



Spray drying

Theory and microbial inactivation

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Together to the next level

Spray dryer overview

Feed system

Atomiser

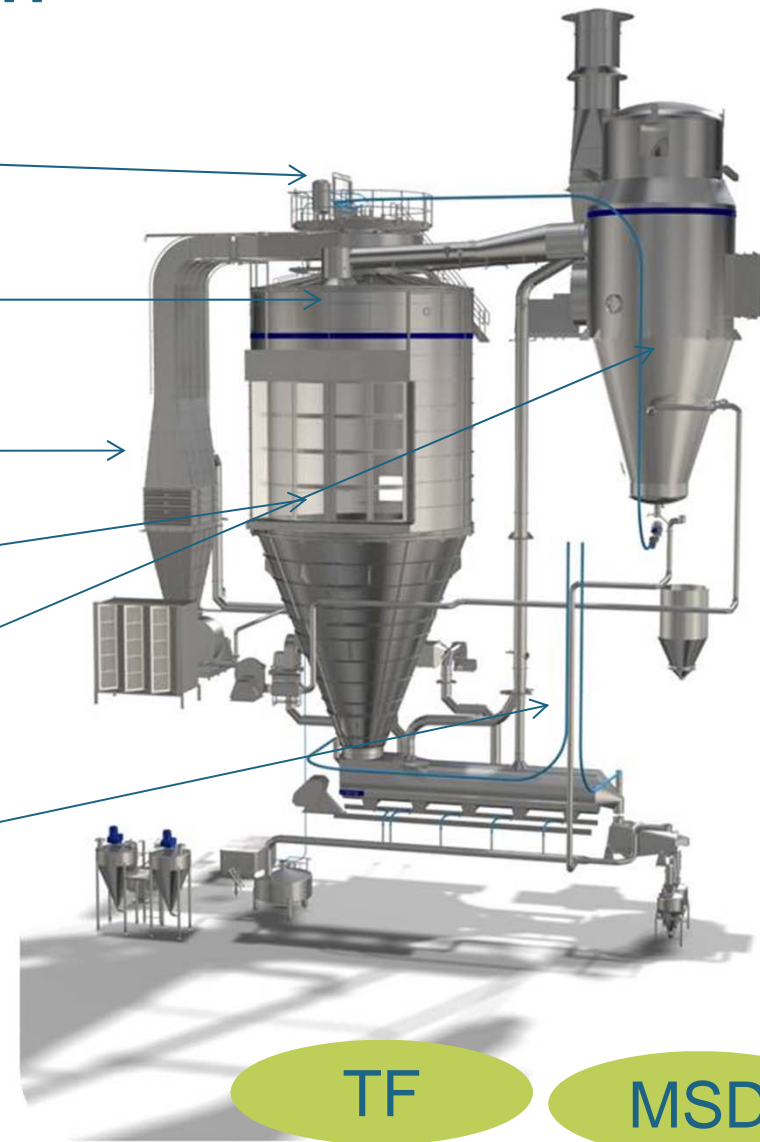
Hot air & air distribution

Drying chamber

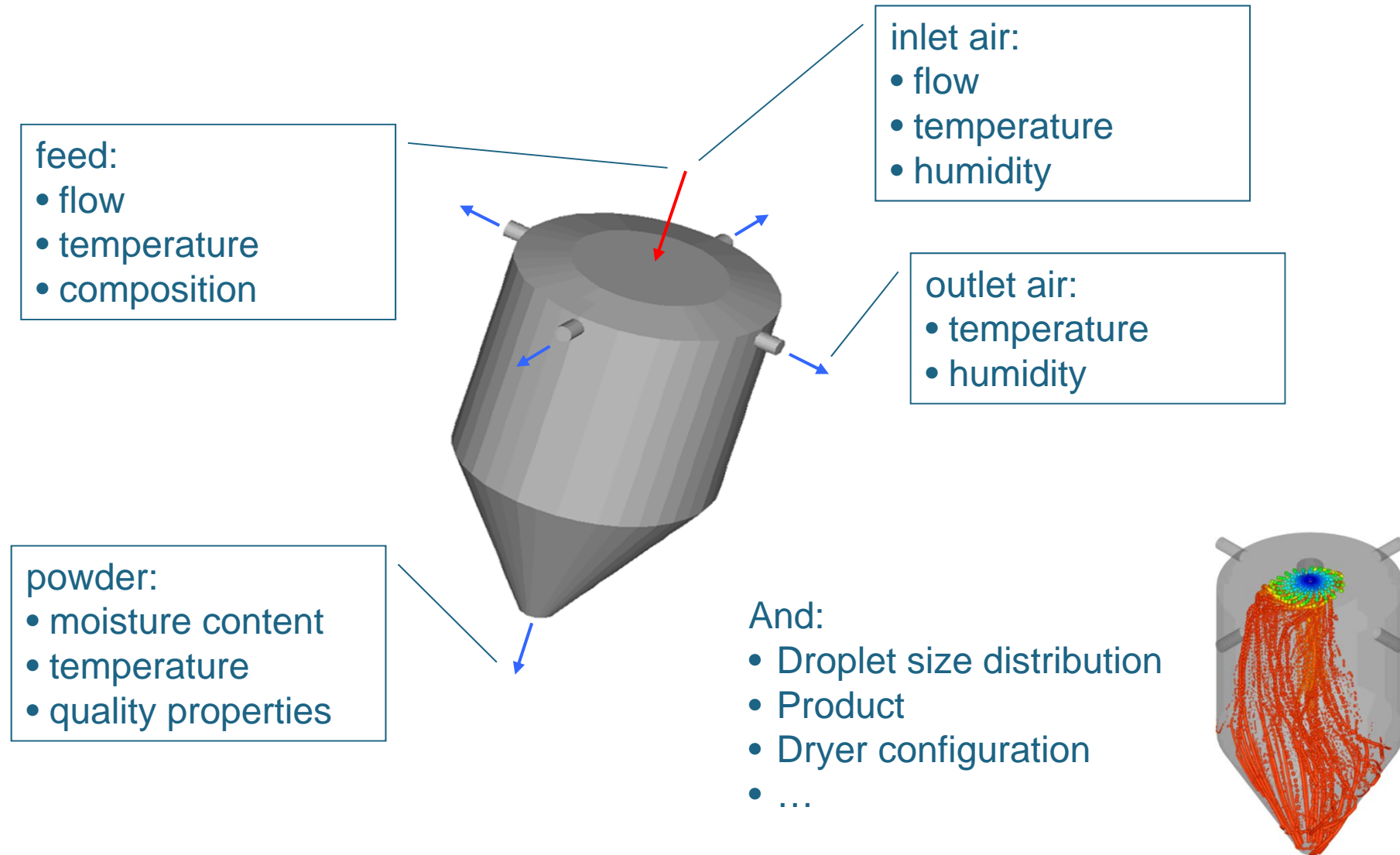
Powder separation

Fines return

Fluidized bed



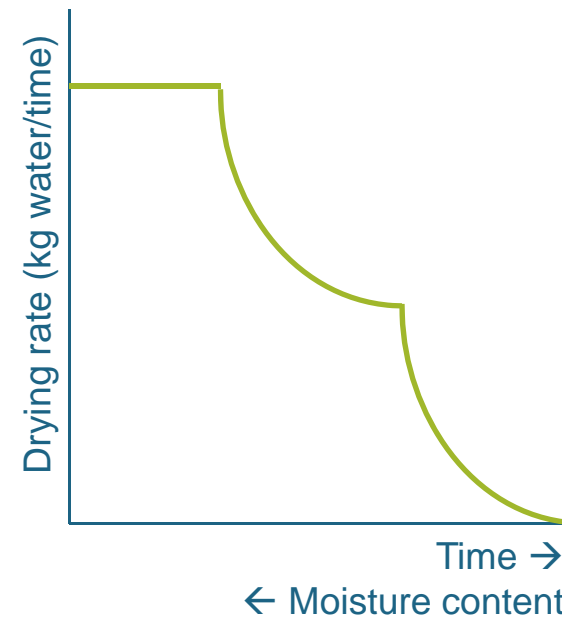
