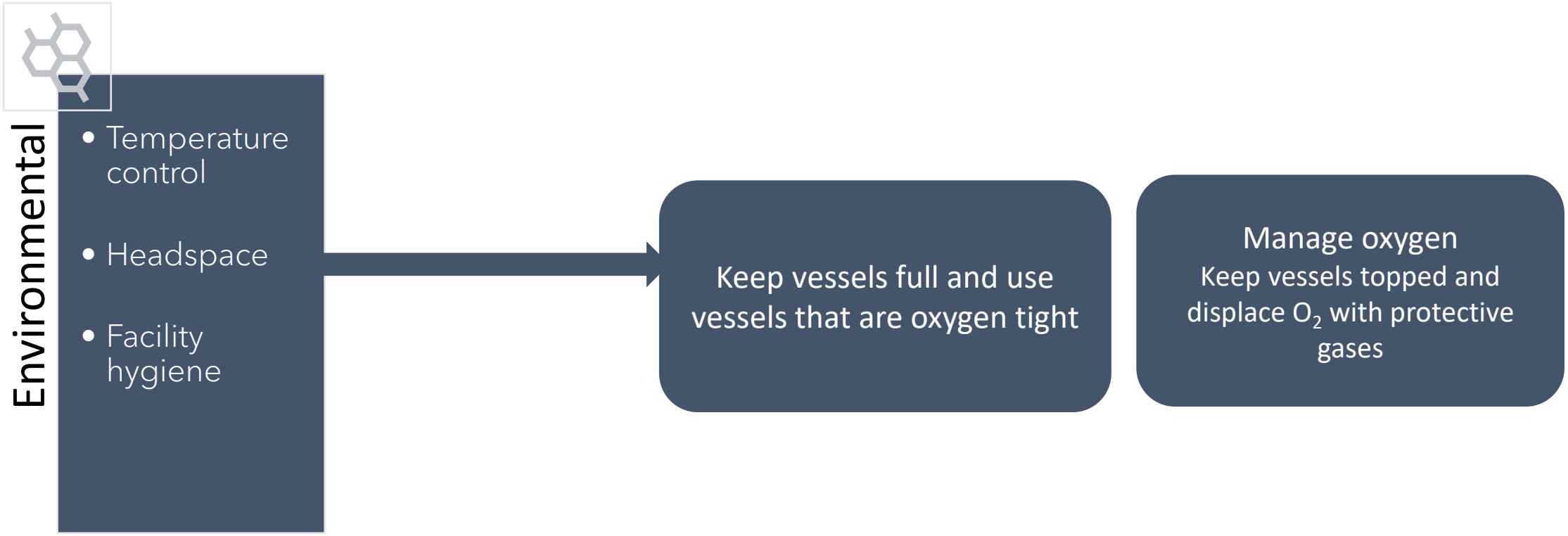
IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)



IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)



IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent spoilage (antimicrobial)

