PINNACLE
BREWERS YEAST
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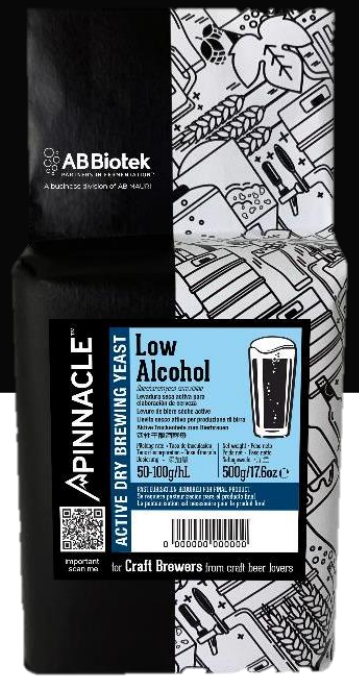

Quality and taste impact of different non-alcoholic beer production methods

AGENDA

- AB Biotek
- Methods for NABLAB production
- Beer examples

CONTACT DETAILS

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ABOUT ABB

Science & technology-driven company specializing in fermentation

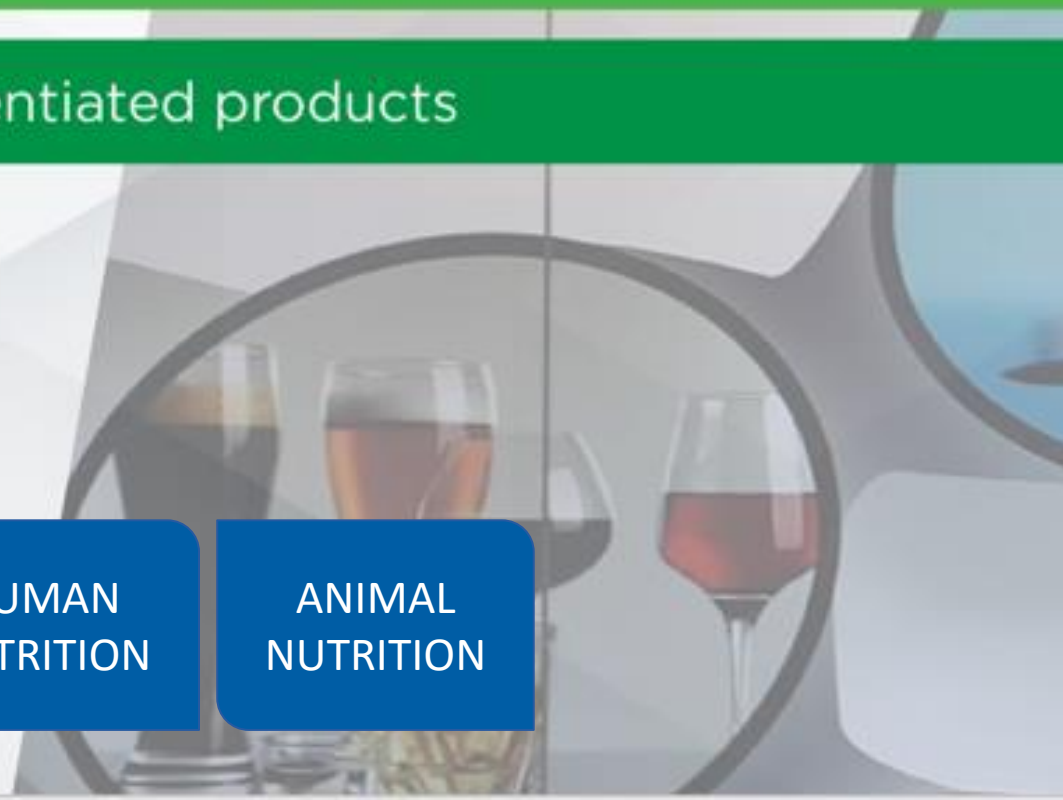
AB Biotek
PARTNERS IN FERMENTATION™

A business division of AB MAURI

PINNACLE
BREWERS YEAST

- Unique advanced yeast & microorganism solutions
- Serving global markets
- Innovative & differentiated products

A global player with decades of experience in dried yeast manufacturing
52 plants
3 R&D centers

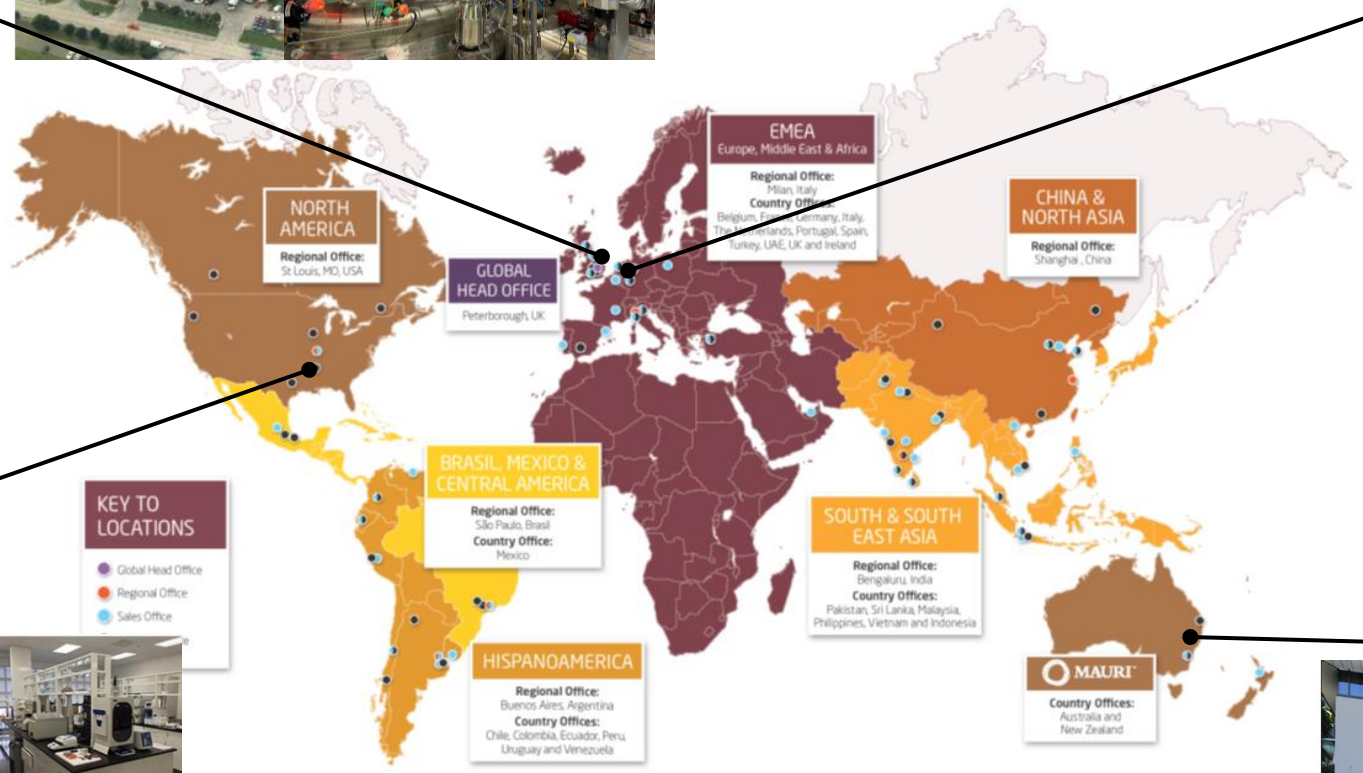


BEER | WINE | DISTILLED SPIRITS | BIOETHANOL | HUMAN NUTRITION | ANIMAL NUTRITION

AB Biotek

EMEA Centre- UK
Fermentation Applications Beverages and Bio-Ethanol , yeast production

