



AMERICAN
CIDER
ASSOCIATION

Practical Guide to Avoiding... Reduction

PRESENTED BY:
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Your go-to cider making resource



ciderinstitute.com

AGENDA

- 1 Reduction:
why your cider sometimes smells like eggs, farts, or rubber
- 2 causes for the off-putting aromas
- 3 how to prevent your cider from going stinky
- 4 practical tips and tricks to keep your cider smelling fresh and tasting delicious





Or on a more positive note
**Optimizing your fruity
and complex cider**

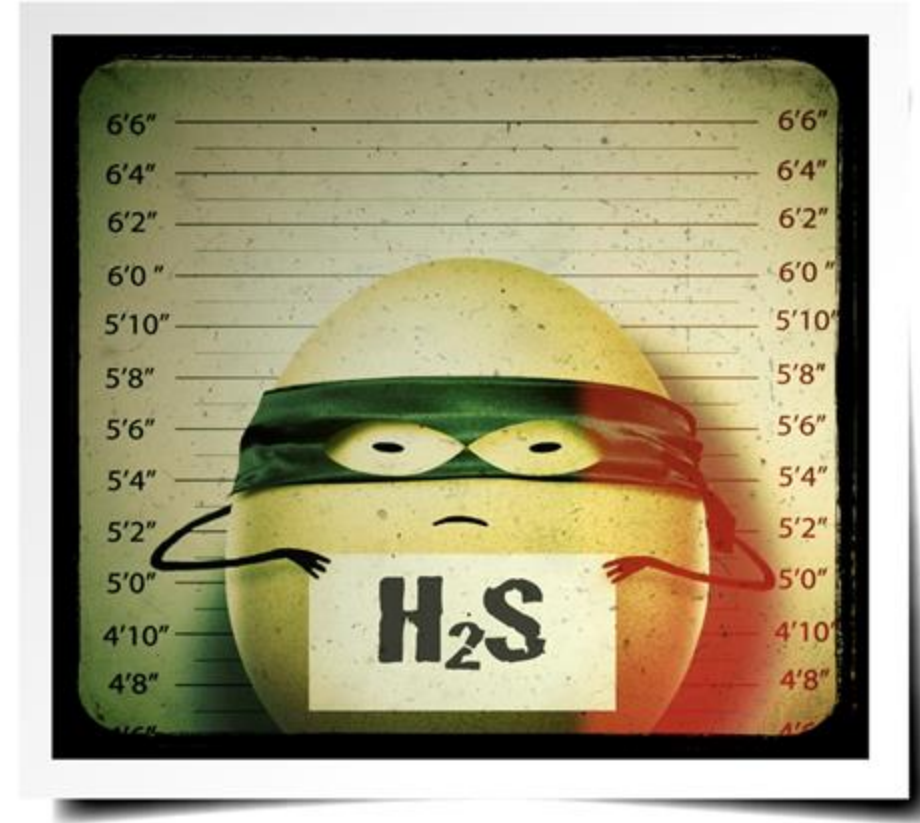
What is it? Where does it come from?

- H₂S (Hydrogen Sulfide)
- Rotten Egg
- Reduced
- Burnt Rubber
- Onion
- Skunky
- Garlic
- Funk

Practical Guide to avoiding... reduction

WHY is my cider stinky?

- *Optimizing your fruity and complex cider*





Effect on aroma during & after fermentation

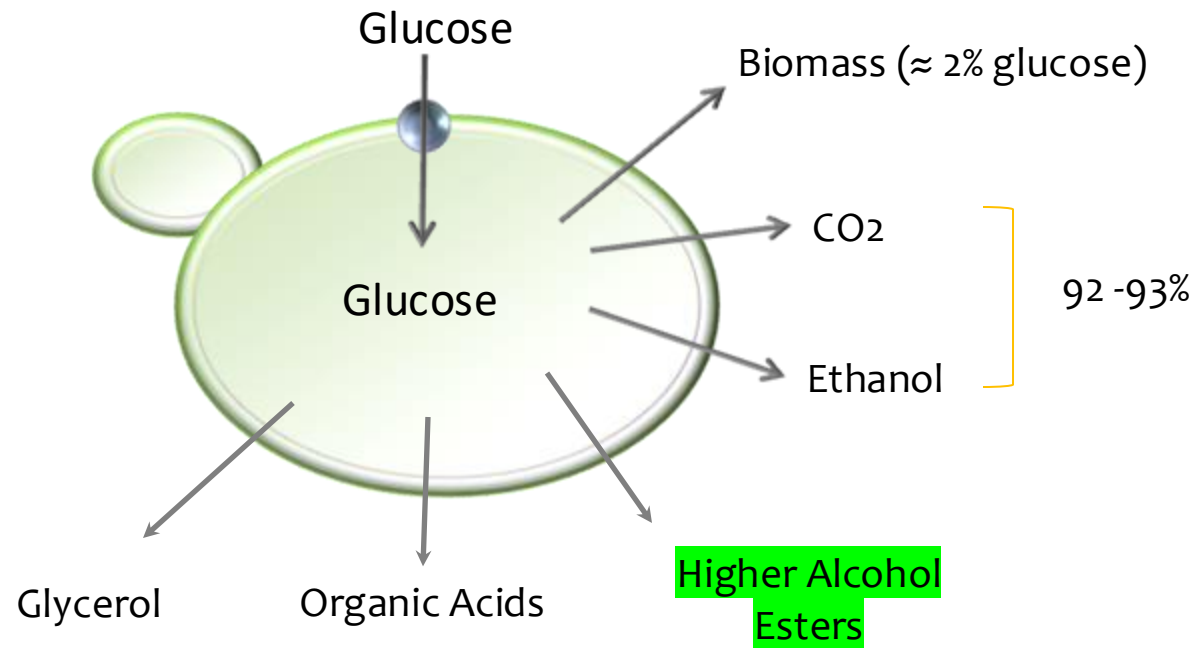
H₂S confers negative aroma attributes to cider:

- ❖ « Rotten egg character »
- ❖ Very low level thresholds of detection: 1,1µg/L
- ❖ Even at level that can't be detected by human nose H₂S can « mask» aromas, and give a « closed» perception.
- ❖ H₂S chemical reactivity can lead to the formation of more deleterious/negative compounds (sulphides and mercaptans) during aging of cider.

What we know

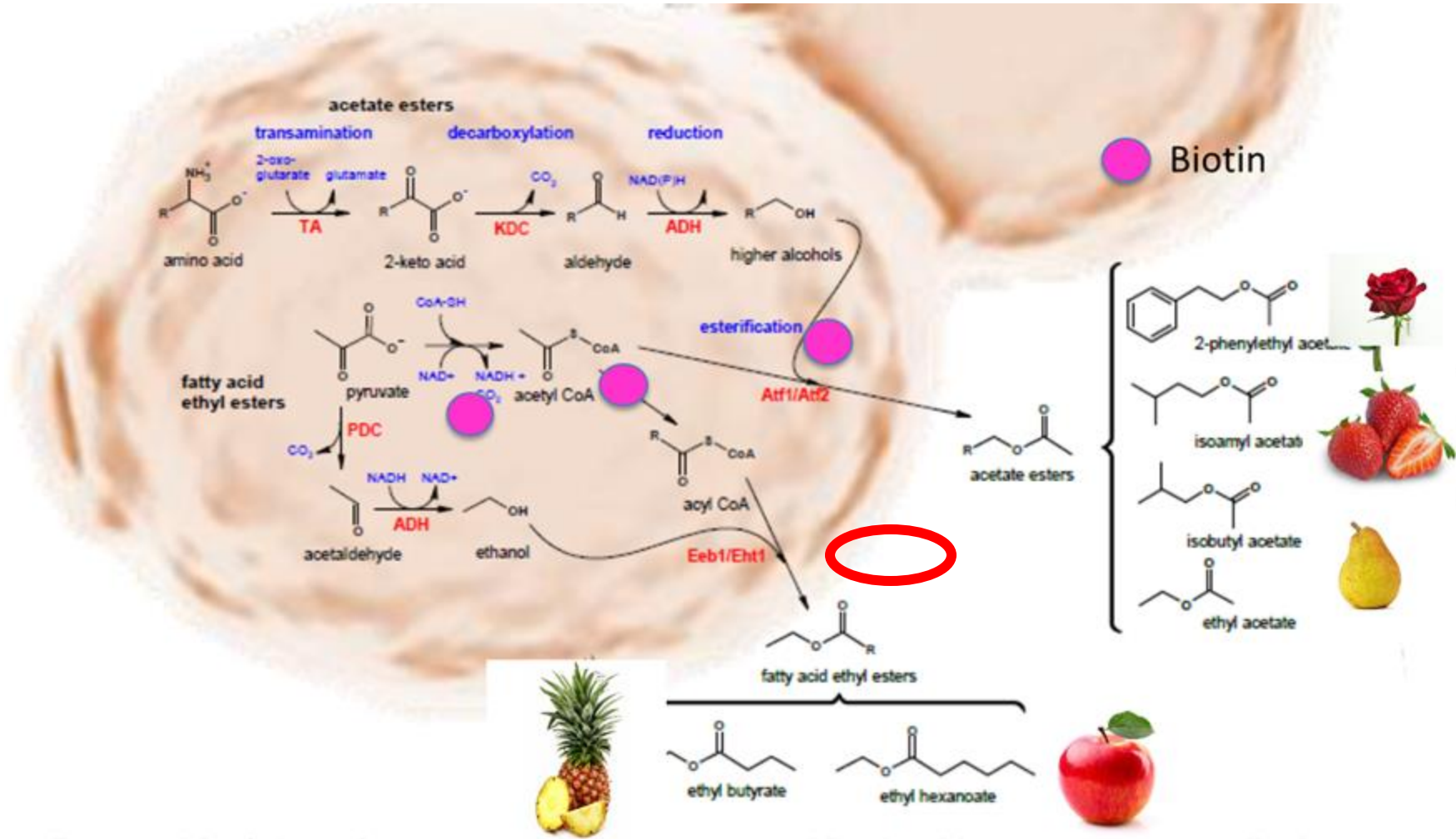
- Fermentation produces CO₂ and alcohol
-and more!