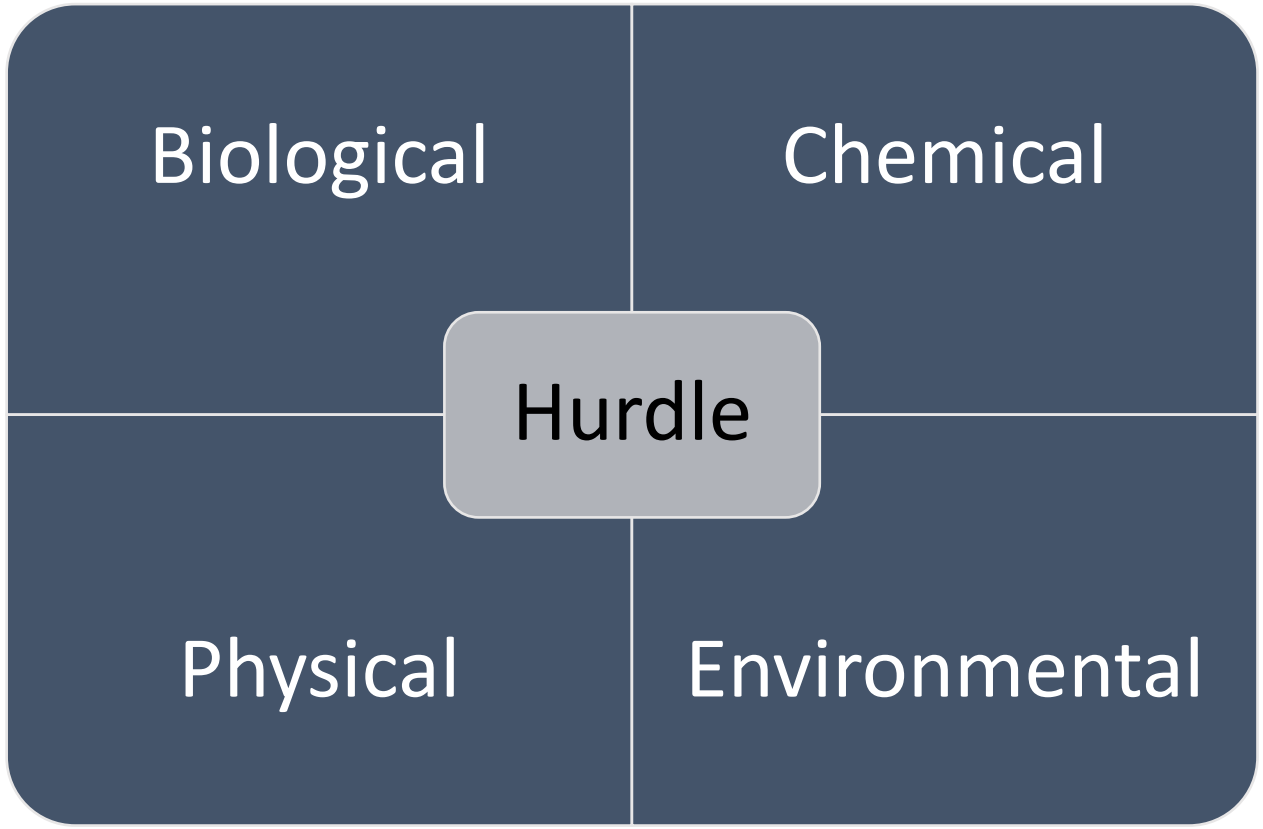
Environmental

- Temperature control
- Headspace
- Facility hygiene

Clean and sanitize- EVERYTHING!

Removes cells/kills 99.9% remaining vegetative cells from equipment and prevents biofilm build-up

HURDLE TECHNOLOGY



The more hurdles that are put in front of the microbes, the more difficult it is for them to spoil your cider!

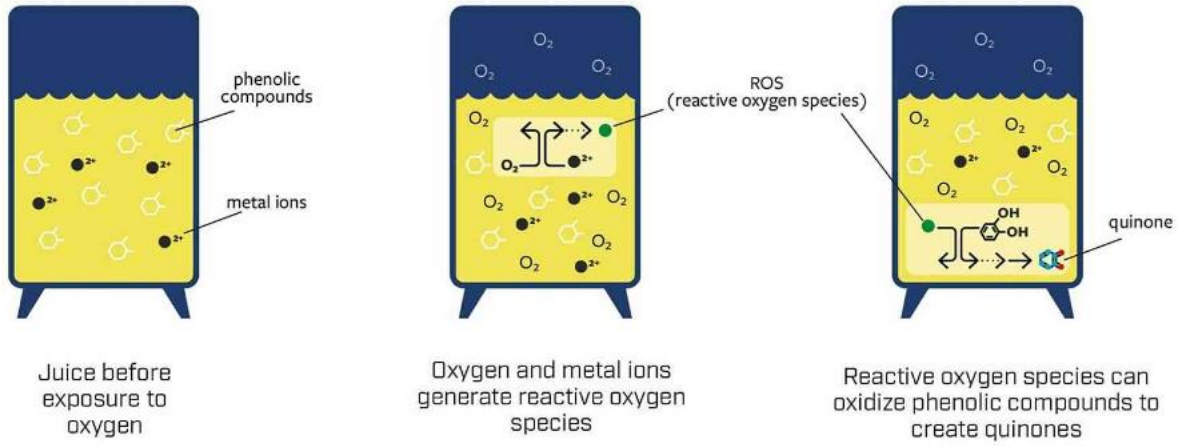
SCOTT LABORATORIES

So, we have antimicrobial activity covered…

You need analysis to confirm!

OXIDATION REACTIONS?

A natural, but controllable, multi-stage process



1. Juice is exposed to oxygen
2. Oxygen interacts with metal ions (Fe) generates reactive oxygen species
3. Reactive oxygen species can oxidize phenolic compounds to generate quinones

IF SO_2 IS UNAVAILABLE, WHAT IS?