EMEA Centre- Netherlands
Fermentation Applications Beverages, Bio-Ethanol and Enzyme Design & Screening



NA Centre
St Louis
Fermentation Applications and Yeast Strain development for Alcohol Beverages, Bio-Ethanol

APAC Centre
Sydney
Global Yeast product development and research. Beverages, Bio-Ethanol applications, and pilot plant

Expectations for a non-alcoholic beer

ABV below 0,5 %

ABV below 0,05%

Tastes like regular beer

- hop and fermentation aromas
- low malty-grainy aromas (most common flaw in NAB)
- no off-notes

Microbiologically stable

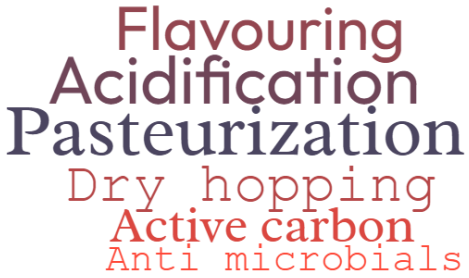
Methods in non-alcoholic beer production

There are more than 15 methods described to make NAB, some subdivided in several subtechnologies

Many are equipment solutions, which are mostly expensive (200k up to 3m)

Combination of methods can do the job better

Auxiliary methods to improve flavour and stability



Acknowledgements and disclaimers

Technology benefits in this talk are generalized for simplicity; however, some technology variants may have slightly different characteristics.
IBD offers an excellent and very complete course on non-alcoholic beer production and much of the content of this talk was taken from there.

Methods in non-alcoholic beer production

PINNACLE BREWERS YEAST

Brewhouse

STANDARD MASH
standard mashing scheme

HIGH TEMP MASH
adapted mashing scheme for low fermentable sugars wort

Fermentation

STANDARD FERMENTATION
high ABV

COLD CONTACT / ARRESTED FERM.
1-3 days at 1-4 °C OR fast crash cooling

MALTOSE NEGATIVE YEAST

Post treatment

DISTILLATION

MEMBRANES

NONE

DILUTION

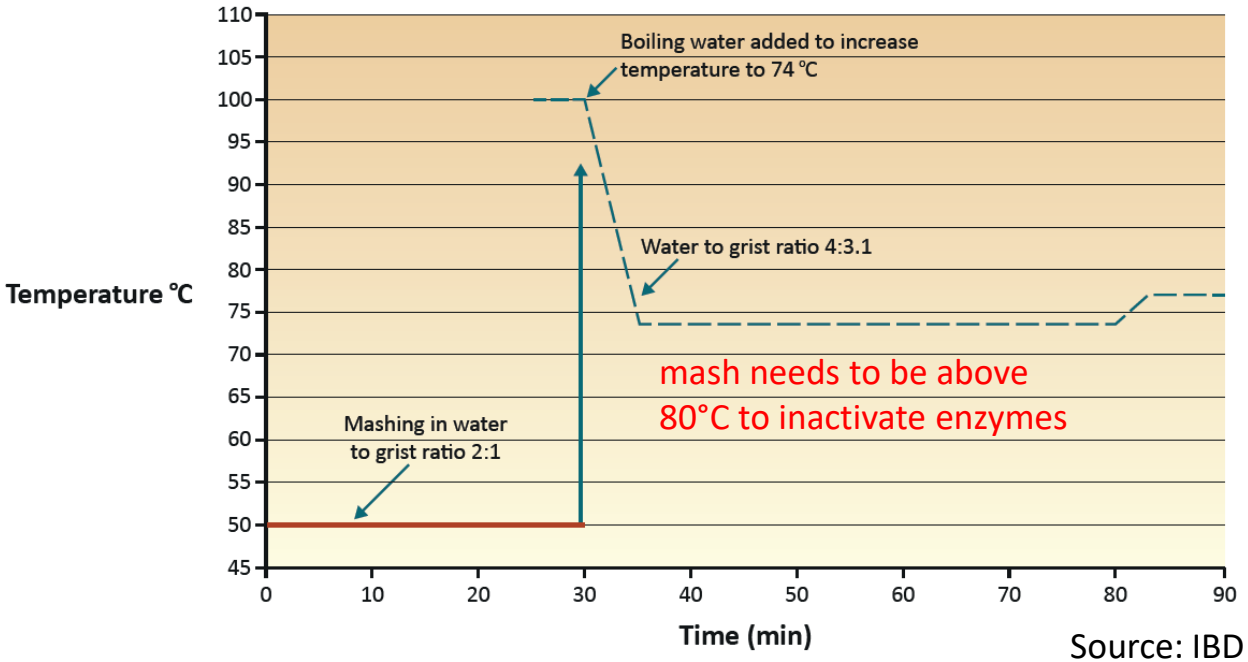
0.0 % ABV

< 0.5 % ABV
only pasteurizer required

Brewhouse methods

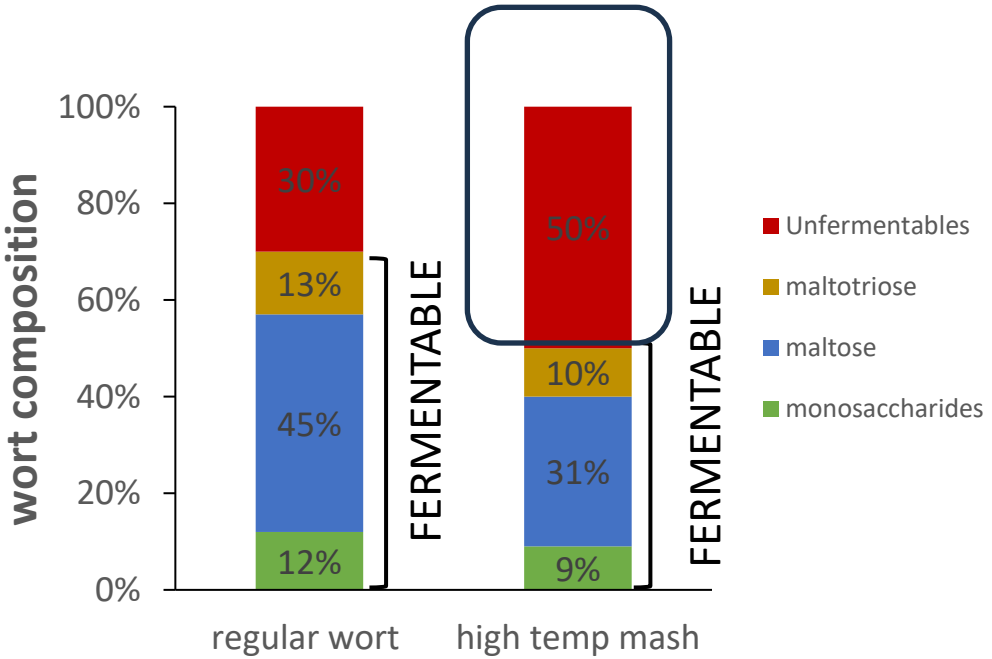
Reduce fermentability of the wort
More dextrins, less fermentable sugars
By mashing at temperatures that are suboptimal or destructive for the starch-degrading enzymes in the wort
Most common are temperature between 74 and 82°C

- Beta-amylase (releases maltose) is inactivated quickly
- Alfa-amylase is active just enough to cut starch and prevent gel formation