Spray drying: many parameters



Drying process

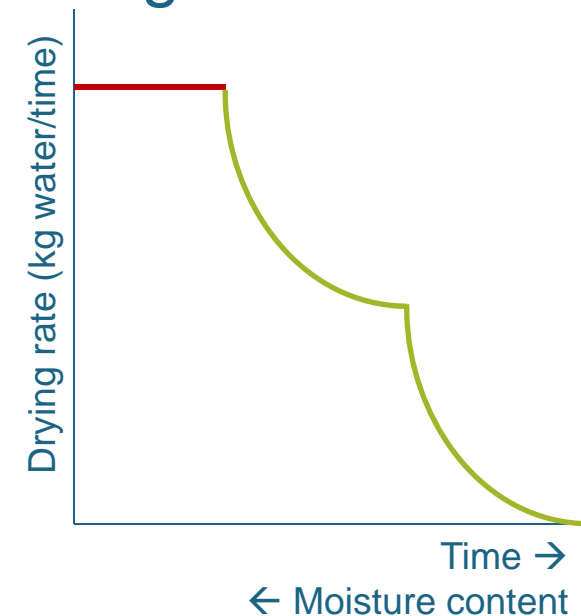
What does a droplet experience?

- 3 stages
 - Constant drying rate
 - Falling drying rate
 - Second falling drying rate



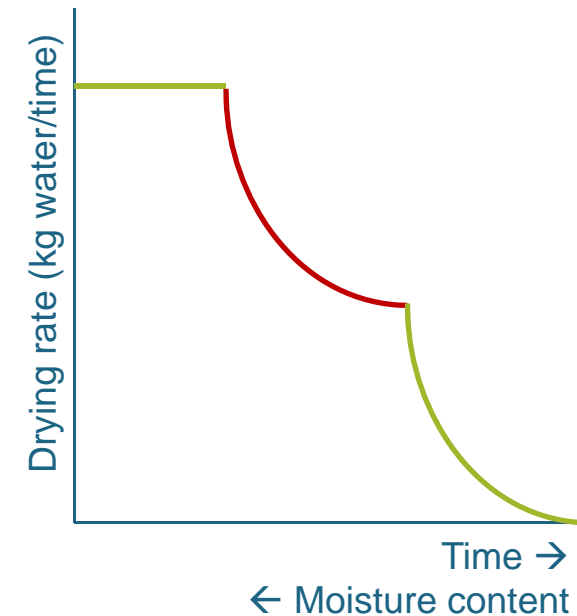
Constant drying rate

- Droplet enters the spray dryer
- Large amount of water available at the surface for evaporation
 - external mass transfer limiting