SCOTT LABORATORIES

To prevent aroma and color degradation (antioxidant)

Antioxidant

- Scavenge O_2
- Scavenge mineral ions
- Scavenge (susceptible) phenolics

- These are general use- check with your regulatory body to determine if permitted

https://scottlab.com/troubleshooting/preventing-and-treating-oxidative-damage-in-cider

IF SO_2 IS UNAVAILABLE, WHAT IS?

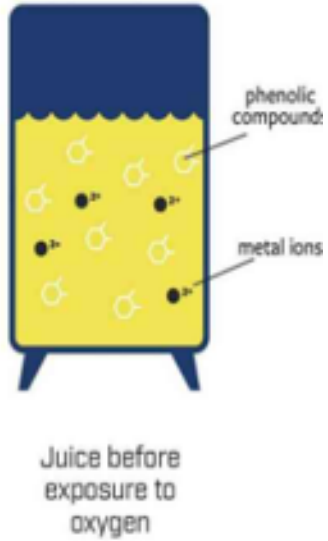
To prevent aroma and color degradation (antioxidant)

Antioxidant

- Scavenge O_2
- Scavenge mineral ions
- Scavenge (susceptible) phenolics

Oxygen is a participant in the subsequent reaction with iron that generates ROS

Removing O_2 removes one of the precursors to oxidation (Reactive oxygen species)



Non-Sacc yeast
Inactivated yeast
Oak Tannins

https://scottlab.com/troubleshooting/preventing-and-treating-oxidative-damage-in-cider

IF SO_2 IS UNAVAILABLE, WHAT IS?

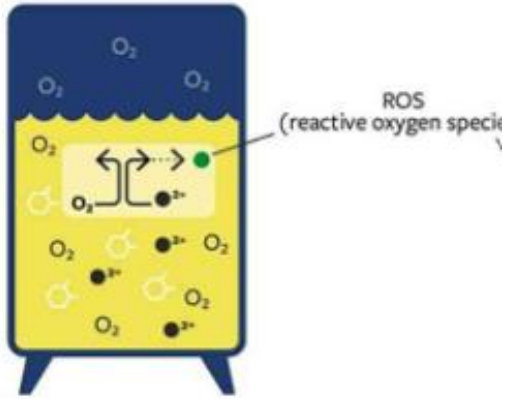
To prevent aroma and color degradation (antioxidant)

Antioxidant

- Scavenge O_2
- Scavenge mineral ions
- Scavenge (susceptible) phenolics

Metal ions, like iron, are very reactive and easily lose electrons

Removing iron removes one of the intermediates/ catalysts of oxidation



Oxygen and metal ions generate reactive oxygen species

Yeast hulls
Gall nut or condensed tannins

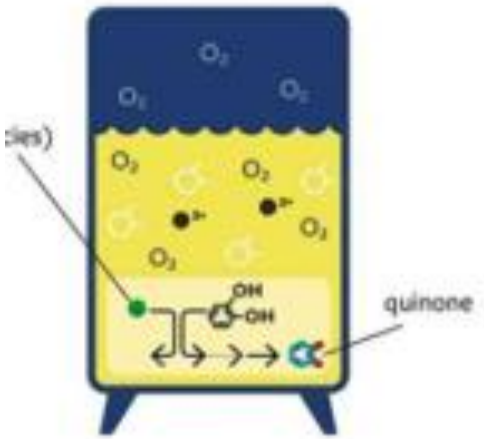
IF SO_2 IS UNAVAILABLE, WHAT IS?

To prevent aroma and color degradation (antioxidant)

Antioxidant

- Scavenge O_2
- Scavenge mineral ions
- Scavenge (susceptible) phenolics

Phenolic compounds contain a dihydroxybenzene ring that the ROS can oxidize to quinone



