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Steam-jet agglomeration of skim-milk powder : influence of the process parameters.

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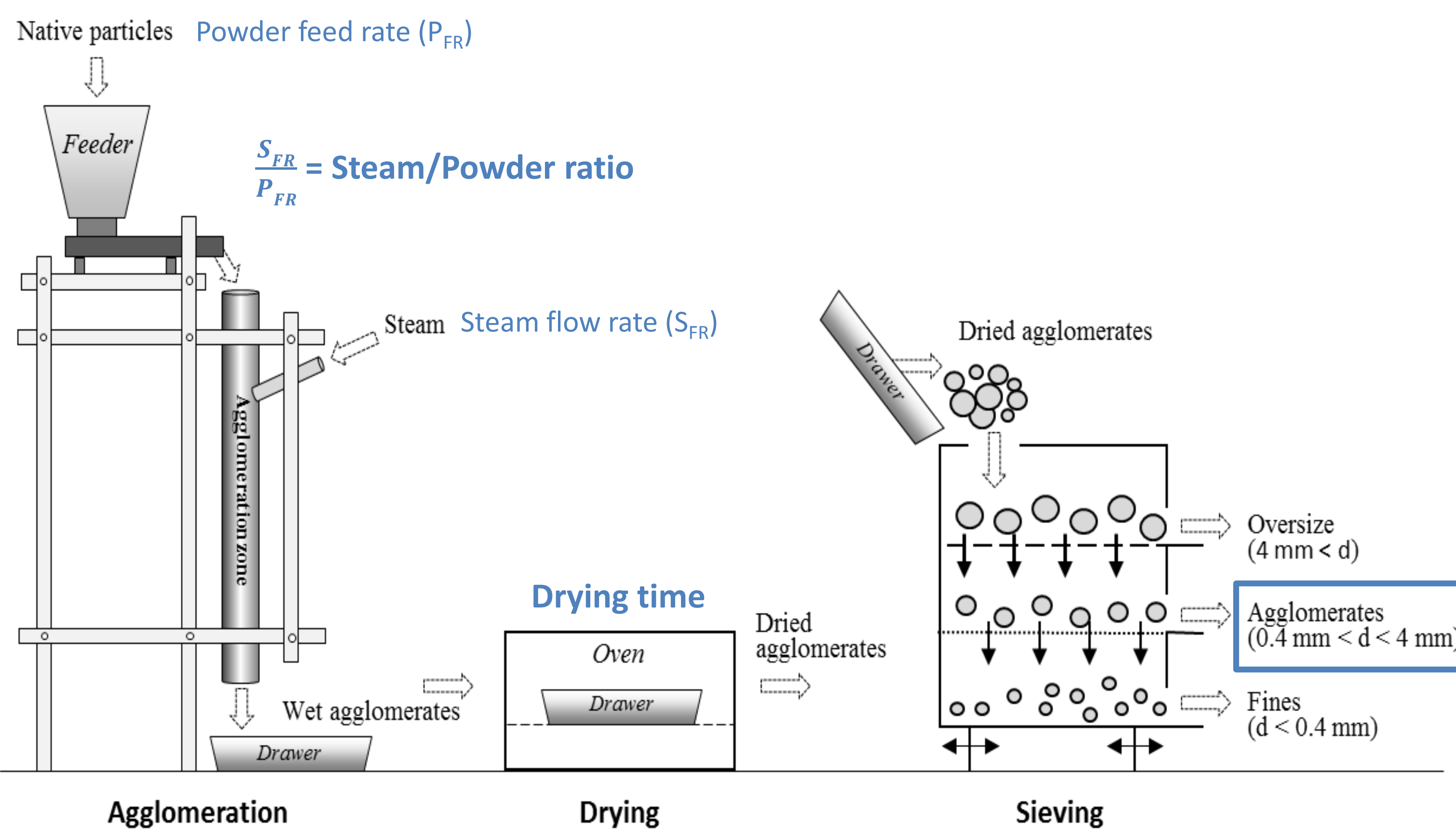
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Issue