- Wet bulb drying!
 - Water drying from outer layer
 - Later diffusion from interior to outer layer



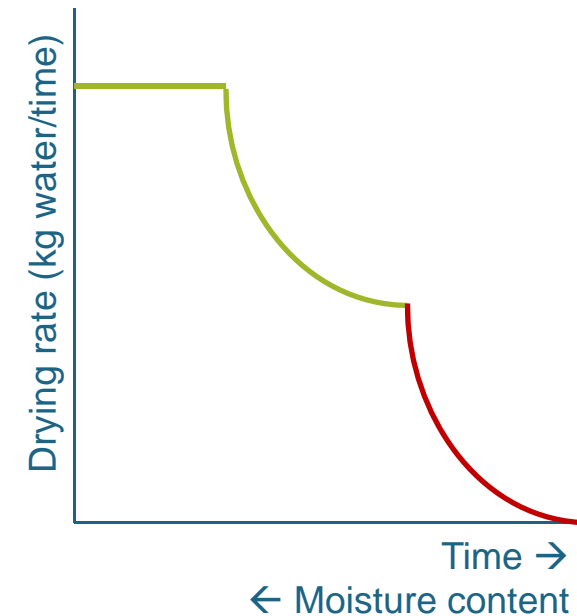
Falling drying rate

- Patches of dry material/crust appear on the outside
- Drying rate is still constant at wet area
 - Overall drying rate decreasing
- $T > T_{\text{wet bulb}}$
- E.g. 30-15 % moisture content for dairy products