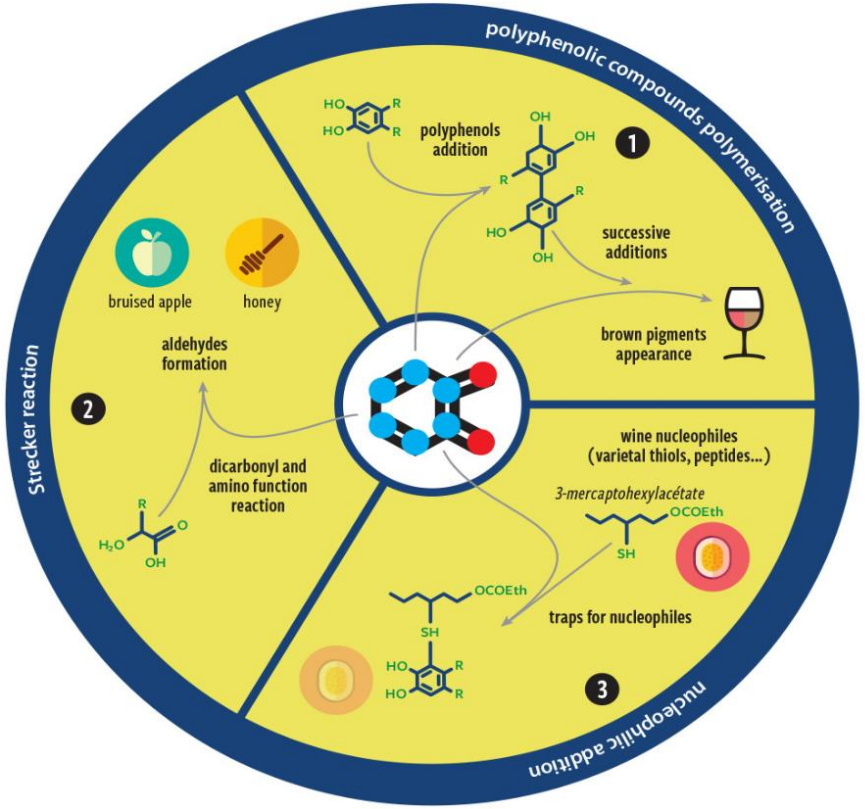
Reactive oxygen species can oxidize phenolic compounds to create quinones

Removing quinones so they are unable to react with nucleophiles ultimately leading to browning

Condensed tannins
Inactivated yeast

OXIDATION REACTIONS?

A natural, but controllable, multi-stage process



If the oxidation cascade is not halted then:

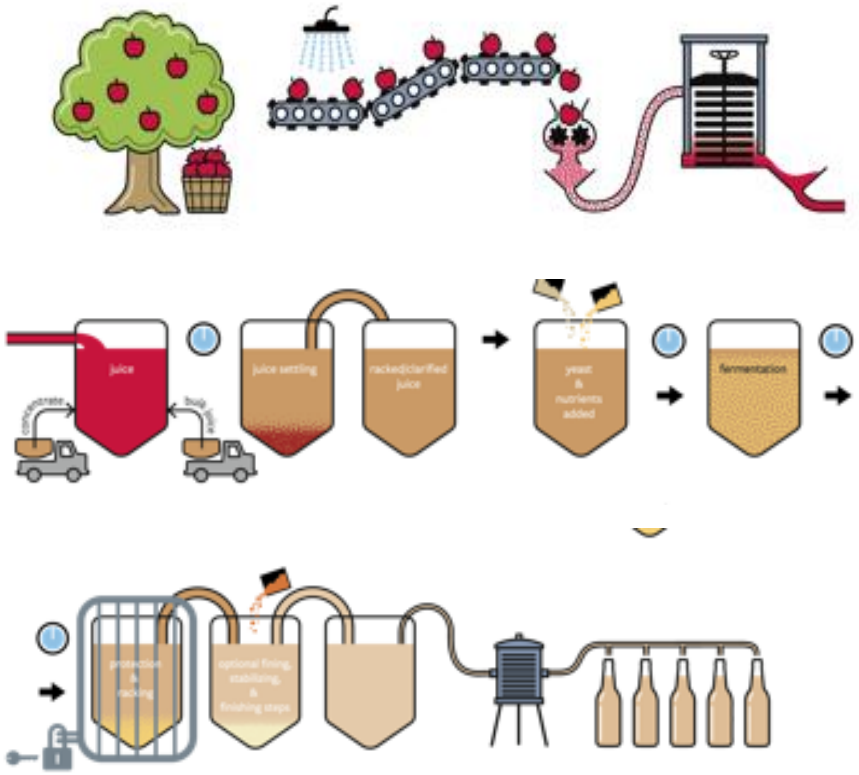
1. When quinones react with polyphenols => Browning occurs
2. Quinones and amino acids interact to form negative sensory compounds (phenylacetaldehydes) => bruised apple/sherry aroma

SO, MAKING CIDER WITHOUT SO_2 IS POSSIBLE….

