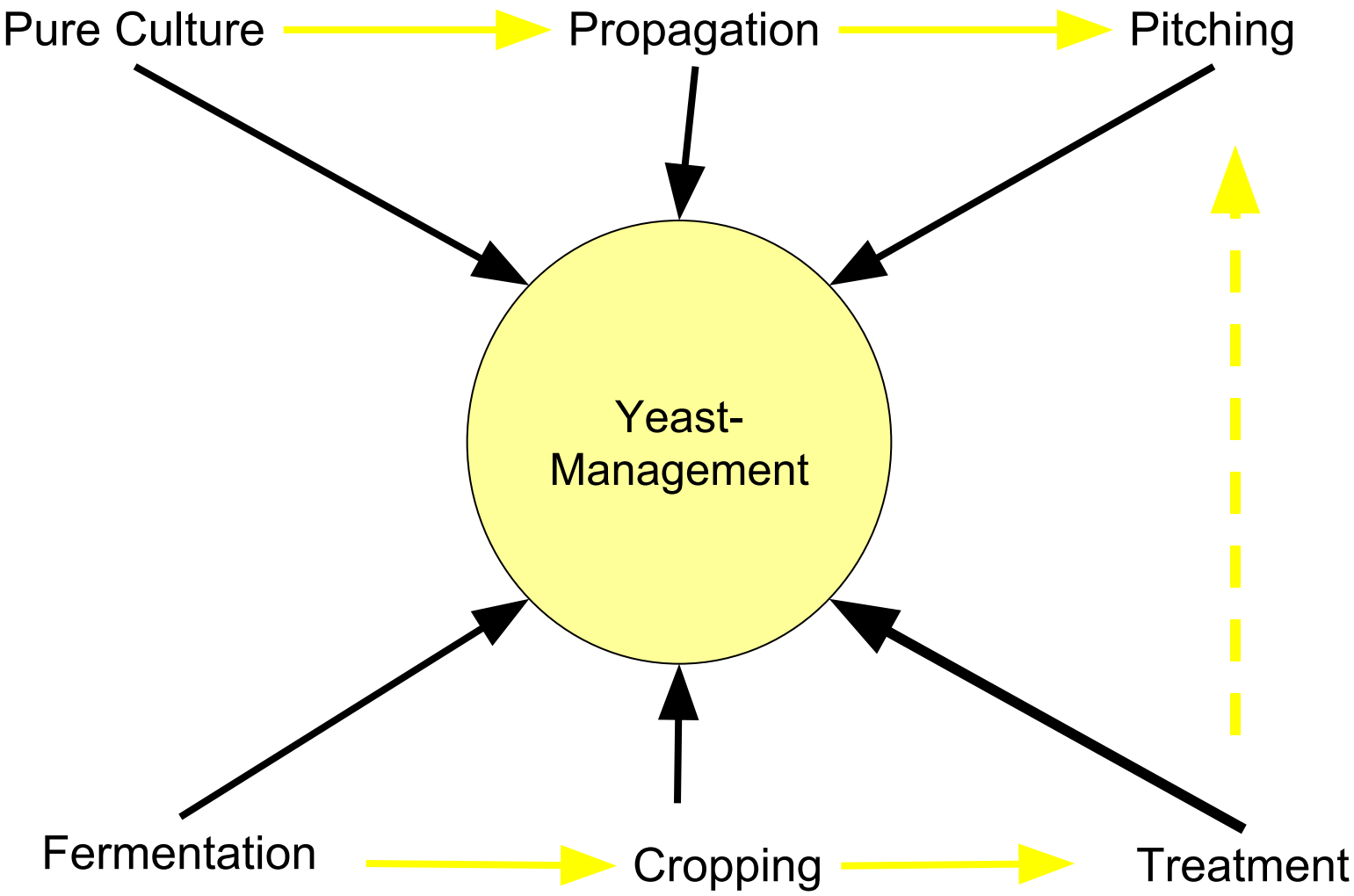
Efficient Yeast Management

Why is „good“ yeast management necessary?

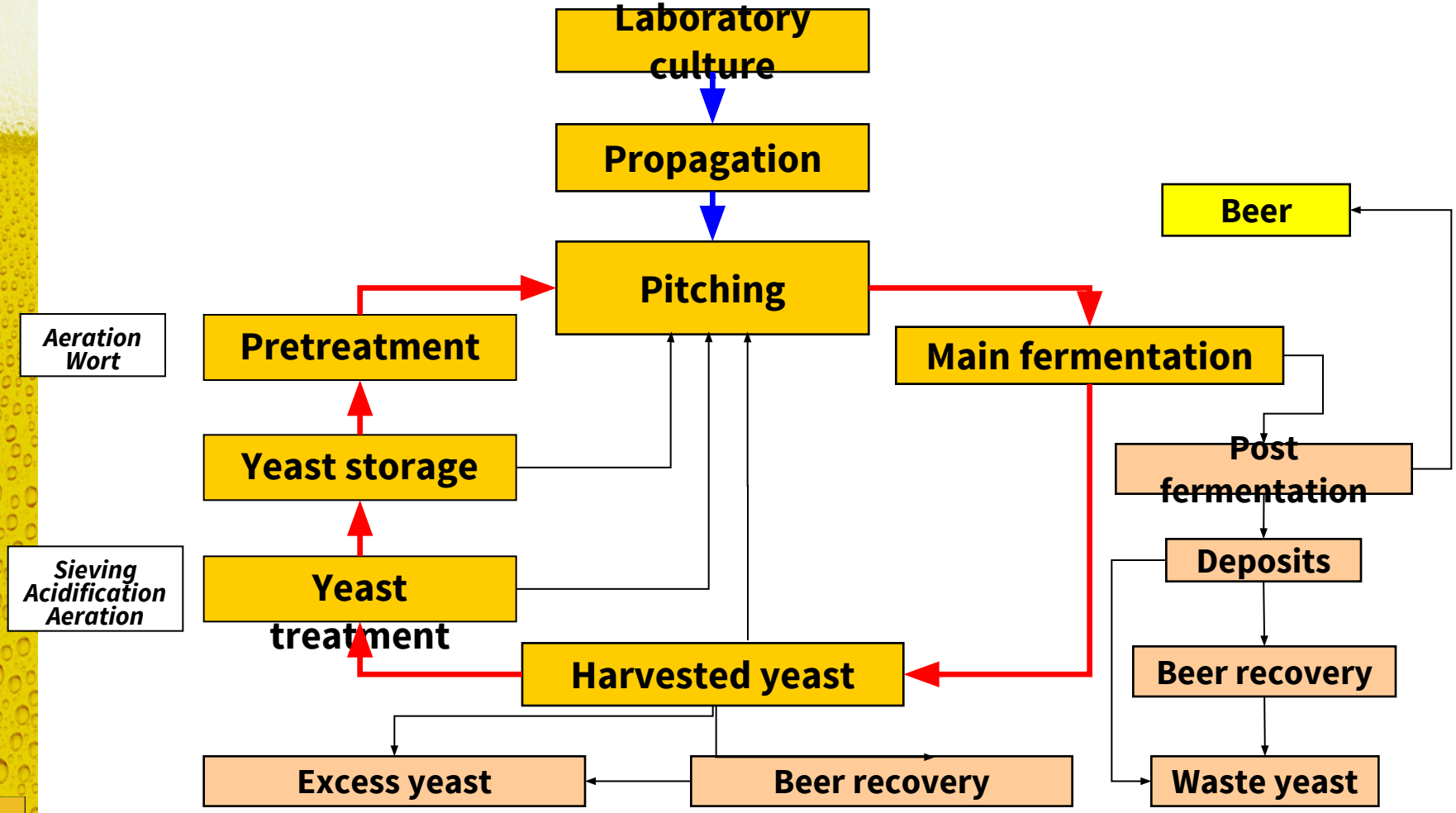
What are the possible consequences of “bad” yeast management?

- Decrease in fermentation speed → capacity problems
- Differences in the final attenuation degree determined in the lab and the attenuation degree of the final product → economics, product “safety”
- Longer maturation times → diacetyl reduction
- Slow pH drop → contamination, non-biological stability, filtrability
- Beer aroma profile changes → concentration ratio of HA to esters changes in favour of HA
- Foam stability decreases
- Turbidity problems → “invisible haze” caused by Glycogen excretion
- “Autolysis taste” → excretion of e.g. fatty acids
- Less formation of reductones → bad flavour stability