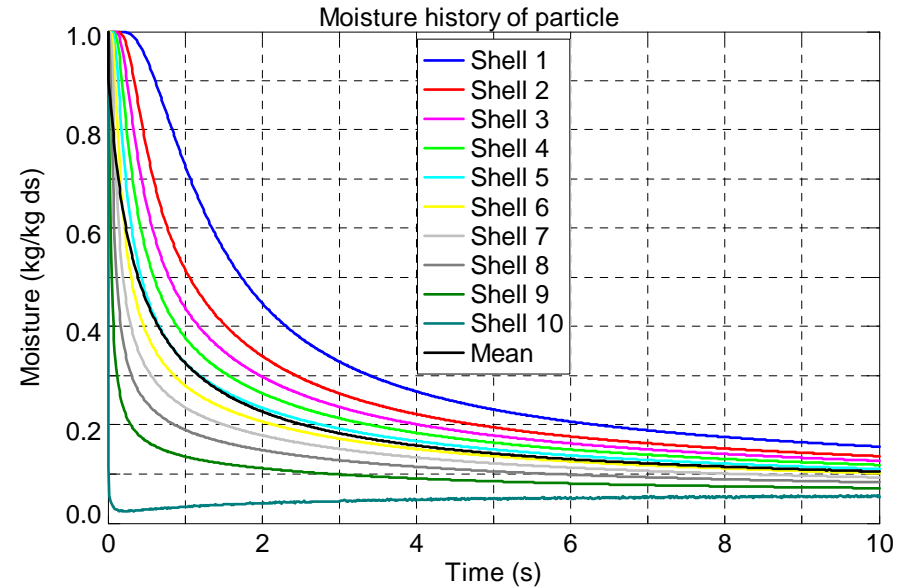
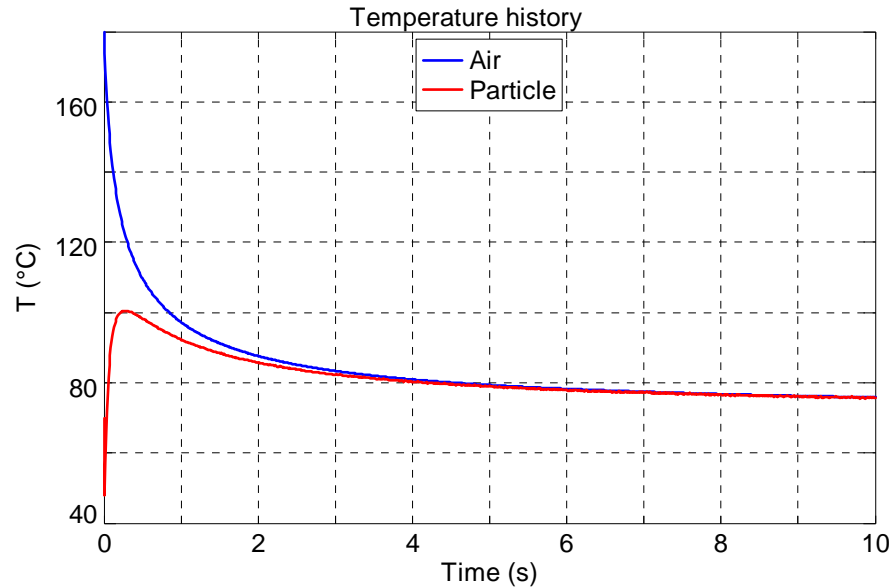


Second falling drying rate

- Solid outer layer
- Internal mass transfer usually limiting
 - Not heat transfer
- Strong moisture gradient
- Beware of crust formation
 - Higher temperature



