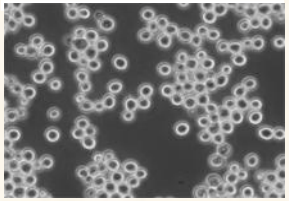


Versuchs- und Lehranstalt für Brauerei in Berlin (VLB) e.V.

Yeast propagation in modern breweries: Innovations and global practices

VLB
BERLIN

Yeast Management- Targets

A good yeast management:

In the brewery:

- need amount of high viable and vital yeast cells in the need time

In Propagation:

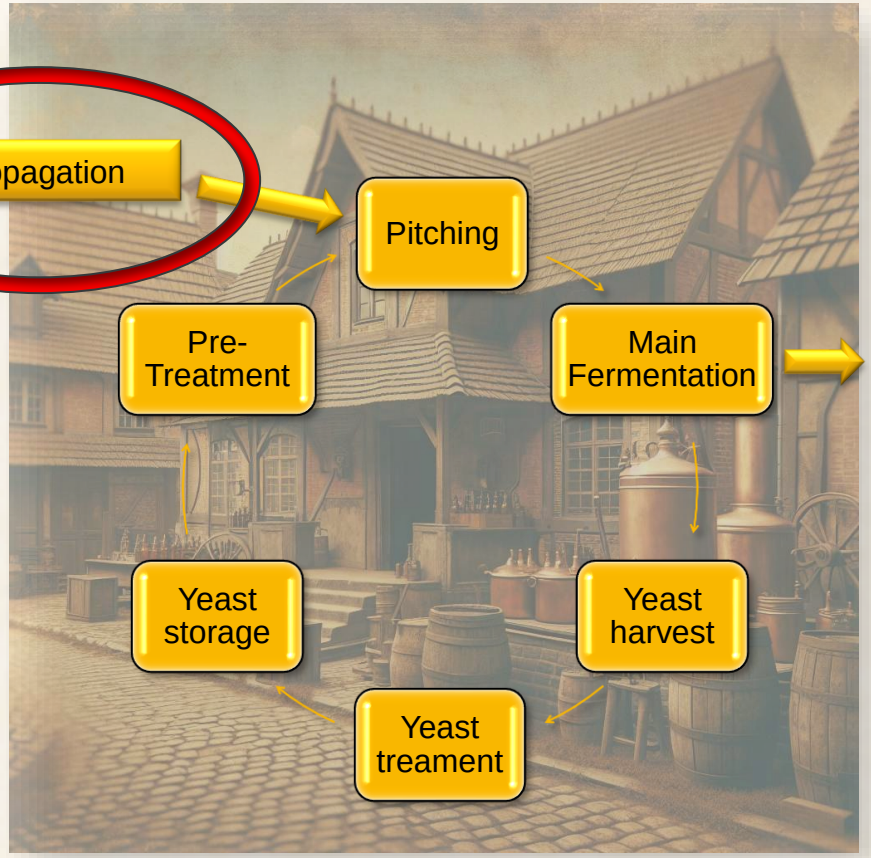
- Short propagation times →maximum specific growth rate of yeast cells

Yeast Management- Targets

Leads to:

- Fast extract decrease at beginning of fermentation
- Fast maturation of green beer- diacetyl reduction
- Intensive fermentation (even with low pitching rate)
- Achieve desired aroma characteristics
- Good foam stability
- Increased taste stability

Ways of Yeast in Brewery



Yeast Propagation

VLB BERLIN

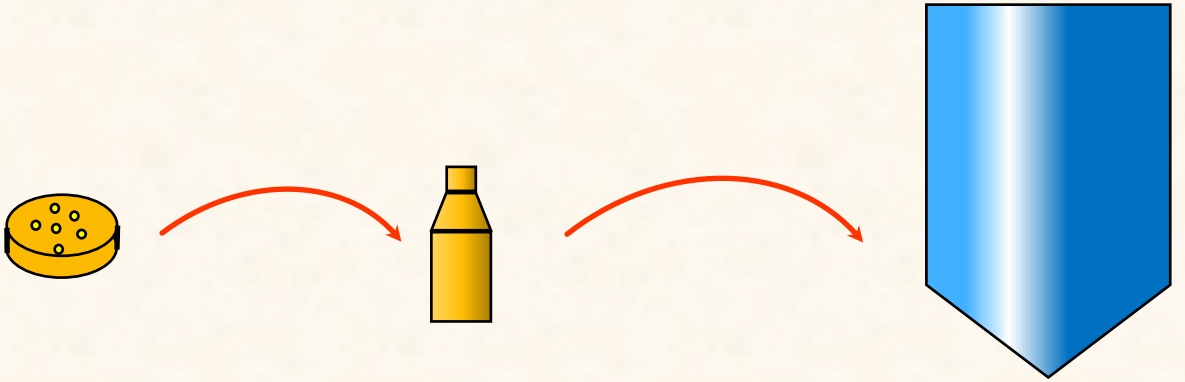
YEAST PROPAGATION
PRINCIPLES of HANSEN'S propagation

1883 Emil Christian Hansen from Denmark first managed it to propagate yeast cultures. He isolated a single yeast cell and multiplied it step by step.

+ improved until today
+ propagate special yeast culture of each brewery
+ Most breweries are propagating their own yeast

➔ guaranties continuous quality of the beer

Propagation set up



Target of Yeast Propagation

„In kürzester Zeit möglichst viel Hefe unter sterilen Bedingungen zu produzieren, mit einem korrekten Stoffwechsel, der zu normaler Gärung und damit zu guter Bierqualität führt.“

