FRICTION AND ADHESION IN FOOD SUSPENSIONS

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International Fine Particle Research Institute workshop on Friction and Adhesion in Wet and Dry Particulate Systems – 19th-20th January 2026

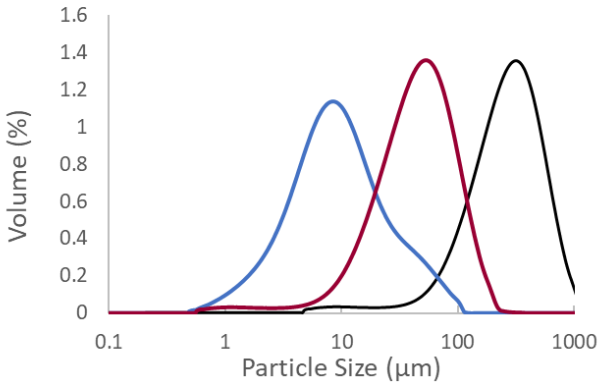
Mondelēz International
SNACKING MADE RIGHT

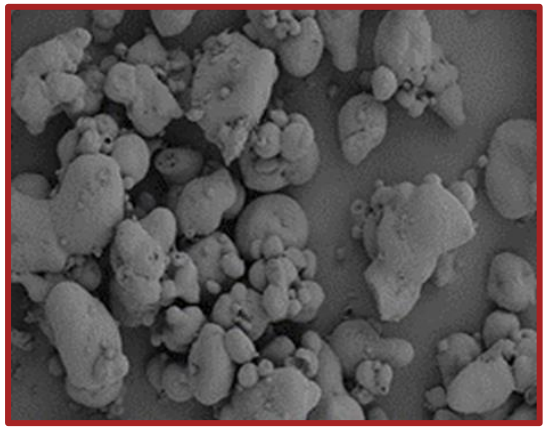
IFPRI

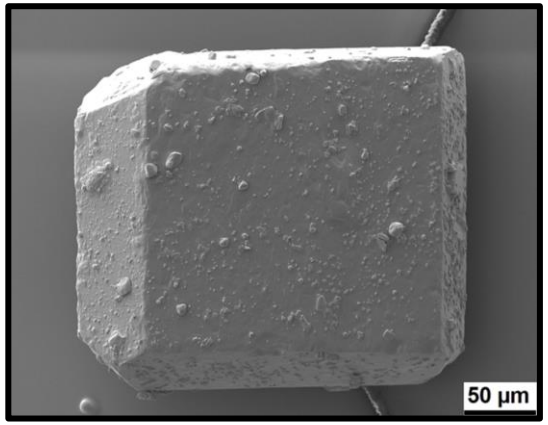
MONDELĒZ: A GLOBAL SNACKING LEADER!