Yeast Management



Ways of Yeast in a Brewery

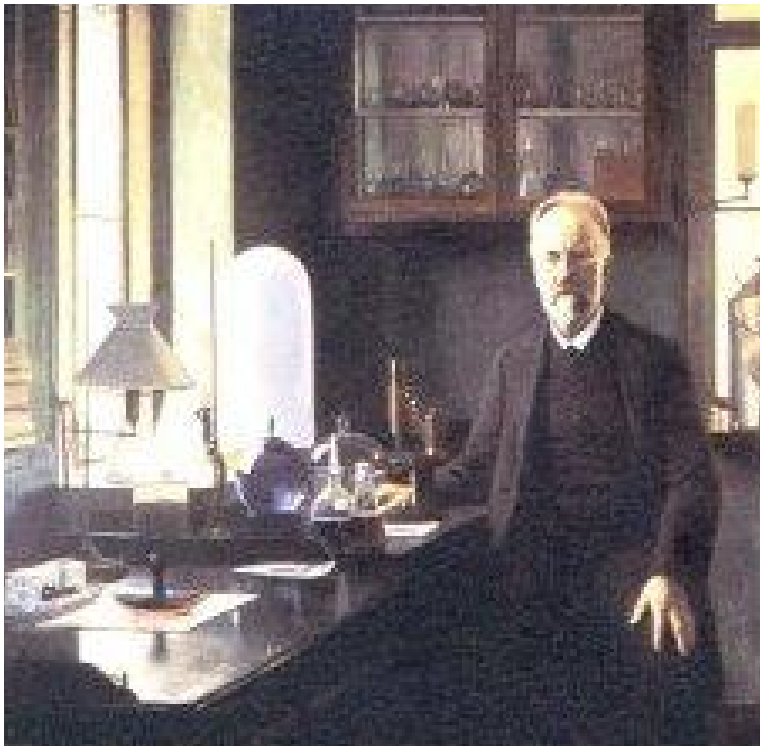


YEAST PROPAGATION
PRINCIPLES of HANSEN'S propagation

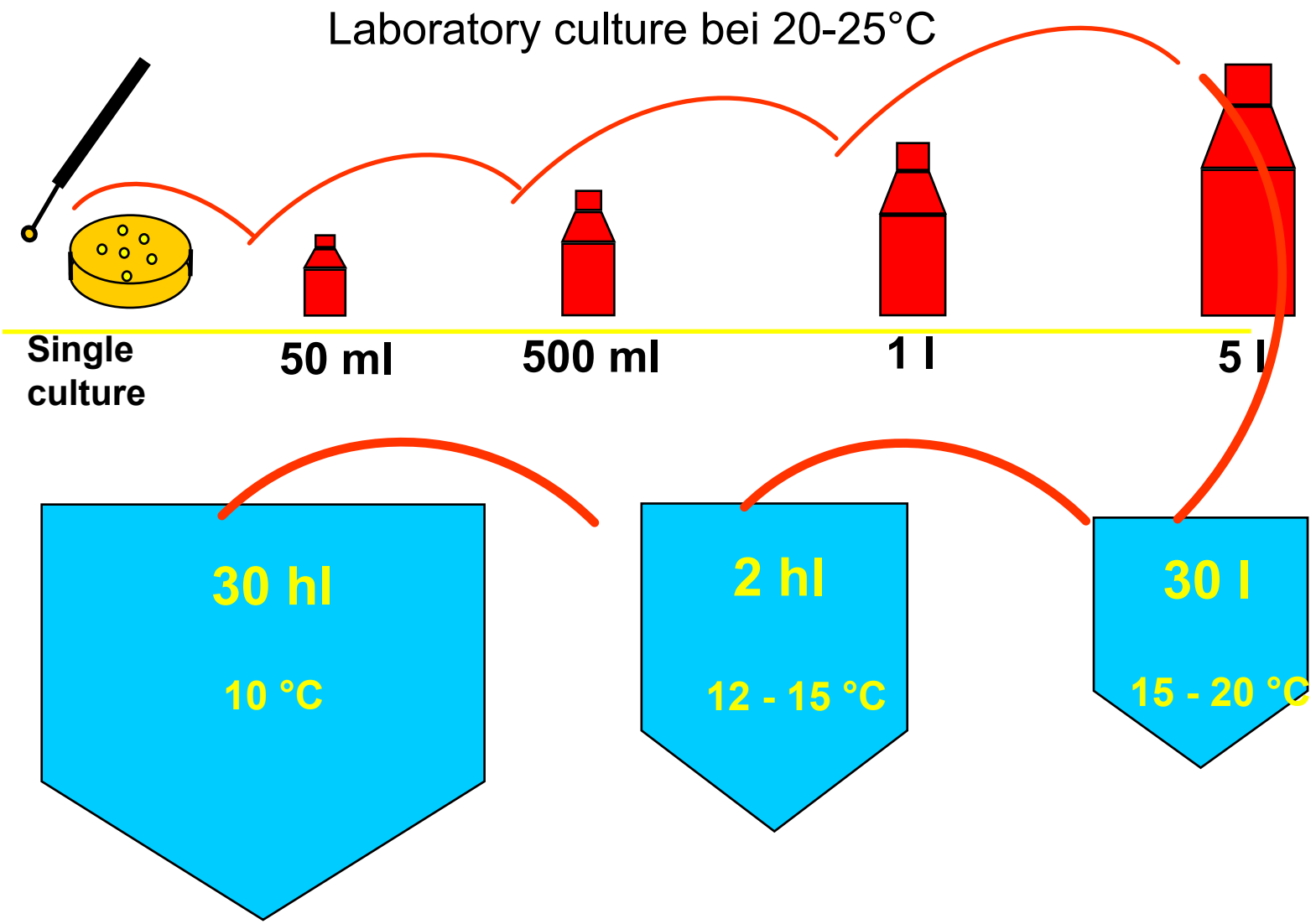
1883 Emil Christian Hansen from Denmark first managed it to propagate yeast cultures. He isolated a single yeast cell and multiplied it step by step.

This way of propagation was improved until today and it is possible now to propagate special culture yeasts with special properties for the demands of each brewery. Today nearly every bigger brewery propagates their yeast on in their own laboratories and propagation plants.

➔ guaranties continuous quality of the beer



Conventional propagation



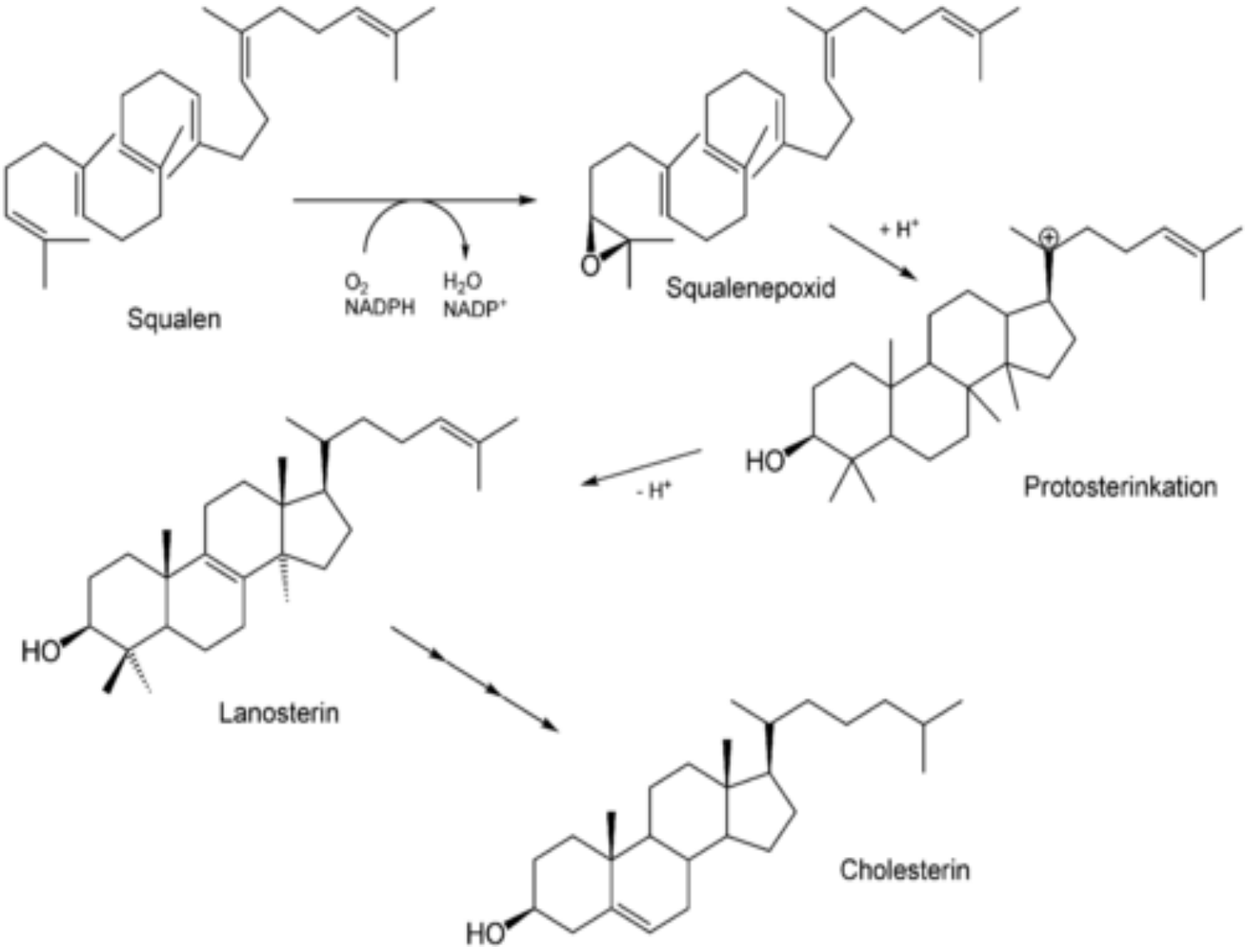
Yeast Propagation Rules

- *Scale-up:* Successive steps of cultivation and scale-up by transferring the yeast suspension into a larger bioreactor / propagation system.
- *Transfer:* 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.
- *Hygiene:* An ideal case is to have a hermetically closed cooling- and propagation system which is fed with sterile wort and sterile filtered air. The system must enable working under sterile conditions.
- *Temperature:* The yeast should be adapted slowly to pitching temperature during propagation.

