The potential of the microwave-vacuum technique in drying of probiotic and starter cultures

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Microbial cultures

- Fields of application of starter cultures and probiotics:

  dairy products, pastries, pickles, raw sausages

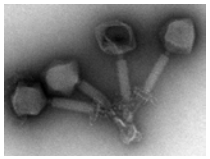
  probiotic foods

- Advantages of direct starter cultures:

  - no contamination by bacteriophages

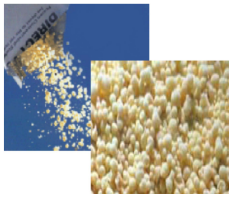
  - reproducible product quality

  - little know-how and personnel expenditure



- Stabilization by: - freezing

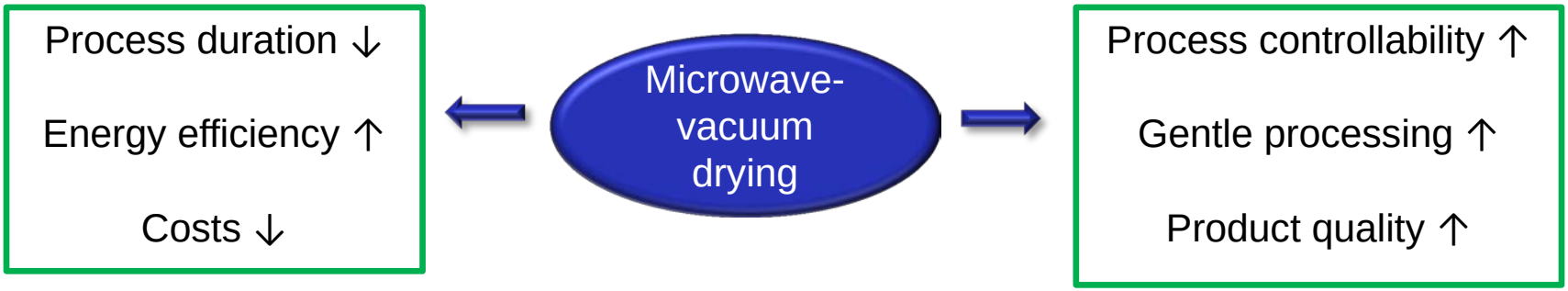
  - drying



Motivation

Current standard procedures in drying of microbial cultures:

Microwave vacuum-drying as an alternative?



Quality aspects of microbial cultures

- Viability
- Metabolic activity
- Storage stability
- Handling

  → Rehydratibility

  → Proper dosability

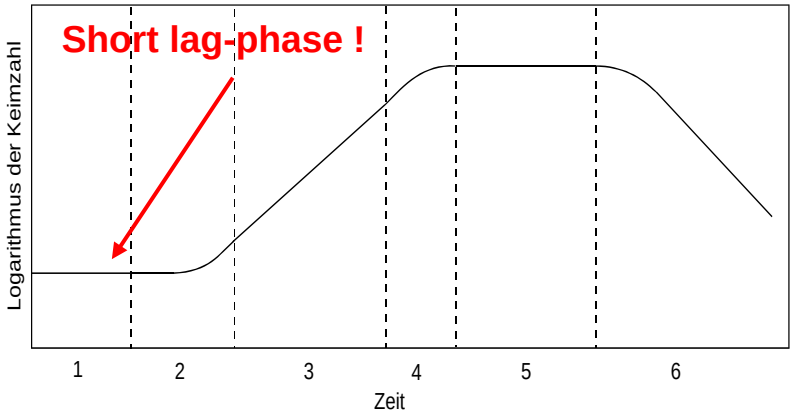
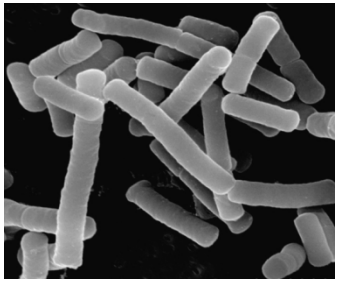
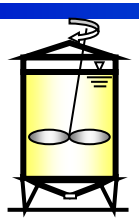


Abb.6.1: Vermehrungsphasen einer Bakterienkultur: 1. Latenzphase, 2. Beschleunigungsphase, 3. exponentielle Vermehrungsphase, 4. Verzögerungsphase, 5. stationäre Phase, 6. letale Phase