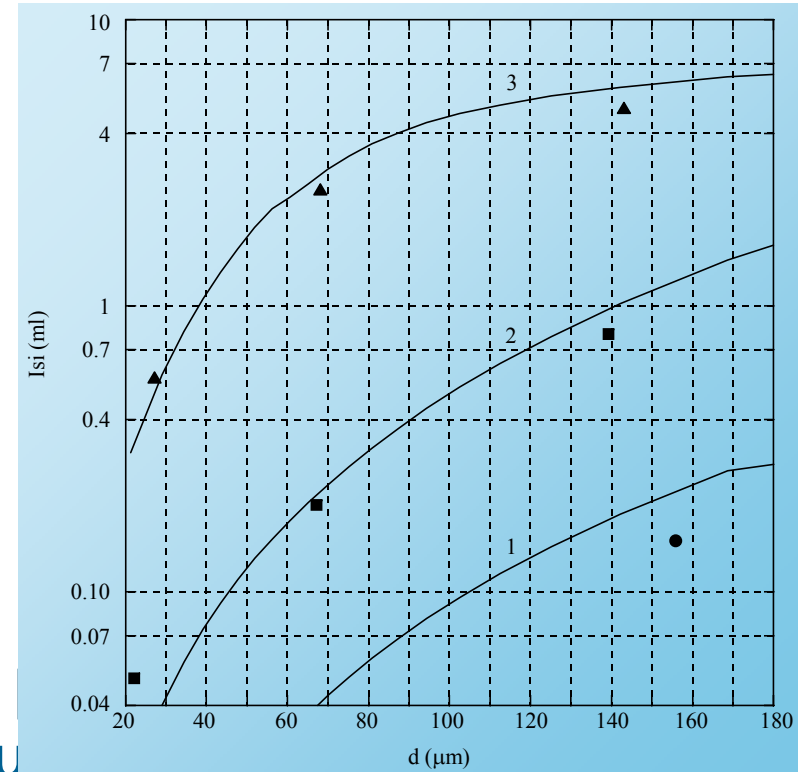
“Real” calculation



- Droplet gets high T during first second
- Most of the dryer at outlet conditions

Heat load

- Insolubility
 - higher=worse
- Higher T
 - Higher insolubility
- Larger particle diameter
 - Higher insolubility
- Low temperature, hygienic
 - Therefore, e.g. usual no drug



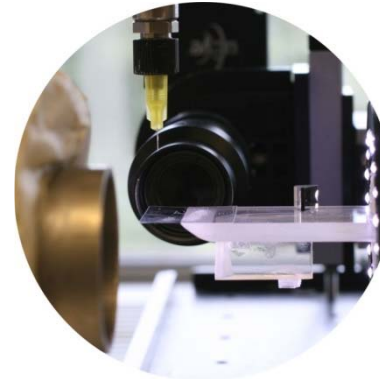
Isi versus particle diameter.

Experimental results (symbols) and model calculation (lines).
Temperatures: 86 °C (1, \blacklozenge); 96 °C (2, \blacksquare) and 114 °C (3, \blacktriangle).

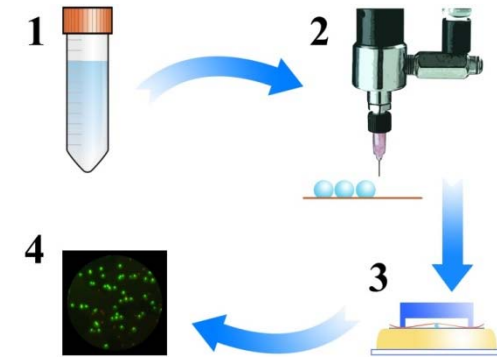
Microbial survival

Microspraydrying

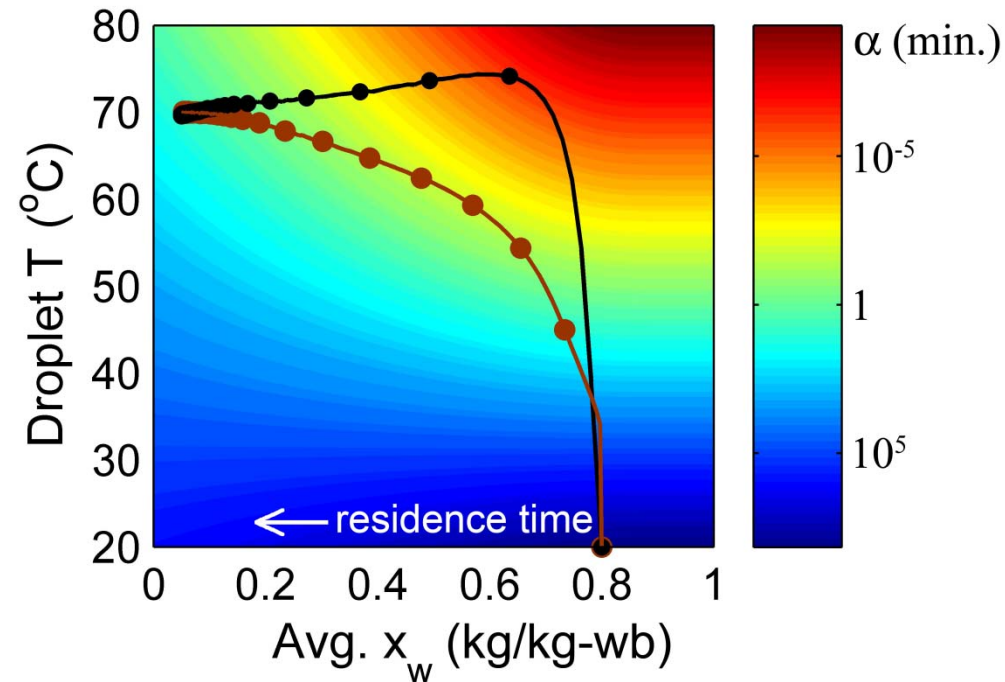
- Survival of probiotic bacteria
 - *Lactobacillus plantarum* WCFS1
 - Survival is opposite of inactivation!
- Drying single droplets



