



Collaboration with Solina

GranuTools instrument range



What do we want to measure :

- Flowing properties
 - Volume or mass per unit of time, Angle of repose or Dynamic angle
- Cohesion (via the cohesive index) = “Probability” not to flow
 - Powder requires energy to start flowing
 - Two different but complementary aspects
- Tribo-electrification
 - Can cause cohesion to fluctuate inside a machine, device or process
 - Measuring cohesion only is not enough

GRANUFLOW™

GRANUPACK™

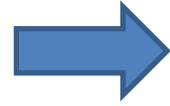
GRANUHEAP™

GRANUDRUM™

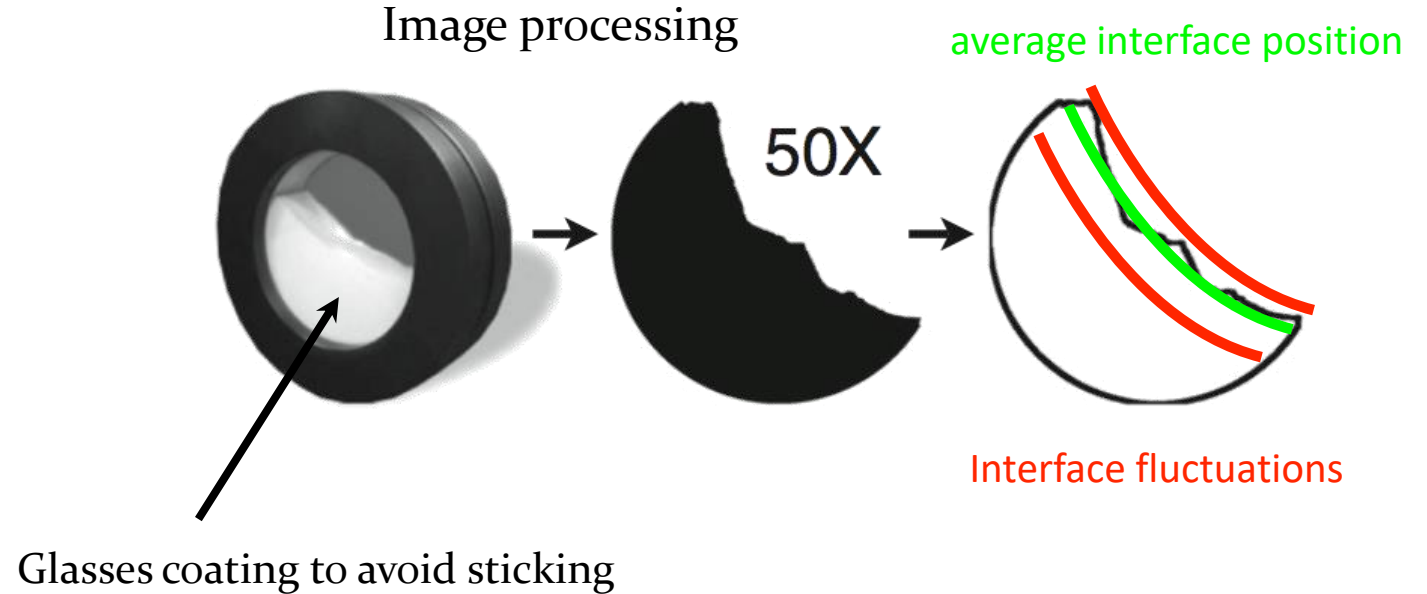
GRANUCHARGE™

GranuDrum instrument

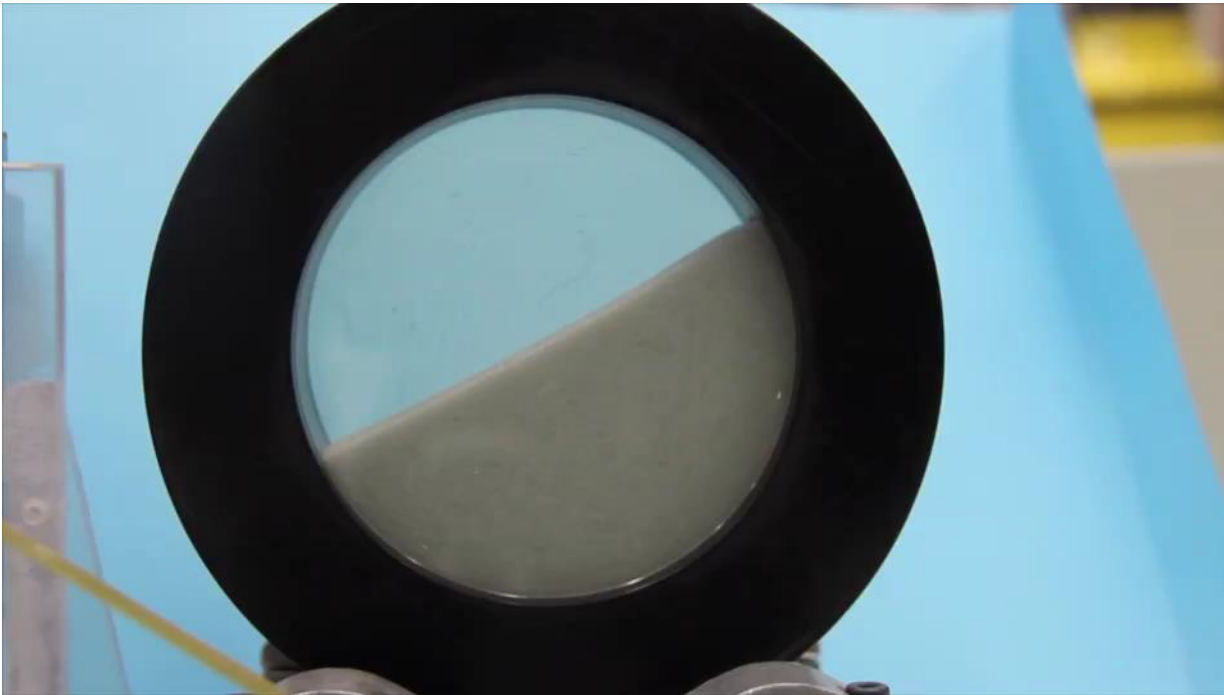
Instrument description



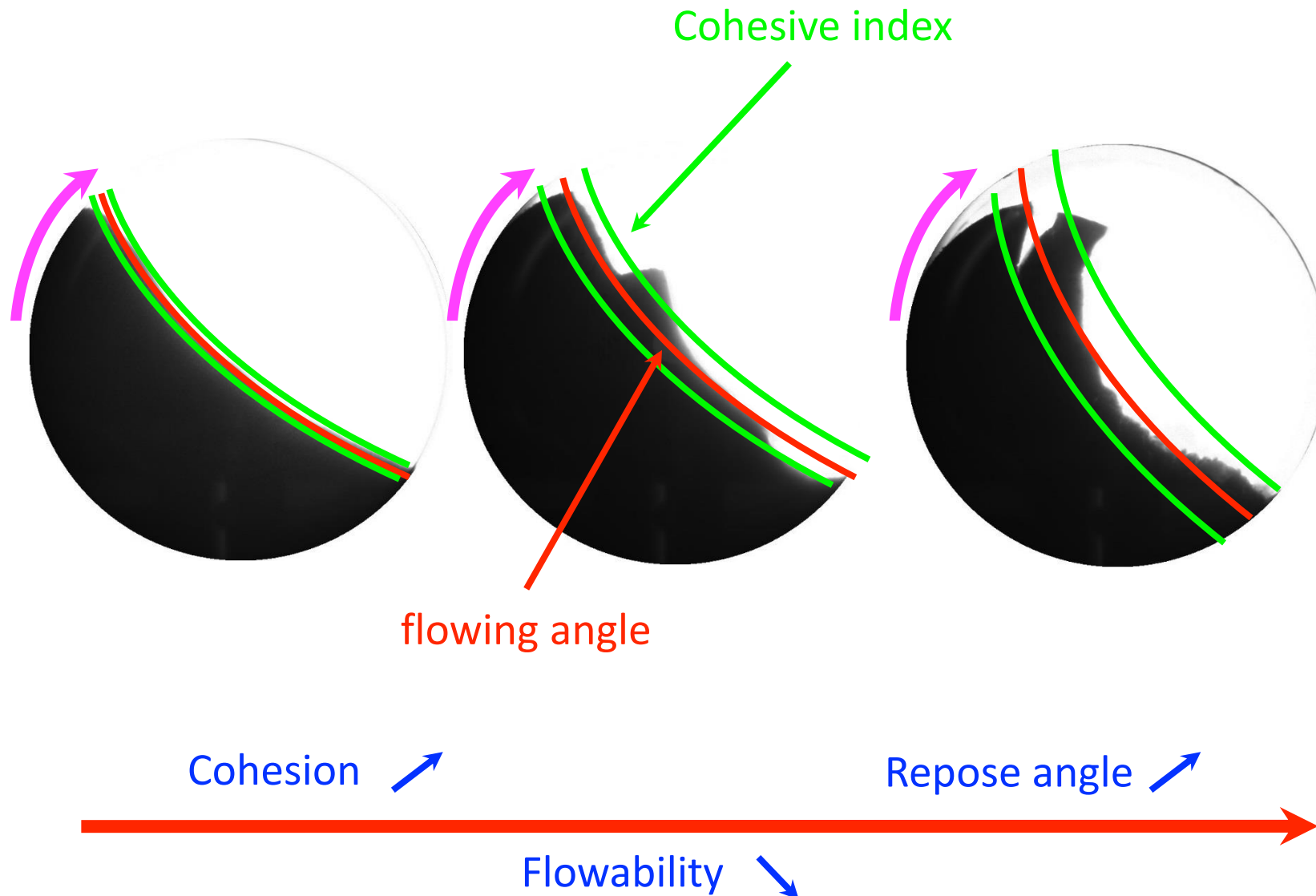
Analyse the flow inside a rotating drum



Cohesive index – physical interpretation



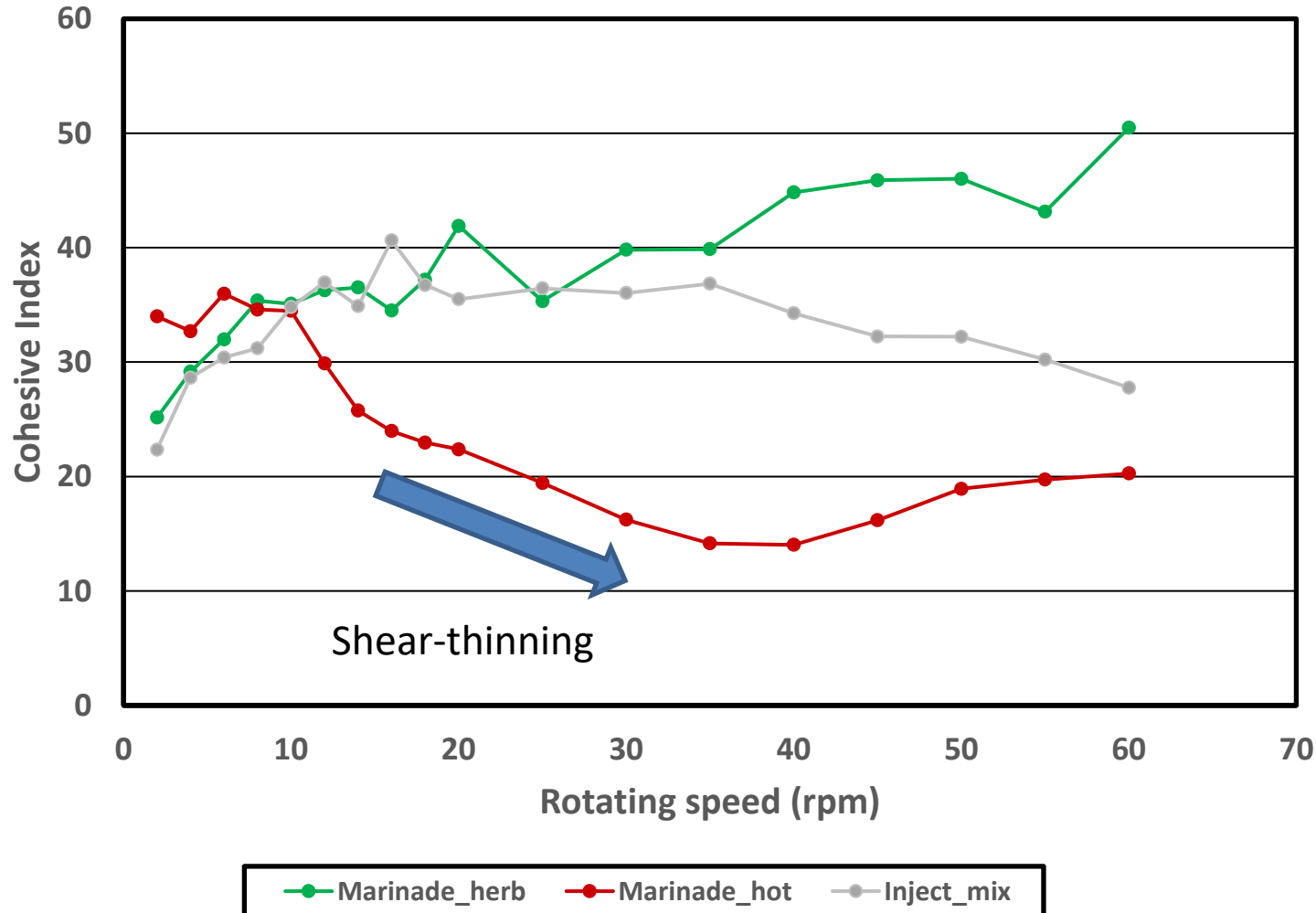
Dynamic angle of repose measurement