Source: IBD

dextrins give a more full body



Drawbacks: starch potentially still present + other enzymes like beta-glucanase, lipase, protease work suboptimal

Brewhouse methods

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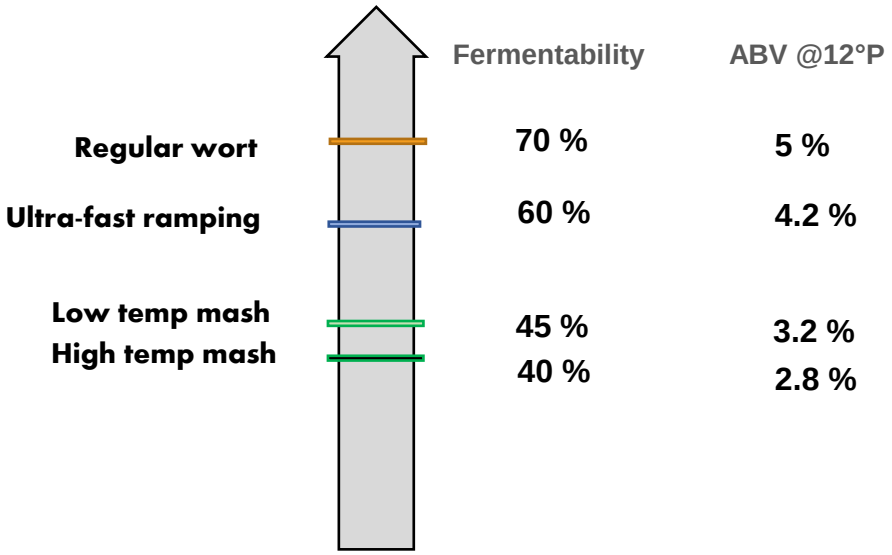
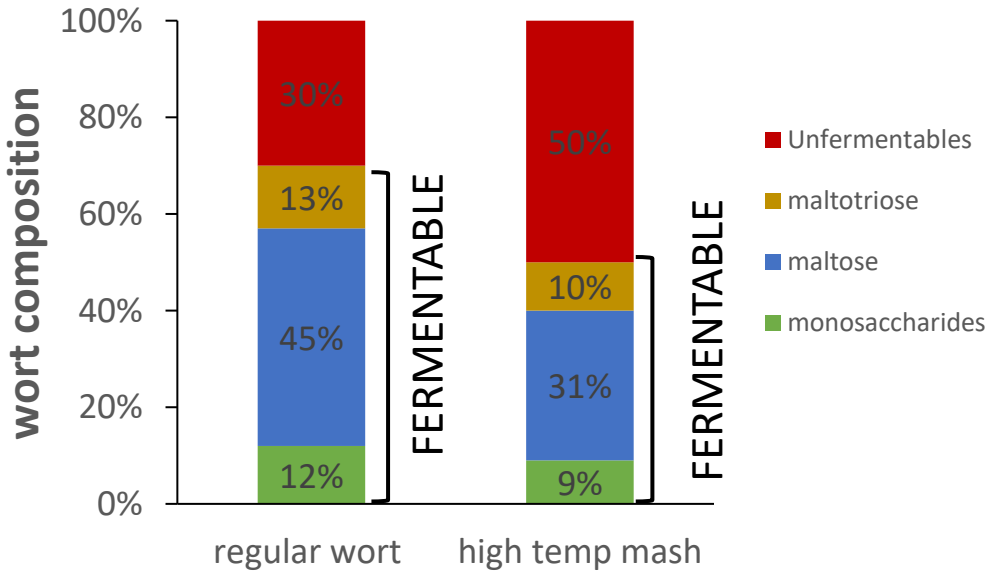
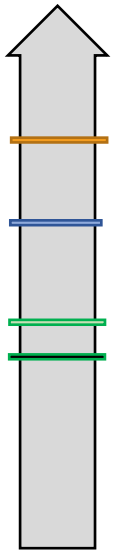




Is 2.8% ABV low enough? No, but…

Dilution



	Fermentability	ABV @12°P	ABV @5°P
Regular wort	70 %	5 %	2 %
Ultra-fast ramping	60 %	4.2 %	1.8 %
Low temp mash	45 %	3.2 %	1.3 %
High temp mash	40 %	2.8 %	1.1 %

Dilution to a typical OE for a NAB, starting from a high temp mash, already brings you very close

Some brewers dilute further, up to 1°P! => <0.5% ABV

OE 3.5°P

OE 3.5°P

OE 5.4°P

OE 1°P

OE 6.1°P

OE 4.5°P

OE 6°P

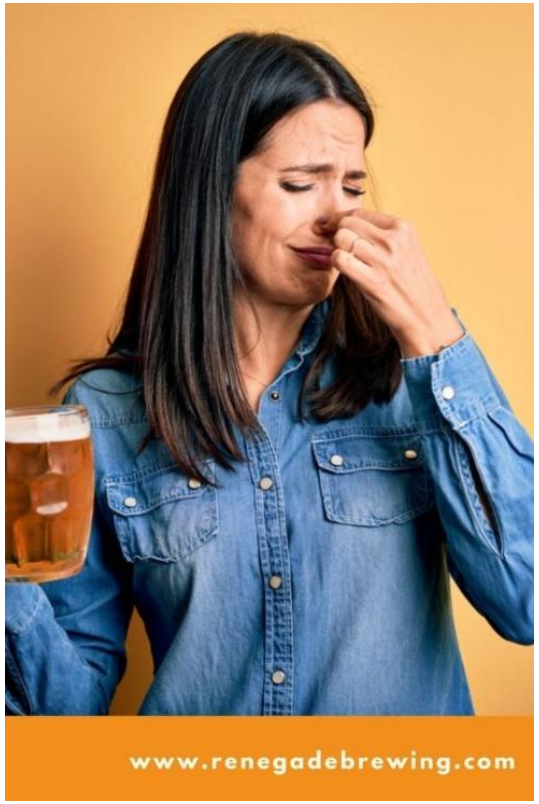
OE 9°P

Most NABs are 3.5-6 Plato, with some exceptions

Fermentation methods

Is fermentation even necessary?

Yeast removes unpleasant worty-grainy aromas in NAB originate from the synergistic interaction between aldehydes, like 2-MB, 3-MB and methional



Name (group)	Threshold (µg L^{-1})	Description
Acetaldehyde (linear aldehyde)	1114–25,000	■ Green apple, fruity
2-Methylpropanal (Strecker aldehyde)	86[a]–1000	■ Produced through Strecker degradation of valine or oxidative degradation of isohumulones (hops component) ■ Grainy, varnish, fruity
2-Methylbutanal (Strecker aldehyde)	45–1250	■ Produced through Strecker degradation of isoleucine or in presence of oxygen ■ Almond, apple-like, malty
3-Methylbutanal (Strecker aldehyde)	56[a]–600	■ Produced through Strecker degradation of leucine or in presence of oxygen ■ Malty, chocolate, cherry, almond
Hexanal (linear aldehyde)	88–350	■ Product from fatty acid oxidation ■ Green, grassy
Methional (Strecker aldehyde)	4.2–250	■ Produced through Strecker degradation of methionine ■ Cooked potatoes, worty
Phenyl acetaldehyde (Streckeraldehyde)	105–1600	■ Produced through Strecker degradation of phenyl alanine ■ Hyacinth, flowery roses
Trans-2-nonenal (linear aldehyde)	0.03–0.11	■ Reaction between heptanal and acetaldehyde or auto-/enzymatic oxidation of linoleic ■ Cardboard, papery, cucumber
Benzaldehyde aromatic aldehyde	515–2000	■ Produced in presence of oxygen ■ Almond, cherry stone
Furfural (heterocyclic aldehyde)	15,000[a]–150,000	■ Product of Maillard and caramelisation reaction (heat indicator) ■ Indicator of flavour instability in beer ■ Caramel, bready, cooked meat
5-Hydroxy-methyl-furfural (heterocyclic aldehyde)	35,784[a]–1,000,000	■ Product of Maillard reaction and caramelisation ■ Bready, caramel