Alcoholic fermentation



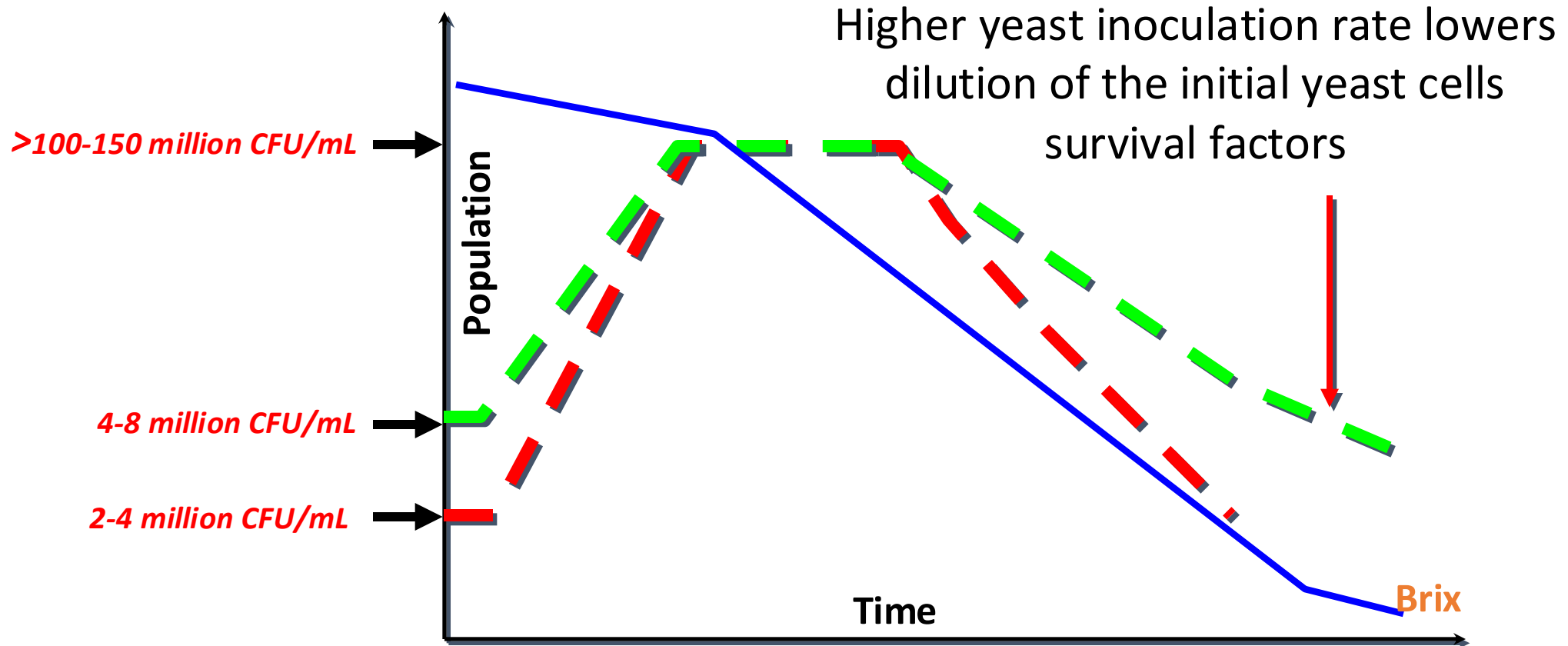
1° alcohol ? ? 16,8 g/l of glucose

Aroma pathways are complex



Key role of biotin in the fatty acids esters synthesis

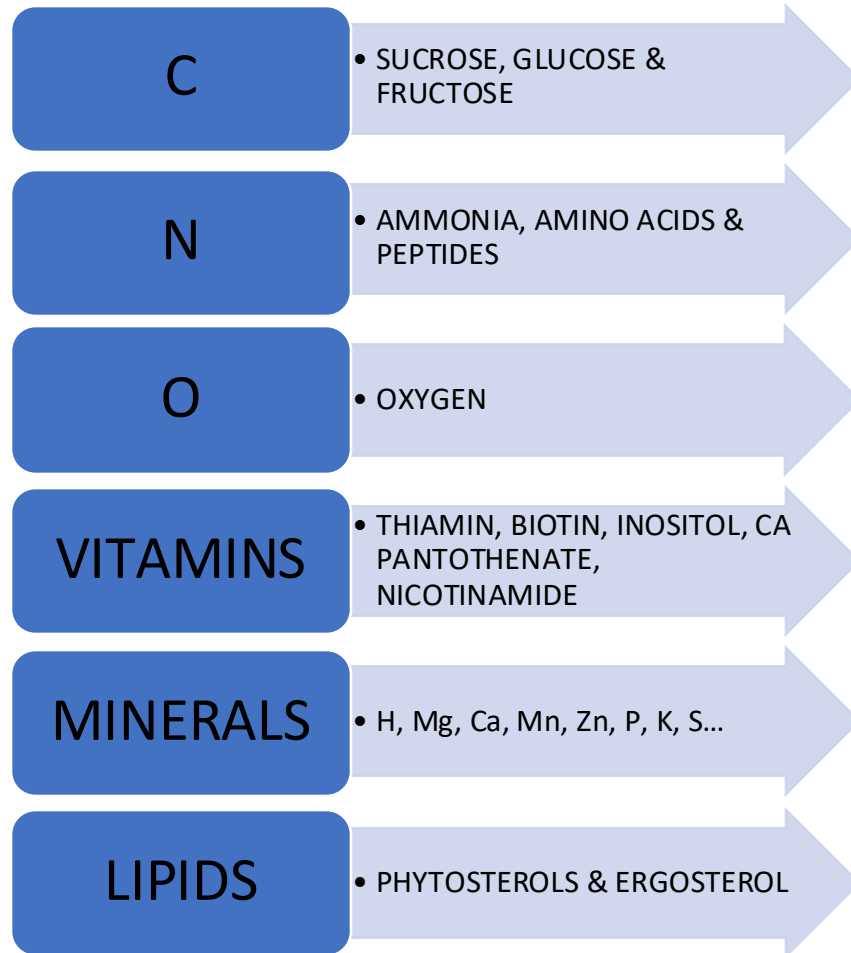
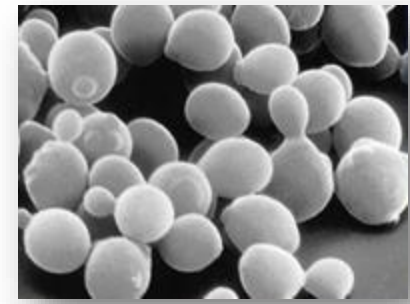
Normal Fermentation Curve



- ❖ Elemental sulfur from orchards or storage
- ❖ Sulfur dioxide (sulfite) additions to prevent spoilage or oxidation in juice
- ❖ Sulfur from sulfur-containing amino acids
- ❖ Naturally occurring sulfates in apples

- ... may be due to the highly complex interactions of yeast strain, yeast nutrient deficiencies, amino acid concentration and composition, and temperature, which all are known to affect H₂S production.

Saccharomyces Nutrient Requirements

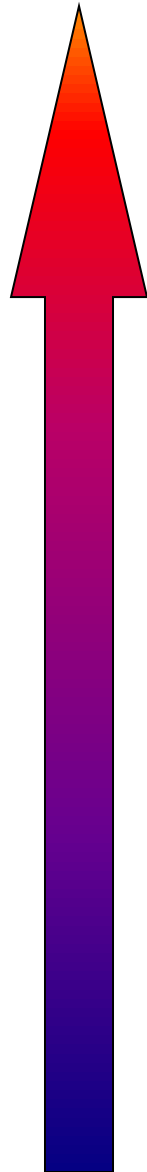


Required for:

- Proliferation
 - Sugar, nitrogen, vitamins & minerals
- Maintenance
 - Nitrogen
 - Lipids (survival factors)
 - Sterols & long-chained fatty acids