→ Aim: Maintainence of technological and biological functionality for direct inoculation without preculturing

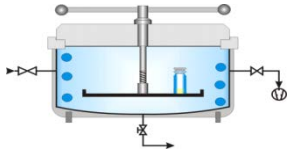


Culture preparation/ Test set-up



Fermentation

Harvest



Drying

Storage

Drying parameters:

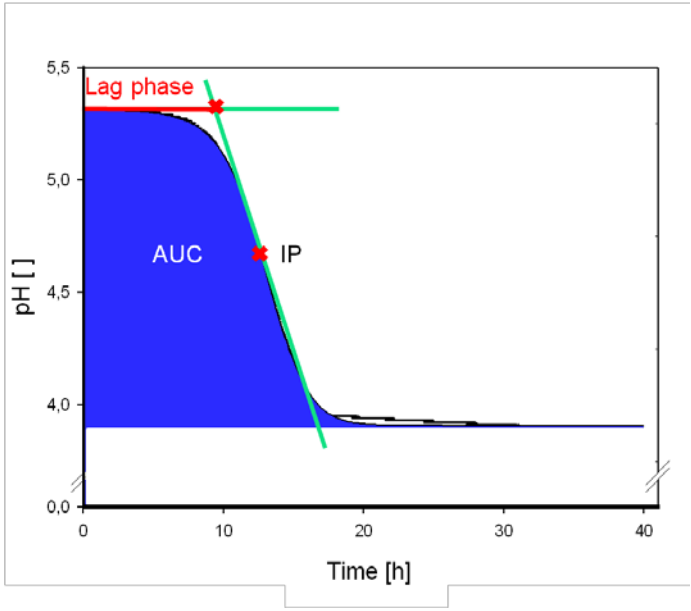
- Model strain: *Lactobacillus paracasei* spp. *paracasei* (F19)
- 100 g cell suspension
- h_{sample} = 0.5 cm
- Drying jar: Duran glass
- Residual water content = 6-7%

Analytics:

- Survival rate by plate count method and flow cytometry
- Acidification power test

$$pH(t) = pH_0 + \frac{a}{(1+e^{\frac{t-t_0}{b}})^c}$$

$$\int_0^{40} pH(t)dt - pH_{end} \cdot t_{end} = AUC$$

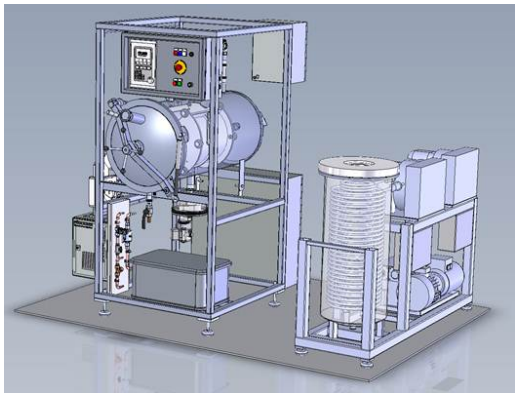


Microwave vacuum dryer

- Manufacturer: Püschner MicrowavePowerSystems, Schwanewede-Bremen, Germany
- Microwave power: max. 1 kW/ 2,450 MHz
- Integrated load cell and IR-camera
- Prozess visualization: online-measuring of

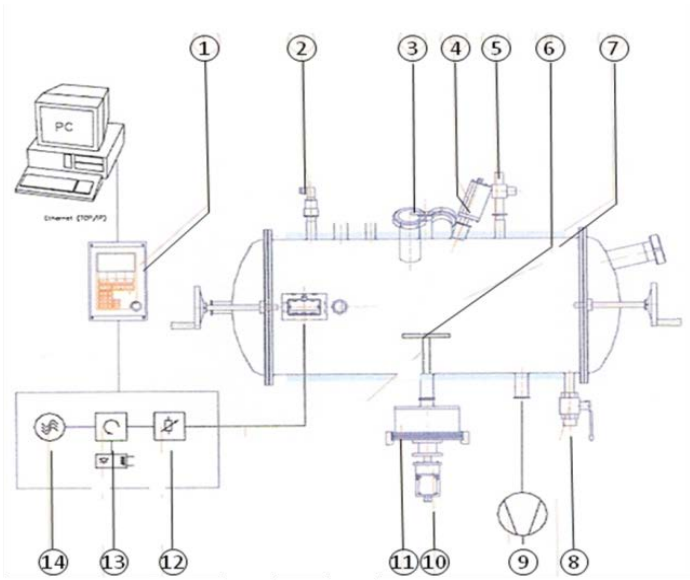
  p, m, T, P
- Influencing factors:

  - Microwave power
  - Pressure
  - Product characteristics (dielectric loss factor)

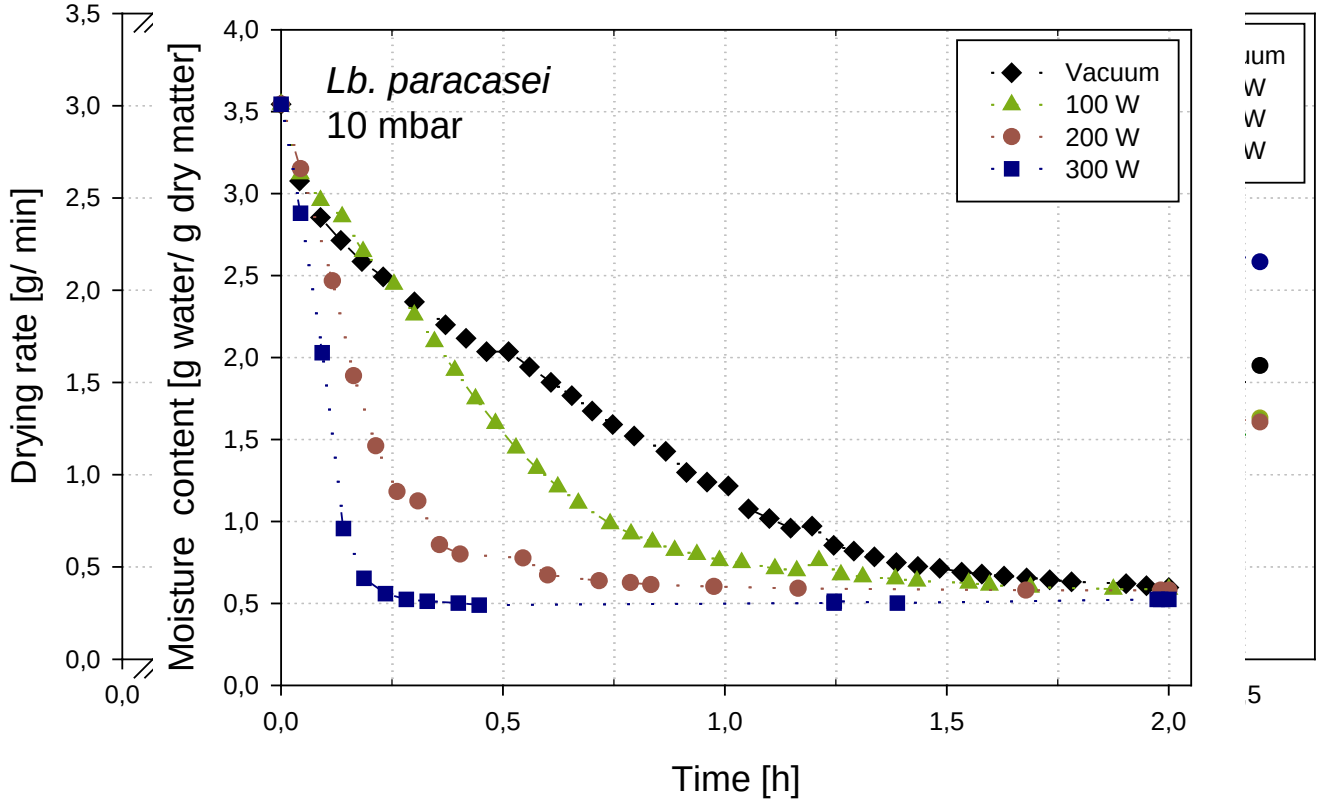


$$P_r = 2\,\pi\, f\, E^2\, \varepsilon_0\, \varepsilon''$$

P_r: Relative absorbed power
f: Frequency
E: Electric field strength
ε_0: Absolute dielectric constant
ε'': Dielectric loss factor