- Compare to large scale

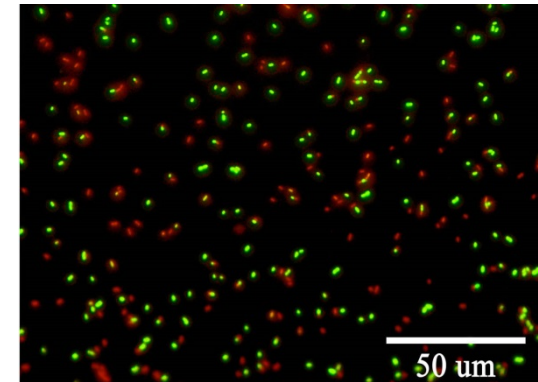
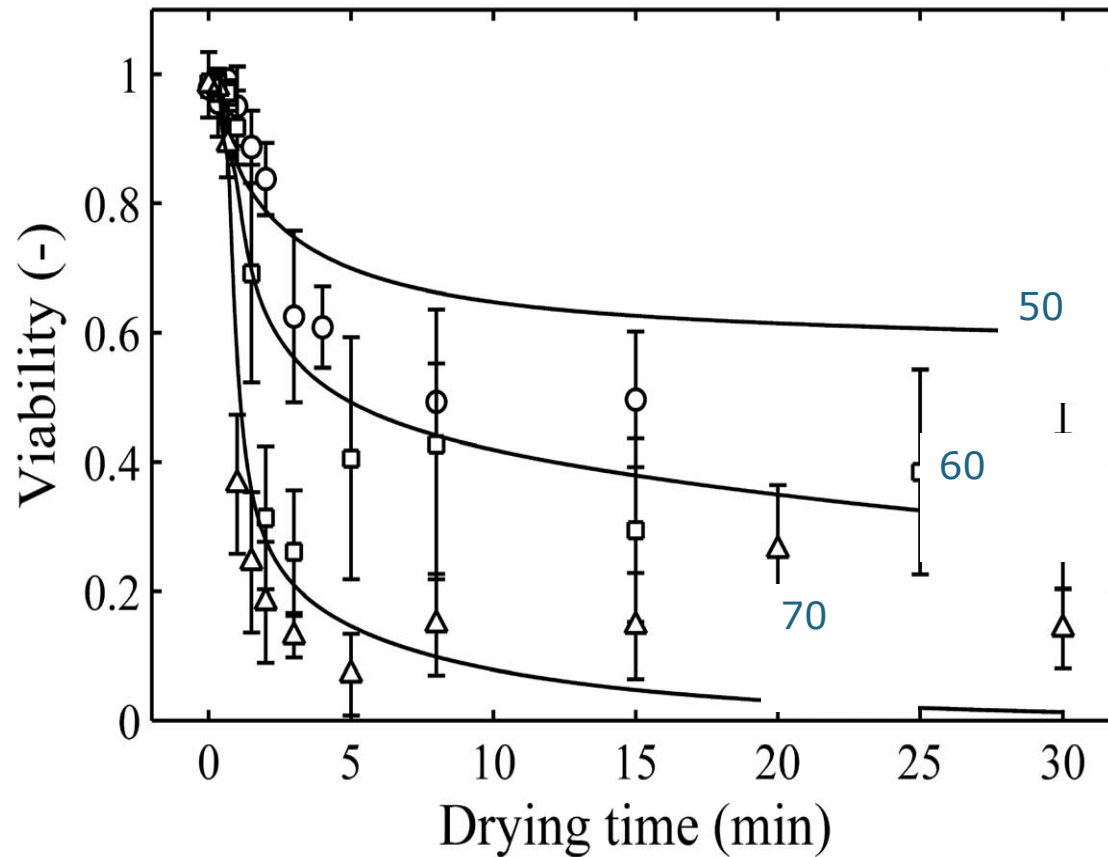


When inactivation?