➤ Nutrients must be **Biologically available** and **Balanced**

Nitrogen for *S. cerevisiae*



+ NH_4^+

Glutamine, asparagine

Glutamic acid

Serine

Arginine

Alanine, aspartate

Valine, phenylalanine, leucine, i

threonine

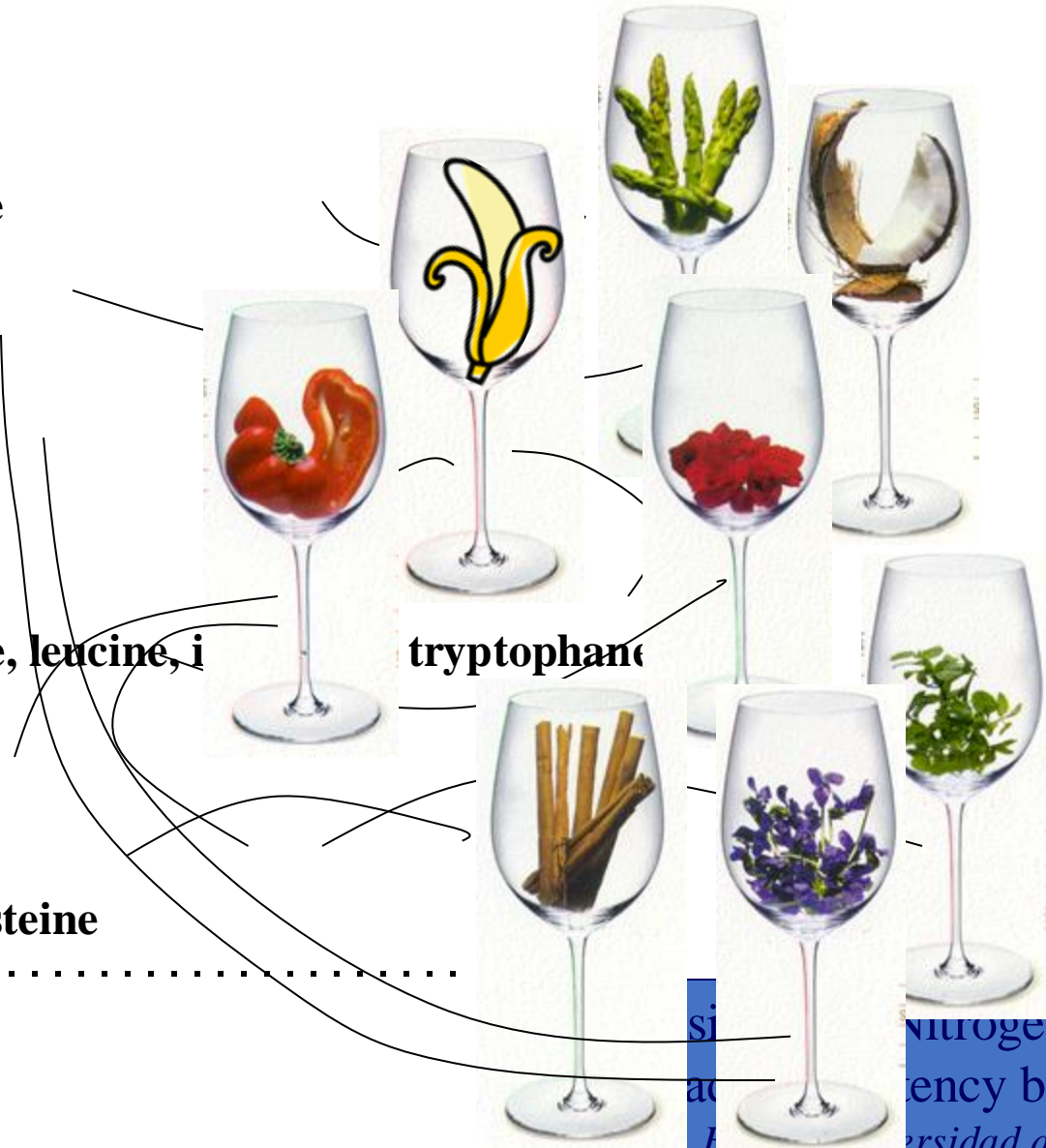
Methionine, tyrosine

Histidine, glycine, cysteine

Proline

PEPTIDES

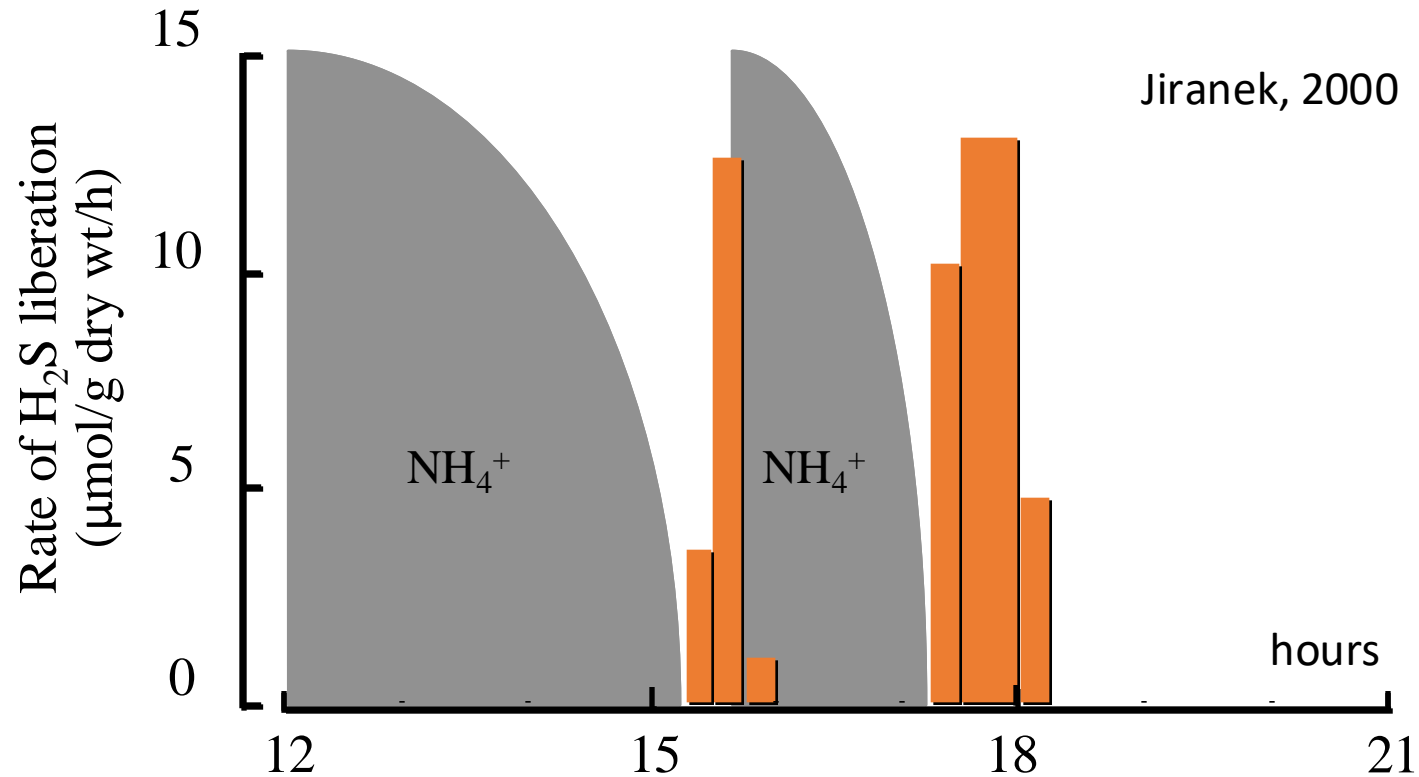
PROTEINS



tryptophan

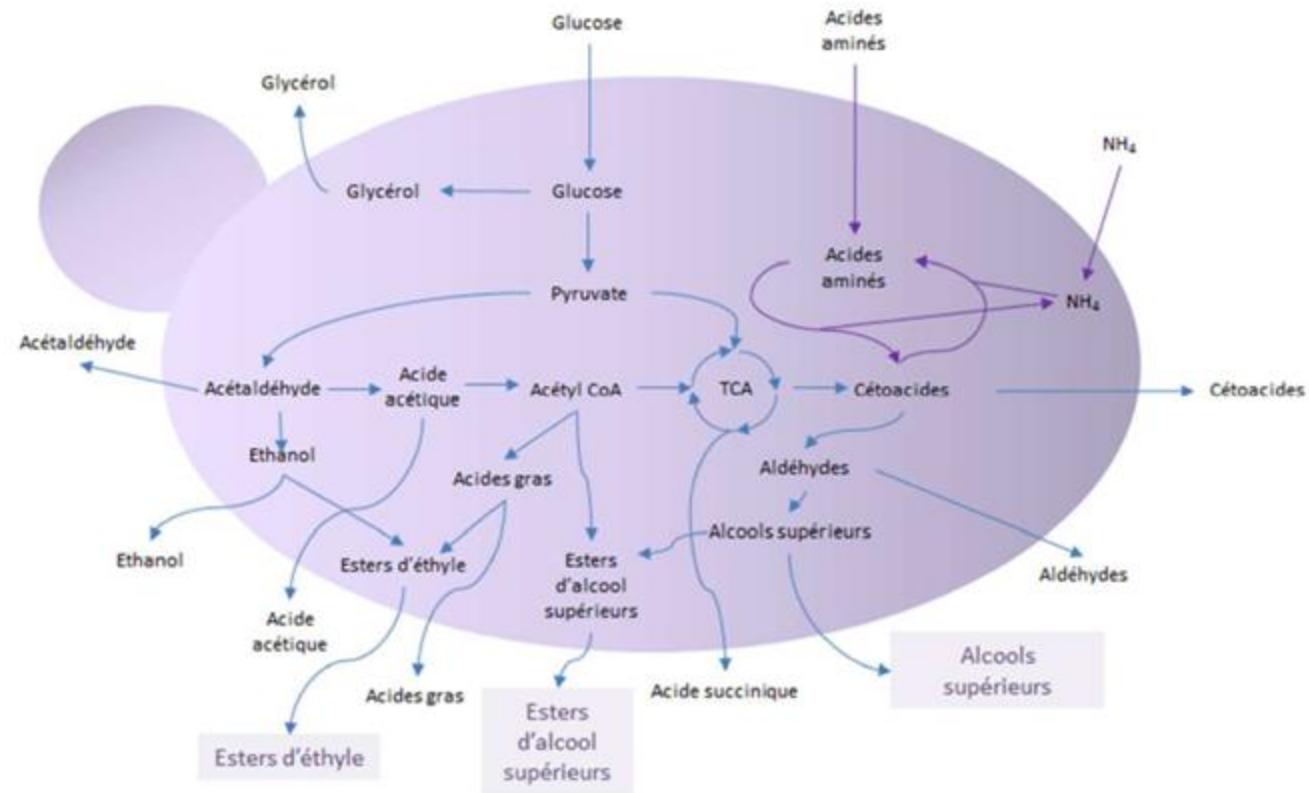
Significance of Nitrogen
 availability by *S.c.*
 University of Davis
 California

DAP addition early



In nitrogen deficient musts the addition of DAP gives more biomass, which is then starving, and producing even more H₂S

Pathways are highly connected and inter-connected



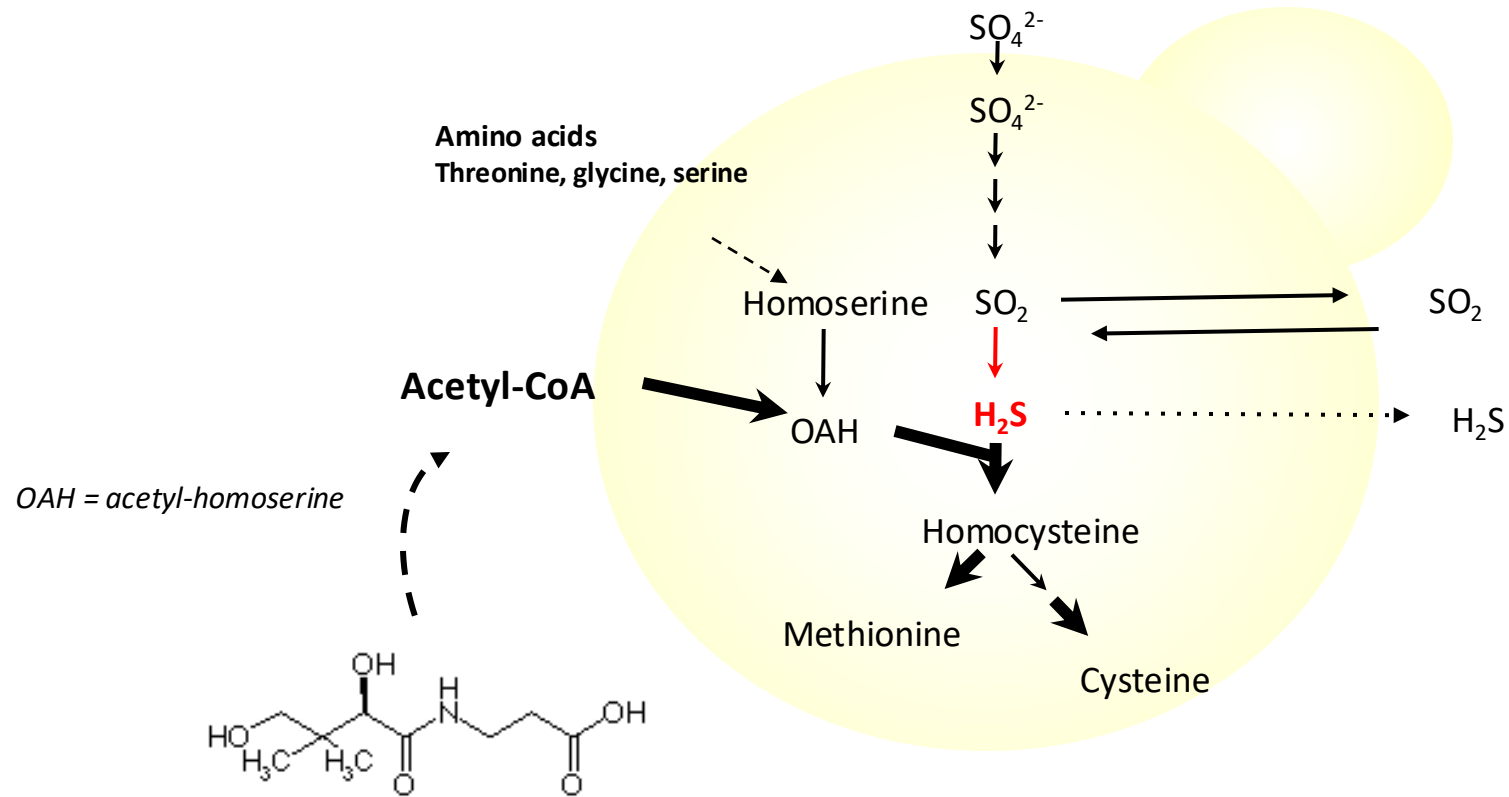
- There is a complex regulation between
 - Temperature
 - Nitrogen
 - Lipid content

Aroma synthesis

- Many secondary metabolites are produced during fermentation
 - a large proportion will have a sensory impact
- Compounds produced include;
 - Higher alcohols
 - Negative correlation between N availability & higher alcohol formation
 - Esters – acetate & ethyl
 - Positive correlation between N availability & acetate esters formation
 - Sulfur compounds
 - N addition decrease H₂S production
 - ‘off-flavours’
 - Excessive N additions, as NH₄⁺, at beginning of fermentation can produce higher glycerol, but also higher acetate

WHY ??