Prof. K. Wackerbauer

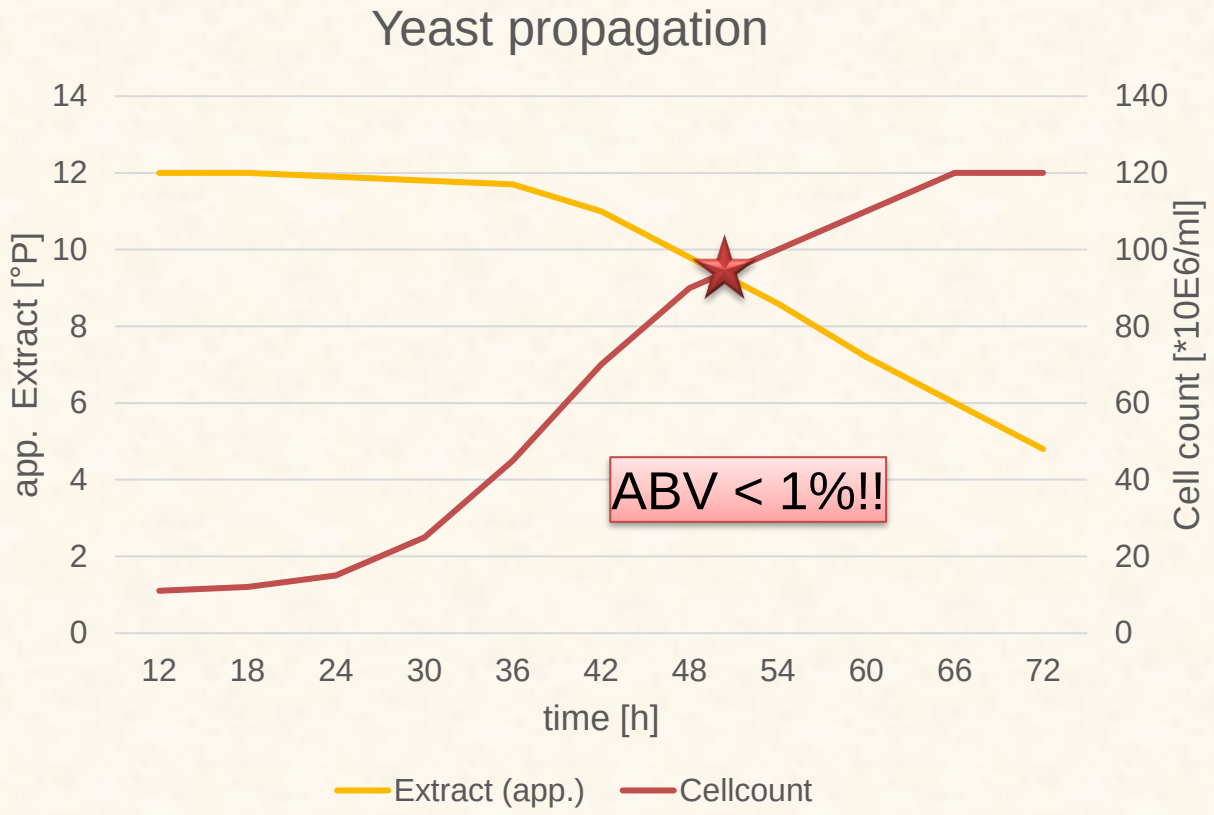
Target of Yeast Propagation

+ Highest possible cell counts after propagation
+ Short propagation times
+ Maximum specific growth rate of yeast cells
+ High part of viable yeast cells in inoculum
+ Optimum physiological conditions of yeast cells at pitching

Yeast Propagation Rules

- Slow adaptation to pitching temperature
- The best stage to transfer yeast to the next propagation step is during the highest rate of multiplication. In this stage yeast can activate defenses against contaminant microorganisms.
- An ideal case is to have a hermetically closed cooling- and propagation system
  - sterile wort
  - sterile filtered air

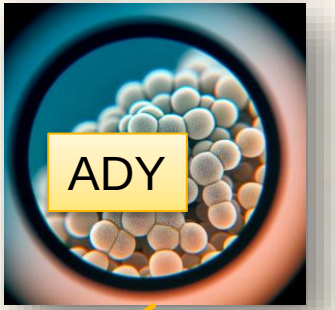
Control of yeast propagation- transfer time



Steps of Inoculation

Slanted agar

Agar plate

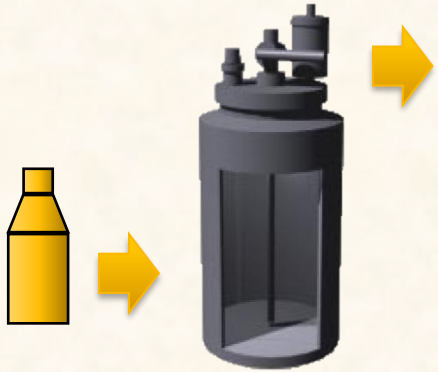


Propagation Transfer Vessel

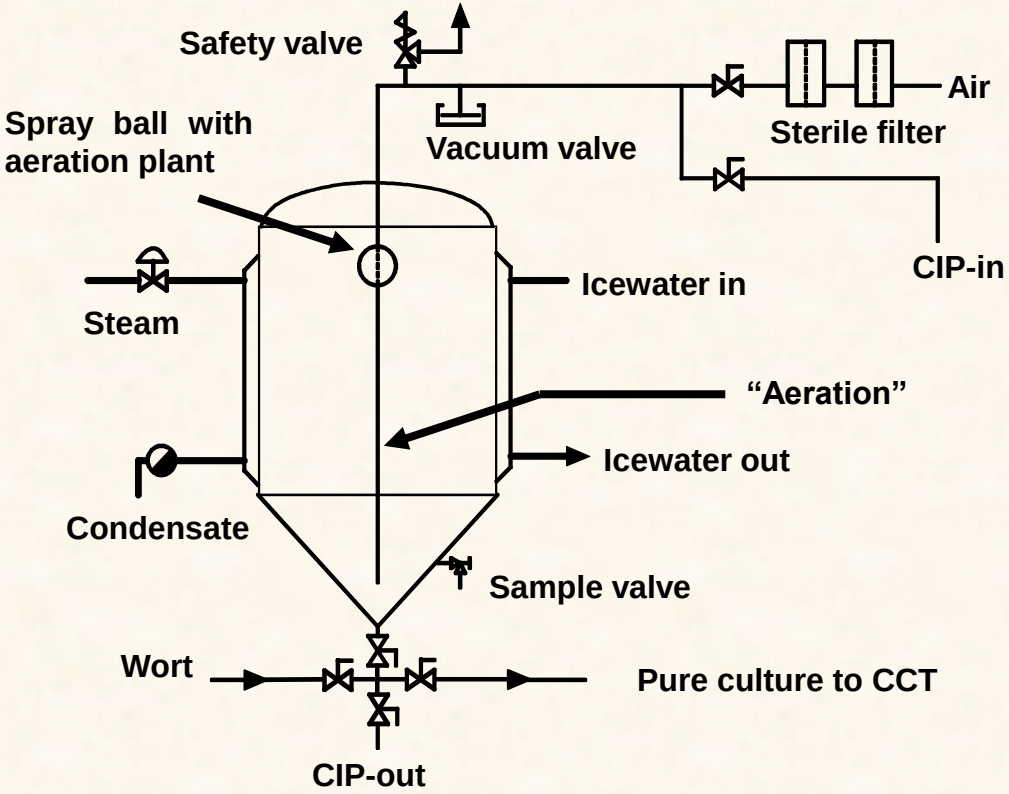
1. Sterile air filter - allows excess pressure to escape