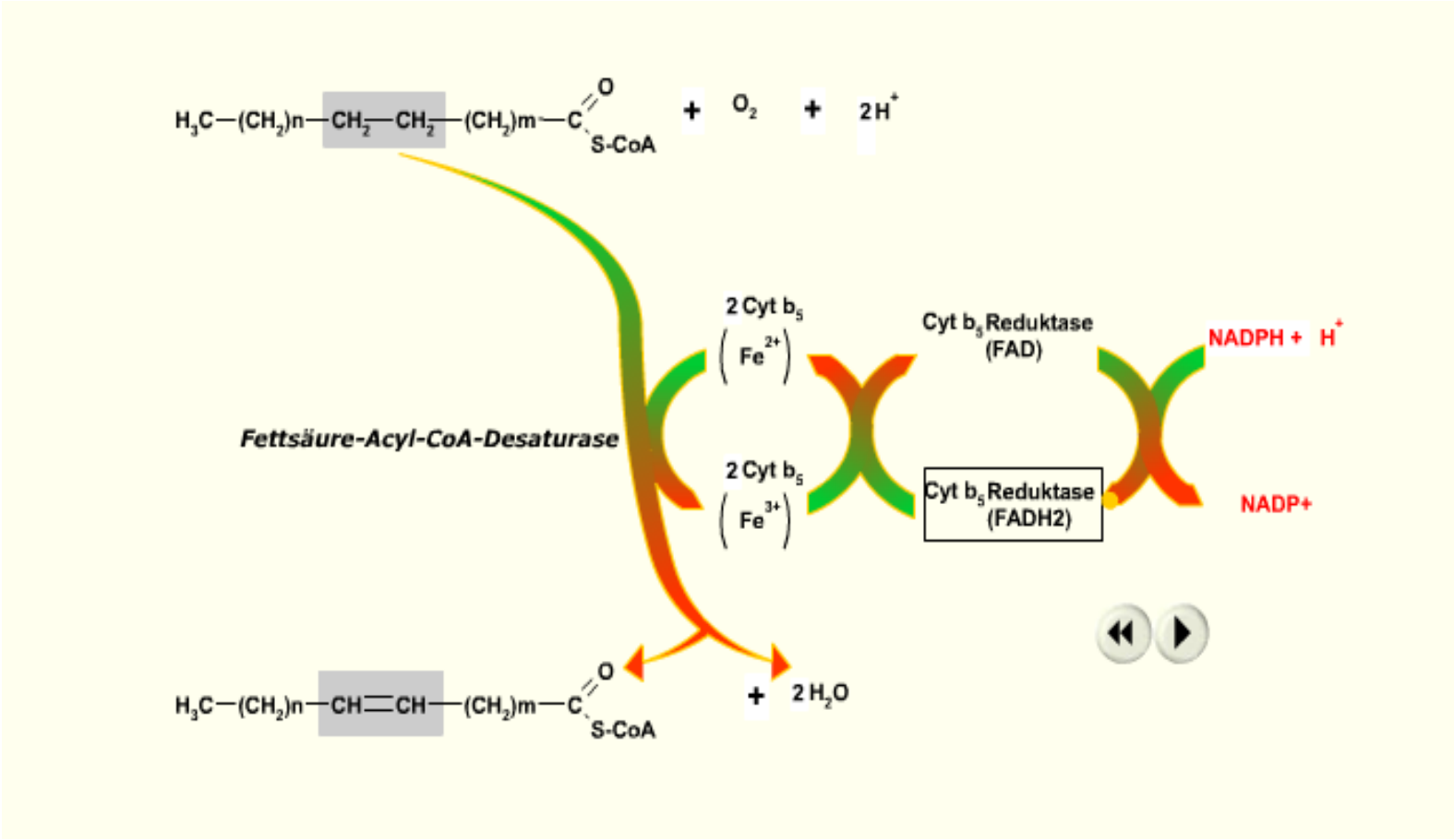
Factors influencing Cell Count during Propagation

- Initial cell count at innoculation
- Temperature
- Pressure
- Dissolved oxygen content and its distribution
- Sugar concentration (Crabtree-effect)
- Nitrogen content of medium (free amino acids)
- Type of yeast strain
- Concentration of minerals and trace elements providing good yeast viability
- Lipids (unsaturated fatty acids)
- Sterols

Influence of Oxygen - Sterols



Influence of Oxygen - Unsaturated Fatty Acids

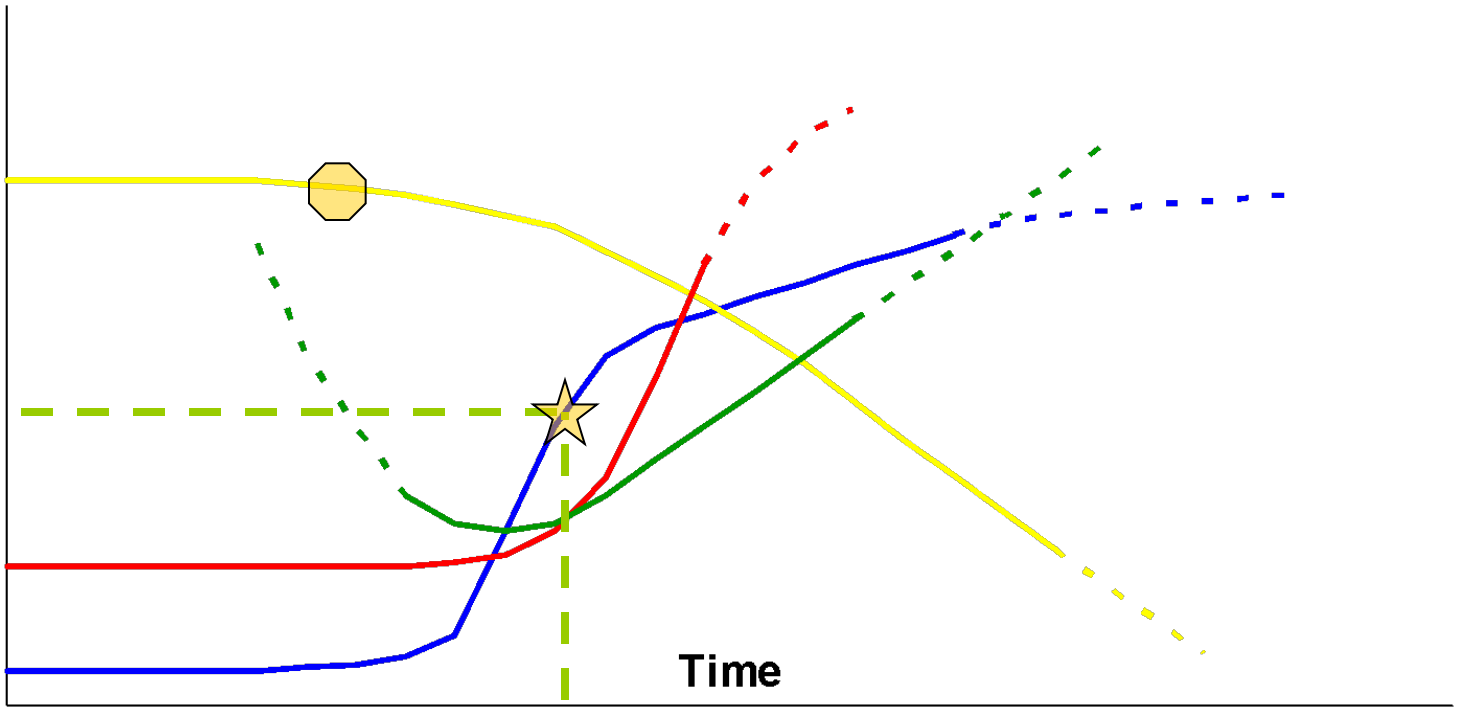


Source: Chemgapedia

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

Important parameters in propagation



- Cell count
- OG
- Gas flow
- Doubling time of yeast cells
- Point in time where OG reduction is parallel to to yeast yield factor
- Point of optimal cell count

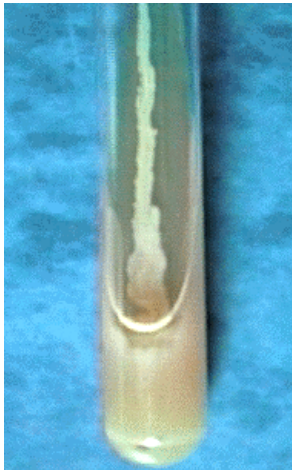
Source: Nielsen

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

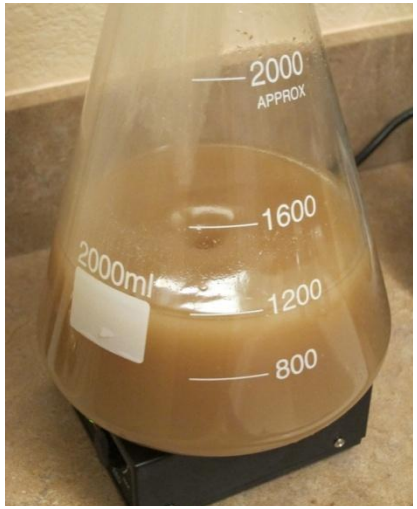
Steps of Propagation - Laboratory



Slanted agar

Agar plate

Inoculating loop



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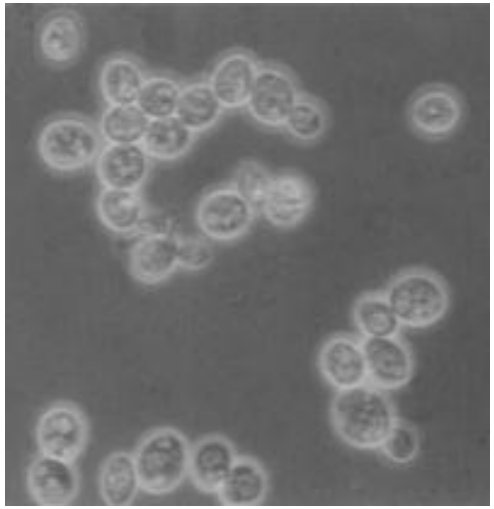
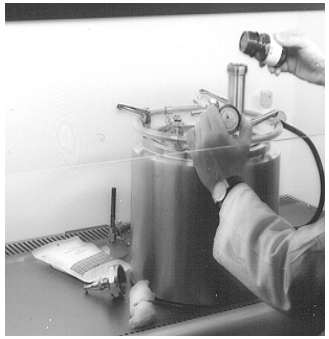