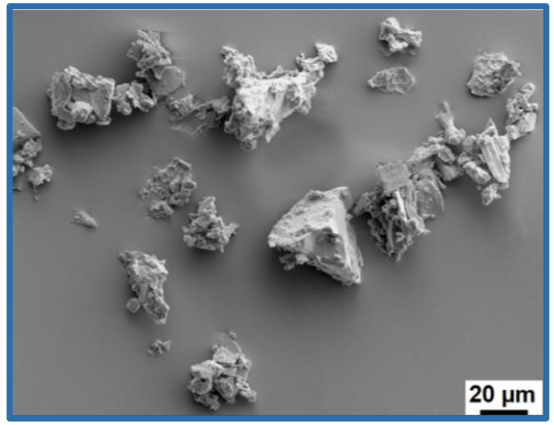
CHOCOLATE

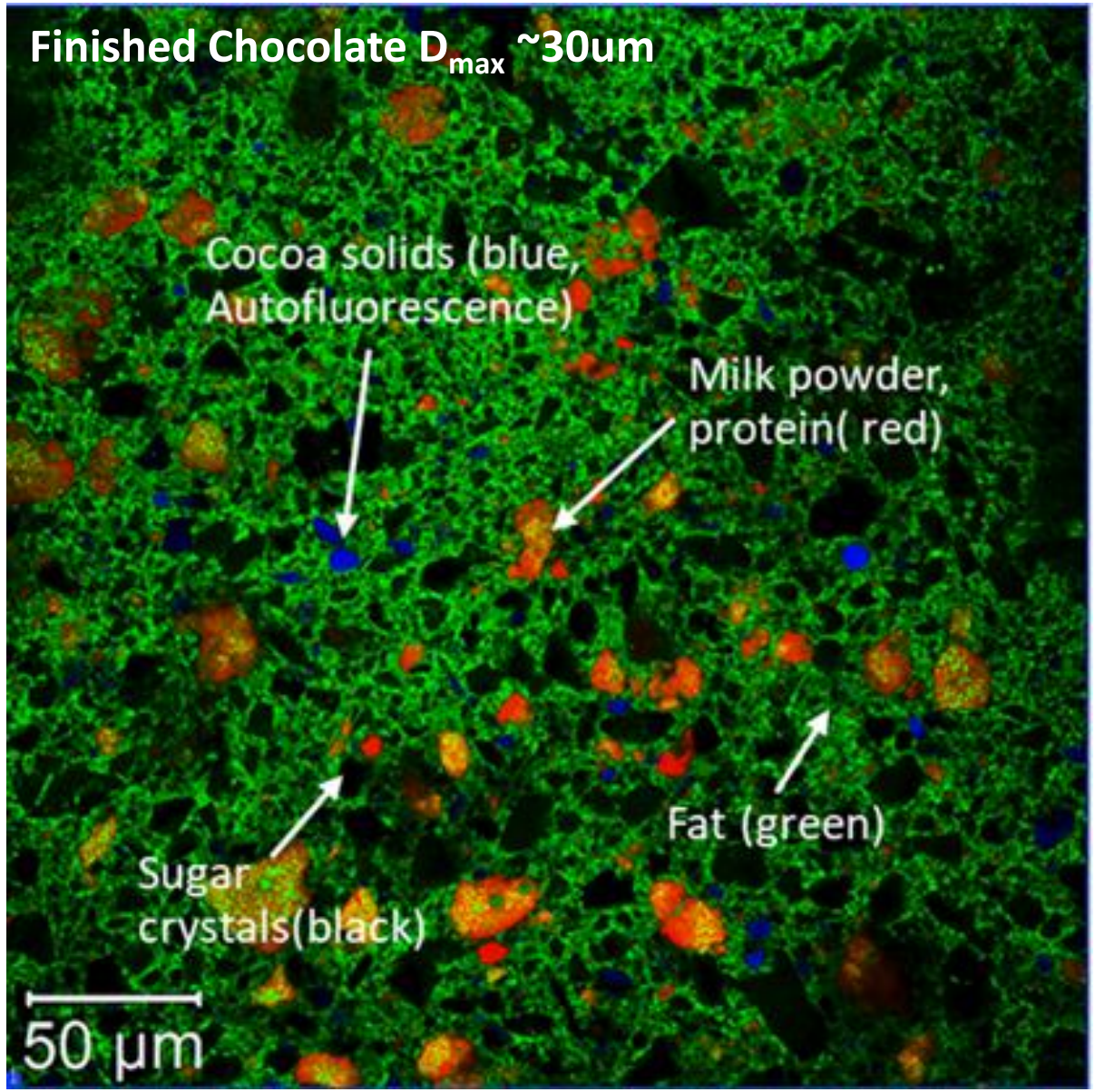
Ingredient	~ Wt %	~Vol %	Nature of particle
Sugar	75	64	Crystalline
Milk Powder			Composite: xtal and amorphous
Cocoa Powder			Amorphous
Cocoa Fat	25	36	Liquid in processing, solid in product