2. Sample tap - allows sterile air or oxygen to be bubbled through the wort

3. Inoculation connection - for adding sterile yeast to wort.



Propagator Installations



Wackerbauer,Evers, Kunerth
Brauwelt 136,1996

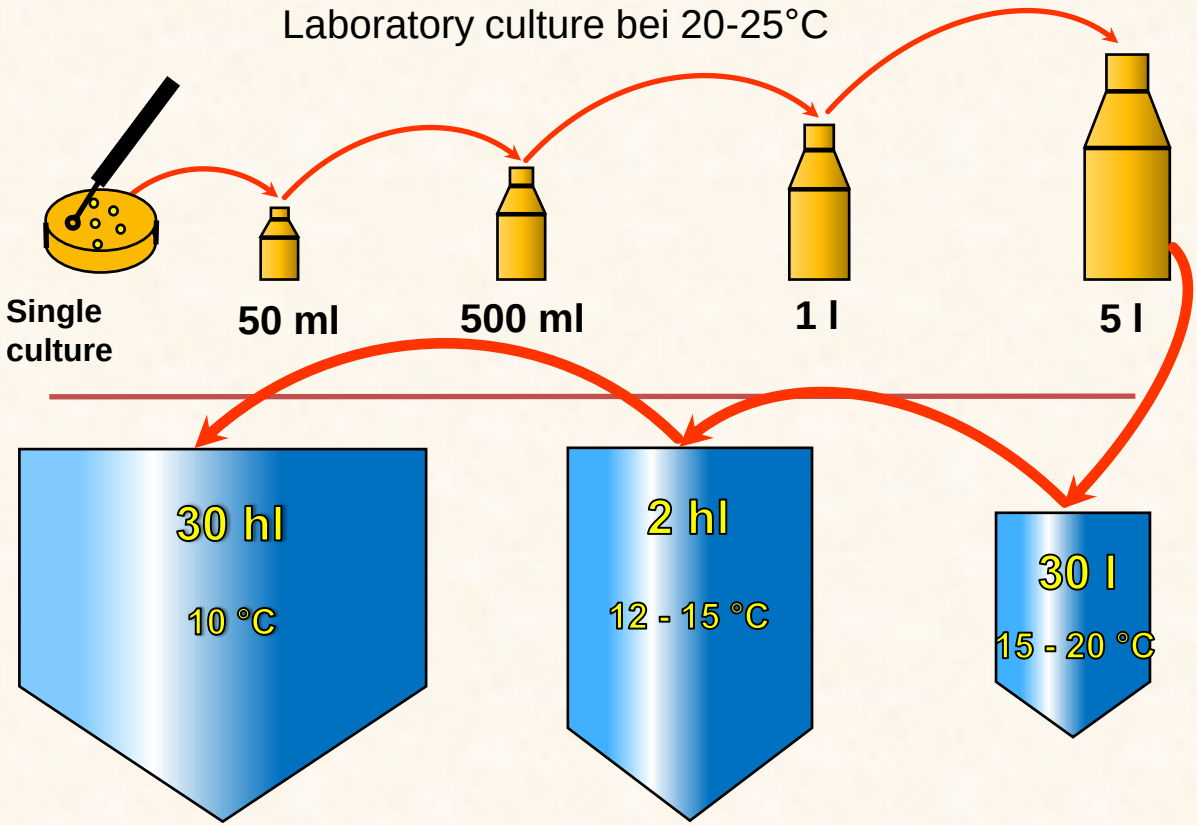
Propagation Procedures

+ Conventional propagation
+ One-tank batch procedure
+ Two-tank batch procedure
+ Repeated fed-batch method

Generation Time of Lager Yeast

Temperature [°C]	Generation time [h]
8	20 – 25
12	12 – 15
15	10 – 12
16	9 – 11
20	6 - 8
25	2 - 3

Conventional propagation

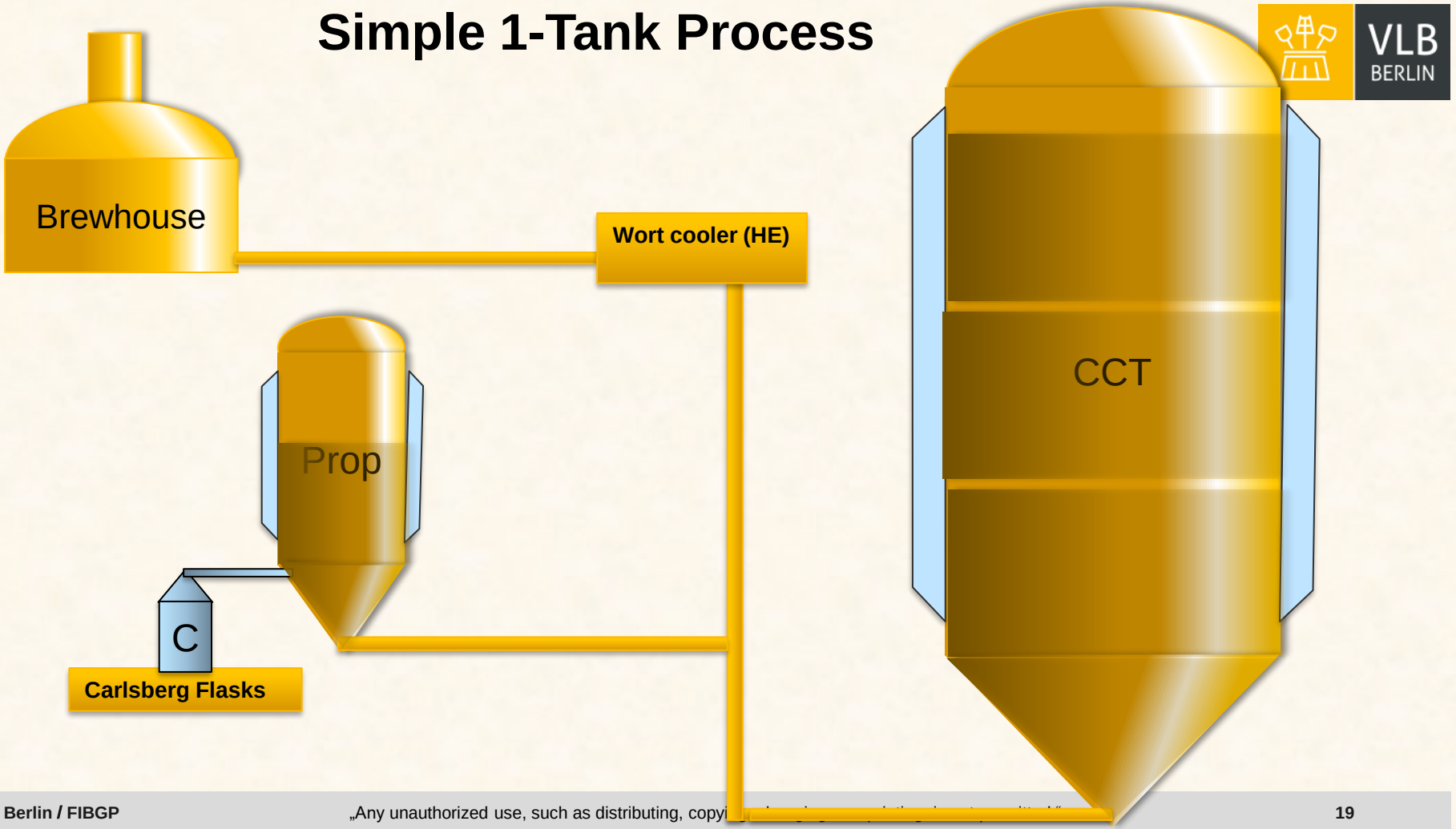


Procedures: Conventional Propagation

Disadvantages of conventional propagation:

+ Each change of vessel creates a risk of contamination
+ High cleaning effort
+ Labour intensive
+ Long propagation time

Simple 1-Tank Process

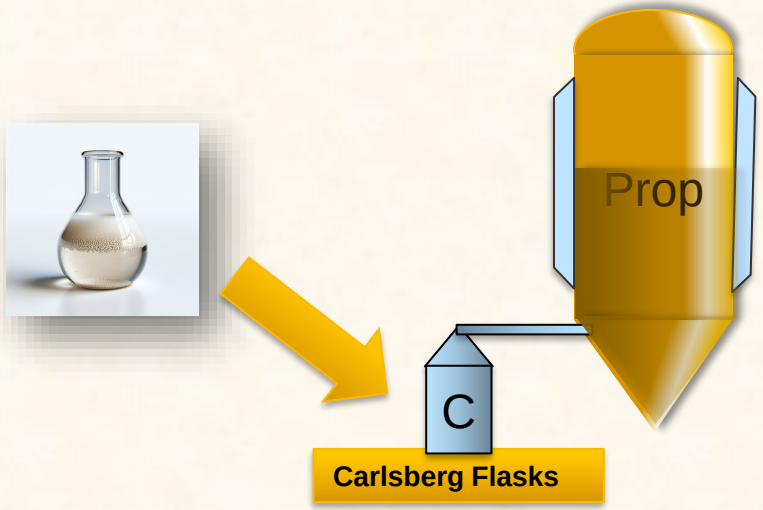


Simple 1-Tank Process

Laboratory:
50 ml pre- culture into 10l Carlsberg flask
Ratio 1 : 200
Interval aeration for 24 h at 20°C

Plant:
10 l CF into 25 hl propagator
In high Krausen statium
Ratio 1 : 250
Interval aeration for 36 - 48 h at 20°C

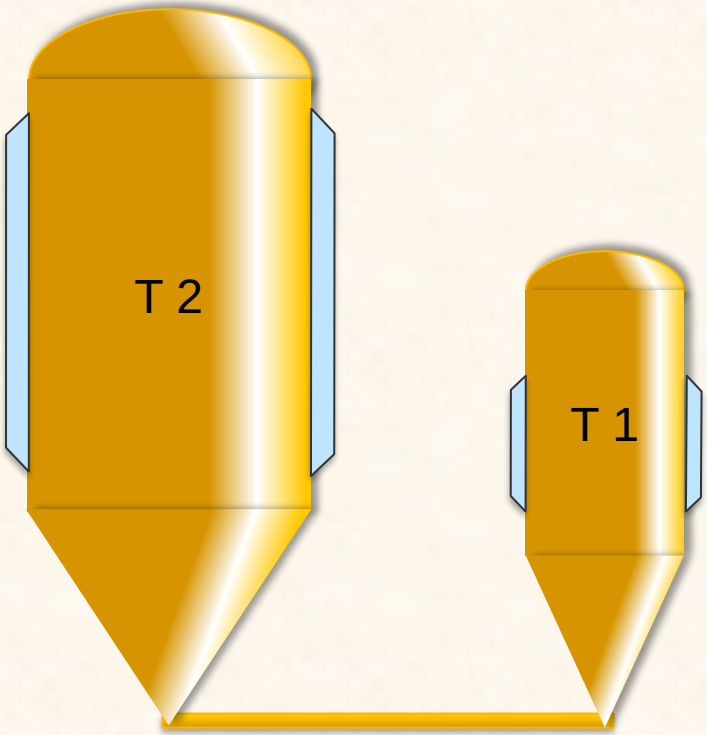
Pitching:
Pitching at high Kräusen into 500 hl wort
Ratio 1 : 20



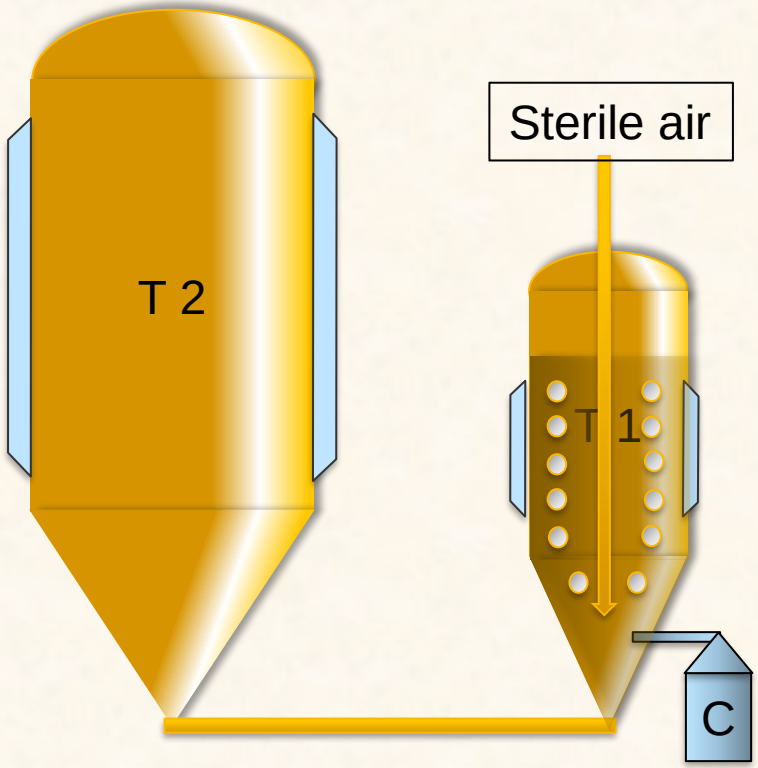
Two Tank Procedure (Assimilation Procedure)

- Two propagators → possible connected by venturi nozzle
- Periodical removal of a specific amount of the yeast and a subsequent refilling of the vessel with wort
- 80-85% used for pitching at (Es→6-7% for 12°P wort)
- 15-20% remain in prop. tank→ topped with wort
- Plant equipment:
  - Agitator
  - Heating/ cooling jacket
  - Measurement equipment: Oxygen, temperature, pressure, pH
- Aeration while pumping from first tank to second tank
- Temp: 8-14°C