Living yeast cells

Propagation

Wort sterilisation

Wort aeration



Pitching

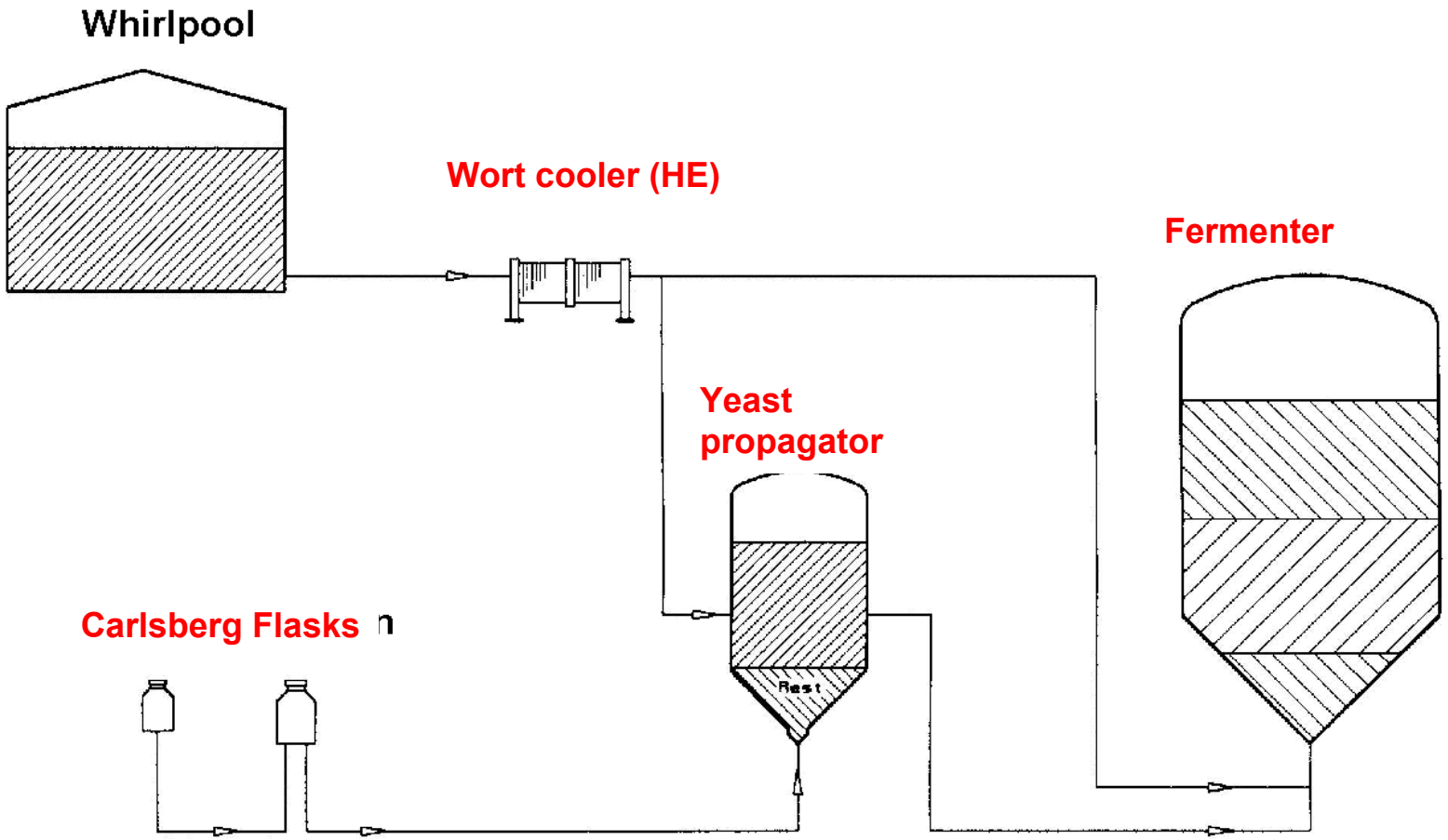
Fermentation

Transfer to yeast propagation vessel

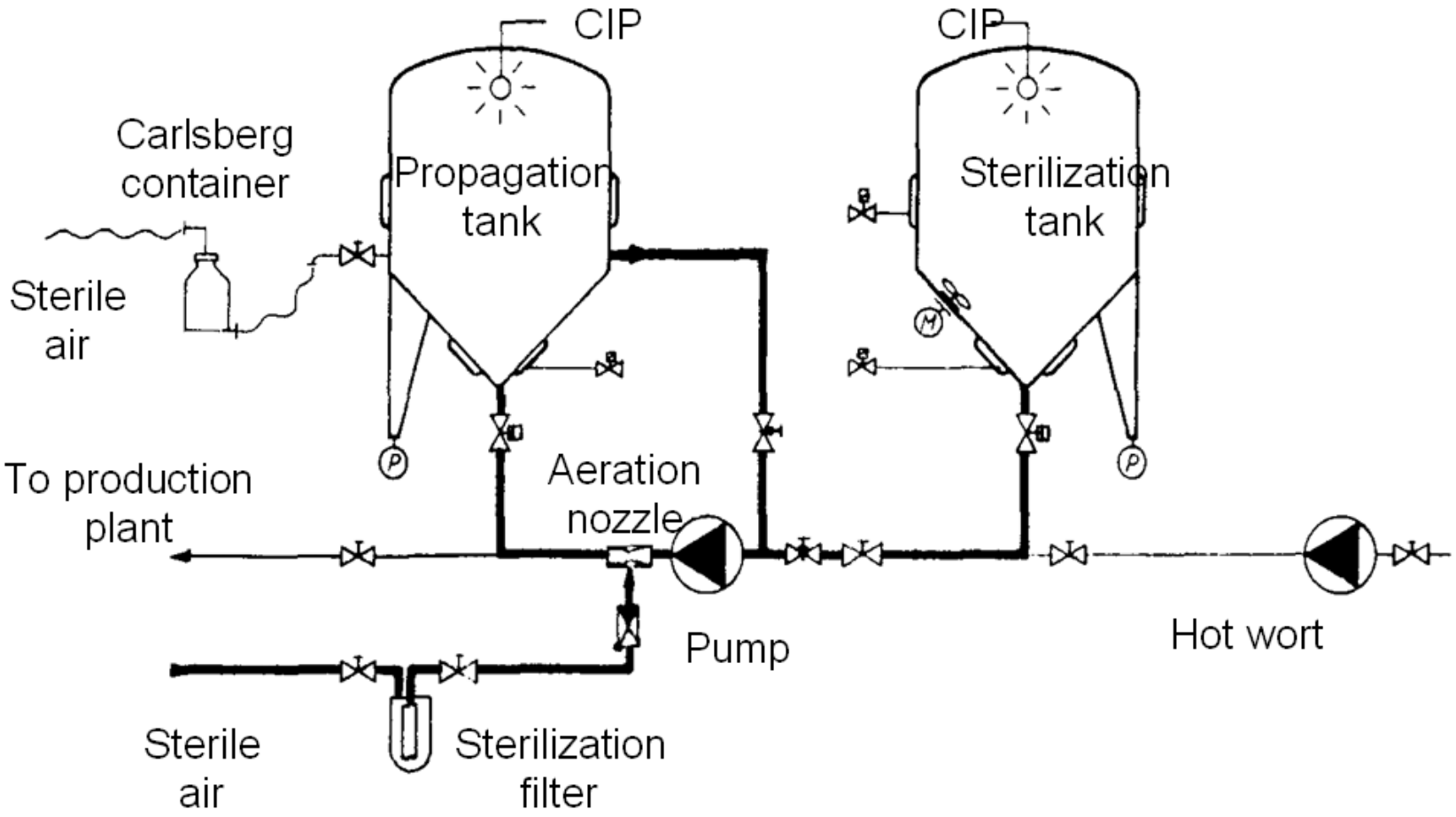
Conventional Yeast Propagation

Area of application	Procedure	Temperature [°C]	Days
Laboratory	From test tube in 2 X 10 ml bottles	25	2
	200 ml		4
	1000 ml		6
	14 l	18	8
Yeast propagation plant	10 hl	16	10
	50 hl	14	12
	250 hl	12	14
Fermentation tank	1250 hl	10 - 12	16