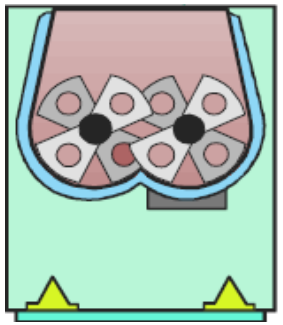






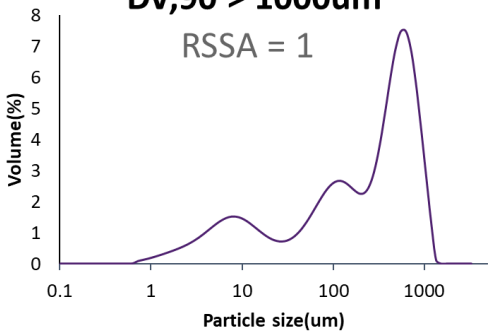
Machine schematics © Bühler AG

MIXING
Mixer/Kneader

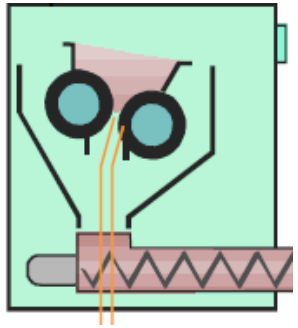


Dv,90 > 1000um

RSSA = 1

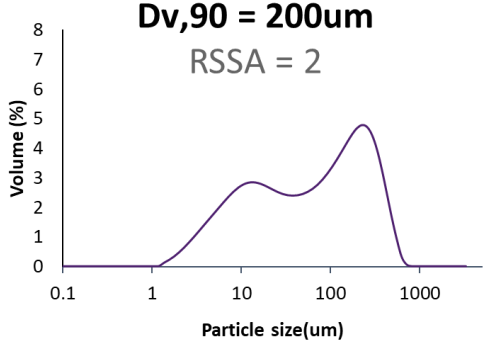


PRE-REFINING
Two-roll Press Mill

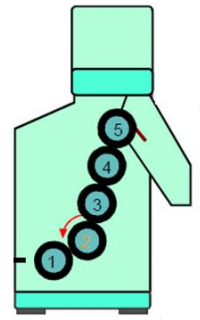


Dv,90 = 200um

RSSA = 2

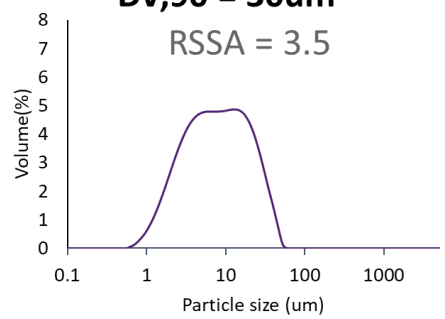


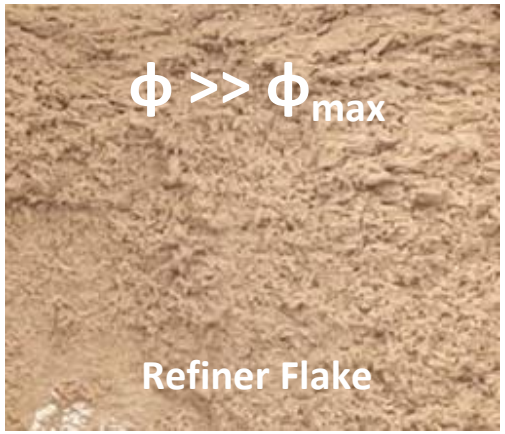
REFINING
Five-roll Press Mill



Dv,90 = 30um

RSSA = 3.5



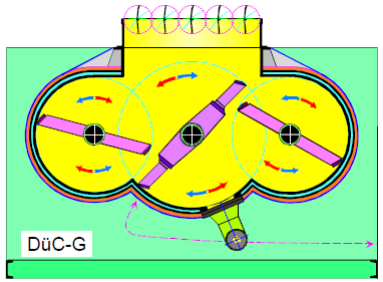