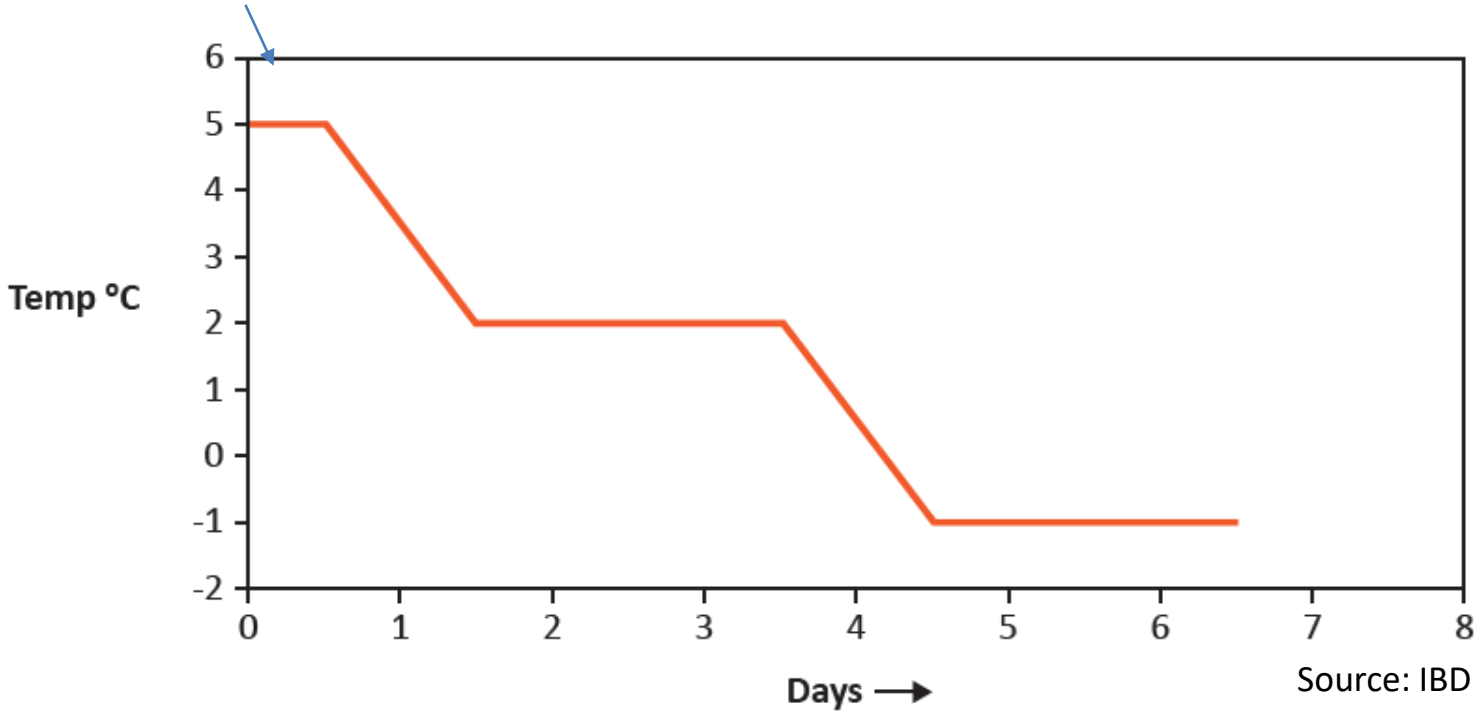
[a] Odour threshold

Gernat et al. 2020

Fermentation methods – Cold contact

Contact of yeast with wort, drastically improves worty-grainy notes, but not completely
One of the oldest (1983) methods to make non-alcoholic beer
Up to 10-20 years ago the most commonly applied method, but overall not well appreciated

Start with dried yeast or washed yeast (alcohol carry-over)
Acidify the wort to pH 4 – 4.5 (stability)
No aeration (no yeast growth, no diacetyl)



Source: IBD

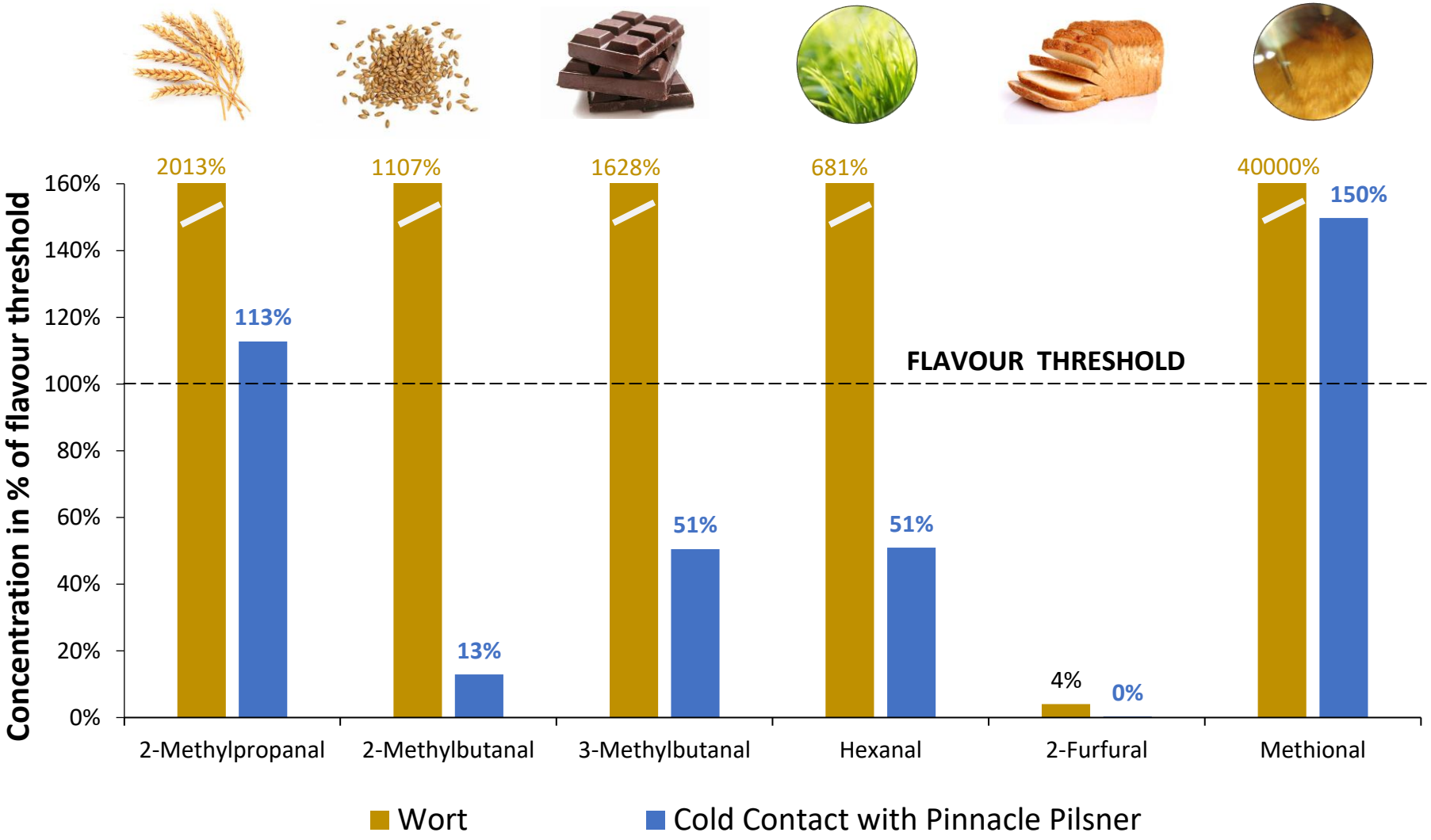
Optional extras to remove aldehydes:

- add active carbon during boiling (or mashing)
- some brewers sparge with CO2 during fermentation or during boiling
- Replace malt by adjuncts that contribute less malty aromas. **Replace up to 40% of malt by rice, corn, high maltose syrup** (**not** glucose or invert syrup!! -> ADF will increase)

Even 0.0 beer is possible. However, still much more worty than 0.5 beer.