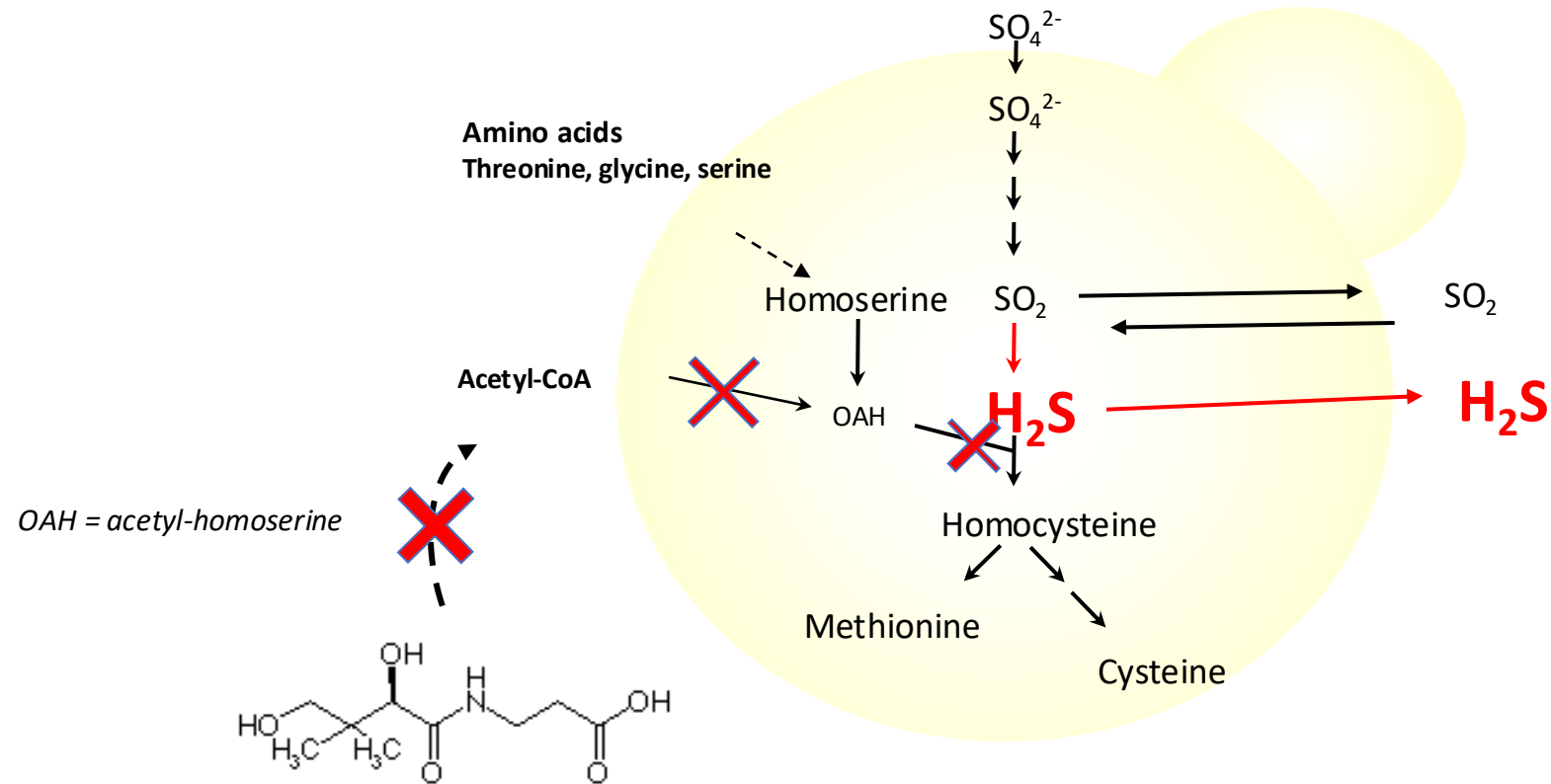
Key role of pantothenic acid in the sulfate assimilation pathway



Pantothenic acid = Acetyl CoA precursor

WHY ??

Key role of pantothenic acid in the sulfate assimilation pathway

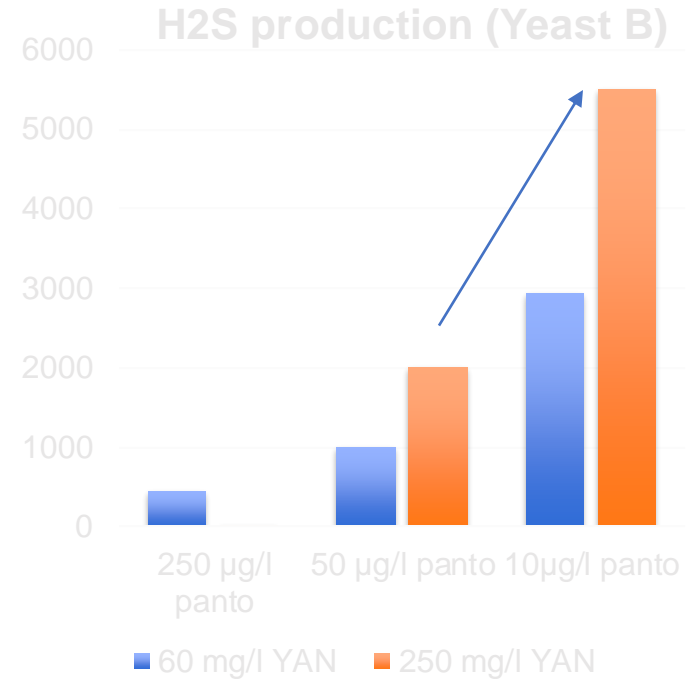
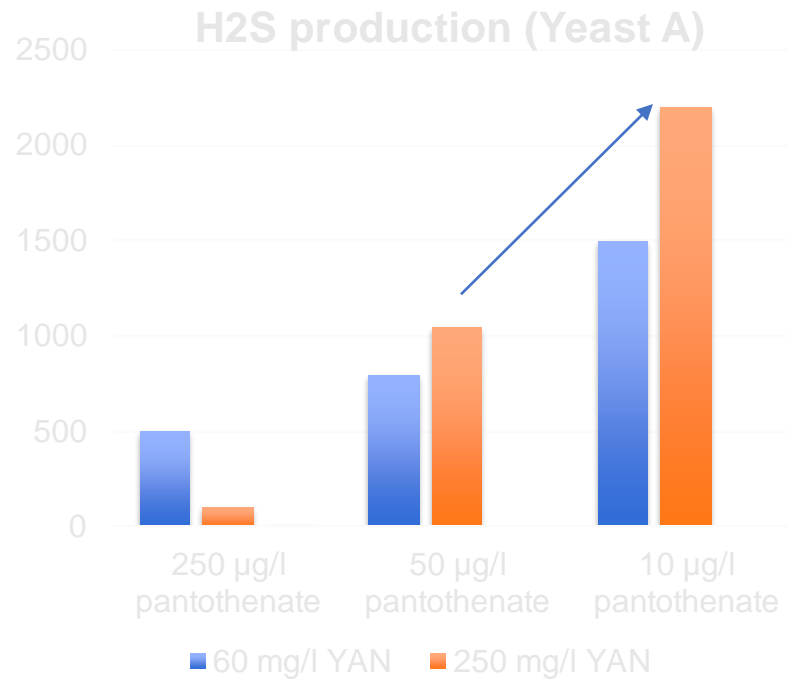


Limitation in Pantothenic acid = less Acetyl CoA

Pantothenate deficiency impact on the H₂S production

Pantothenic acid B5 : 3 concentrations : (250, 50 & 10 µg/L).
YAN : 2 levels : Low YAN (60 mg/L) or High YAN (250 mg/L).

(Wang et al, 2003)

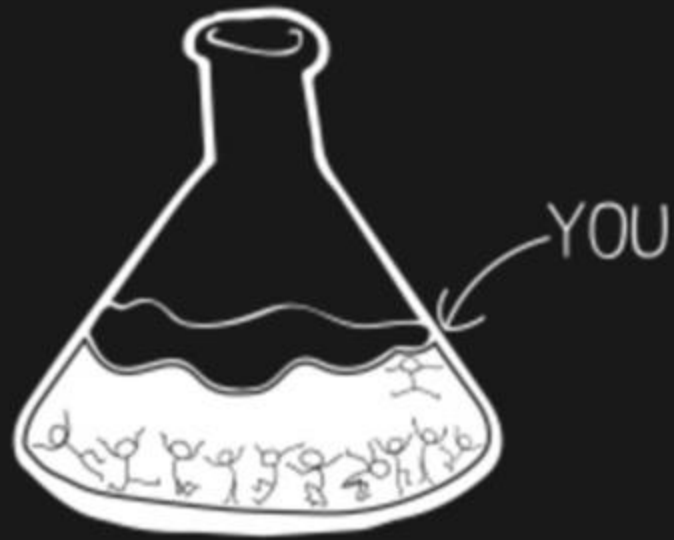


Pantothenate deficiency

❓ leads to high H₂S production, even more with high YAN (nutritional imbalances)