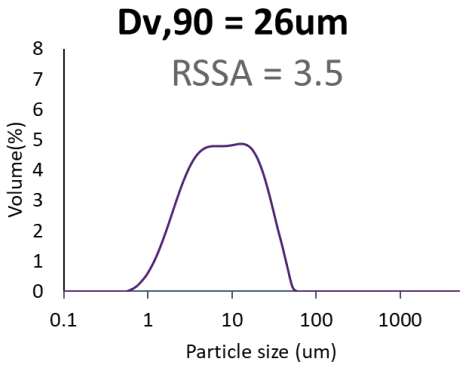
RSSA = relative specific surface area, calculated assuming spherical particles from Malvern Data

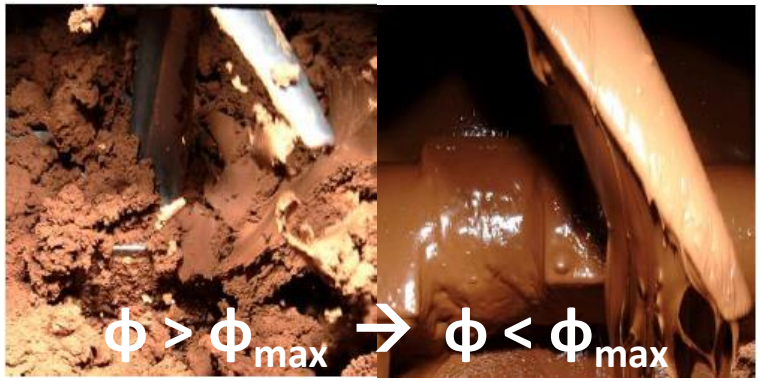
M. Orsi *et al.*, Manuscript submitted to Rheologica Acta.

Xabier Legarreta., EngD Thesis, University of Birmingham, 2018

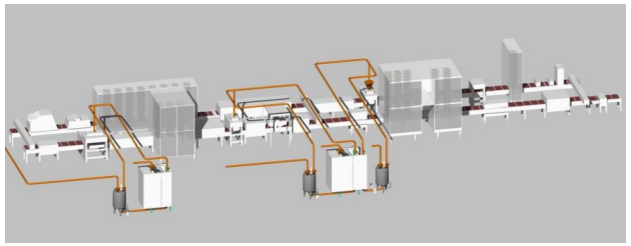
CONCHING
Kneading/Mixing

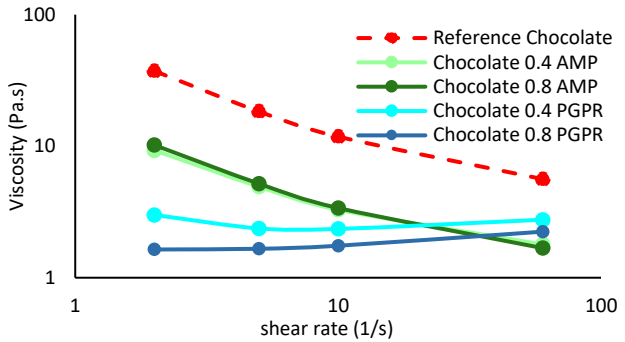




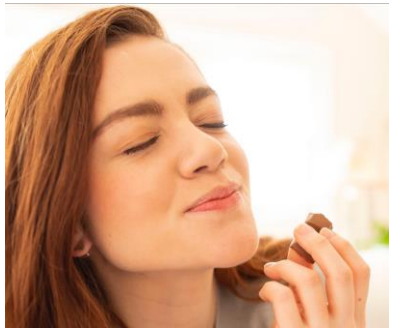


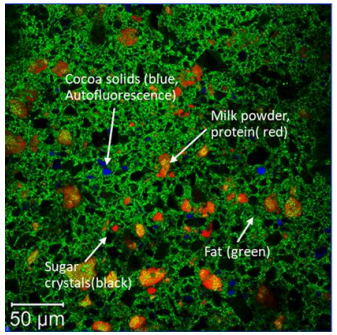
MOULDING/FORMING
Pumping/Flowing/Wetting