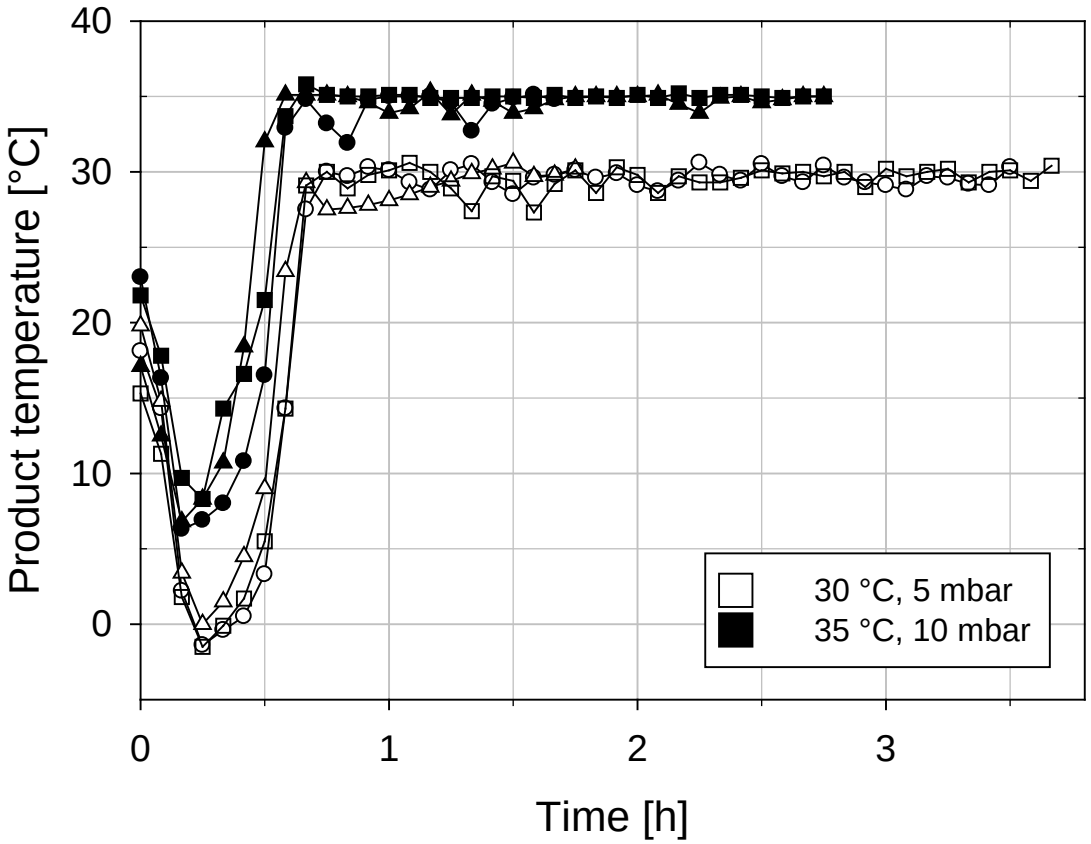
Drying rates



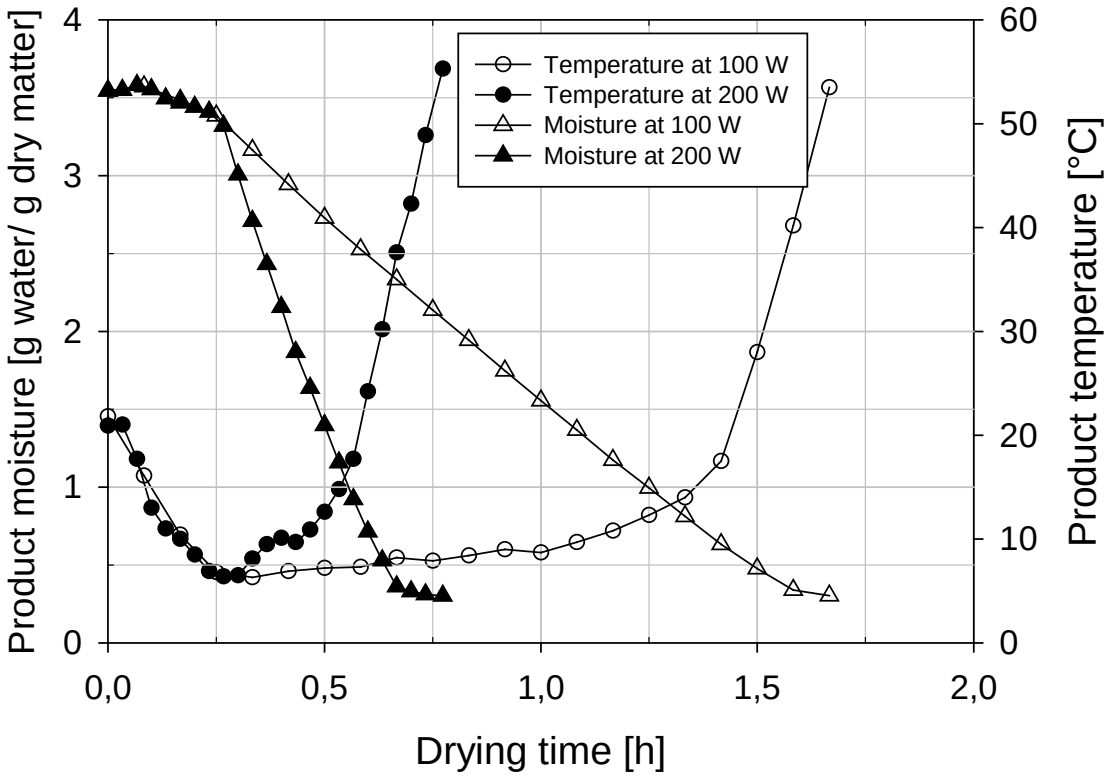
→ Clear dependence of the drying rate on the microwave power input