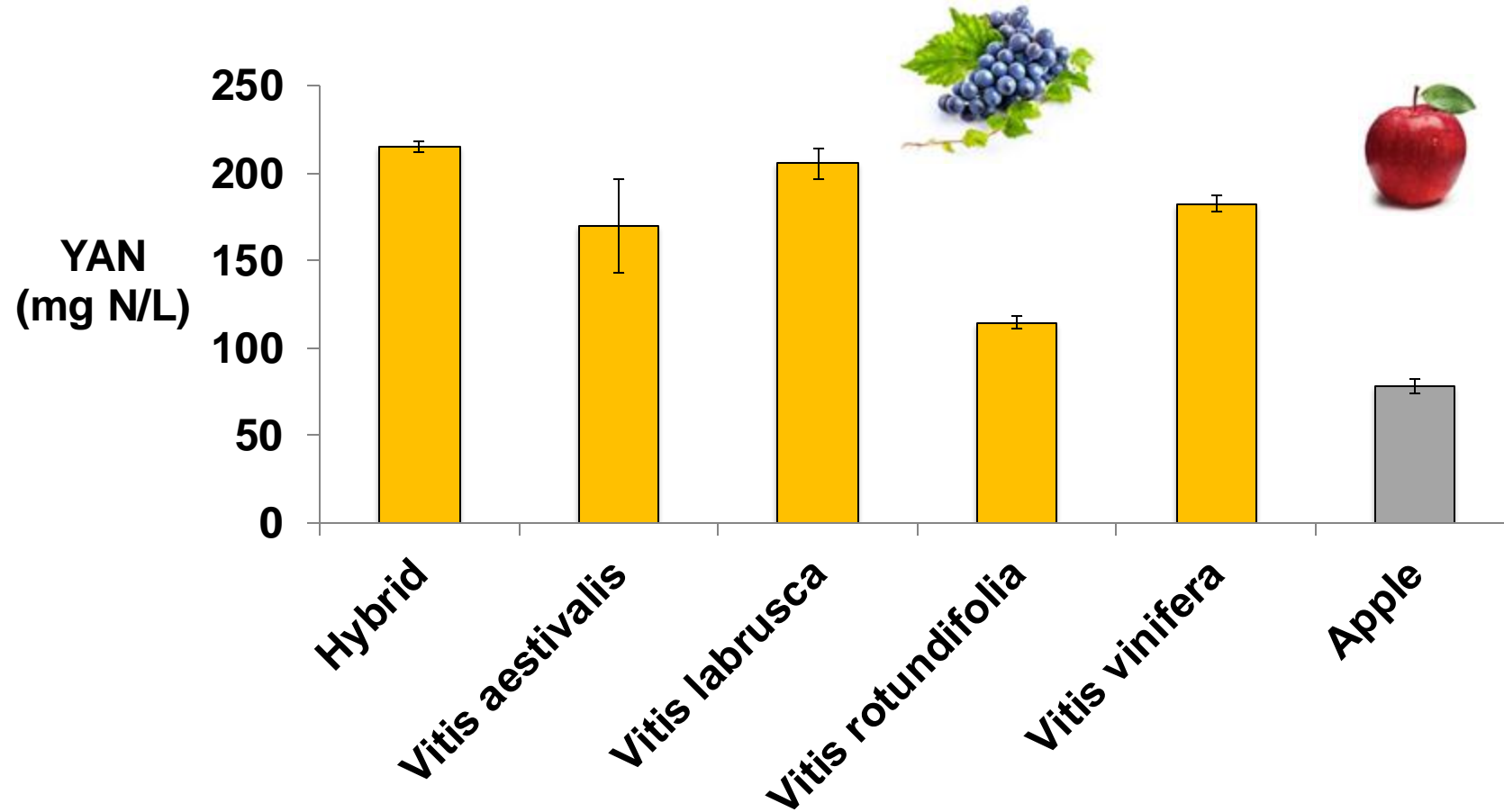
Is this the fault of your yeast?

IF YOU'RE NOT PART OF
THE SOLUTION



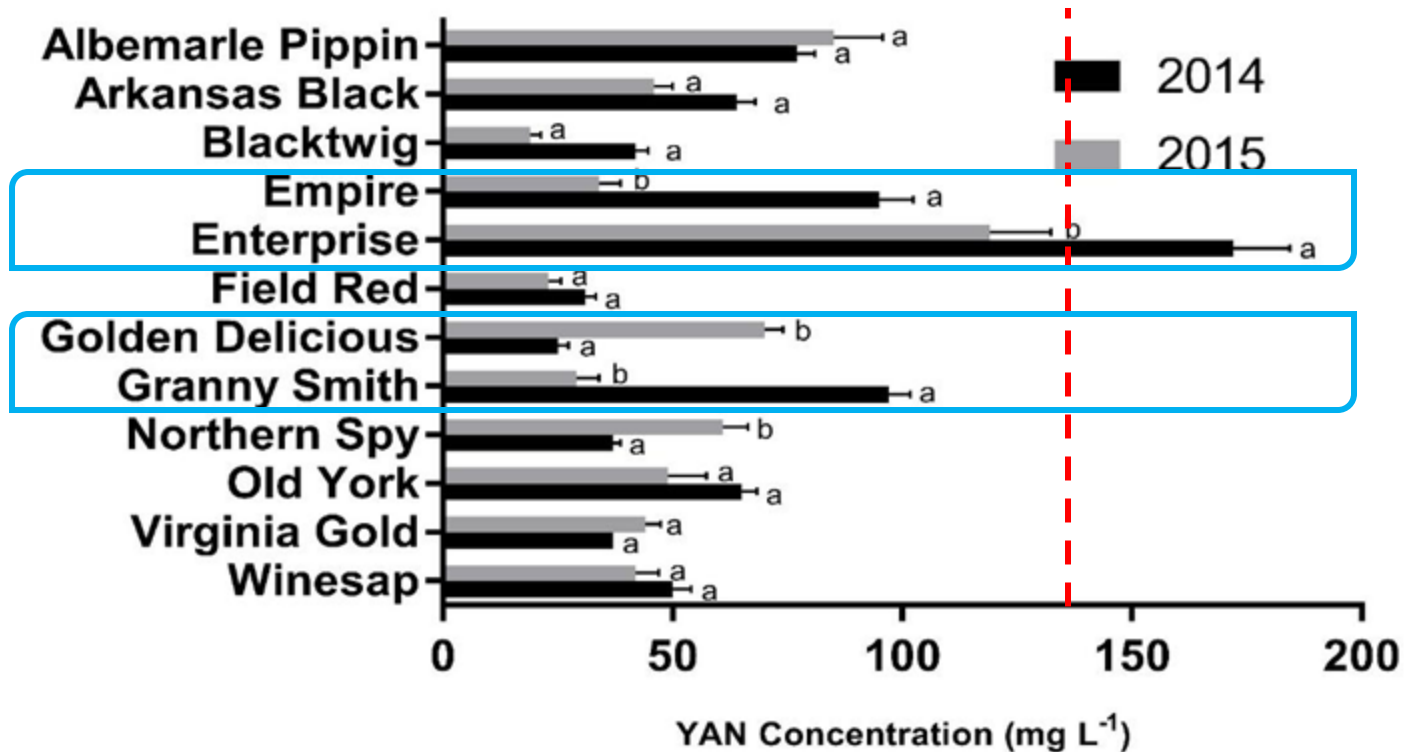
YOU'RE PART OF THE
PRECIPITATE

YAN in different Fruit



➤ Supplementation with yeast nutrients is necessary

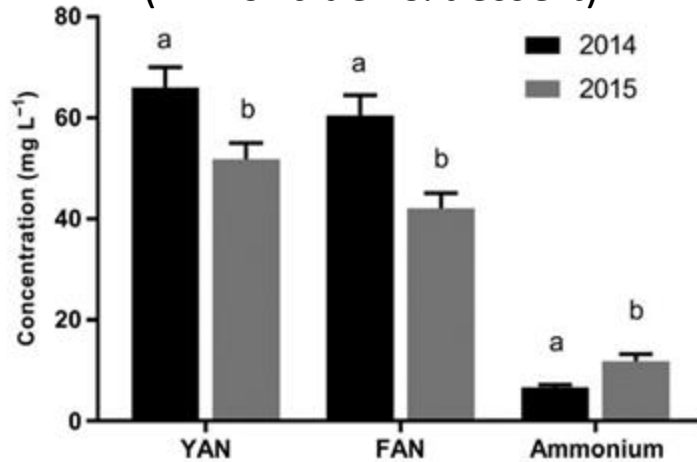
YAN Survey of Virginia-Grown Apples



- YANs vary between variety and also vintage
- 95% are below the 140 ppm required for an efficient fermentation

Nitrogen availability in apples

12 different apple cultivars
(mix of cider & dessert)



Boudreau et al. 2017 Fd Sci Nutri 6, 119-123

- YAN
 - Predominately amino acids
 - Factors influencing YAN concentration
 - Orchard management
 - Crop load
 - Cultivar
 - Juice clarification

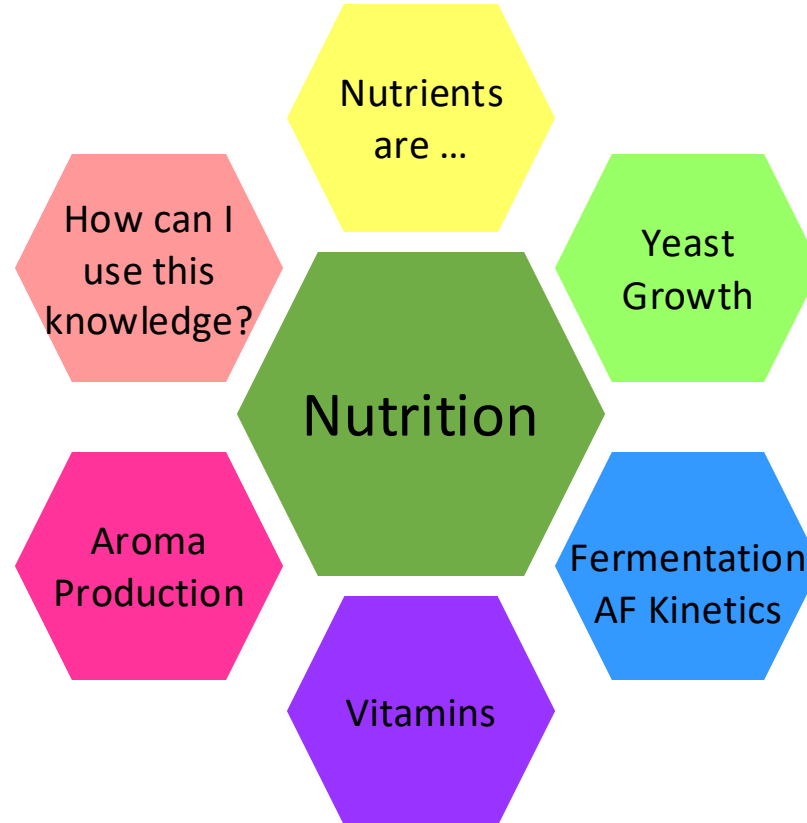
➤ **Supplementation with complex nutrients is recommended**

Vitamin	Unit/100g	With skin	Without skin		Delicious	Golden Delicious	York Imperial	Stayman	Rome Beauty	
Vitamin C	mg	5.7	4.0	Mineral	(mg/100g)					
Vitamin B1	mg	0.02	0.02		Calcium	4.07	4.97	1.97	2.05	3.07
Vitamin B2	mg	0.01	0.01		Magnesium	2.72	2.43	3.20	2.68	2.88
Niacin	mg	0.08	0.09		Phosphorus	12.70	10.00	12.40	14.70	12.50
Pantothenic acid	mg	0.06	0.06		Potassium	90.70	72.70	104.00	117.00	91.30
Vitamin B6	mg	0.05	0.05		Sodium	0.92	0.89	0.89	0.87	0.98
Folacin	µg	2.8	0.4		Copper	0.04	0.04	0.04	0.0	0.04
Vitamin A	retinol equivalent	5.3	4.4		Zinc	0.11	0.12	0.13	0.14	0.14
Vitamin B12	µg	0	0		Manganese	0.02	0.03	0.04	0.02	0.02
					Iron	0.06	0.07	0.05	0.09	0.03

Source: Gebhardt et al., 1982.