Two Tank Procedure

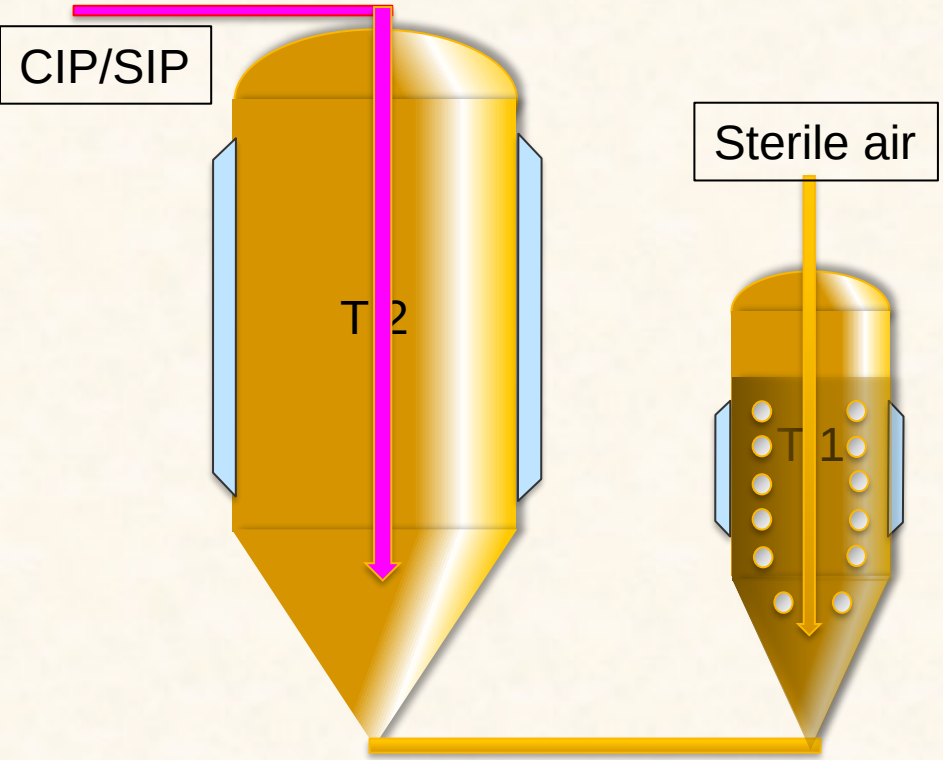


Two Tank Procedure



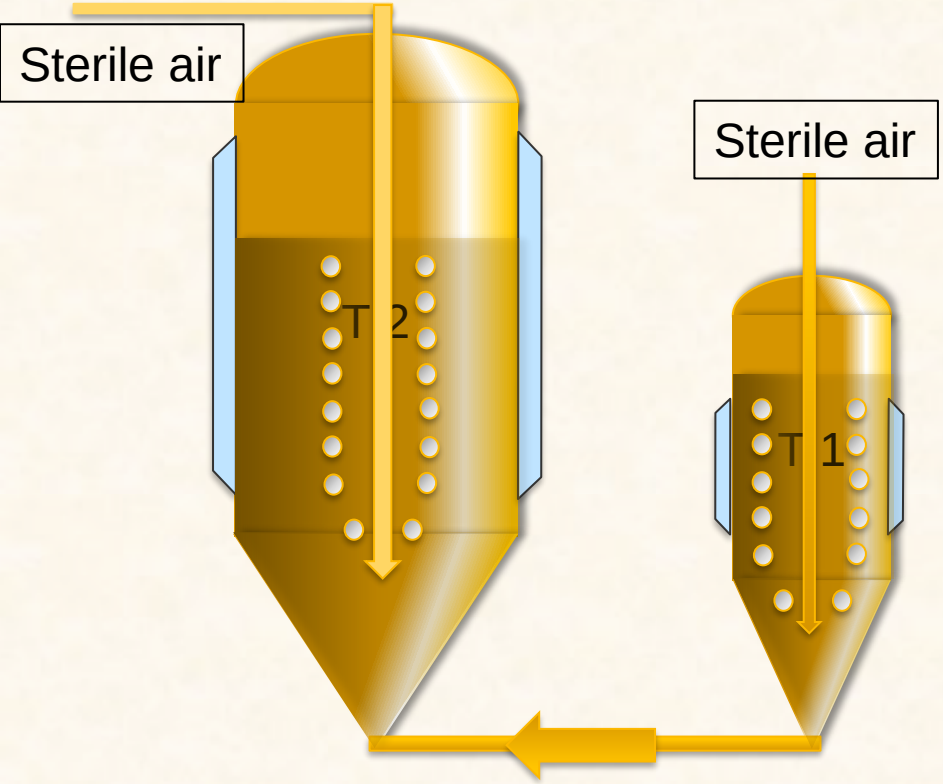
- Filling of T1 (e.q. 10 hL)
- Sterilsiation of wort in T1
- Cooling of wort in T1
- Pitching from Carlsberg flask