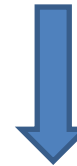
GranuDrum results

Flowability measurements

Bratwurst and Chips were too sticky to be measured

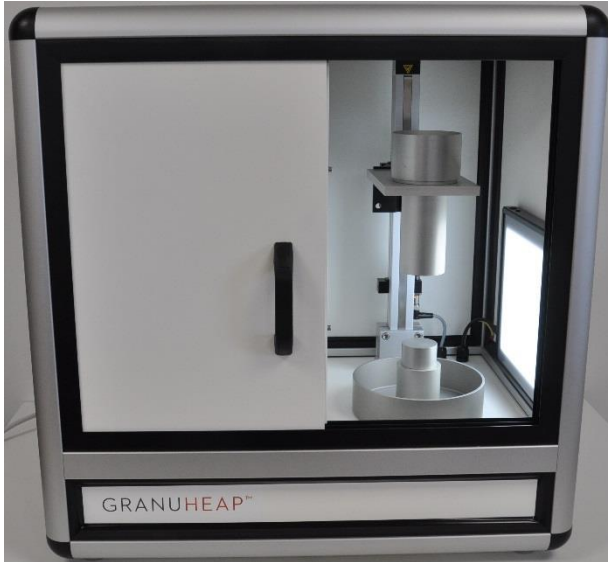


Marinade_hot exhibits the best flowability



- Less cohesive (due to grains sizes?)
- Probably easier to mix

The GranuHeap instrument



Principle: analyzing the shape of a heap

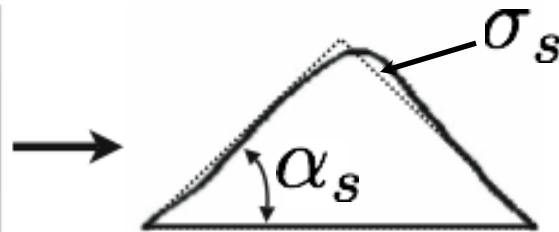


Non cohesive granular



Cohesive powder

Method:

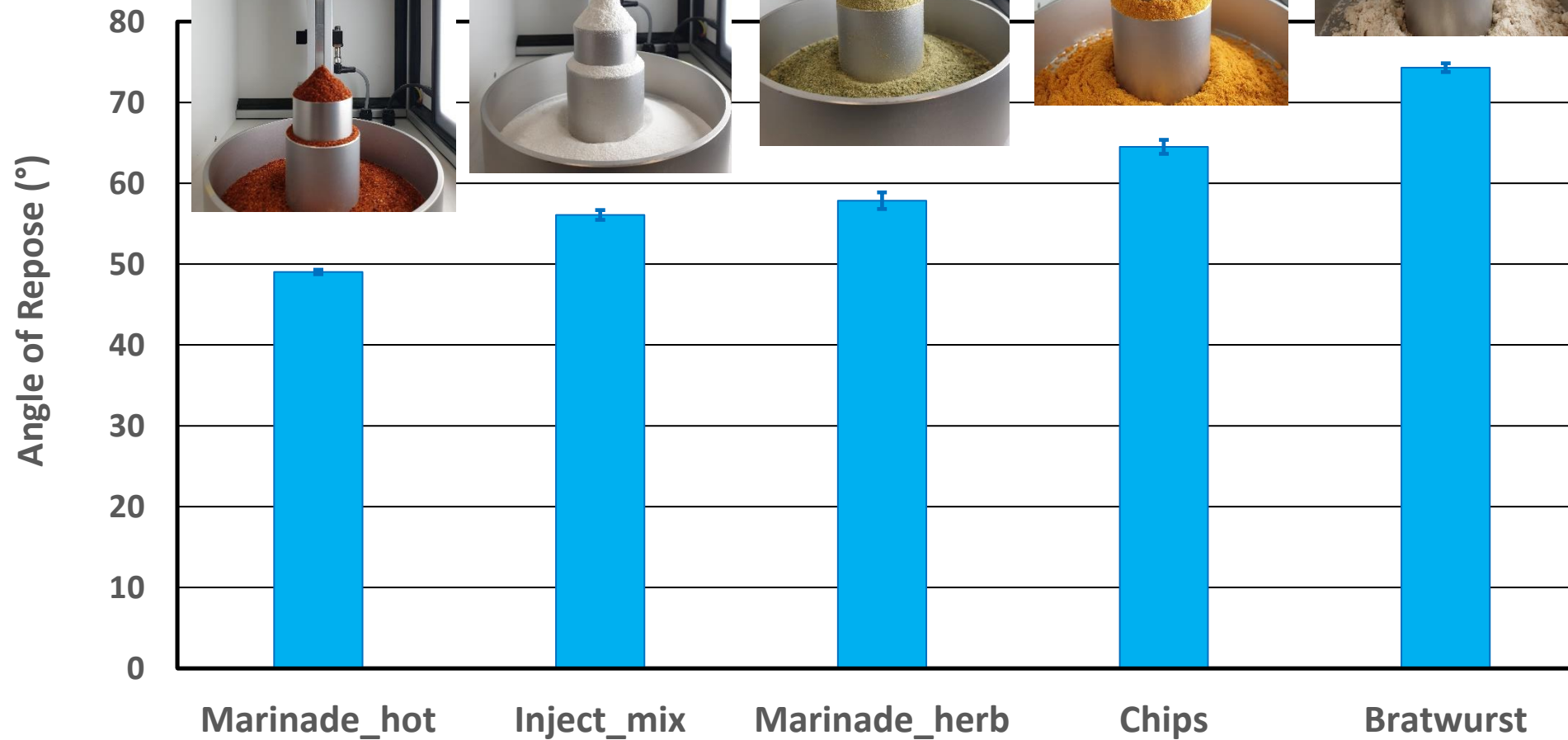


Static angle (angle of repose) α_s

Cohesive index σ_s