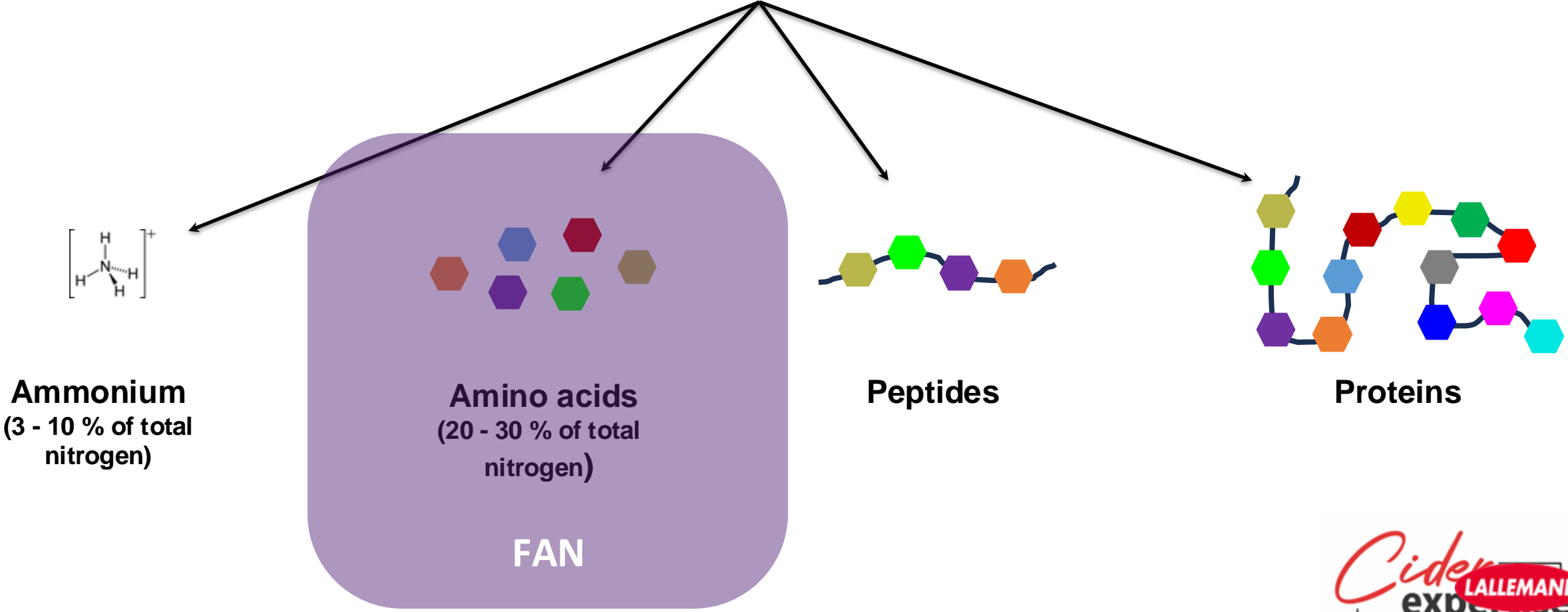
Briefly on yeast and nutrition

Nutrition is multifaceted

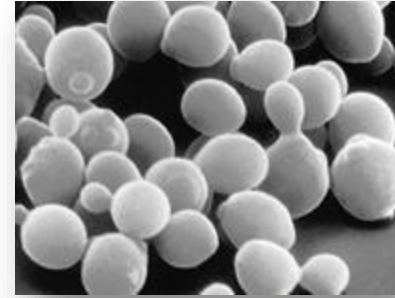
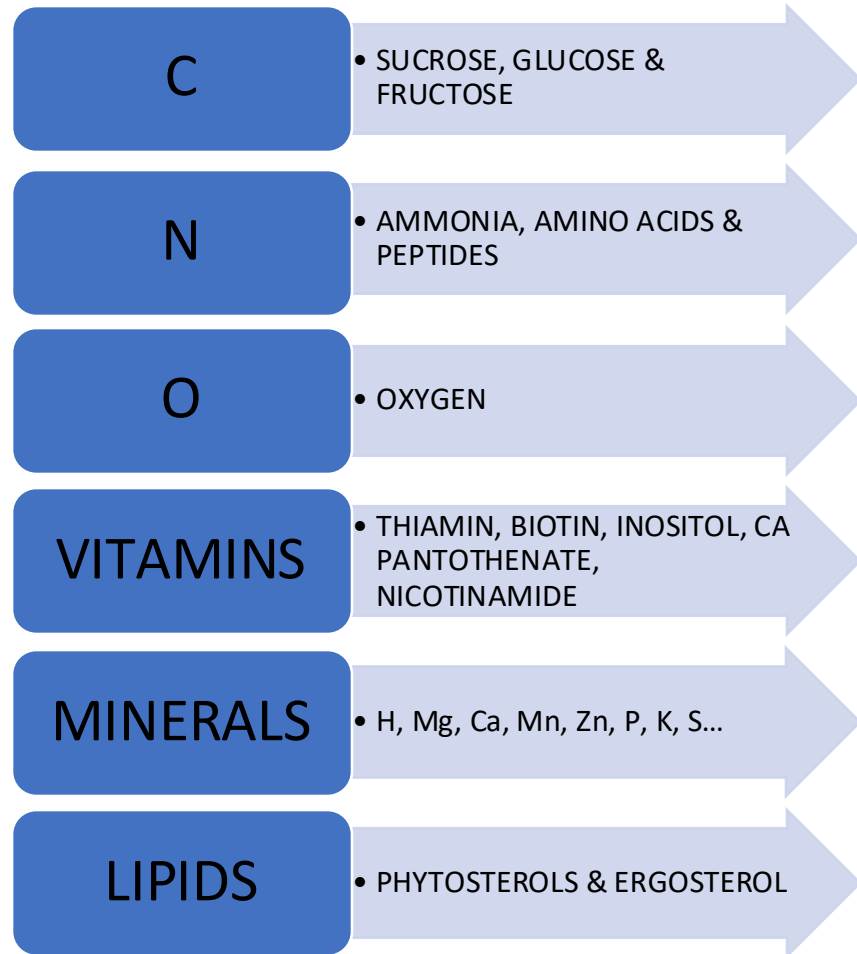


The inevitable YAN

TOTAL NITROGEN (0,1 to 1 g/L) in must



Saccharomyces Nutrient Requirements



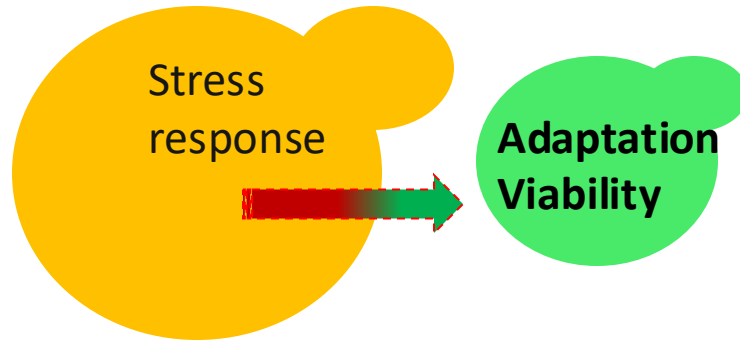
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 - Sterols & long-chained fatty acids

➤ Nutrients must be **Biologically available** and **Balanced**

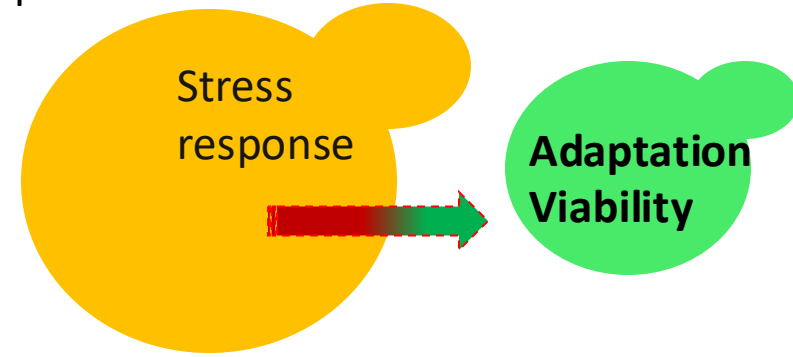
Nitrogen has an important role in signalling a stress response & yeast cell death