Two Tank Procedure



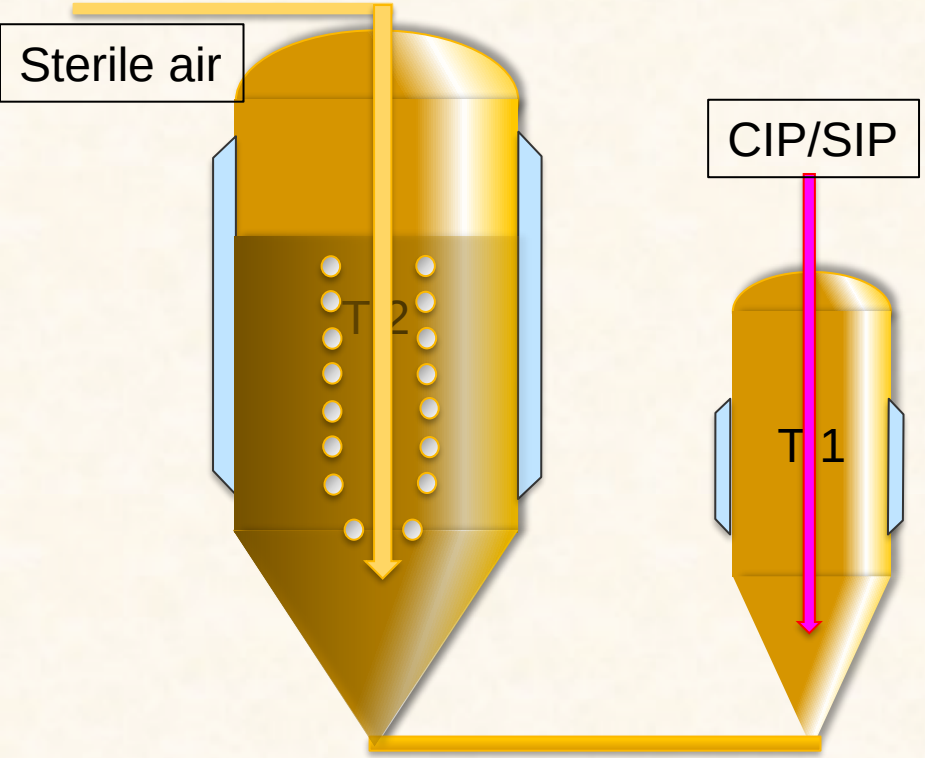
- Propagation in T1
- T2 in CIP/SIP

Two Tank Procedure



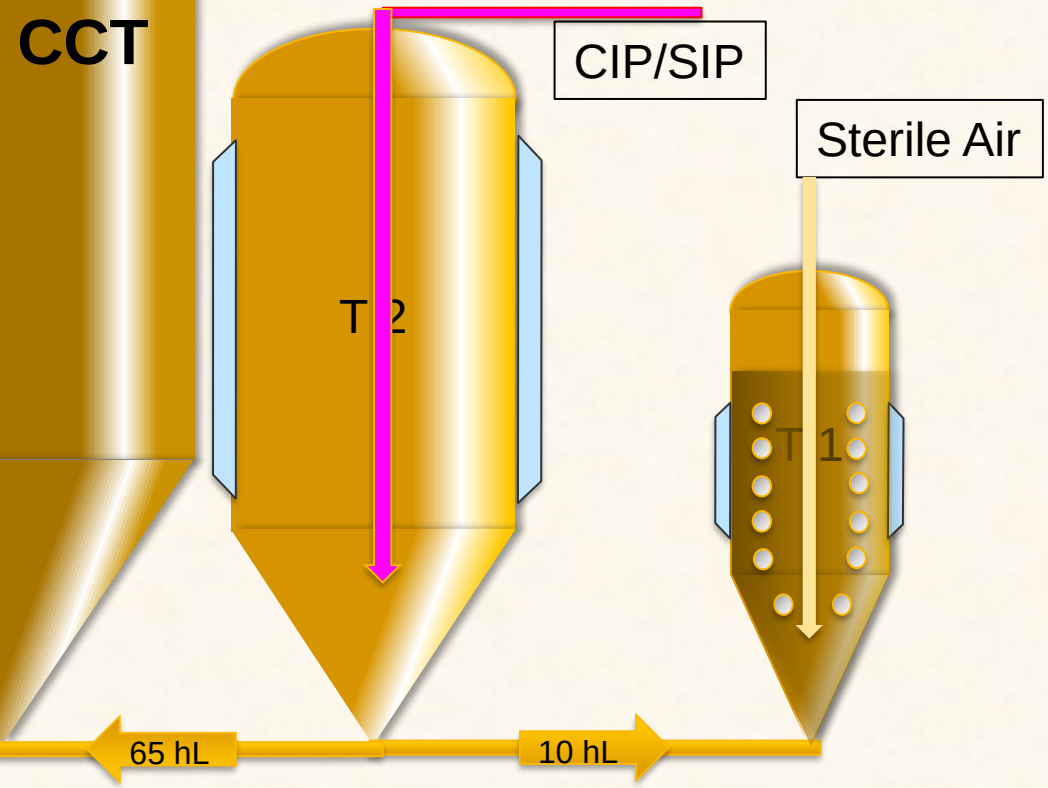
- Filling of T2 with wort (e.q. 65 hL)
- Sterilisation of wort in T2
- Cooling of wort in T2
- Aeration of T2
- Pitching from T1

Two Tank Procedure



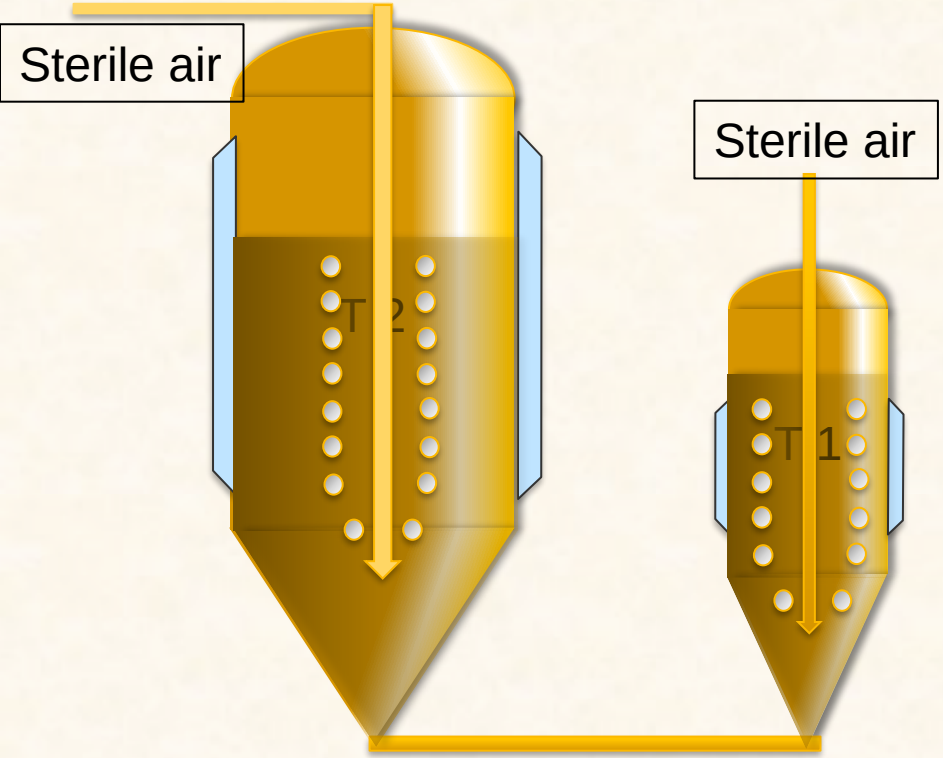
- T2 in Propagation
- T1 in CIP/SIP

o Tank Procedure



- Empty T 2 to CCT, pitching 65hL
- 10 hL into T1
- T2 CIP and SIP

Two Tank Procedure



- Filling of T2 with wort (e.q. 65 hL)
- Sterilisation of wort in T2
- Cooling of wort in T2
- Aeration of T2
- Pitching from T1