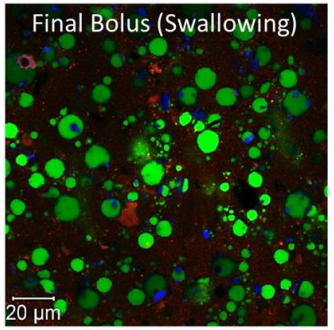




EATING
Comminution/Melting/Dissolution





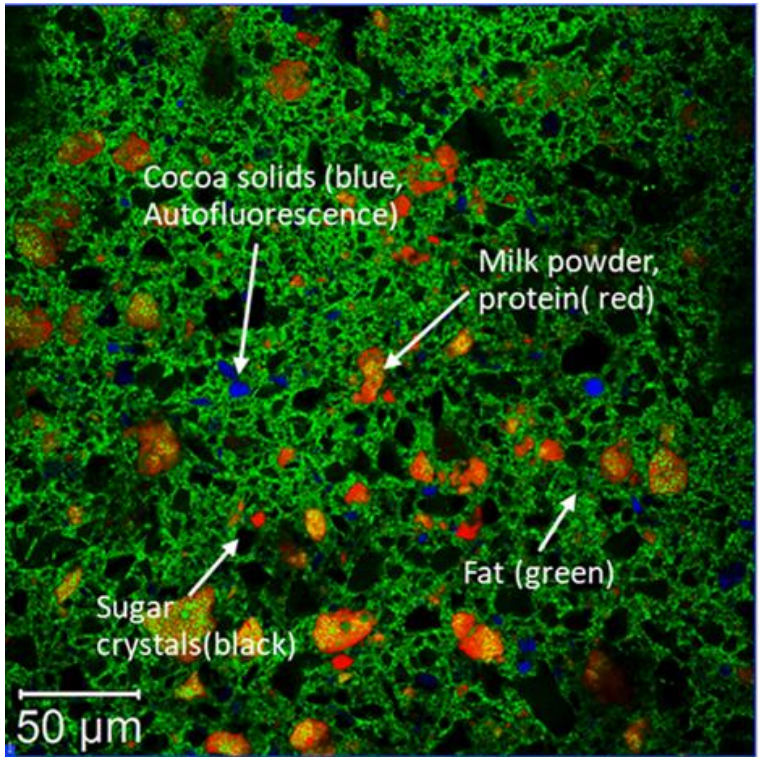


E. Blanco *et al.*, Proc. Natl. Acad. Sci. U.S.A. 116.21 (2019). doi: 10.1073/pnas.1901858116.

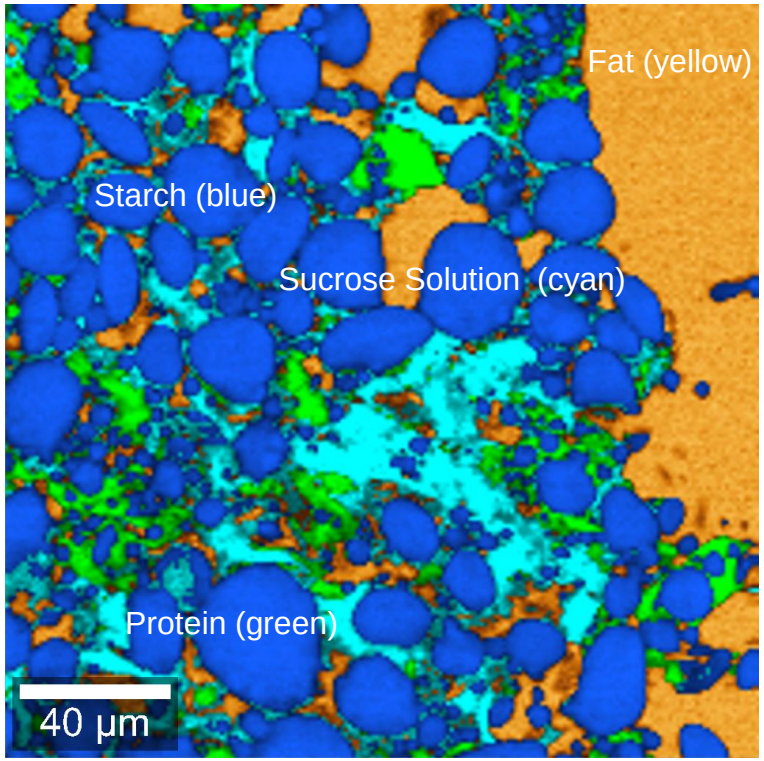
J. A. Richards *et al.*, Manuscript in preparation.