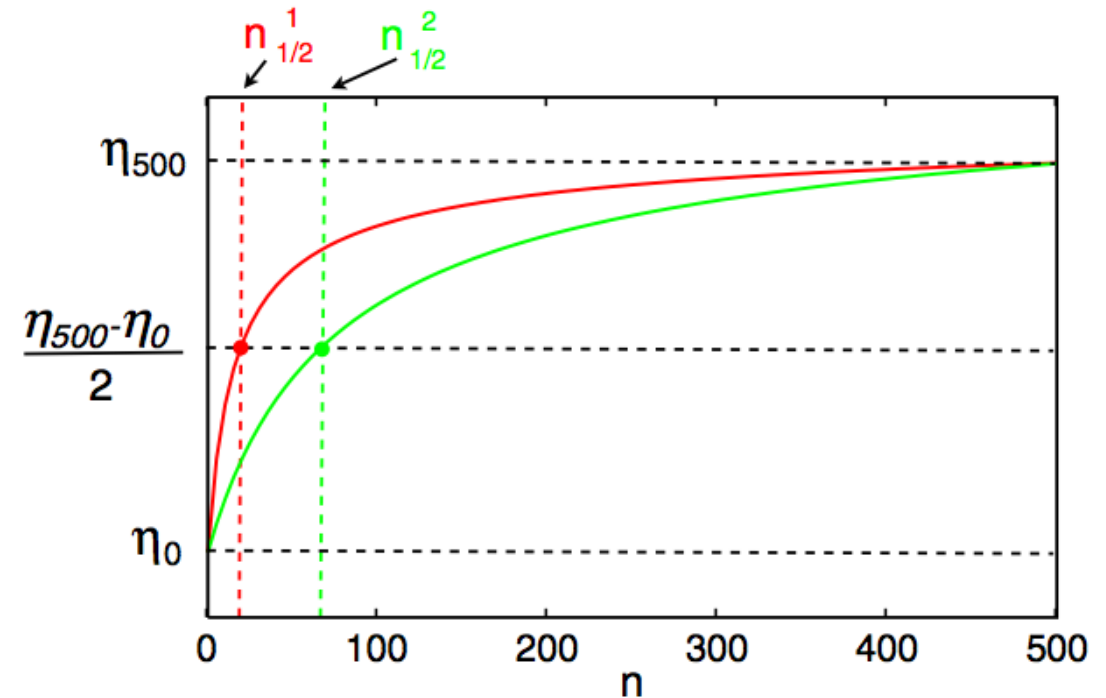
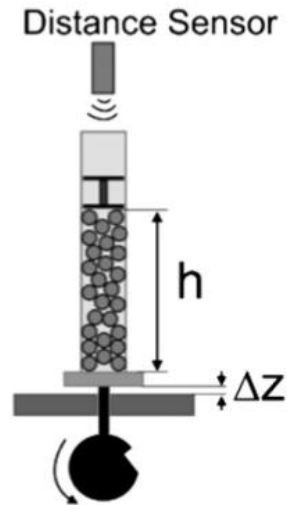
Complex heap shape → rotation of the heap