Repeated Fed Batch Method

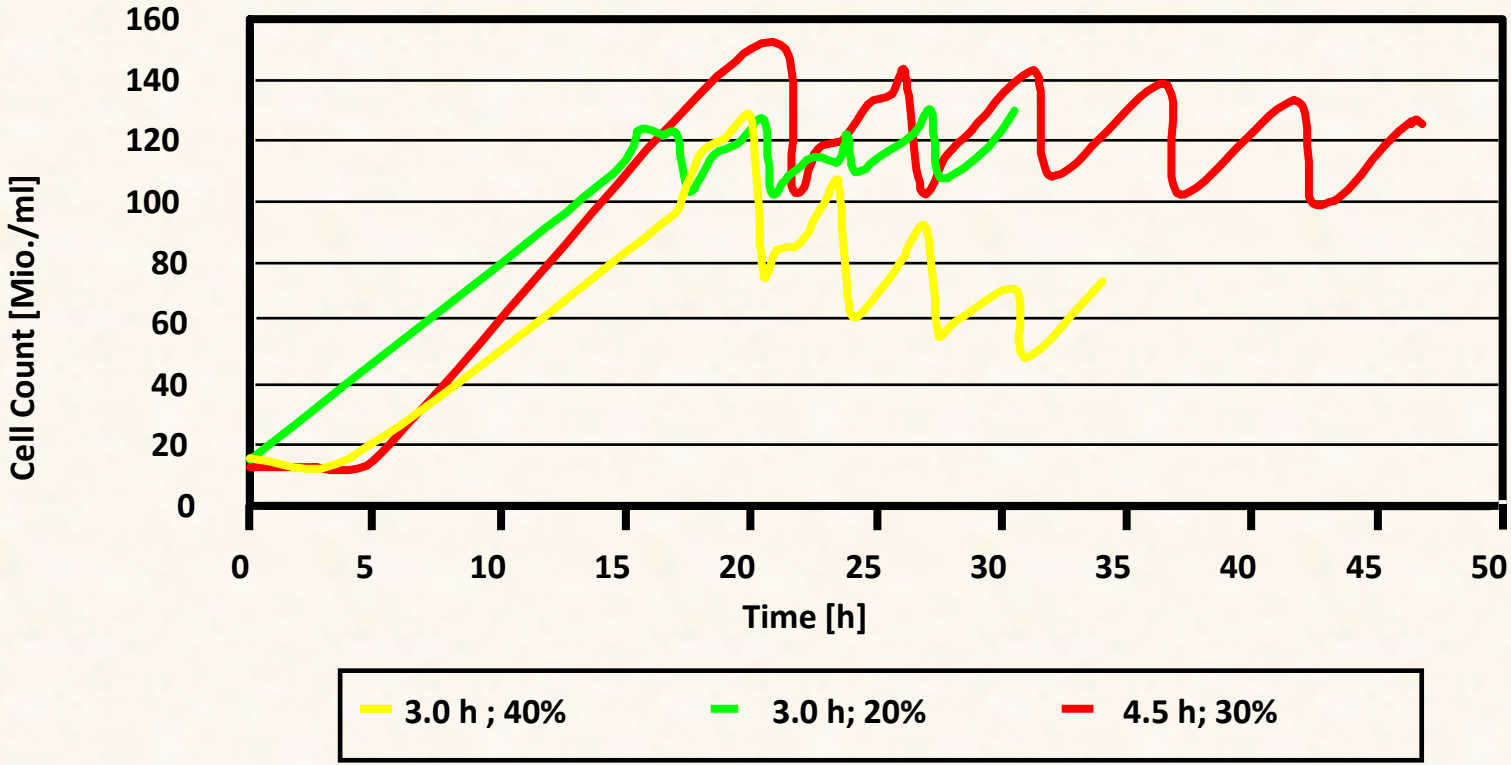
- periodical removal of the yeast and a refilling with wort

  ➔ shortens the lag-phase of the yeast growth
- temperature approx. 20 ° C
- constant oxygen concentration of 0,2 mg/l at high krausen stage
- stable operating state:

  ➔removal of 20% propagation wort over a period of 3 hours

  ➔removal of 40% propagation wort over a period of 4,5 hours
- Removal of 40% of the total propagation wort over a period of 3 hours is too much ➔ total yeast cell count decreases

Procedures: Repeated fed Batch



Source: Methner, VLB Dresdener Brauertag 2005

Influencing factors

VLB BERLIN

Influence of Oxygen

Oxygen to low:

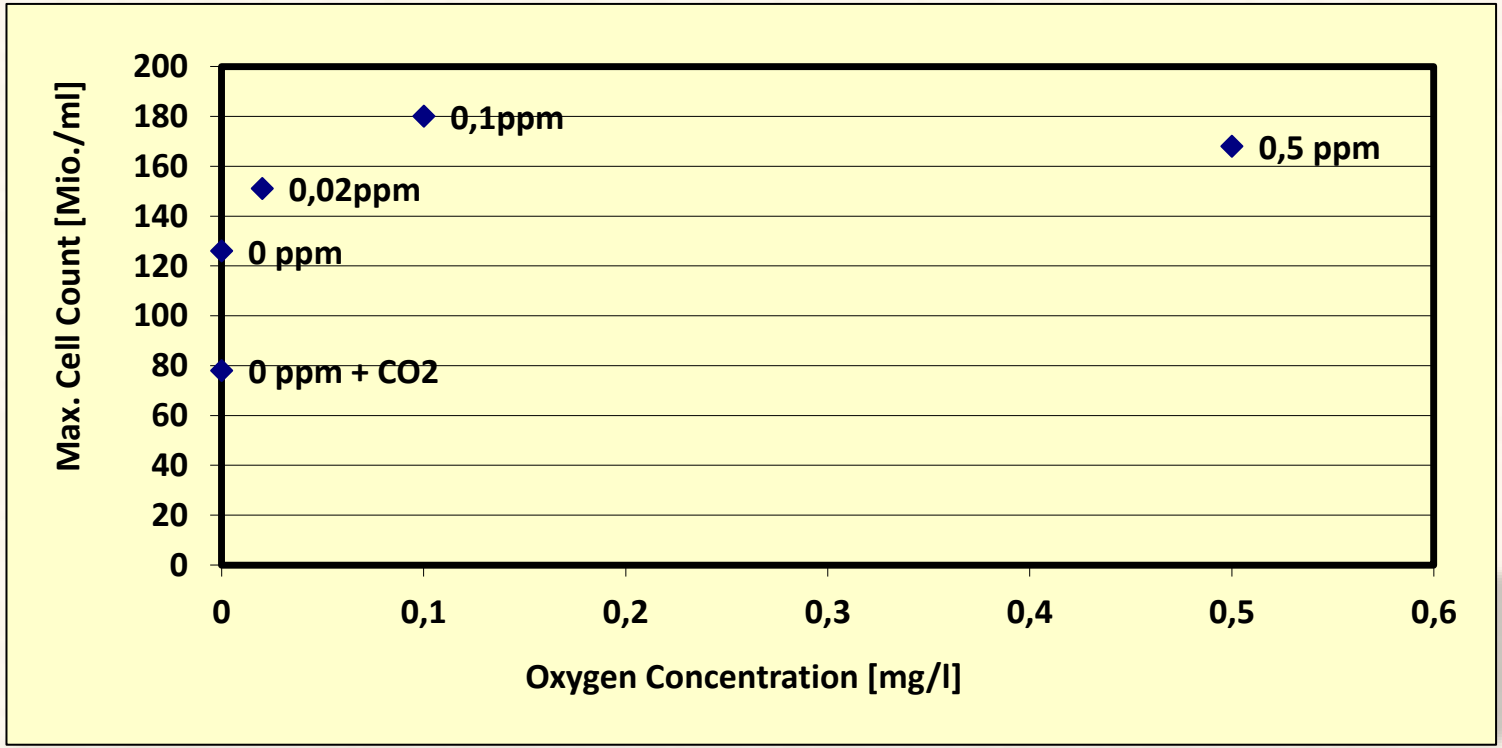
- limited aerobic growth
- low yield factors
- long doubling times
- foam problems