Fermentation methods – Cold contact

Contact of yeast with wort, drastically improves worty-grainy notes



Fermentation methods – Maltose negative yeast

Many yeast species available:

- Saccharomyces cerevisiae
- Saccharomycodes
- Pichia kudriavzevii
- Pichia kluyveri
- Cyberlindnera
- Zygosaccharomyces
- Torulaspora delbrueckii
- and more…

Some more pronounced in aroma, others more clean

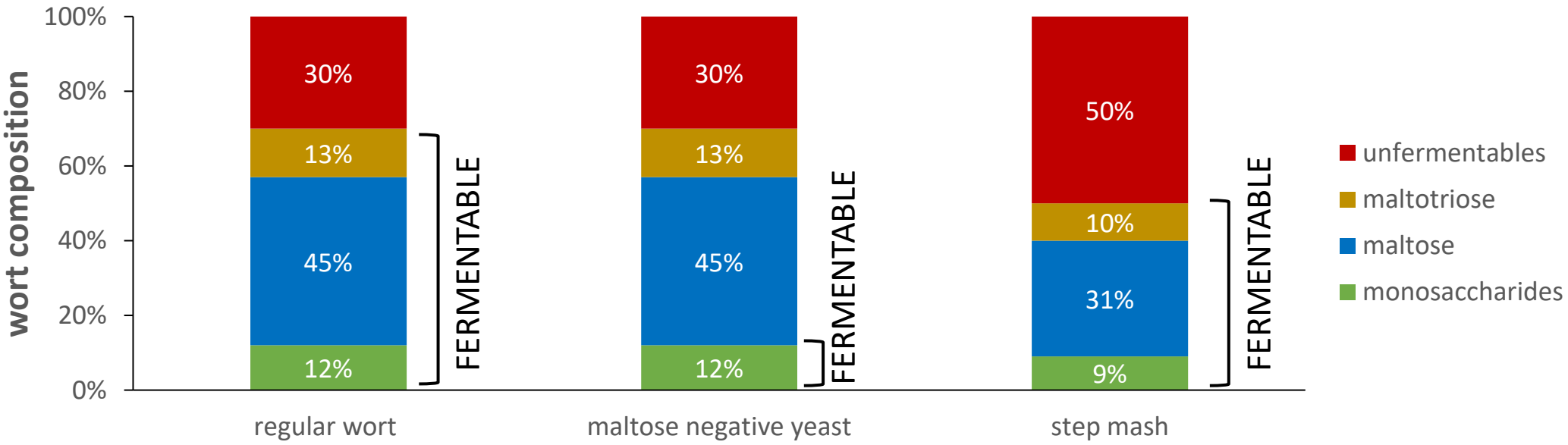
In essence, NAB yeast has the function to:

- ferment only glucose (10% of the wort sugars) -> low alcohol
- remove worty-grainy aldehydes
- drop pH
- no off-flavours

Maltose negative yeast vs. regular yeast

works well with regular wort

malt with low fermentability (crystal…) or unmalted grains (barley) can increase the OG for same ABV