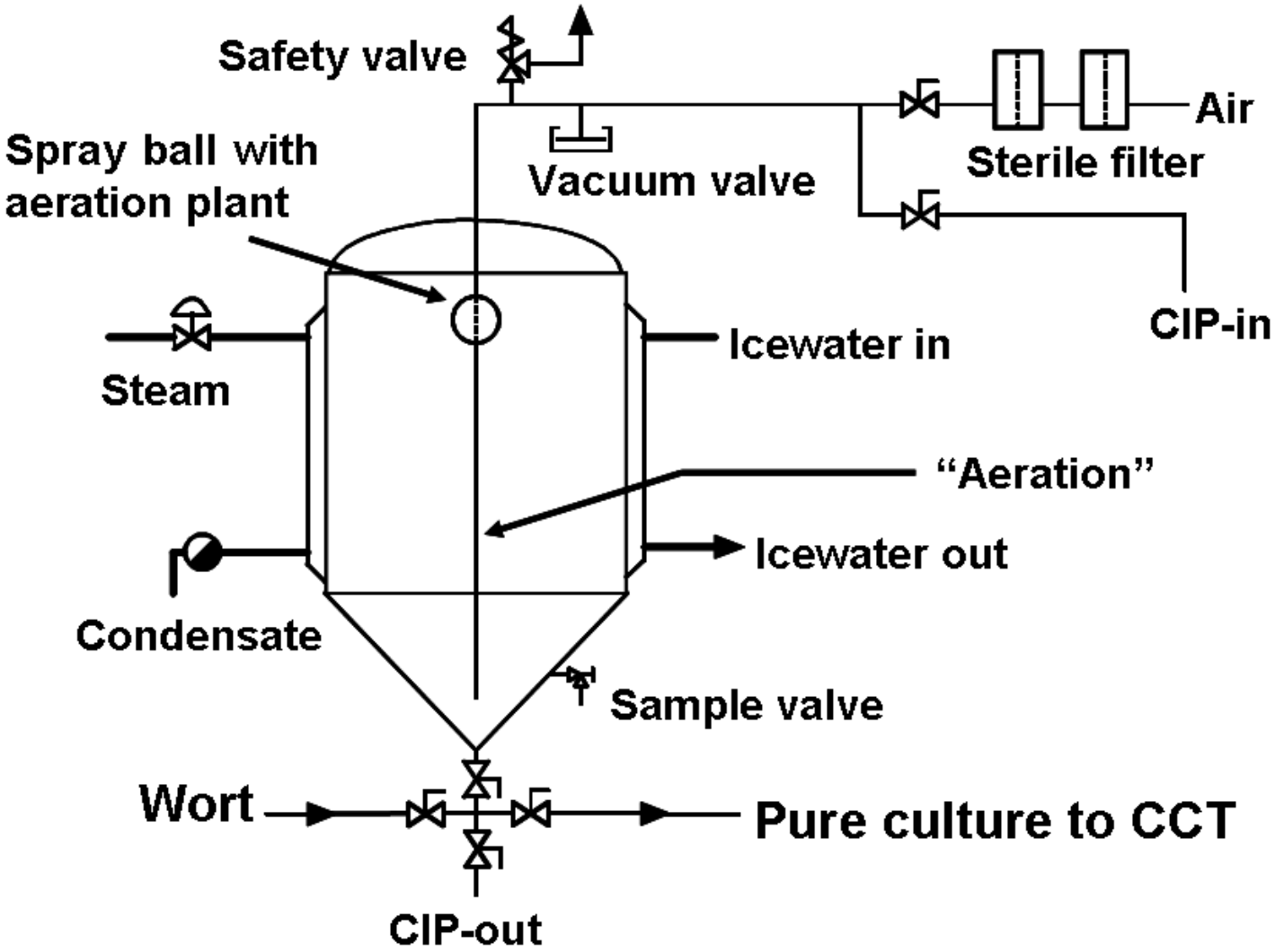
Simple 1-Tank Process



One Tank Propagation-Plant with Wort Sterilization Unit



Procedures: Single Tank Propagation



Source: Wackerbauer, Evers, Kunerth Brauwelt 136,1996

Procedures: Single Tank Propagation

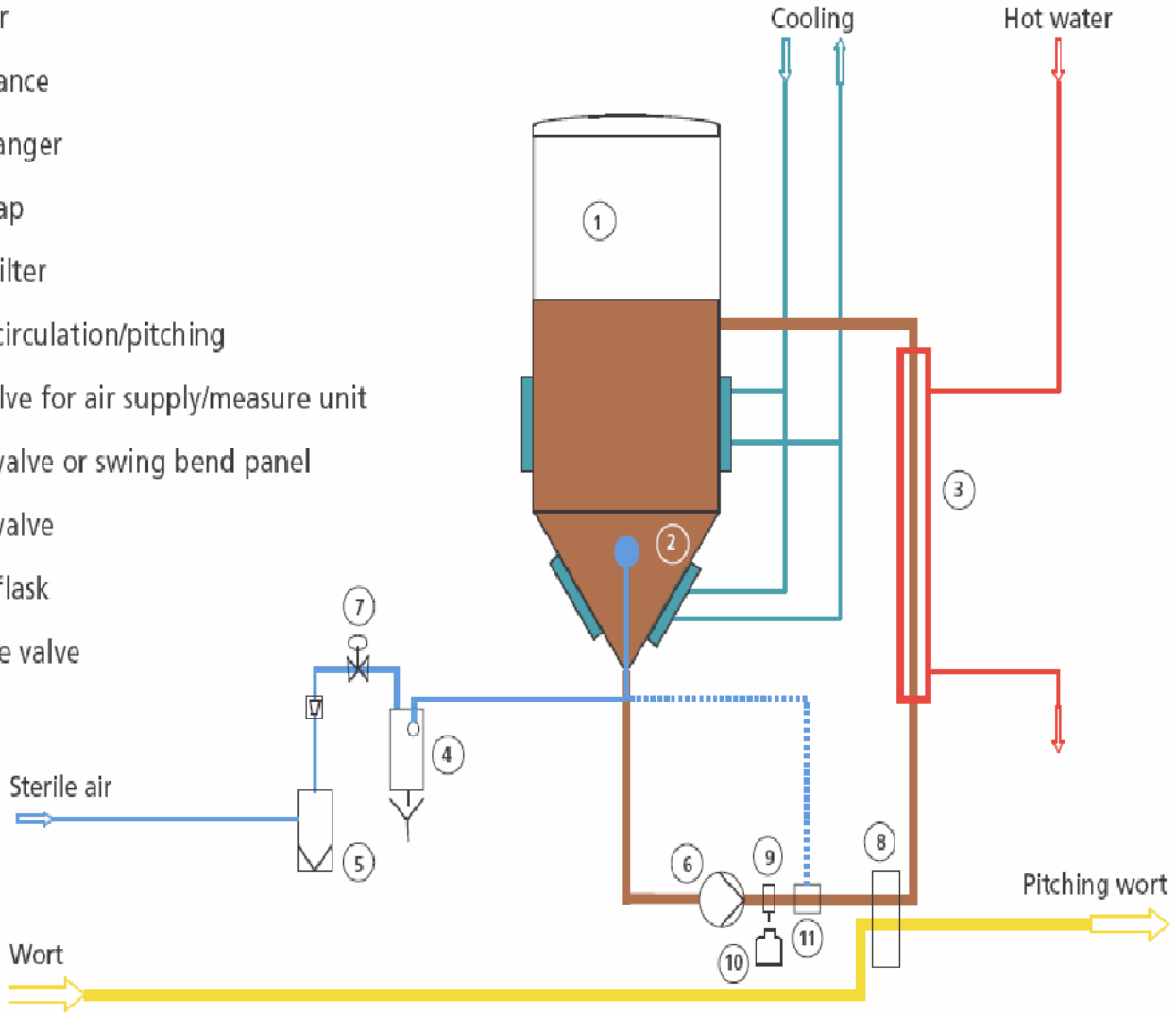
Advantages compared to conventional propagation:

- (Fast yeast growth due to continuous aeration)
- Small risk of contamination (no transfer of the wort to the fermenter)
- No risk of degeneration of the yeast
- Simple
- Cheap
- Less labour