Oxygen to high:

- Cost-intensive (high energy demands)
- Foam formation in the propagation plant
- Damage of the foam positive substances
- Oxidative stress

→ sterile air with 21 % oxygen provides a much better yeast growth than 100 % pure oxygen

Propagation: Aeration



Source: Methner, VLB Dresdener Brauertag 2005

Propagation: Aeration Control

Air supply depends on:

+ Number of cells/biomass present in the propagator
+ Phase of propagation (log-phase or lag phase)
+ Specific oxygen transmission rate of the propagator (has to be determined in place by step response)

In praxis often found:

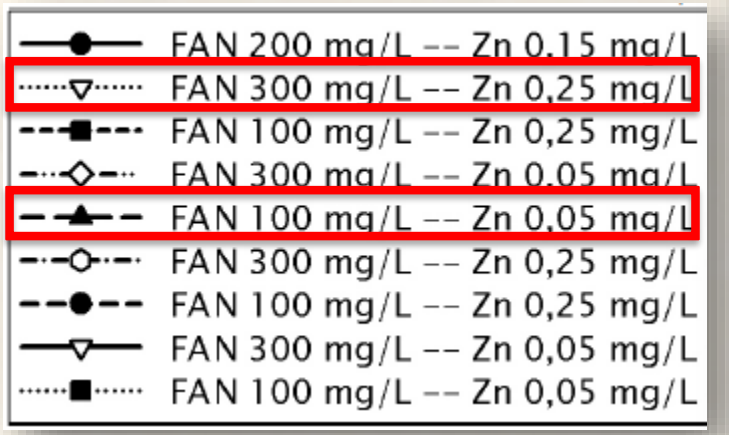
+ Aeration control by foam
+ Aeration control by oxygen content of exhaust gas
+ Aeration control by an experienced based program

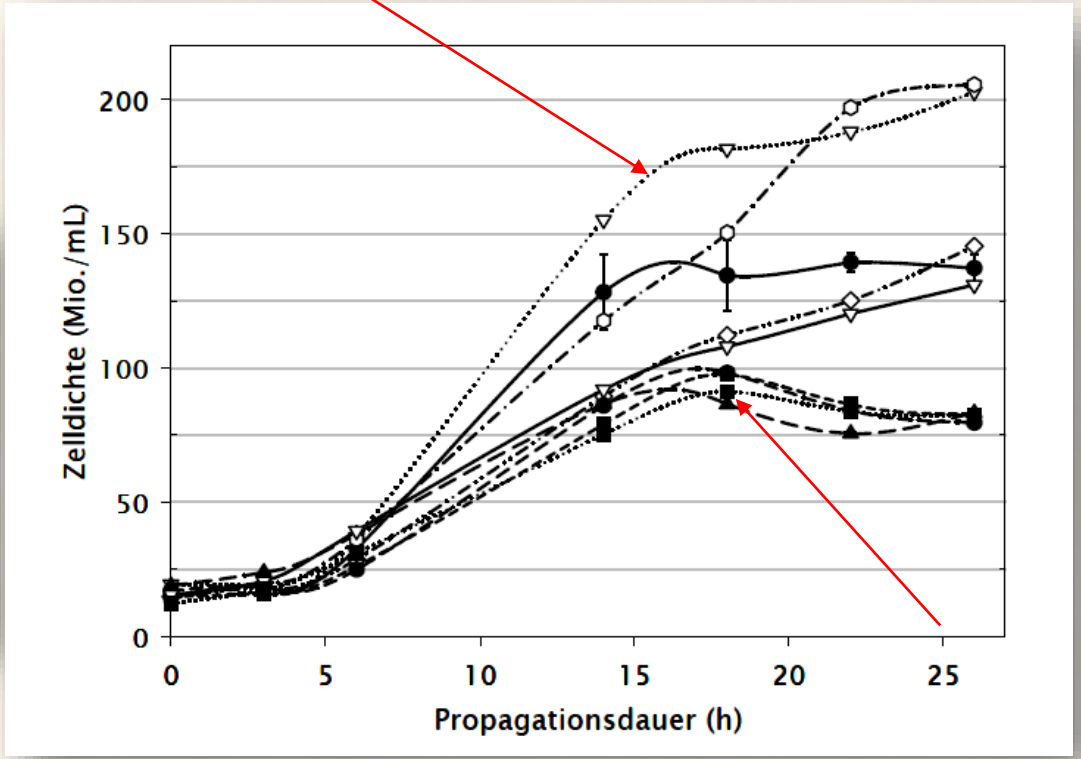
Relation between free Amino Acids and Yeast Growth

Free amino acids in pitching wort in mg/l	Yeast growth in million cells/ml
110	~ 30
130	~40
150	~55

- wort should contain around 200 mg/l FAN → 80 – 120 x 10^6 cells per ml
- free amino acid consumption from pitching wort to the final beer should be between 100-140 mg/l

FAN and Zinc

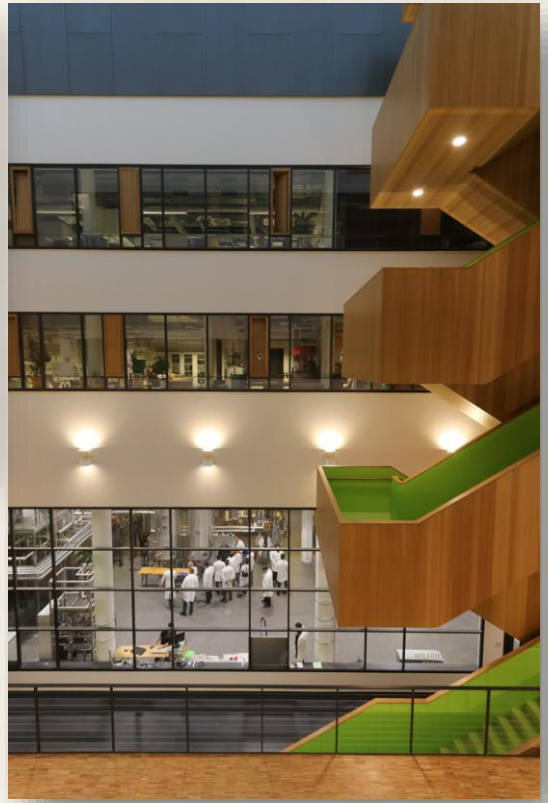




Source: Weigert C.: Erhöhung der Zelldichte während der Propagation von Bierhefe; Diss. Berlin 2010

Take Home Message

Thank you for your attention!



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(FIBGP)