→ Process can be controlled via microwave energy input

Performance and replicability of drying process



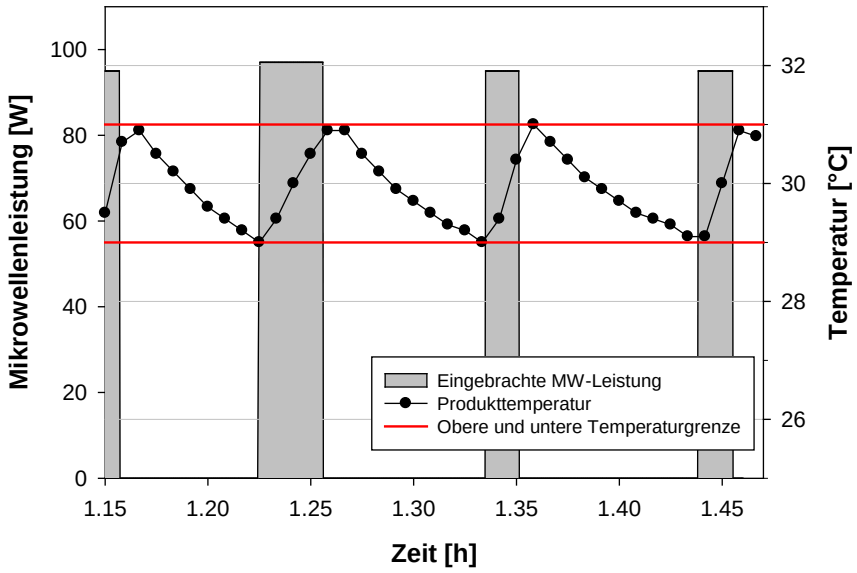
Drying profiles for continuous microwave input