Source: Wackerbauer, Evers, Kunerth Brauwelt 136,1996

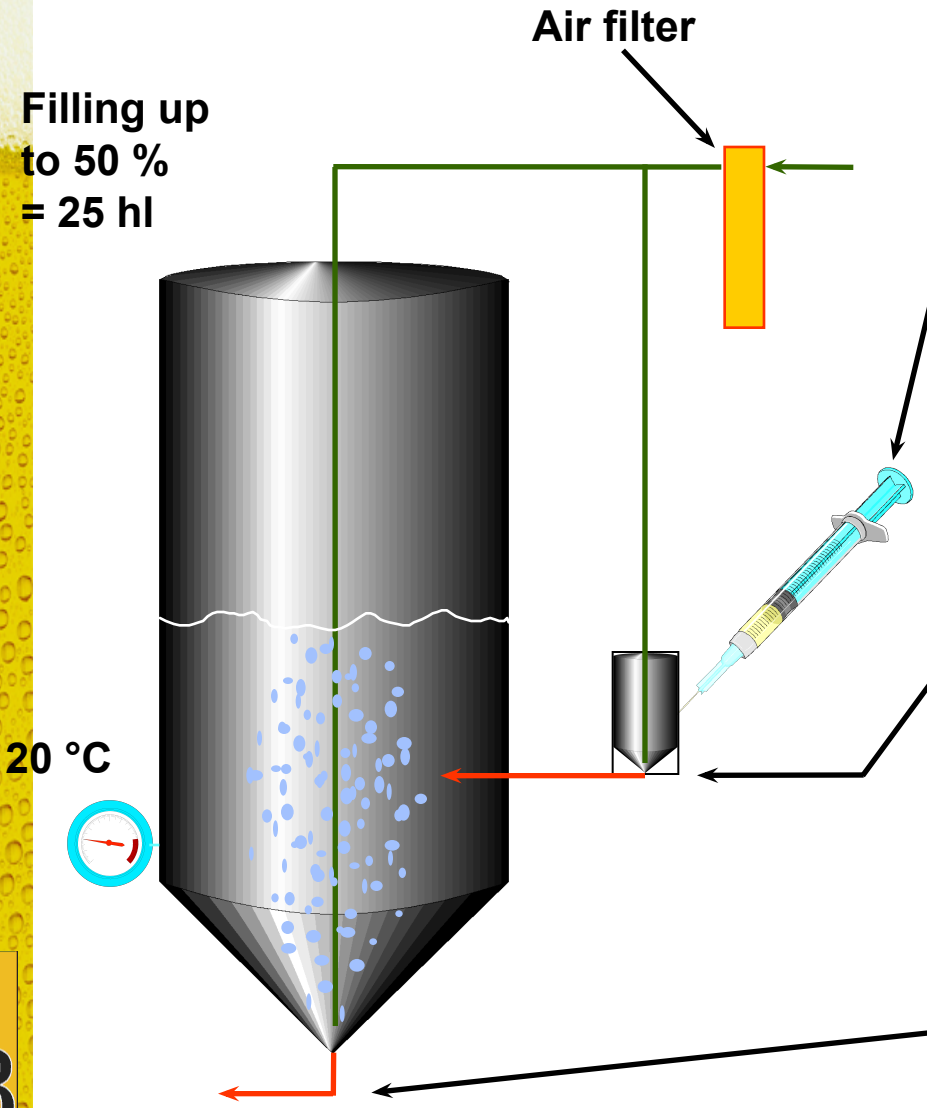
Procedures: Single Tank Propagation

1 Propagator
2 Aeration lance
3 Heat Exchanger
4 Product trap
5 Sterile airfilter
6 Pump for circulation/pitching
7 Control valve for air supply/measure unit
8 Mixproof valve or swing bend panel
9 Sampling valve
10 Carlsberg flask
11 CIP Impulse valve



Source: GEA

Procedures: Single Tank Propagation



Laboratory:

Adding 50 ml culture
in a ten liter Carlsberg flask
Ratio 1 : 200

Interval aeration for 24 h at 20°C

Plant:

From the Carlsberg flask at high Kräusen in a 25 hl propagator
Ratio 1 : 250 to 1 : 300

Interval aeration for 36 - 48 h at 20°C

Pitching:

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

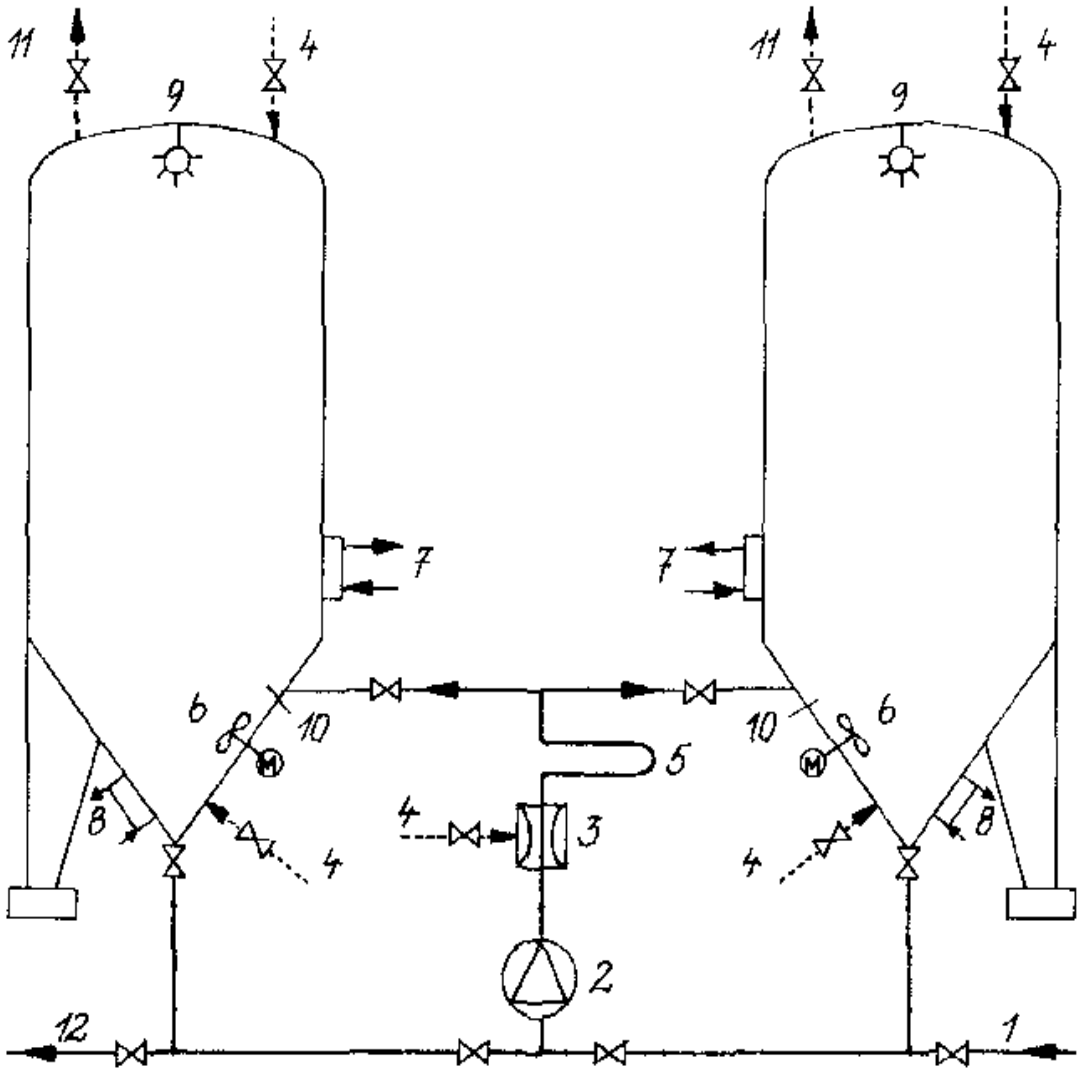
Source: Wackerbauer, Evers, Kunerth Brauwelt 136,1996

Two Tank Procedure (Assimilation Procedure)

- Two propagators → 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%)
- 15-20% remain in prop. tank→ topped with wort
- Plant equipment:
    - Agitator
    - Heating/ cooling jacket
    - Measurement equipment: Oxygen, temperature, pressure, pH
- Aeration while pumping through system
- Temp: 8-14°C

Procedures: Repeated fed Batch

1. Wort inlet
2. Frequency regulated pump
3. Venturi tube
4. Sterile air
5. Air solution stage
6. Agitator
7. Cooling
8. Heating
9. CIP
10. Measuring line for O_2, pH, extract
11. CO_2
12. Yeast



Yeast Cropping

Necessity of cropping:

- Yeast settles to the bottom of the tank
  - Although the metabolism has slowed down the cells are still alive
  - Cannot be cooled (bad heat conductivity) → heat development → higher metabolic activity!
- Stress conditions must be avoided
  - may lead to an excretion of substances or even cell lysis which has a negative influence on beer quality (pH, foam, turbidity, flavour, etc.)

Technological conclusion:

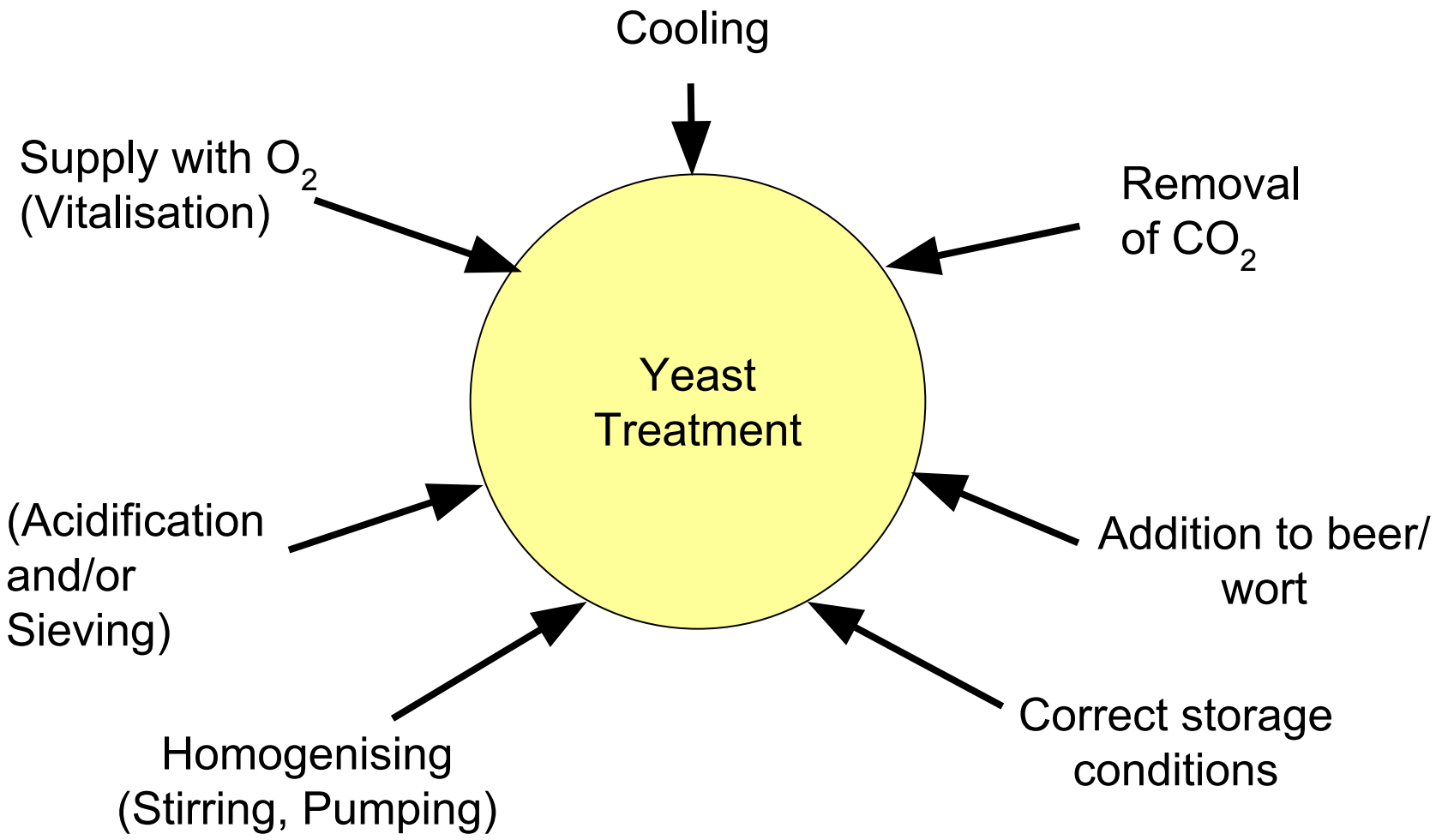
- Cropping should be carried out as soon as possible!
- Directly after the main fermentation!