5.5 °P beer

2.4% ABV

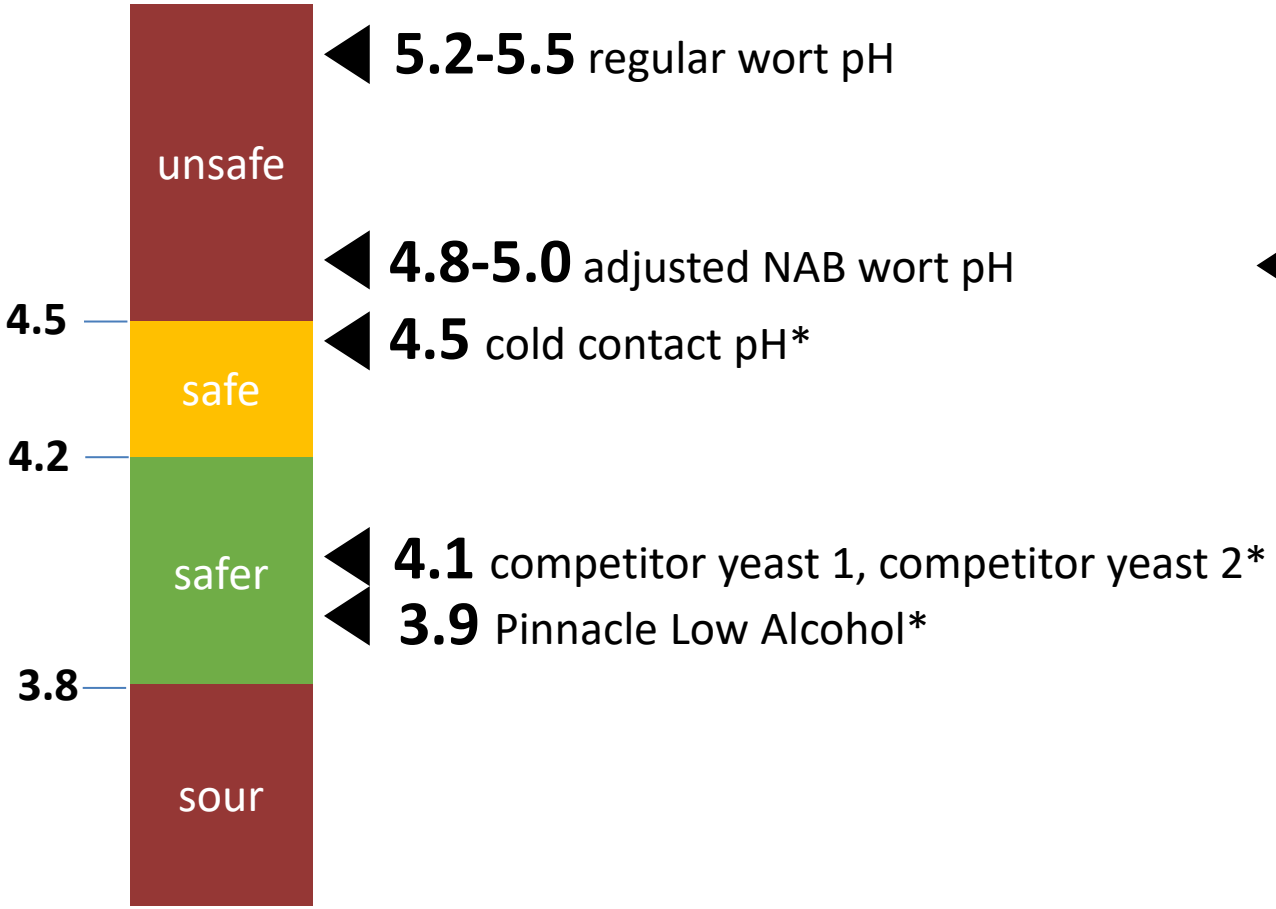
0.4 % ABV

1.7% ABV

NO DEALCOHOLISATION REQUIRED

Low pH is crucial for microbial stability

Pasteurization ≠ sterilization
Low pH and pasteurization work hand in hand

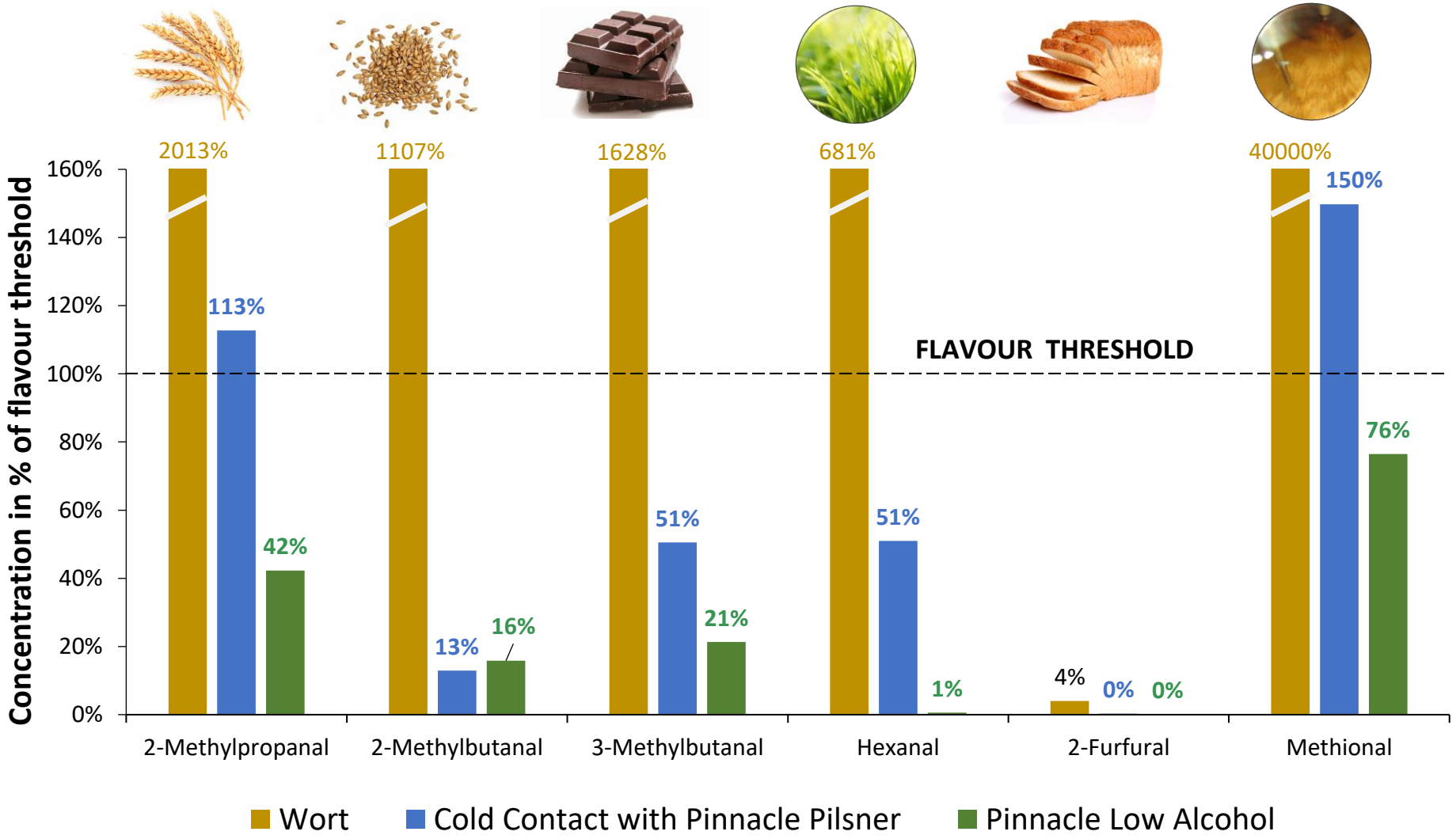


Recommendation to pre-acidify the wort
The yeast will do the rest

* from wort with pH 4.8

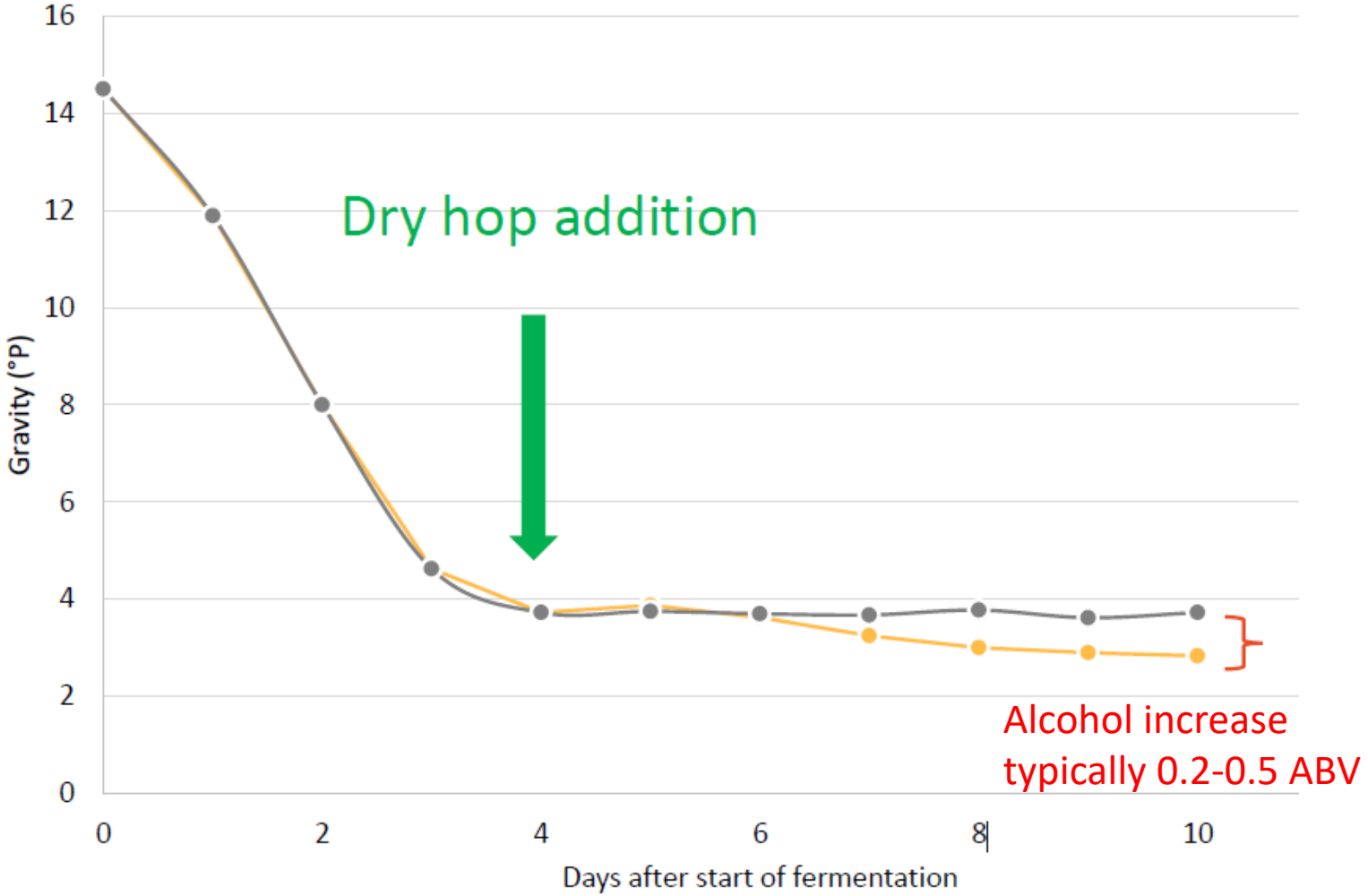
Yeast cleans out worty flavours

… better than cold contact (and in line with distillation and membrane dealcoholisation)