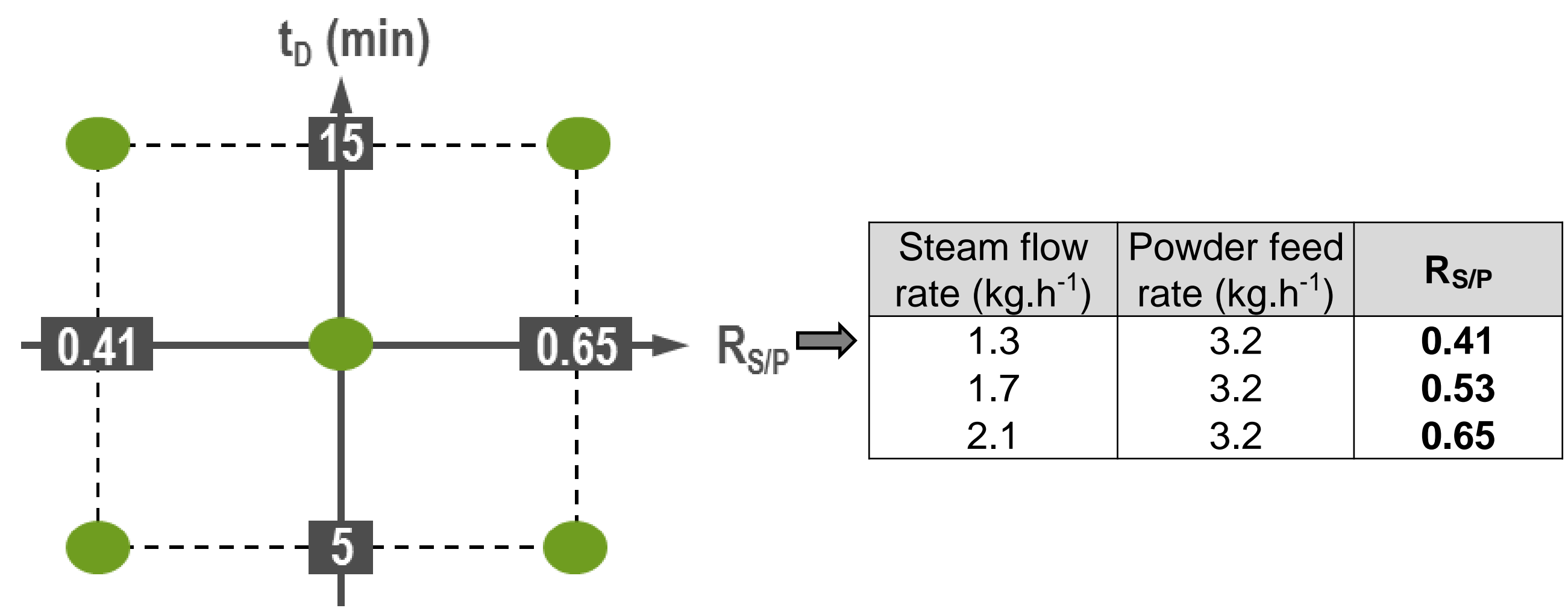
- Steam-jet agglomeration is used in the dairy industry in order to obtain **instant powders** with improved rehydration.
- Quality control of industrial products remains **experimental** and **empirical** :
 - Steam-jet agglomeration = **black box** process (closed, fast, random collisions).
 - Instant properties = **multi-factorial** causes (structure, composition, physicochemical state).
- Few scientific studies on dairy powders agglomeration and mainly performed with other technologies → **lack of knowledge**.
 - **How can we study and identify the key process parameters that should be controlled ?**

Experimental strategy

A steam-jet agglomeration pilot plant was developed :



- Two process parameters were studied : the **steam/powder ratio ($R_{S/P}$)** and the **drying time (t_D)**. One factorial design was realized in triplicate :



- Characterization** of the agglomerates : Circularity, Feret diameter, mechanical strength, water content and wetting time.
- Statistical analysis** : linear model after standardization of the data.

Results & discussions

Structure of the pilot plant agglomerates :



- Raw material (left) : Skim-milk powder
- Pilot plant agglomerate (middle) : **porous** structure, **irregular** shape
- Industrial agglomerate (right) : dense structure, spherical shape, regular surface

Influence of the process parameters :

	Circularity	Feret diameter (mm)	Mechanical strength (N)	Water content (g.100 g ⁻¹)	Wetting time (s)
↗ Steam/Powder ratio	↘	↗↗ 1	↗	↗	↗↗↗
↗ Drying time	-	-	↘↘	↘↘↘ 2	↗↗
Interaction	-	-	-	-	↗↗ 3

- Steam/Powder ratio** : more liquid bridges comes with more steam available, leading to **larger** agglomerates.
- Drying time** : increasing the drying time leads to the formation of **dry** and **brittle** agglomerates.
- Interaction** : instant properties mechanisms are complex → difficult to identify a **key process parameter** to control.

Conclusions

A steam-jet granulation pilot plant was developed during this study :

- During the agglomeration step, the steam/powder ratio controls the **extent of granulation** in the studied range of values.
- The drying step is crucial for the **storage evolution** to prevent microbial growth, caking or breakage.
- Further studies are needed to understand the **instant properties mechanisms**.

This pilot plant will allow to study :

- The **agglomeration mechanisms** → hydrotextral diagram (solid volume fraction vs water content).
- The **interactions** between the raw material properties, the process parameters and the product properties.
- The **correlations** between the agglomerates properties to understand the mechanisms of the instant properties (multivariate data analysis).