Pitching yeast

Requirements	**Guide value**
derived from pure culture	1-5 generations
high vitality	e.g.: depletion of (at least) 1% fermentable extract within 24 hours after pitching
free of contamination	no beer spoilage bacteria, no wild yeasts
high viability	dead cell concentration: ≤ 5%

According to Prof. G. Annemüller

Yeast Treatment



Yeast Treatment before Storage

- Cooling
  - To reduce the metabolic activity the yeast must be cooled if it is not used directly for re-pitching
  - ≤ 5°C

- Removal of CO_2
  - CO_2 is a cell toxin
  - this is even more important, if yeast is cropped from CCV

- Yeast should not be stored for more than approx. 48 hours

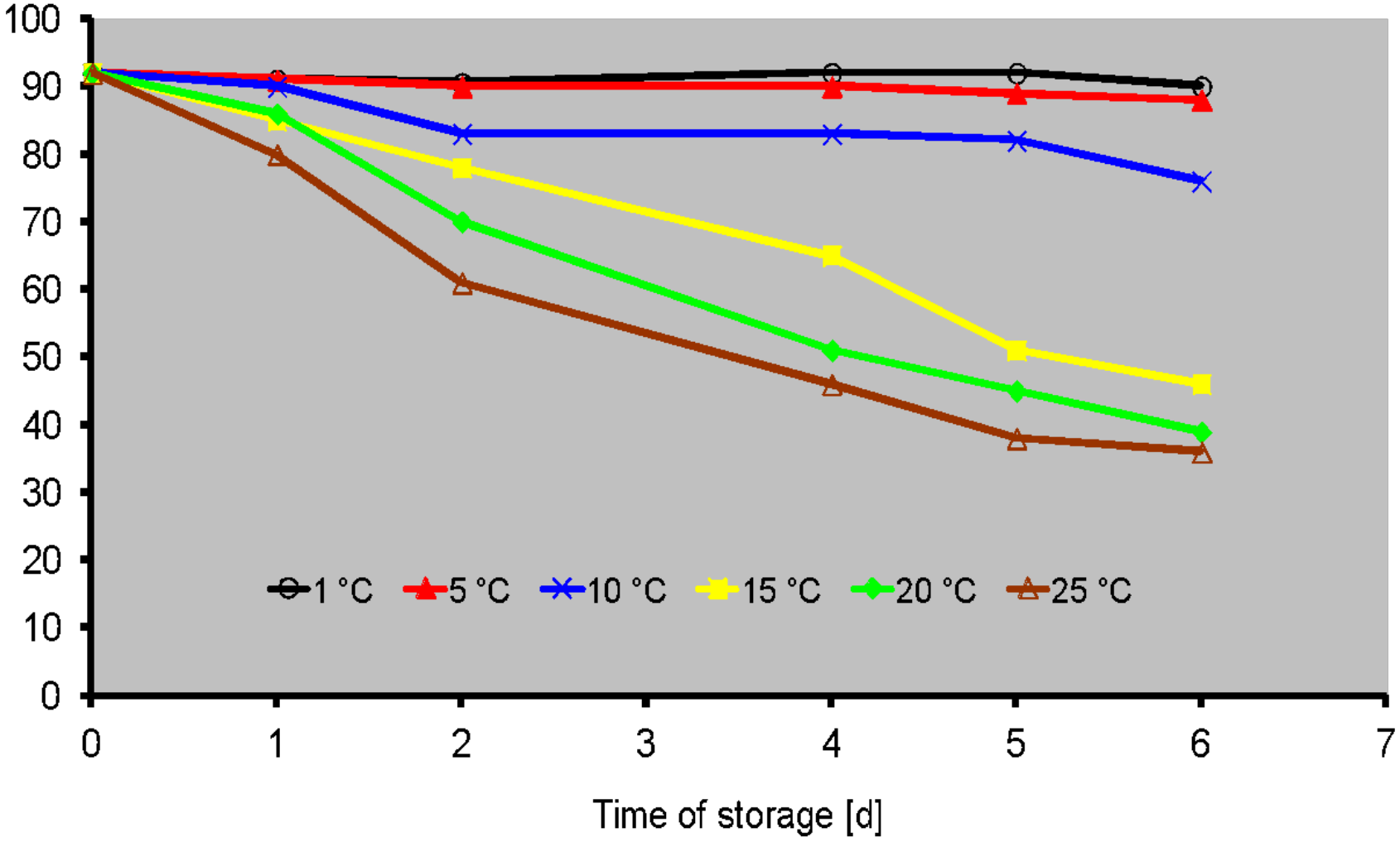
Yeast Storage

- Yeast uses slight amounts of sugars for keeping up its vitality during storage:

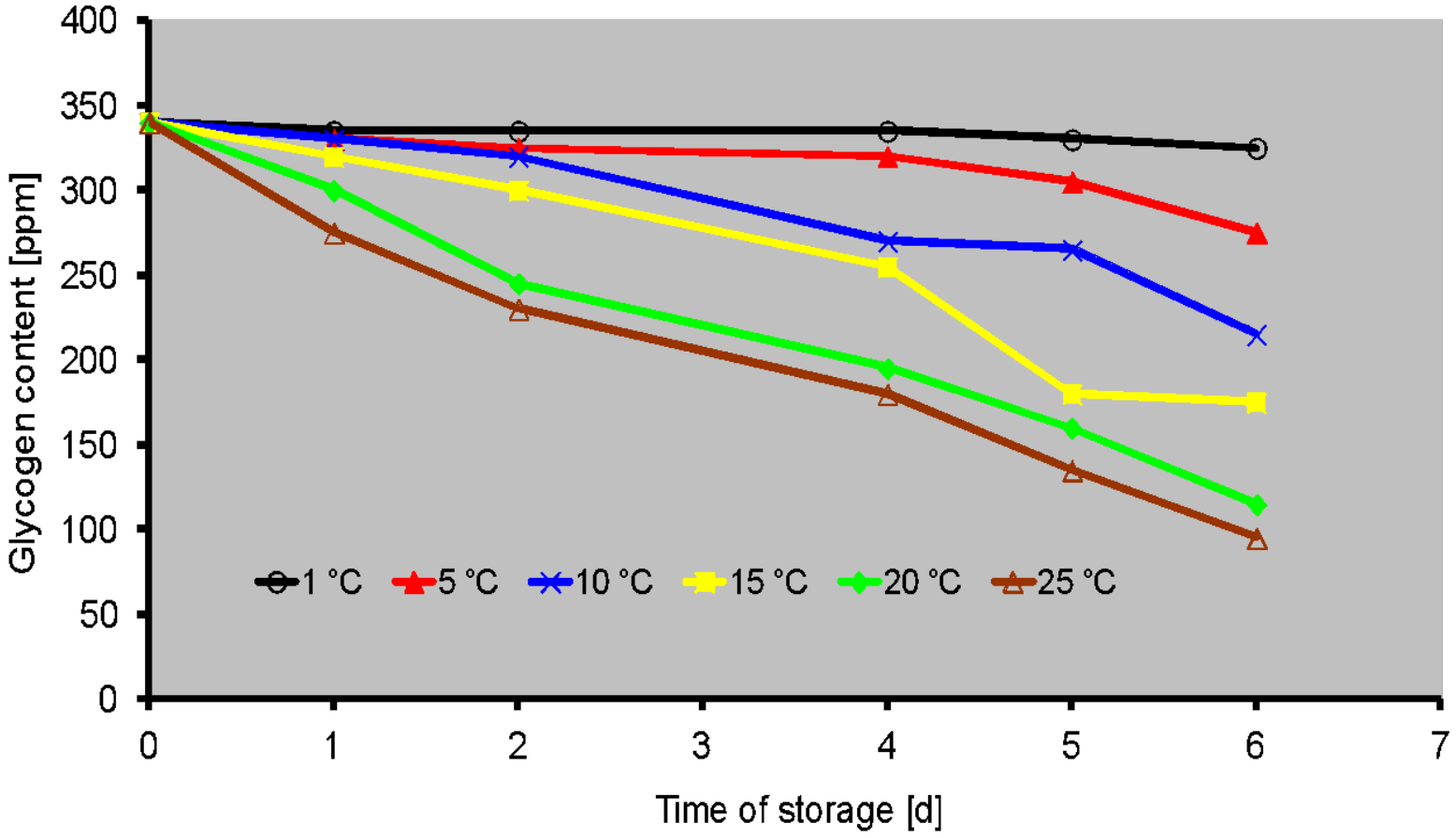
  0.2 % extract/d

- As soon as no more fermentable sugars are available yeast use their storage carbohydrates (glycogen) for survival.
- The longer yeast is stored, the more important are cool storage temperatures.
- The re-addition to wort can lead to a loss of certain substances (shock-excretion) resulting in:
  - Prolongation of the lag-phase
  - Decrease of the fermentation rate