Hopping – ABV increase due to hop creep

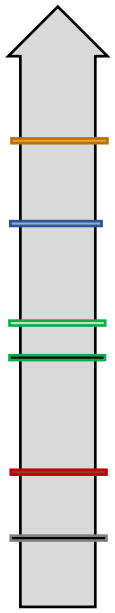
Many brewers rely on flavourings or dry-hopping to mask remaining worty notes and create more flavourful NAB
Dry hopping introduces release of glucose that yeast can ferment -> **ABV increase** and diacetyl formation



How to avoid hop creep:

1. Late hopping instead of dry hopping
2. Dry hop cold < 4°C
3. Keep the time short
4. Don’t overdo hop load (hop creep is proportional)
5. Remove sedimented yeast
6. Avoid oxygen pick-up (yeast growth restarts)

Method comparison



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Low temp mash	45 %	3.2 %	1.3 %
High temp mash	40 %	2.8 %	1.1 %
Maltose negative yeast	15 %	1 %	0.4 %
Cold contact	1-10 %	0.5 %	0.2 %

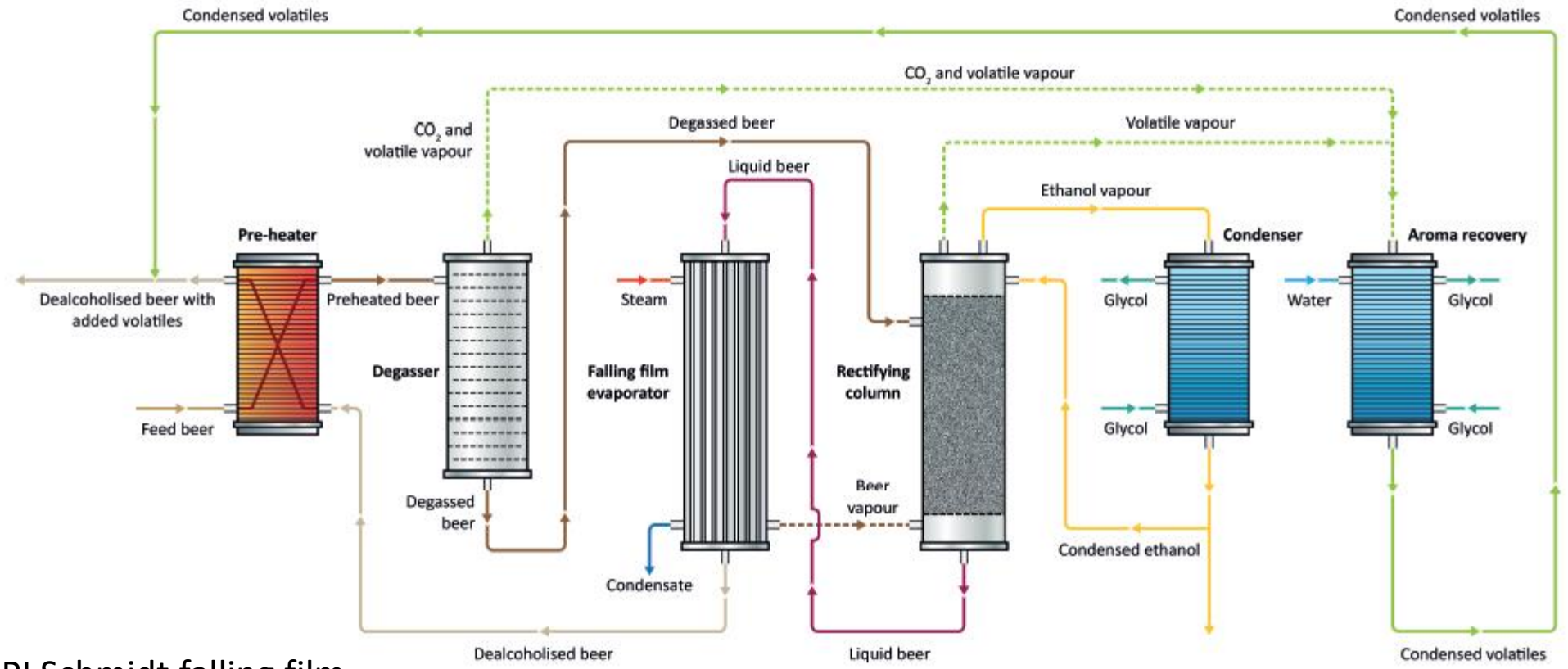
low body if diluted to <0.5% ABV

often worty, no yeast aroma, unfermented hops

how to get to 0.0% beer?

Equipment methods – thermal dealcoholization

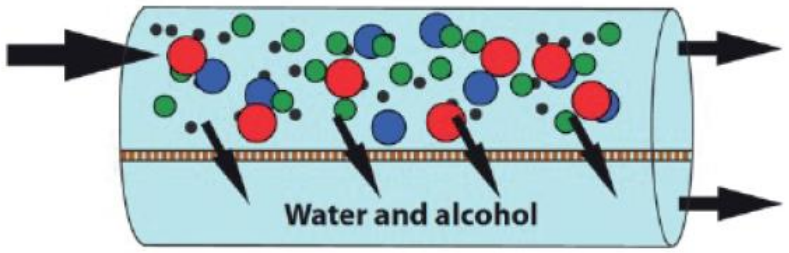
based on the principle of low temperature (+/- 40-50°C) evaporation of alcohol with steam under low pressure (40-120 mbar) -> low heat stress



API Schmidt falling film

Equipment methods – membrane systems

based on semipermeable membrane that allows passage of water and alcohol, but not most aroma compounds