GranuHeap results



The GranuPack instrument

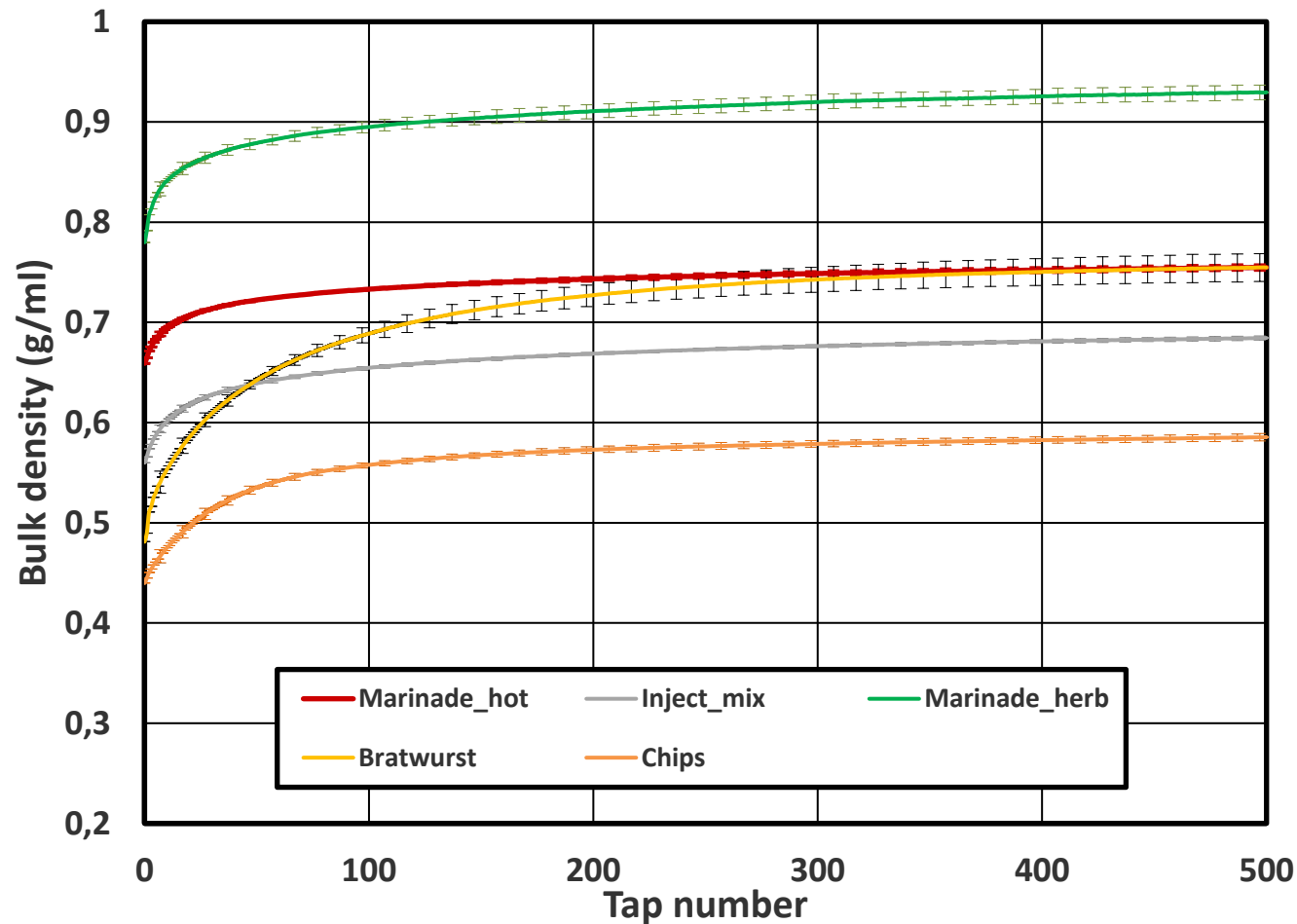
Evolution of the density of a pile submitted to a series of taps



Measurables:

- ✓ Apparent (bulk) density
- ✓ Tapped density
- ✓ Hausner ratio
- ✓ Dynamical parameter $n^{1/2}$

GranuPack results



➡ Highlight very small differences between batches

- We can classify the powders according to their Hausner ratio
- Lower $n\frac{1}{2}$ -> faster packing