But it takes a lot more effort and vigilance to maintain product quality!

IF SO_2 IS UNAVAILABLE, WHAT CAN I USE WHEN?

Putting it all together



Pre-Fermentation

Non-Saccharomyces yeast: Initia
Tannins: Essential Antioxidant, etc.
SIY: Glutastar
Separation techniques: Clarification, centrifugation
Environmental control, Temperature and pH management

Fermentation

Saccharomyces: Strain choice based on style

Post-Fermentation

SIY: Pure-Lees Longevity
Additives: Bactiless, No Brett Inside, Lysozyme, Sorbic acid, Velcorin
Tannins: Essential Antioxidant, etc.
Separation techniques: Clarification, filtration
Environmental control, Temperature and pH management

THANK YOU FOR YOUR ATTENTION…

SCOTT LABORATORIES

Nichola Hall

General Manager- Fermentation & Enology

Nicholah@scottlab.com

FERMENTATION & ENOLOGY

BEVERAGE INTEGRITY & FILTRATION

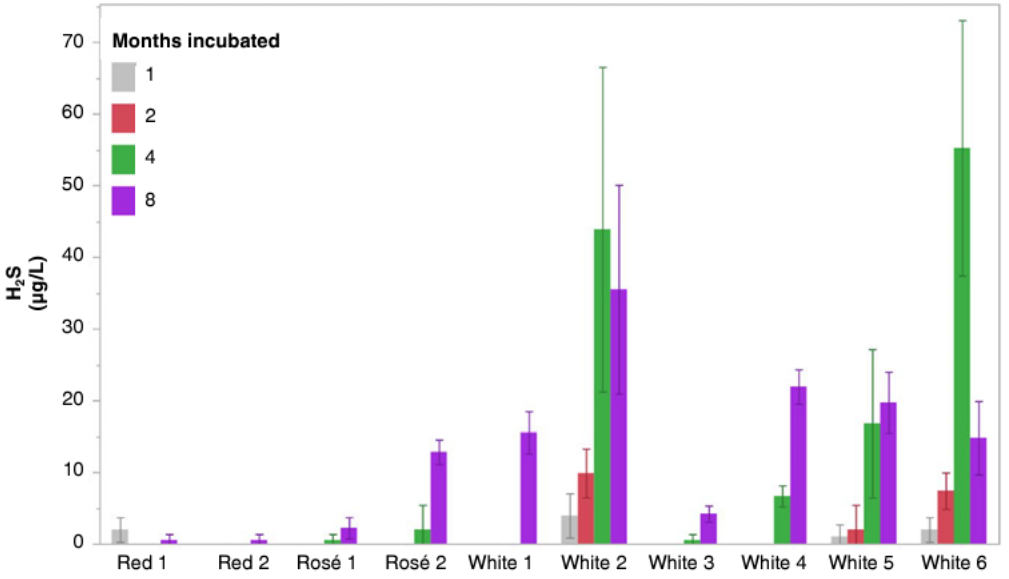
EQUIPMENT, PARTS & SERVICE

CORK & PACKAGING

SCOTT LABORATORIES

SCOTT
LABORATORIES

Image: Montgomery A. et.al., (2022) AJEV, Vol 74



	Red 1	Red 2	Rosé 1	Rosé 2	White 1	White 2	White 3	White 4	White 5	White 6
H_2S, epoxy-lined cans (µg/L)	0.4	0.3	1.4	7.4	8.0	39.7	2.3	14.3	18.3	35
H_2S, glass storage (µg/L)	n.d.	5.2	n.d.	2.2	n.d.	2.0	n.d.	n.d.	n.d.	n.d.

Figure 1 Hydrogen sulfide (H_2S) as a function of storage time (one, two, four, or eight months) for 10 commercial wines packaged in replicate BPA-epoxy-lined cans (n = 3 per time point for each wine; error bars represent one standard deviation). Average H_2S levels after four and eight months for each wine stored in BPA-epoxy-lined cans or in glass are reported below the bar chart. n.d., no data.

Vesari et al… https://www.ajevonline.org/content/ajev/74/2/0740022.full.pdf
Montgomery et. Al, https://www.ajevonline.org/content/ajev/74/1/0740011.full.pdf
Microbial data: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8063962/