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- ☐ Poster
- ☐ 2nd year PhD student
- ✓ 3rd year PhD student

Energy-efficient superconcentration-granulation based process to manufacture dairy powders: Limiting factors

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Abstract:

Drying is crucial for valorization of high-moisture dairy products. Conventional processes comprise of vacuum-concentration (VC) followed by spray-drying (SD) to remove moisture. SD accounts for half the energy but only removes <10% of total moisture. Marked energy savings (10.7-23.5%) were reported for whey permeate (WP) by replacing SD with superconcentration (~80% w/w dry matter (DM)) and granulation (Towerless drying; PST). Energy savings were directly linked to superconcentration extent, i.e. concentration in excess of VC. This work investigated limiting factor for superconcentration and influence of composition.

Physical properties of concentrates were characterized as a function of DM. A lab-scale model was developed to simulate PST. Four dairy products were evaluated to cover range of composition.

Maximum superconcentration was linked to onset of highly cohesive (sticky) phase, wherein extreme resistance to flow was detected. Onset of cohesive phase was marked by dramatic rise in viscosity, yield-stress and cohesion. Ring-shear measurements confirmed DM range for highly cohesive phase (flowability-function <1, i.e. hardened/non-flowing state). Cohesive phase was demarcated within DM range, which was highly influenced by composition. Higher protein content resulted in earlier onset of cohesive phase (e.g. skim-milk ~62% DM), whereas higher lactose delayed onset (WP ~80% DM). Consequently, lower protein streams can be superconcentrated to higher DM compared to higher protein streams, which also reflects magnitude of energy savings achievable. Remarkably, a simple technique of measuring agitator power consumption reliably mapped the cohesive phase.

Furthermore, effective granulation was related to end of cohesive phase. Interesting reconstitution behavior was revealed as a function of composition. High lactose permeates compared favorably, whereas high protein skim and fat-filled milk powders demonstrated poor solubility.

Relevant tools and techniques were provided which can outline operating conditions for optimum performance and screen different ingredients to evaluate application of energy-efficient PST approach to enhance process sustainability and profitability.