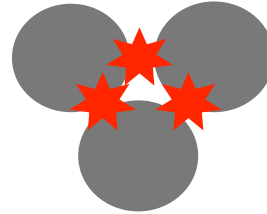
Sample Name	$\rho(0)$ (g/ml)	$\rho(n)$ (g/ml)	$n\frac{1}{2}$	Hr
Marinade_hot	0,659	0,755	20,4	1,15
Inject_mix	0,780	0,930	17,9	1,19
Marinade_herb	0,560	0,684	23,9	1,22
Chips	0,440	0,585	29,5	1,33
Bratwurst	0,481	0,755	34,4	1,57

- Marinade_hot: lower cohesion
- Inject_mix: faster packing
- Bratwurst : High Hr / very cohesive

Caking problem



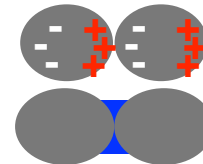
Particles + interactions



Collective
behaviour

Forces acting on grains

- Gravity
- Contact forces (friction, elasticity)
- van der Waals forces
- Electrostatic forces
- Capillary forces
- Hydrodynamic forces

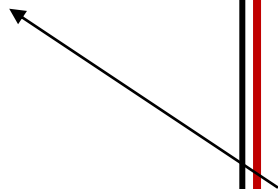


Cohesive forces

Grains properties

- Size
- Shape
- Surface
