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Improved whey permeate drying using high pressure gas/liquid dosing during spray atomisation

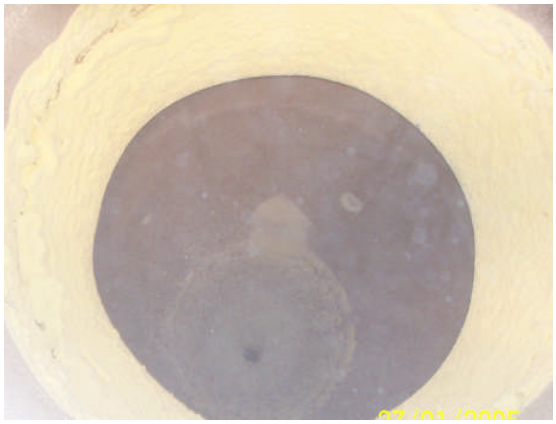

Figure 1. Deposits of whey permeate powder in the spray drier chamber

Key external stakeholders:

Irish dairy processors and whey ingredient manufacturers on behalf of their dairy farmer members

Practical implications for stakeholders:

- Modification of the feed dosage systems using high pressure gas dosing into the concentrate line to nozzle atomisers of spray driers looks promising as a means of improving permeate drying without undue deposit formation
- Such a high pressure gas/liquid dosing is uniquely installed on Moorepark's MTL Tall-form drier and may be availed of by stakeholders and clients to pursue more detailed R&D investigations
- Complementary on-site specialised analytical services such as microscopy (National Food Imaging Centre), rheology and particle size monitoring serve enable a comprehensive development programme to be pursued

Main results:

High pressure CO_2 dosing in the concentrate feed line to the spray atomiser would appear to potentially benefit whey permeate drying. It would appear that the beneficial effects may be attributable more to changes in powder physical properties rather than alteration of the glass transition states. It is recommended to that careful control of the gas dosing is exercised in order not to impact negatively on the wettability behavior of the powders

Opportunity / Benefit:

Processing conditions established during the course of the study may be used by dairy company R&D personnel in order to accomplish improved spray drying of whey permeates using novel technologies installed on the pilot plant drying facilities are Moorepark Technology Ltd. The results of such investigations would be readily scalable to industrial manufacturing scenarios.

Collaborating Institutions:

None

Contact Phil Kelly Email: phil.kelly@teagasc.ie.

Teagasc project team: Dr. Phil Kelly (PI)
Mr. Jim Kelly
External collaborators: none

1. Project background:

Global Whey production is currently expanding at an annual rate of +2%. While whey powder represents the high level of production at 2.38 Mt, its annual growth rate of +1% pales in comparison with permeate powder which is enjoying 10-20% annual expansion, albeit from a much smaller base (0.76 Mt). Permeate powder is increasingly sought for product formulation and standardisation purposes. However, it is a challenging product to dry using standard spray drier configurations because of stickiness behaviour associated with lactose transition states.

Both whey and permeate drying use broadly similar technologies. However, differences emerge at a physico-chemical level: absence of true protein in permeate makes drying more difficult, viscosity increases in concentrates (> 40%TS), while the thixotropic nature of permeate concentrates means that viscosity decreases with increasing shear. In addition, economic factors predominate since permeate is a low value by-product stream with lower TS than whey, hence the impetus is towards energy efficient processes that require as much removal of water as possible by evaporation before drying.

2. Questions addressed by the project:

- The objective of the project was to investigate whether adaptation of the feed conditions to the nozzle atomiser of a spray drier could be used to favourably influence resulting permeate powder particle formation so as to allow improved flow without undue deposit formation in the drying chamber and ancillary components e.g. cyclone, rotary valve and fluidised beds.
- The question was whether a novel high pressure gas/liquid dosing system installed on Moorepark's MTL Tall-form drier for modification of food ingredient functionality would benefit the drying of permeate feedstocks by minimising stickiness and particle adhesion within the drier chamber.

3. The experimental studies:

Spray drying of permeate concentrate containing 40% TS at 65°C was undertaken with 3 levels (0.13; 0.25; 0.50%) of high pressure CO_2 injection. The Tall-form spry drier was configured to operate with 3 spray nozzle lances with drying inlet and outlet temperatures of 185°C and 85°C, respectively. The external fluidized beds VF1 and VF2 were 65°C and 30°C, respectively. Spray drying was also conducted in both regular and agglomerated mode. By this is meant that 'regular' powder generally has poorer dissolution behavior. Agglomeration, on the other hand, exploits the recycling of fine powder particles into the spray atomization zone during drying in order to promote clustering of small semi-dry particles with large ones – the resulting 'agglomerates' facilitate improve wettability and dispersibility characteristics during subsequent powder contact with water.

Key powder properties monitored throughout the individual treatments includes Bulk Density, Particle Density and Wettability

4. Main results:

High pressure CO_2 dosing during permeate spray drying resulted in powders which were more porous (contributing to more rapid drying of powder particles) and reduced deposit formation. However, excess dosage of high pressure CO_2 tended to make powders more bulky. For this reason, judicious use of gas dosing is required in order to maintain drying with minimal deposit formation over time at the expense of small compromises in powder bulkiness.

Effects of high pressure CO_2 dosing into the concentrate feed line

- There was no visual evidence of chamber deposits/stickiness occurred during drying of permeate
  - Only slight differences in the material state of the powders as expressed by the T-Tg values (glass transition behaviour) were observed
- Flowability improvement
  - High pressure gas-injected powders were more porous, and contributed to a more rapid drying powder particles

Contact Phil Kelly Email: phil.kelly@teagasc.ie.

- Incremental changes in particle structure as a result of gas injected appeared to be more significant that particle surface characteristics

- Bulk Density
  - Excess gas injection has a potential downside as it tends to make powders more bulky, hence it is necessary to strike a balance between stickiness control and powder bulk density distortion.

Table 1. Lower levels of CO2 dosing at the lower level favours retention of desired Bulk Density and better Wettability properties

Mode	% CO_2 dosing	Bulk density (g/mL)	Wettability (sec)	
Regular powder*	0.13	0.53	17.5	optimum CO_2 dosing conditions for regular powder
	0.25	0.33	> 60	
	0.5	0.2	> 60	
Agglomerated powder	0.13	0.34	24	optimum CO_2 dosing conditions for agglomerated powder
	0.25	0.32	9	
	0.50	0.2	> 60	

* Typical bulk density of regular powder (without gas dosing): 0.76

5. Opportunity/Benefit:

Modification of the feed dosage systems to the nozzle atomisers of spray driers looks promising as a means of improving permeate drying without undue deposit formation. It appears that the more rapid drying occurring as a consequence of better particle porosity may be pivotal in influencing stickiness behaviour. The process however, requires validation at industrial scale where higher concentrate solids and different lactose crystallization conditions prevail. As a first step, it is recommended that permeate and whey concentrates prepared on industrial scale evaporators should be tested on the pilot scale Tall-form drier which uniquely incorporates the above described high pressure gas dosing system at Moorepark Technology Ltd.

6. Dissemination:

J. Kelly, P.M. Kelly, D.J. O'Callaghan & S.A. Hogan (2009) *Spray drying whey permeate*, presentation given at the 4th International Symposium on Spray Dried Dairy Products Symposium, 15-17th April, Melbourne, Australia

Popular publications:

Dairy Levy Funding Research Report 2013

7. Compiled by: Phil Kelly

Contact Phil Kelly Email: phil.kelly@teagasc.ie.