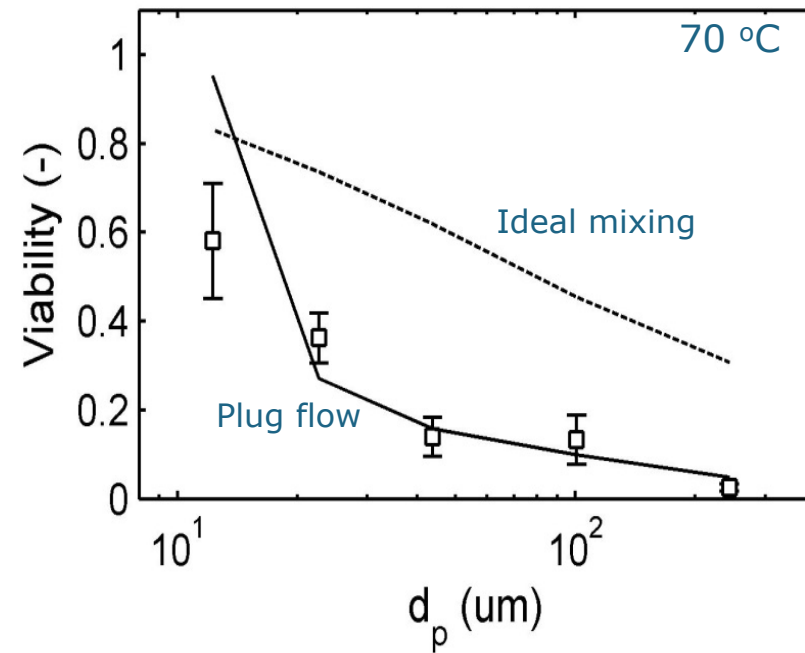
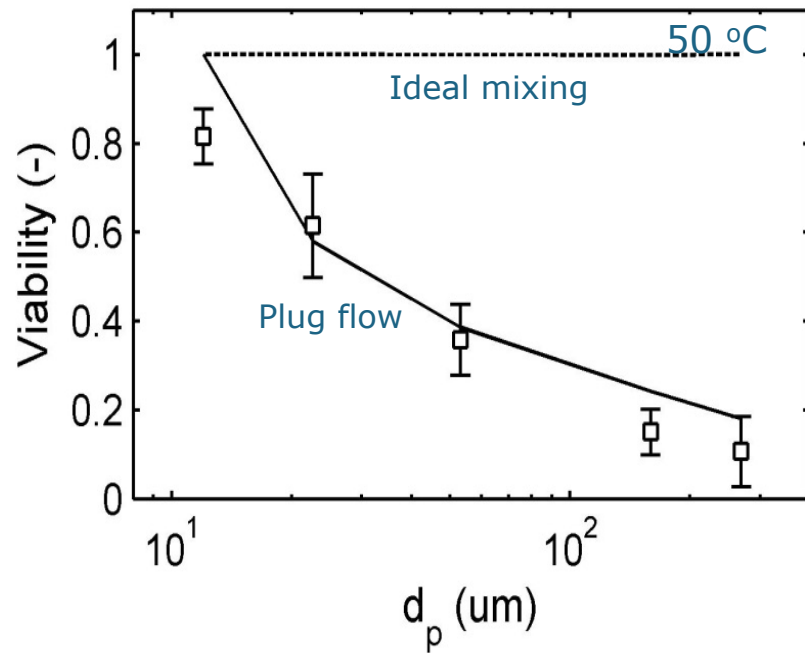