Apples depleted for nitrogen



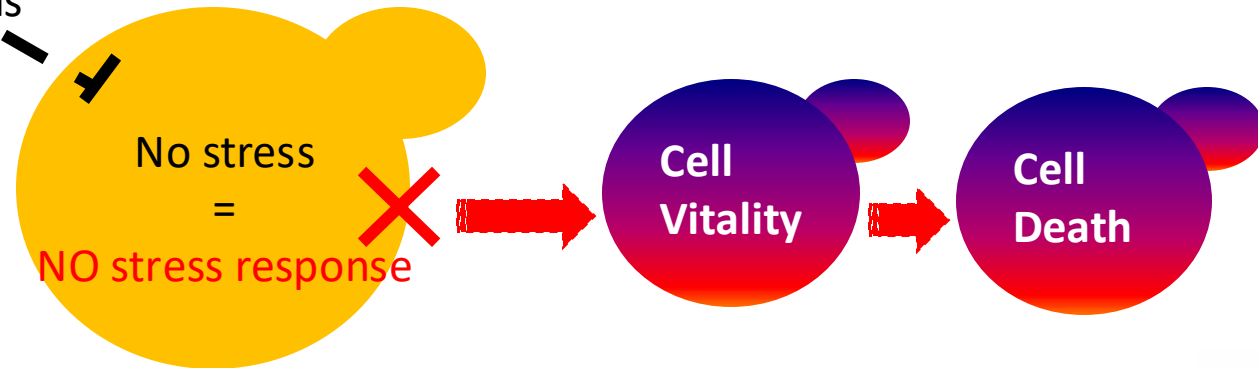
N- starved cells

Depleted for N



Micro nutrient-starved cells

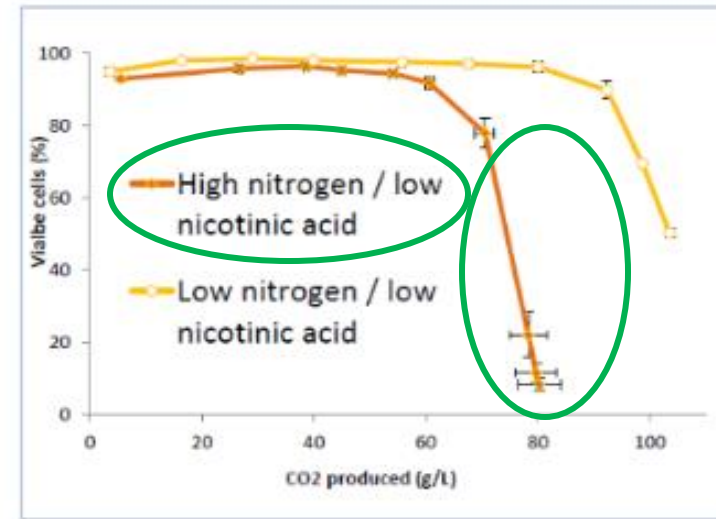
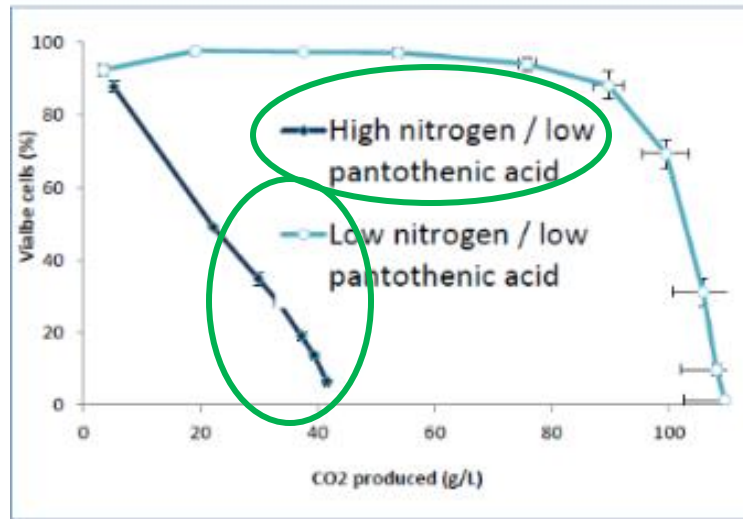
Amino acids
High NH_4^+



Micro nutrient-starved cells

Nutritional imbalances

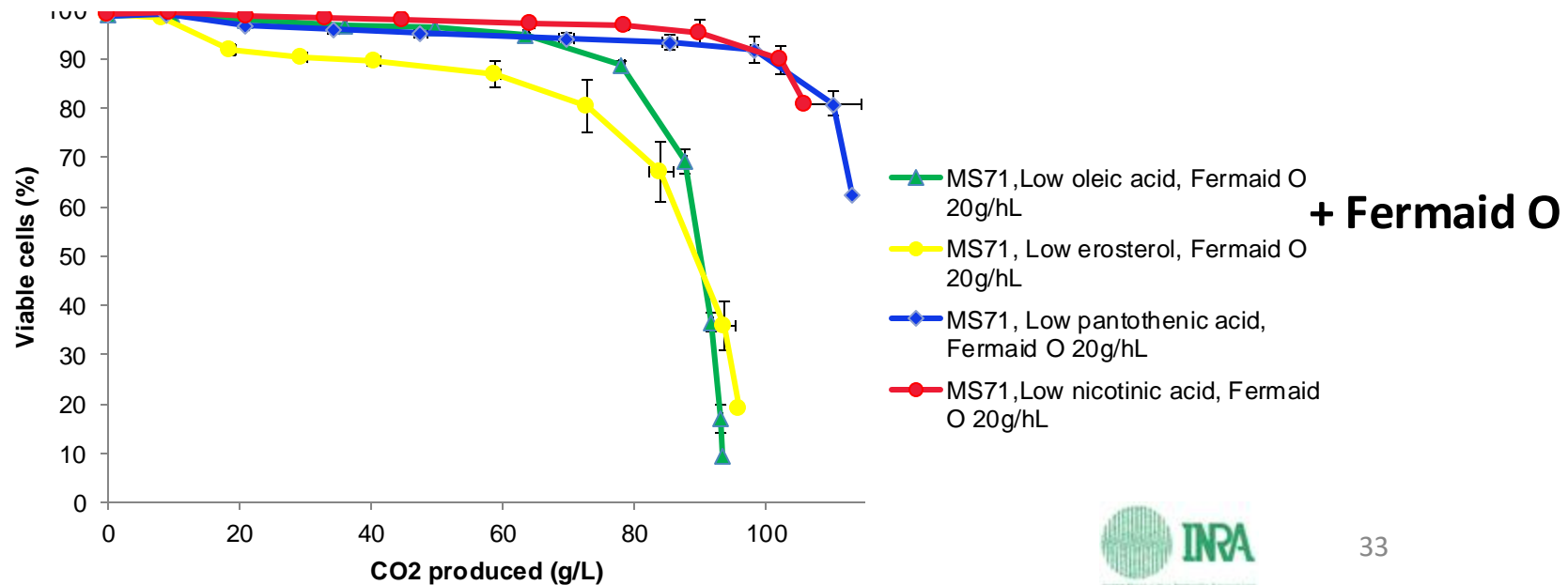
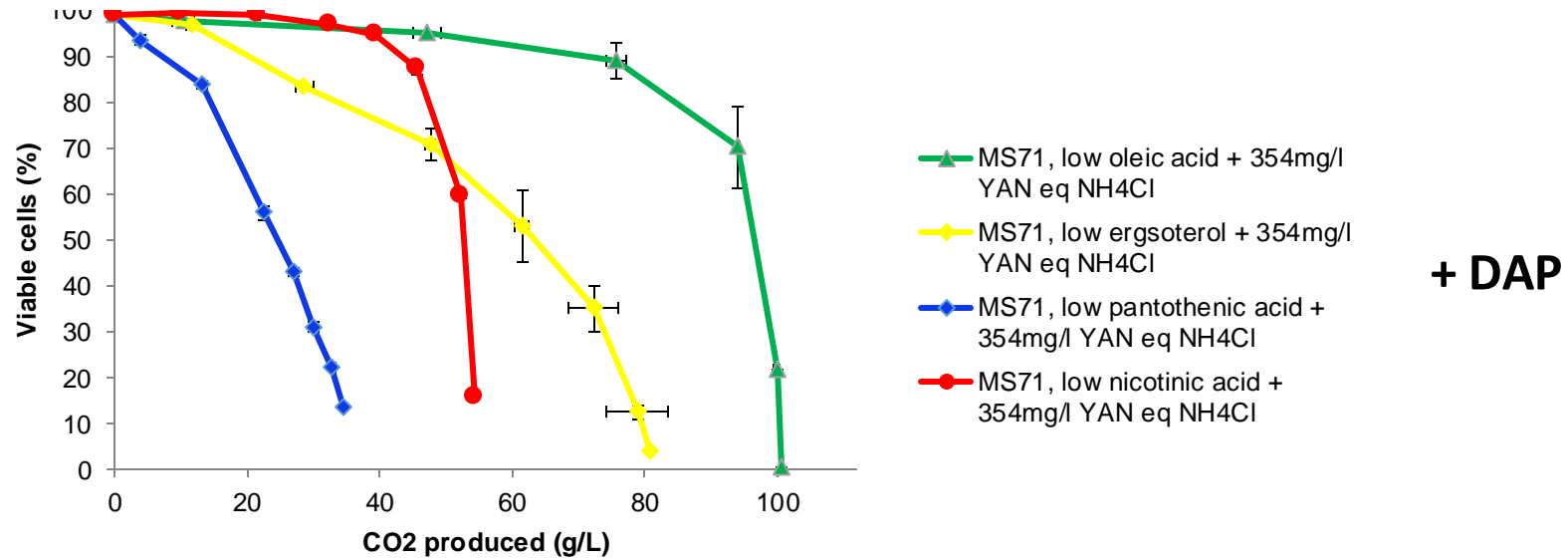
Impact of vitamins on yeast viability



Duc C., 2017
(PhD Lallemand – INRA)

- Vitamin starvation triggers cell death in a nitrogen-dependent manner
- *GoFerm Protect Evoltuion and Fermaid O will prevent/limit this risk*

Nutritional imbalances: addition of DAP vs additon of Femaïd O : Impact on viability



Supplementation decisions

- Always go for complex first
 - More efficient
 - Better aromatics
 - Controlled growth
 - Controlled fermentation
- Back up if needed with DAP

Improved wine yeast : QTL strategy

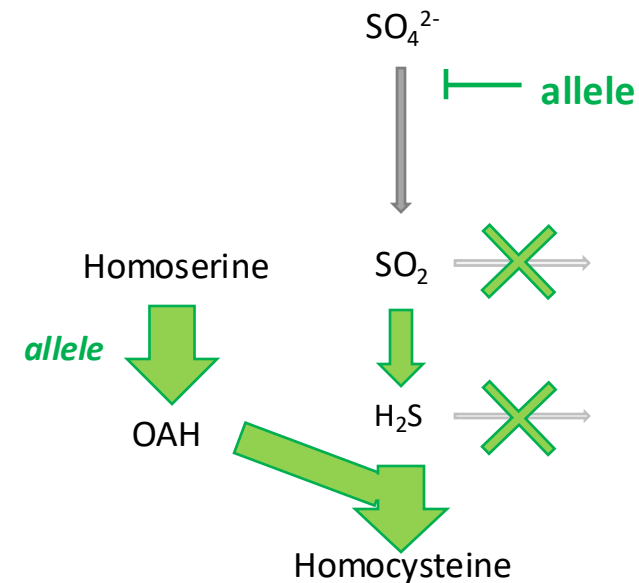
QTL
PROCESS

Improved wine yeast : QTL strategy

Low SO₂ & low H₂S

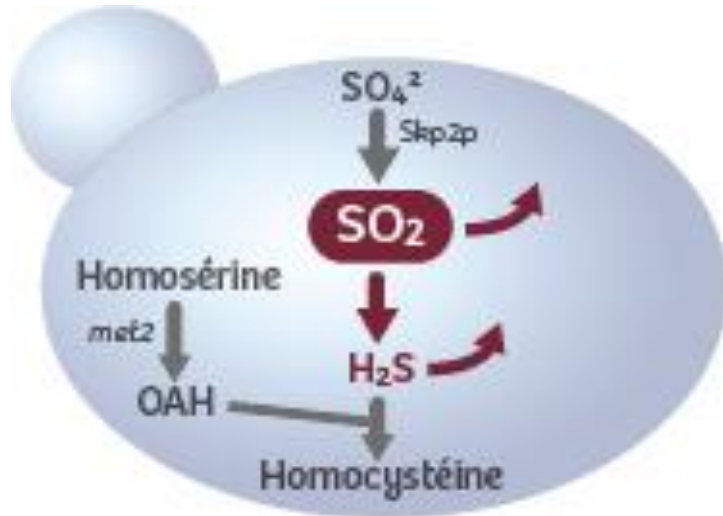
Transfer of the alleles responsible for the control of SO₂, H₂S and acetaldehyde production :