RICH WORLD OF FOOD SUSPENSIONS

Finished Chocolate



Short Sweet Biscuit Dough



Bread Dough

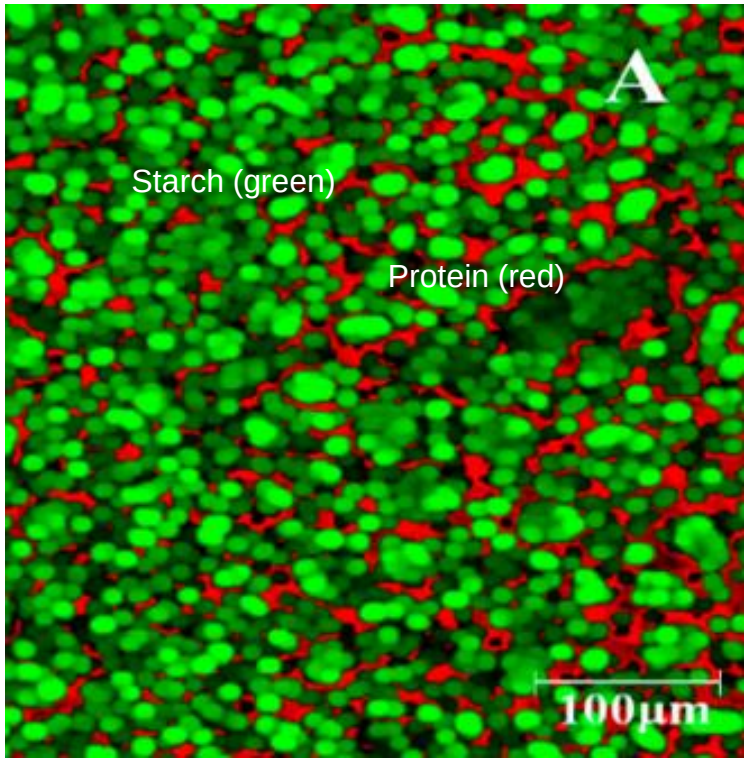


Image: D. Atudorei *et al.*, Foods 2021, 10, 1542

SUMMARY & REQUIRED KNOWLEDGE & CAPABILITIES

WET FOOD SUSPENSIONS

Complex materials, frequently processed close to, and above, their jamming limits.

"Wet" Food suspension are characterized by:

- Inhomogeneous particle populations
- Broad particle size distributions
- Diverse particle shape
- Diverse particle mechanics
- Complex, occasionally multiple, fluid phases often containing surfactants

The presence of the fluid phase introduces important forces that modify and/or act in addition to friction and adhesion between particles:

- Cohesion
- Lubrication
- Hydrodynamic

Knowledge/Capability	
Analytical	Rapid, robust methods: 1. to determine maximum packing fraction. 2. Validated and understood phenomenological tests to characterize bulk rheological and tribological properties
Quantitative Microstructural Mechanistic Understanding	Improved quantitative mechanistic understanding of how microstructural properties affect bulk behaviour.
Mathematical Models	Computationally efficient models for the bulk rheological and tribological behaviour of wet particulate systems based on their microstructural properties. • Valid across wide range of deformations and deformation rates

THANK YOU!

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