- High temperature
- High moisture content

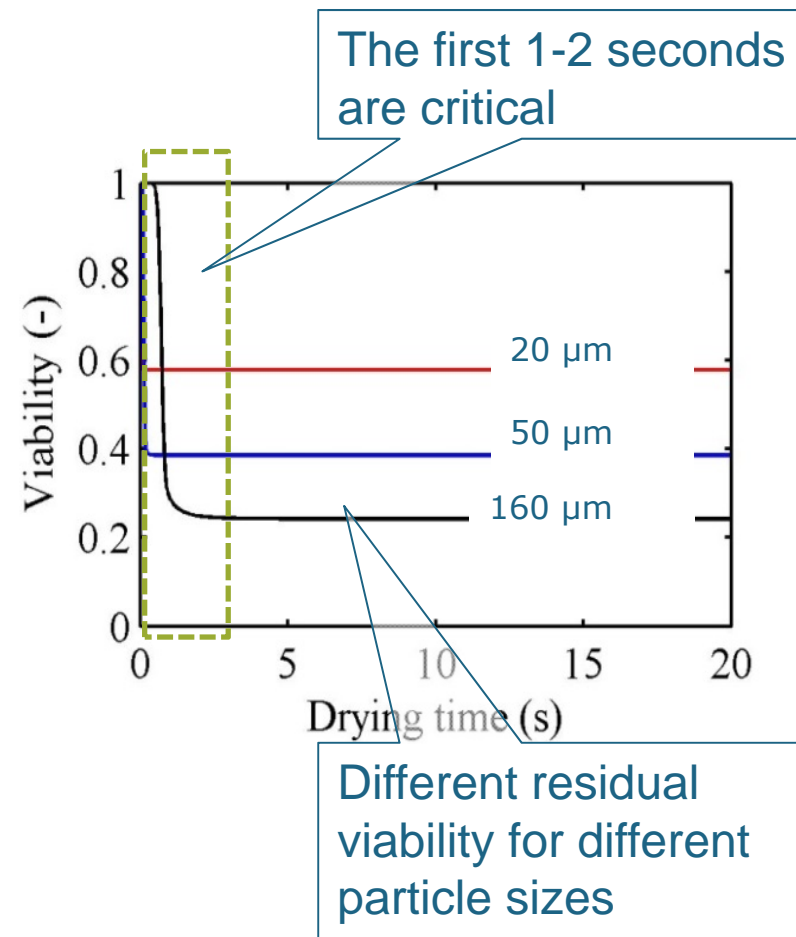
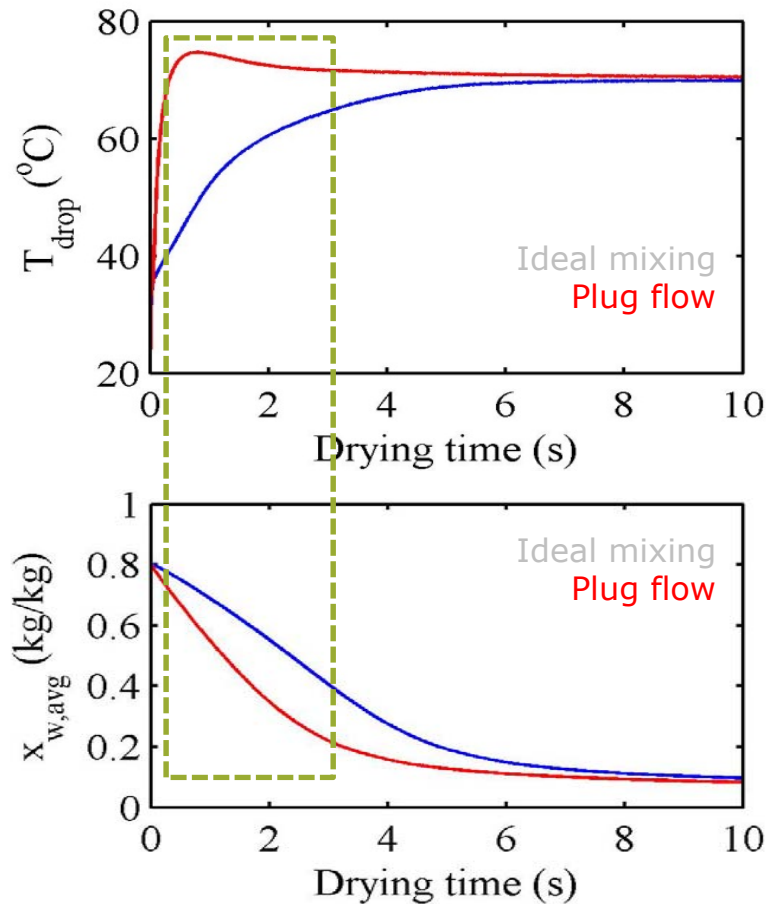
Drying at different temperatures



Drying with different droplet sizes



When in a spray dryer...



Concluding...

- Spray drying is affected by many parameters
 - Air temperature in-out
 - Feed flow
 - Solids content
 - Droplet size distribution
 - Type of product
 - Dryer configuration
- Spray drying does affect microbial inactivation
 - Viruses expected to be of similar behaviour
 - Exact kinetics will be completely different!