Creation of new strains low SO₂, low H₂S and low acetaldehyde producer

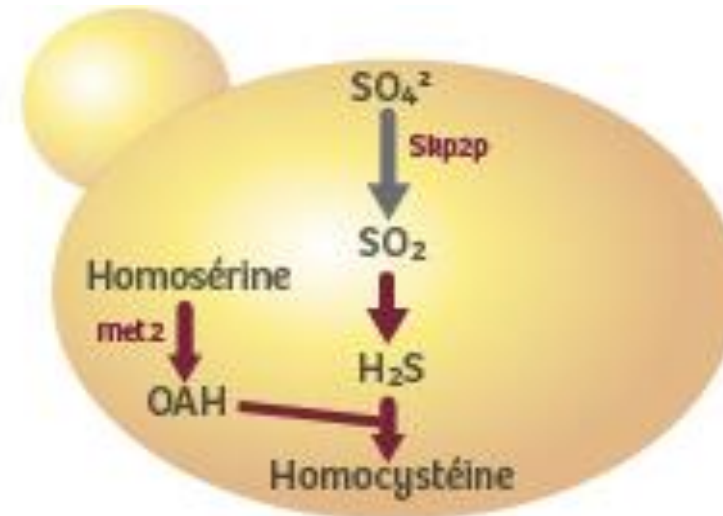


Yeast and SO₂ production

LALVIN
ICV **OKAY**®



High sulfite producing strain



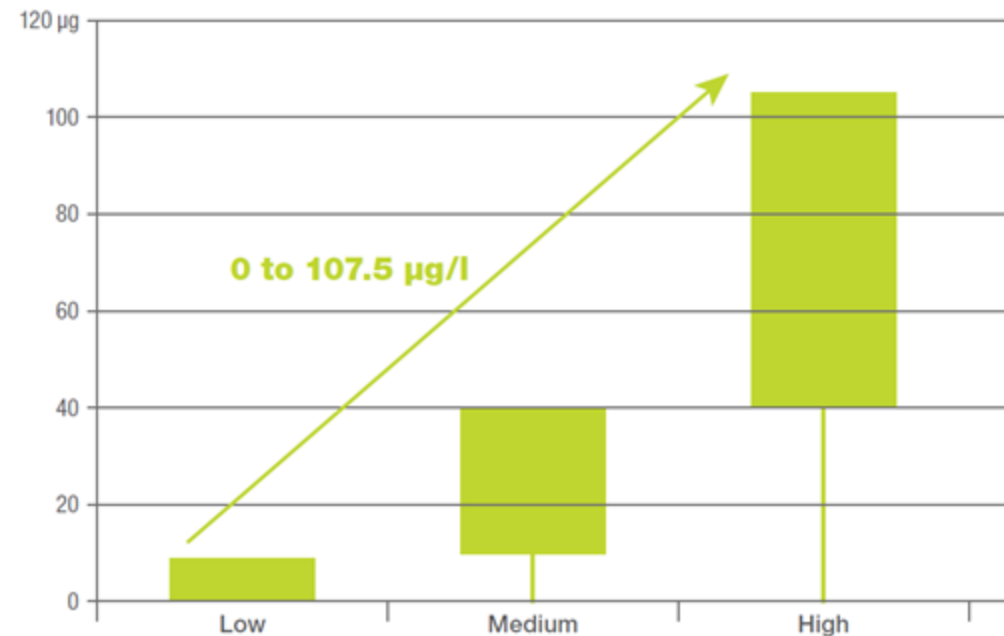
Low sulfite producing strain



Genetic variation among yeast

Among 50 wine yeasts, ranges of production were arbitrary divided into three groups depending on the total amount of H₂S produced from a 350 mL juice.

(S.Park, UC Davis; 2004/2005)





Less varietal aroma masks!



its low capacity to produce H₂S is a great advantage to fully leave expression of aroma from quality apples.

Asset

Combines *robust* characteristics

- ❖ Low NTU
- ❖ Low temperature
- ❖ Low nutrition needs

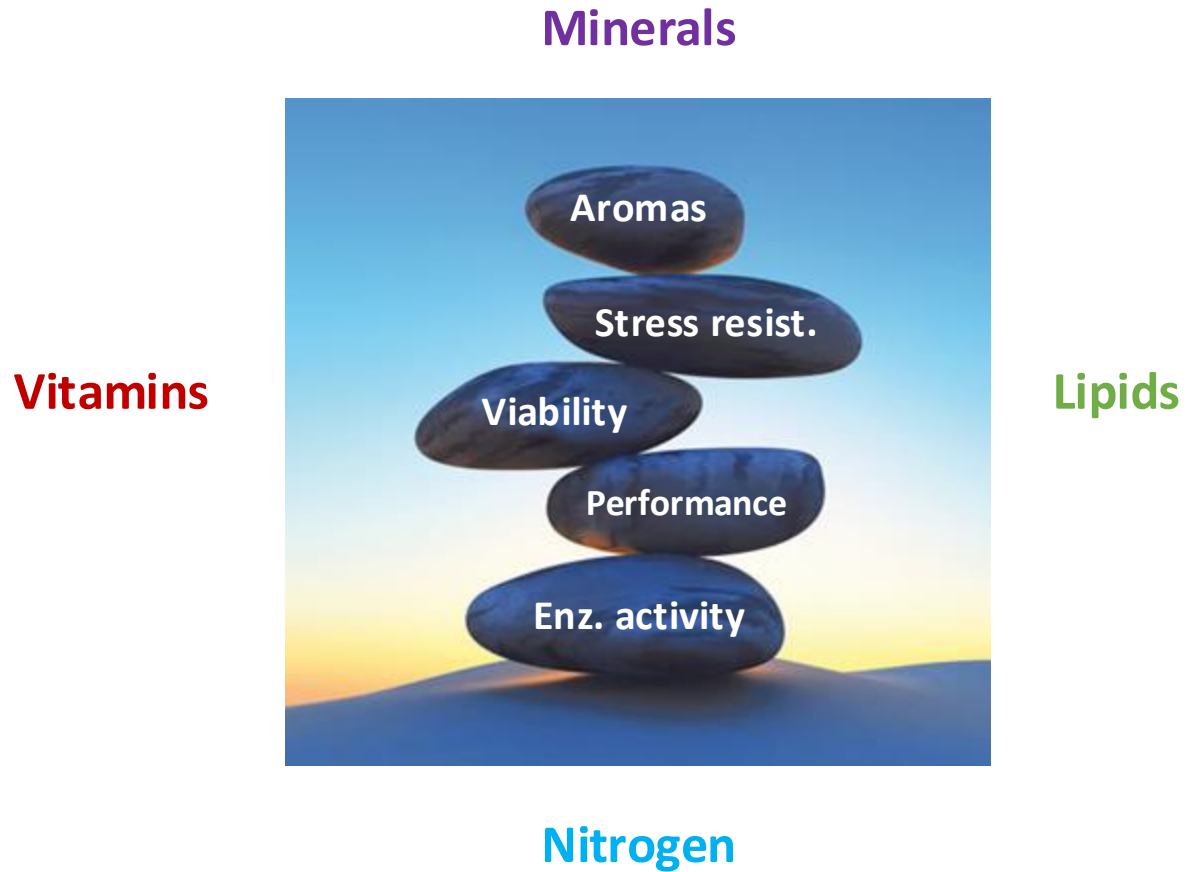


To conclude

All is a question of balance

Nitrogen, **YAN management** during the AF is important....but **not enough**

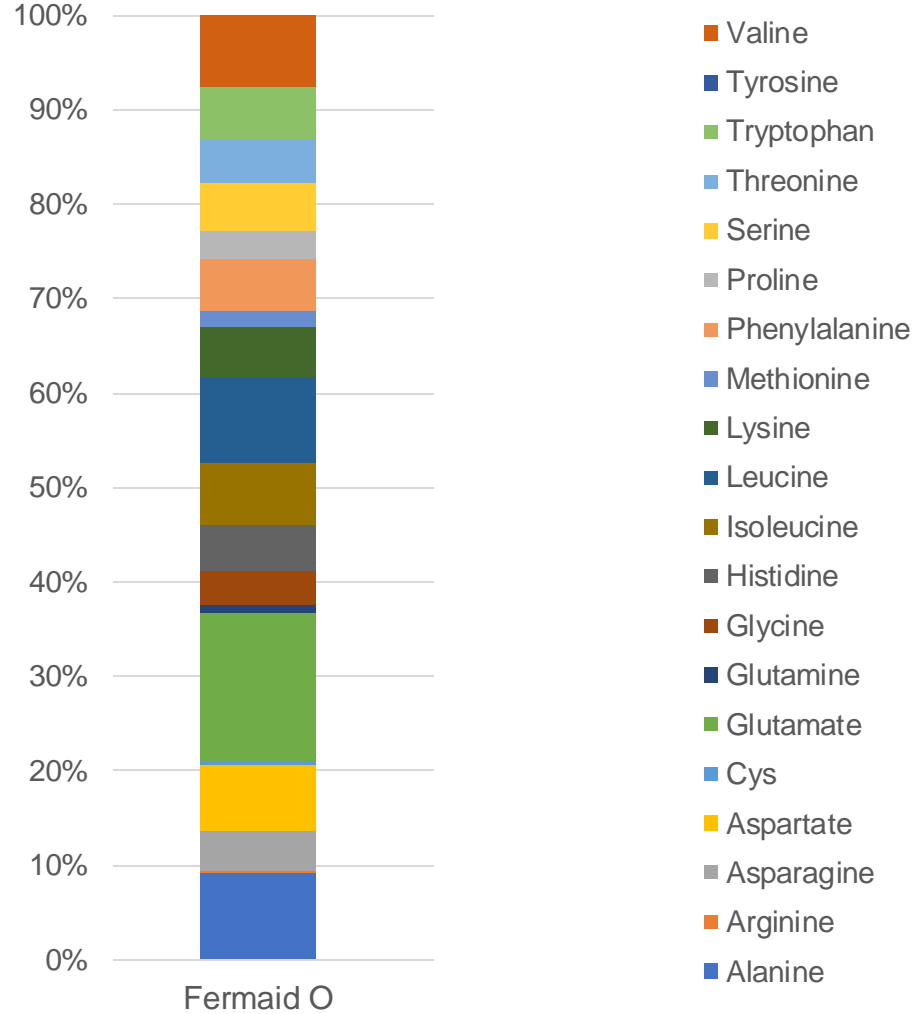
The **notion of balance** and synergy between **micro-nutrients & nutrients** is **key**



Amino acid composition of Nutrient products



The Australian Wine Research Institute



Scrimgeour et al, 2019