- Physico-chemical properties

Humidity

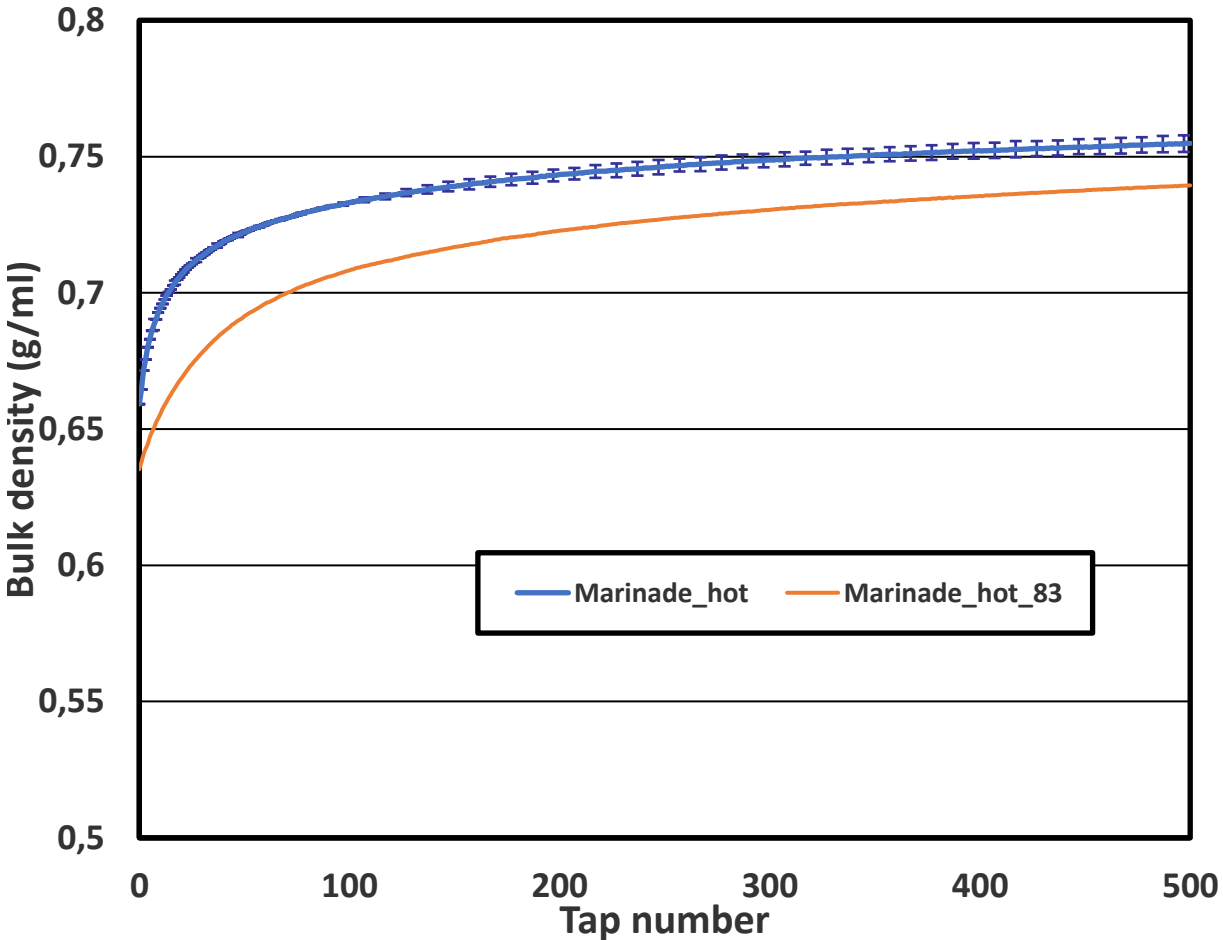
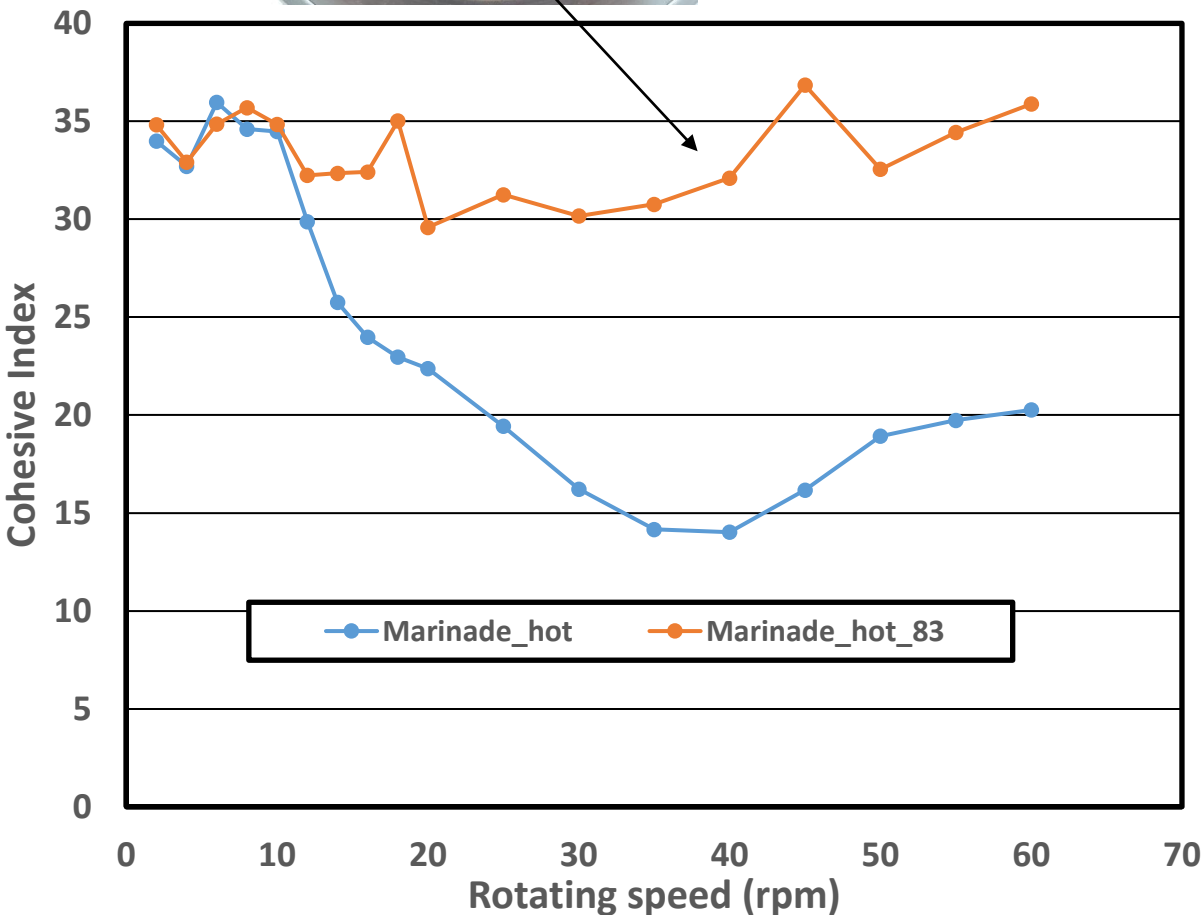


Caking problem



Influence of humidity

Sample Name	$\rho(0)$ (g/ml)	$\rho(n)$ (g/ml)	$n\%$	Hr
Marinade_hot	0,659	0,755	20,4	1,15
Marinade_hot_83	0,635	0,739	42,6	1,16



Conclusions

- GranuDrum:
 - Marinade_hot exhibits the best flowability with a shear-thinning behaviour
- GranuHeap:
 - Powders can be classified accurately according to their angle of repose
 - Simple and fast measurement
- GranuPack:
 - Very accurate: allows to discriminate slight differences between batches
 - Powder are precisely classified from their Hausner ratio
 - Access to the whole packing curve
 - Dynamical parameter $n_{1/2}$ gives insight on the packing velocity