Water and alcohol crossing the membrane (image courtesy of Alfa Laval)

new systems reduce significantly the water usage and make this technology viable

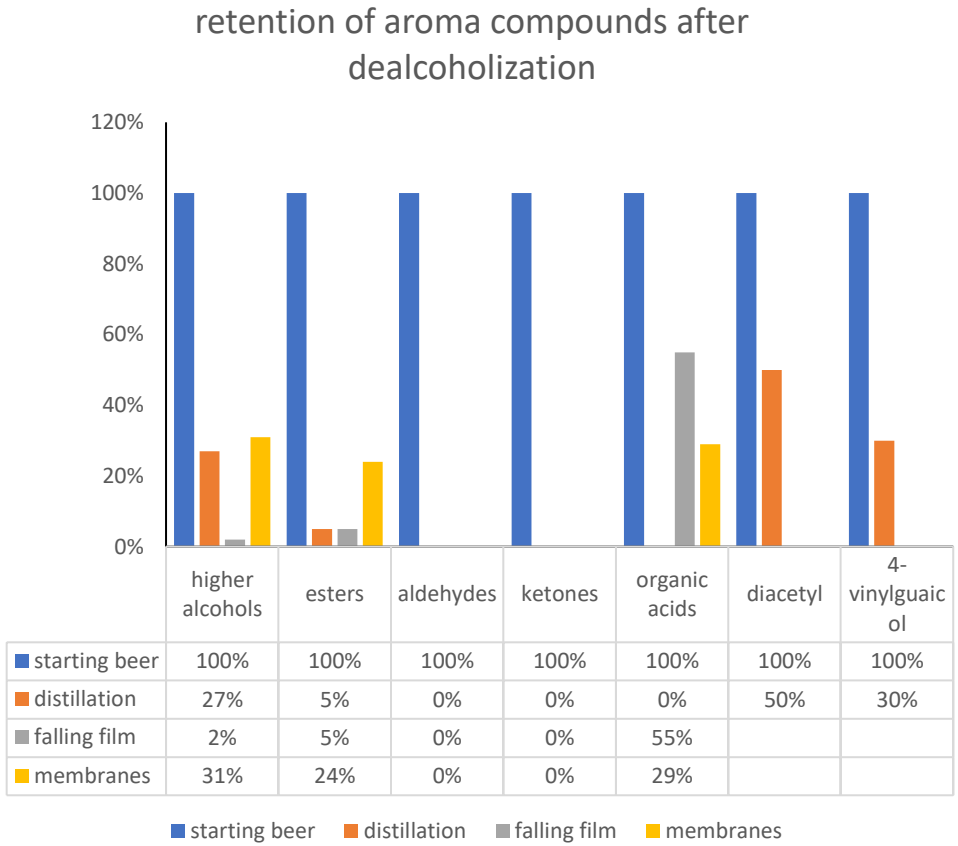
Equipment methods – overview

equipment methods are great

- deliver 0.0% beer
- allow complete fermentation and thus very low worty-grainy notes

but…

- have a high initial investment cost
- consume significant amounts of energy
- remove most of the hop and yeast flavour and therefore often require flavouring (except for some of the most recent systems)



	higher alcohols	esters	aldehydes	ketones	organic acids	diacetyl	4-vinylguaiacol
starting beer	100%	100%	100%	100%	100%	100%	100%
distillation	27%	5%	0%	0%	0%	50%	30%
falling film	2%	5%	0%	0%	55%		
membranes	31%	24%	0%	0%	29%		

source: IBD

most of the data come from trials with early prototypes. Today more advanced systems are available, especially membrane that have much higher retention.

Examples of NABLAB beers made with different methods

Water, malted barley, hop extract, **natural flavoring**

Water, malted barley, sugar, hop extract, **natural aroma**

Water, malted barley, **glycerine**, hops, natural

Pale Ale, Rye Malt, Toasted Wheat, Chocolate Spelt, hop.

?

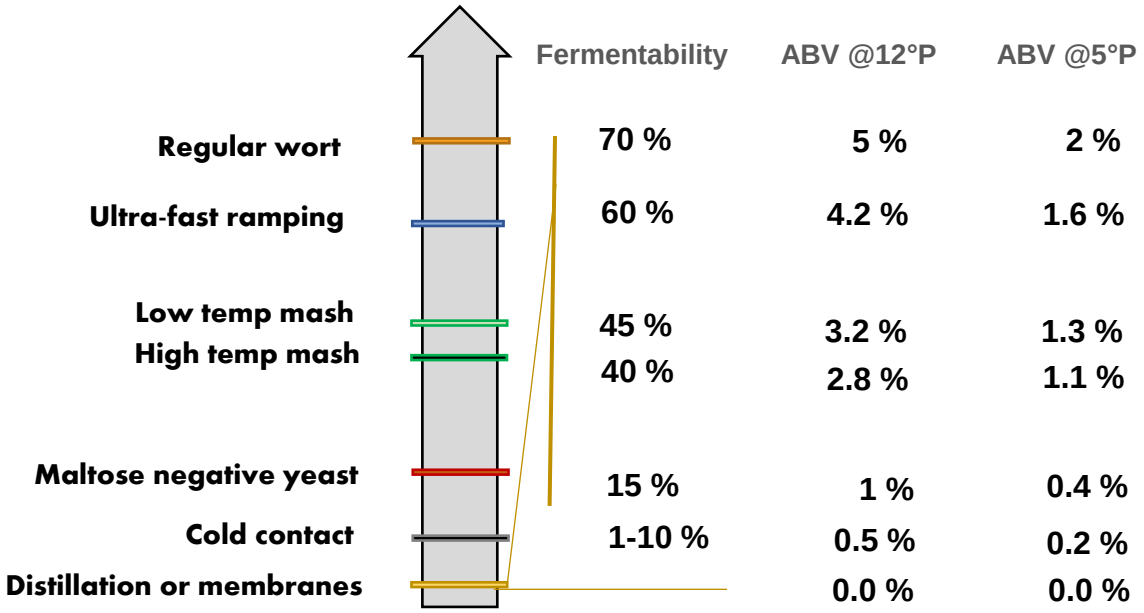
Water ,**Dietary fibre, Soybean peptide, hop, fragrance, acidulant, caramel color, antioxidant (vitamin C), sweetener (acesulfame K)**

	Heineken 0.0	Stella Artois 0.0	Big drop lager	BBBP Pico nova	Older NA beers	Asahi Dry Zero
OE (°P)	5.4	4.5	1	3.5		1.4
ABV	0.0	0.0	<0.5	0.3		0.0
pH	4.4	4.3	3.8			3.9
TBU	16	19	23	30		19
Method	distillation	distillation	dilution	yeast	cold contact	formulation

This summary is limited to beers from which the production process can be deduced by analysis of the final product. The real production process may still be different

Final notes

The ideal technology does not exist



low body if diluted to <0.5% ABV

often worty, no yeast aroma, unfermented hops

$$$, requires flavouring

Technologies can be combined

- High temperature mash + Dilution + Dry hopping produces decent NABs
- Maltose negative yeast + Unmalted cereals delivers a full-bodied beer below 0.5% ABV
- Maltose negative yeast + Distillation results in significant energy savings vs. using regular yeast

Every technology requires (tunnel or batch) pasteurization

Pinnacle Low Alcohol

Produces low alcohol levels

≤ 0.5 % ABV @ 5 Plato

≤ 1 % ABV @ 10 Plato

Clean neutral aroma, versatile strain

- Non-phenolic
- Low diacetyl
- Low esters
- High reduction of worty-grainy taste (aldehydes)
- Flavour can be tuned by dry-hopping, specialty malts or flavour addition

Safe Saccharomyces cerevisiae strain, GRAS

Available in dry format (as from Q2 2024 @Brouwland and SBI)

Pitching rate: 40-80 g/hl - **Fermentation temperature**: 18 – 25 C

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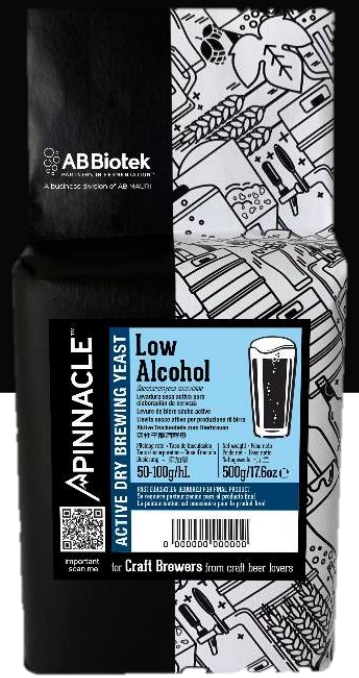

Thank you for your attention