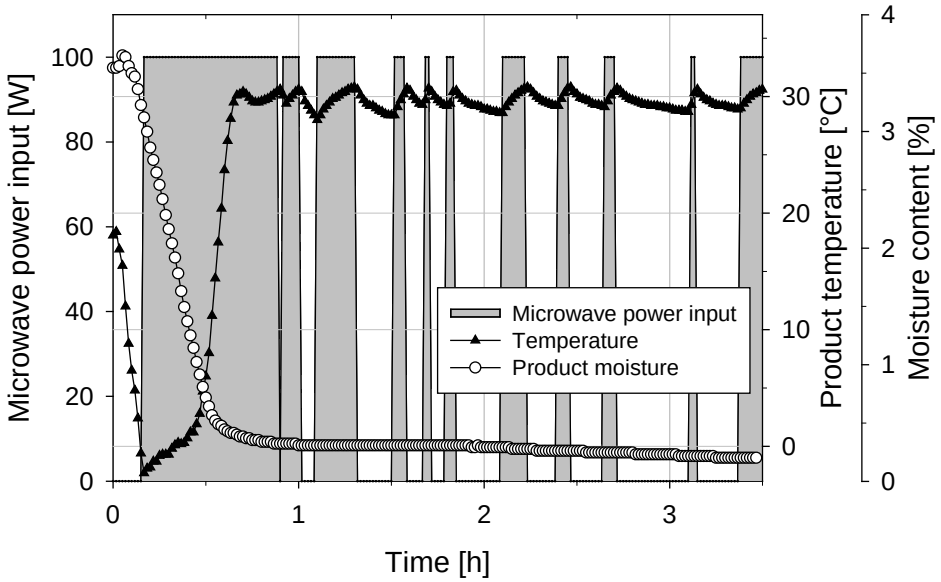


→ Drying below critical residual water content leads to detrimental product temperatures

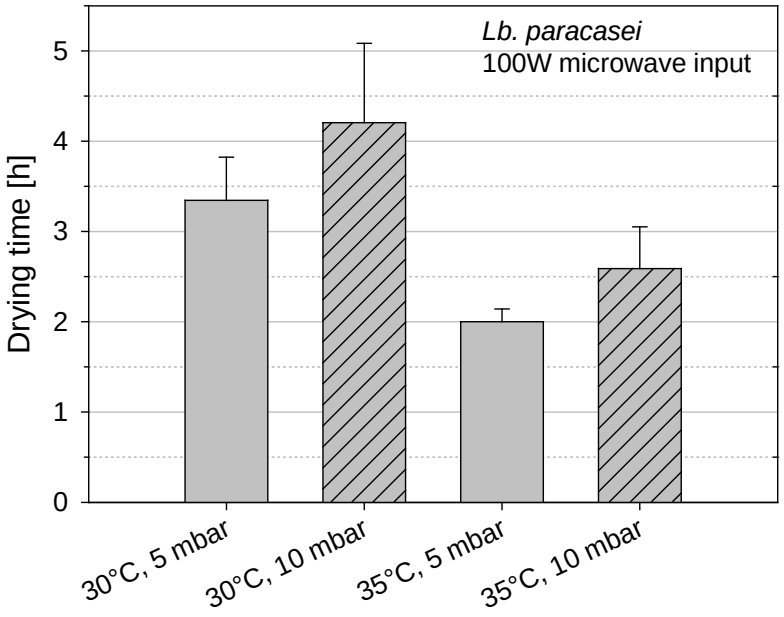
Pulsed microwave input

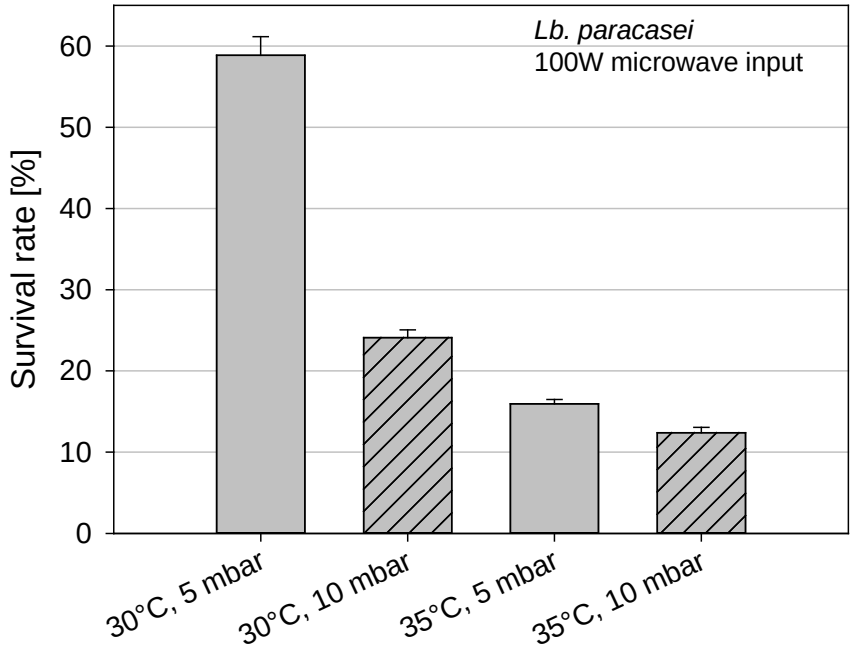
Pulsed energy input: Temperature regulation according to T_{max}