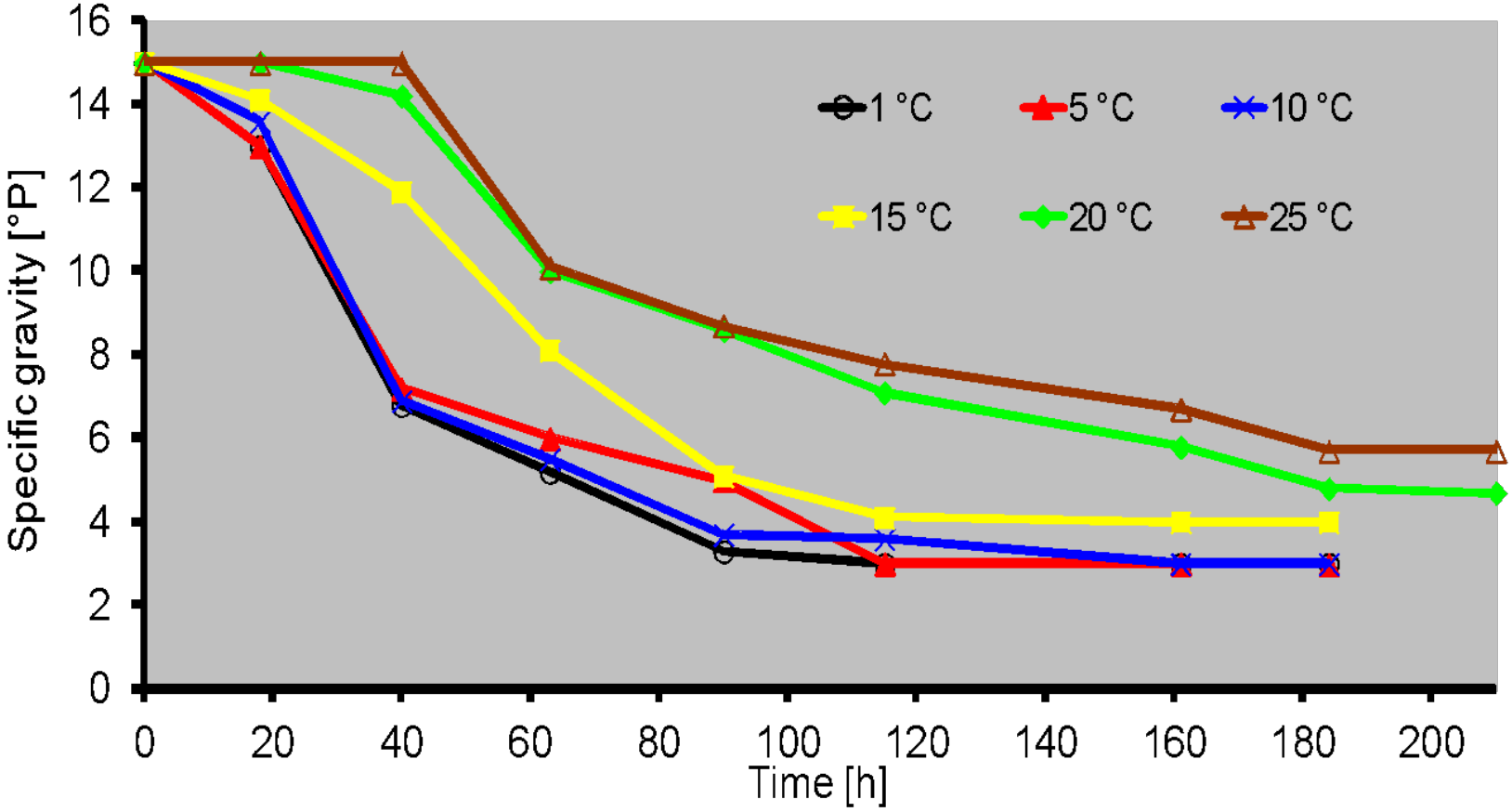
VIABILITY YEASTS STORED AT DIFFERENT TEMPERATURES



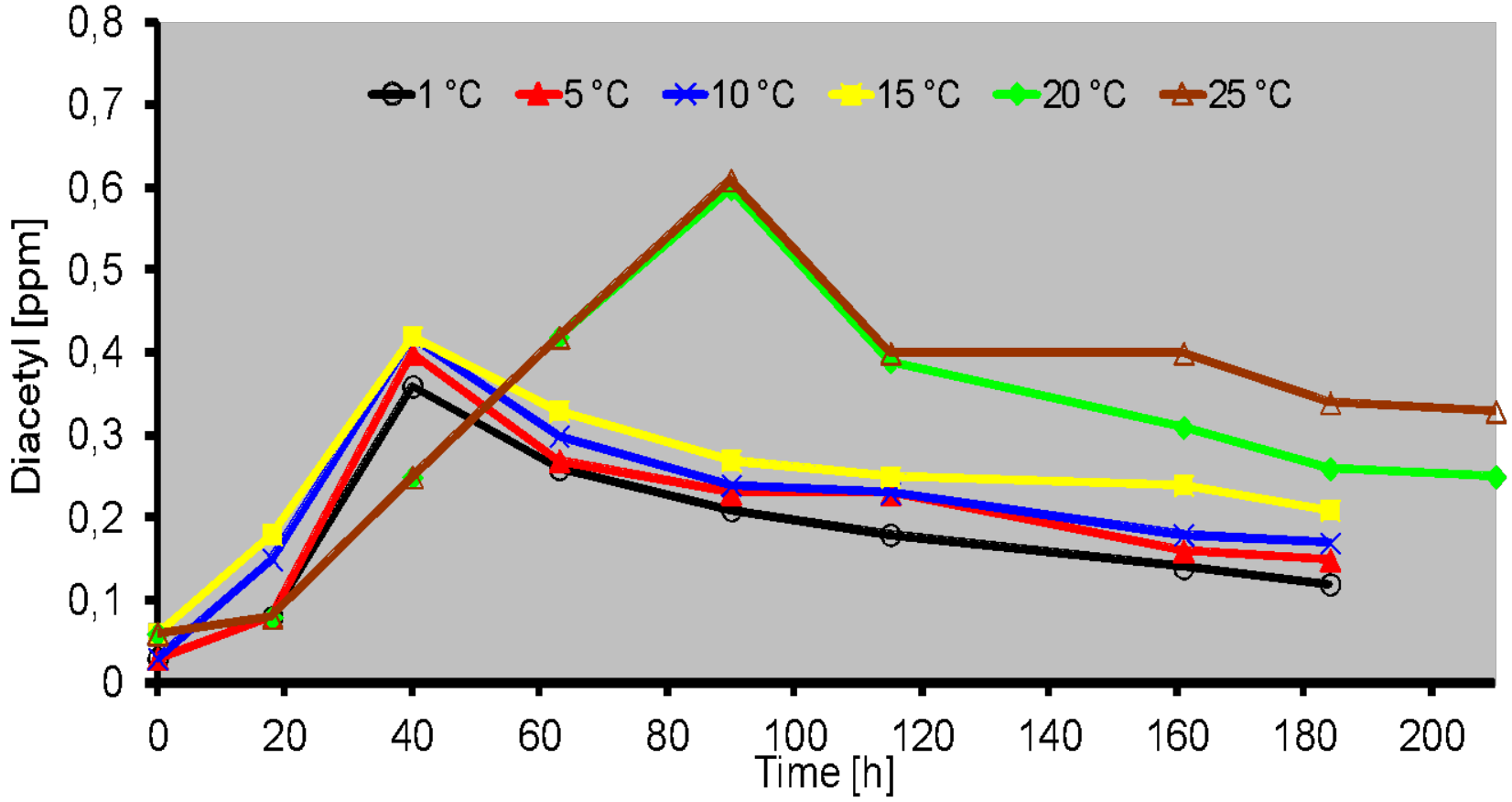
GLYCOGEN CONTENT OF YEASTS STORED AT DIFFERENT TEMPERATURES



FERMENTATIONS WITH YEASTS STORED AT DIFFERENT TEMPERATURES



DIACETYL IN FERMENTATIONS PITCHED WITH YEASTS STORED DIFFERENT TEMPERATURES



Disadvantageous Possibilities of Yeast Treatment

- Stirring
  - Better homogenization of the yeast
  - Biological risk
- Washing with water
  - Yeast releases stored-up components
- Sieving
  - Distribution of the flocculated yeast
  - Risk of contamination
  - Sometimes apparent improvement of fermentation velocity through aeration
- Acidification

Yeast acidification - Theory

- Yeast is able to keep its intercellular pH at a constant level, even at a pH of 2 → “Proton Pump” in cell membrane
- Bacteria do not have the ability to survive in an acidic environment
- No effect on contaminations with other yeasts
- Acidification harms yeast as well:
  - Demineralization
  - Nutrients are also washed out
- Practice:

  → Use of phosphoric or sulphoric acid (10 %)

  → Decrease of pH to 2,1 … 2,5 for 2 … 5 hours

  → Temperatures at 0 °C