Influence of chamber pressure and product temperature on drying time and survival

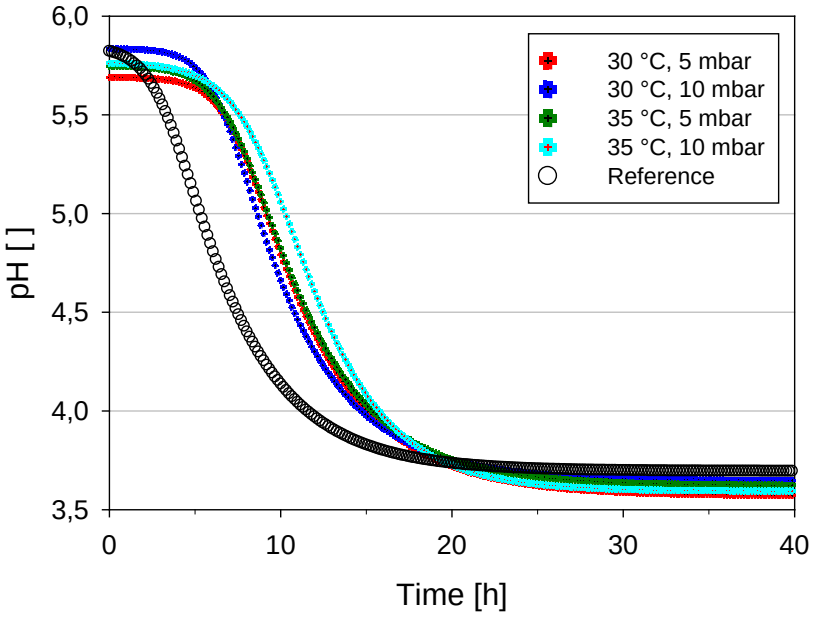


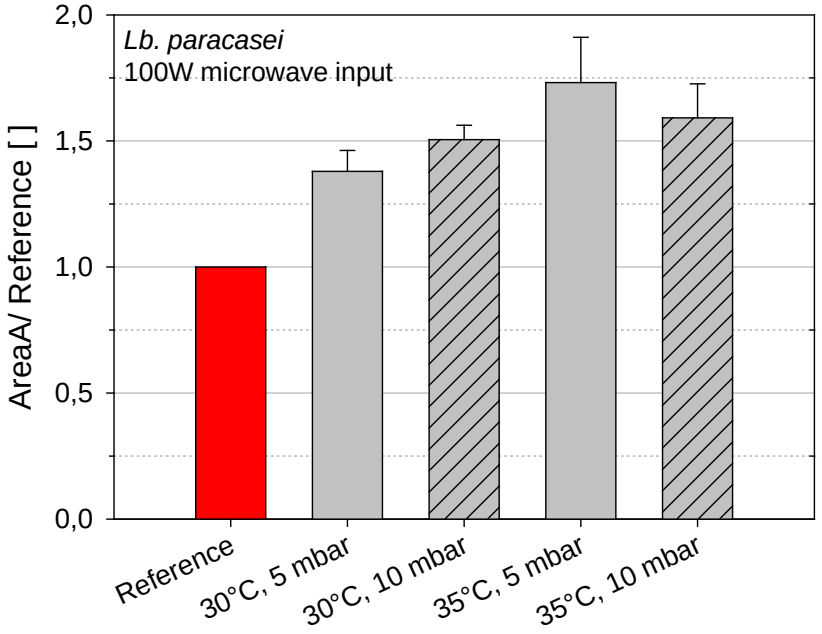


→ Besides microwave power input T_{max} determines drying time

→ High survival at low T_{max} and low chamber pressures

Influence of chamber pressure und product temperature on acidification activity





→ Low T_{max} and low chamber pressures are favourable for vitality

Summary

Microwave vacuum-drying of lactic acid bacteria is generally possible!

- Microwave enables **shortening of drying time up to 90%** in comparison to freeze and vacuum drying
- **Pulsed microwave input** enables **gentle drying** and thus **high survival rates**

→ ***Microwave vacuum-drying has got the potential to overcome many inconveniences in the drying of lactic acid bacteria and so could replace or at least complement the established drying techniques***