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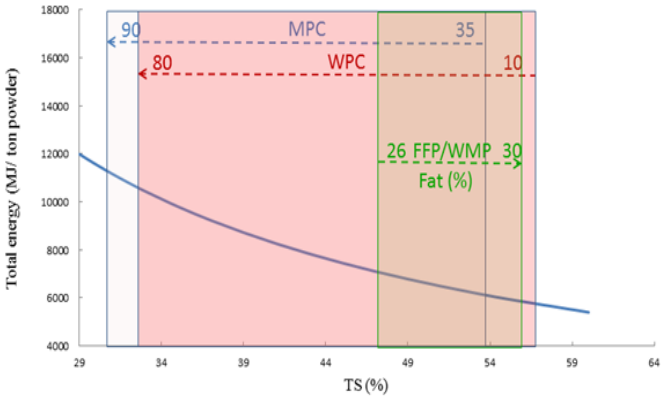
Innovation technologies to increase energy efficiency during drying of dairy protein ingredients



Key external stakeholders:

Fat-filled and skimmed milk powder producers
High protein powder manufacturers
Academic and research institutes

Practical implications for stakeholders:

- This project was a large collaboration between Teagasc Moorepark, University College Cork, University of Limerick and a number of Irish dairy industry partners, under the EI funded Dairy Processing Technology Centre (DPTC).
- Increasing the solids content of dairy protein concentrates prior to spray drying has a number of significant benefits, particularly from an energy efficiency perspective, but is often underlined by an increase in viscosity which can result in plant fouling, blockages and increased cleaning cycles.
- To be able to increase the solids content of dairy concentrates prior to drying, while minimising processing issues, would allow for a significant increase in energy efficiency and reduction in cleaning /downtime costs.

Main results:

The key results from the work performed at Teagasc were:

- Dairy concentrate viscosity can be predicted based on heat treatment, protein standardization media and solids content, allowing for informed decisions to be made during evaporation.
- High turbulence/shear can reduce viscosity of protein concentrates during high temperature heat treatment.

Opportunity / Benefit:

The data is available to all industry partners categorized under product type and can be used as for future applied research in the dairy industry. Also, a number of peer-reviewed papers were published in scientific journals for public dissemination (See dissemination section).

Collaborating Institutions:

University College Cork, Ireland (UCC) (DPTC)
University of Limerick (UL) (DPTC)

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1. Project background:

Dairy protein ingredients such as skim milk powder (SMP), whey protein concentrates (WPC) / isolates (WPI), milk protein concentrates (MPC), fat-filled and whole milk (WMP) powders, are among the most widely produced and commercially important commodities, used across a wide range of food applications. Such products are generally produced by heat treatment, homogenization, evaporation and spray drying, with the entire process having significant energy usage. However, spray-drying remains the most energy intensive and widely used technology in the dairy industry, with energy consumption of the spray-dryer (4 MJ/kg removed water) significantly higher than that of the evaporator (0.3 MJ/ kg removed water). Therefore, increasing the total solids (TS) content of product prior to drying, while maintaining relatively low viscosity can improve process efficiency. Furthermore, heat treatment which is carried out to decrease the microbial load, increase heat stability and assists in achieving the desired functional properties of the final ingredients, results in whey protein denaturation/aggregation leading to increased viscosity of the concentrates. This limits achievable TS, and might cause gelation of these concentrates prior to spray-drying or cause significant fouling at the spray-drying nozzles.
The aim of this project was to improve the efficiency of spray drying by improving evaporation conditions to ensure higher TS are supplied to the dryer, while controlling viscosity and minimizing fouling issues. The research was also focused on a achieving a better understanding of processing areas such as heat treatment, protein standardization, evaporation, homogenization, membrane filtration and other novel technologies.

2. Questions addressed by the project:

- What are the factors that limit processing of dairy protein concentrates?
- Is there in-process factors that may help reduce fouling during evaporation/concentration processes?
- Can viscosity of dairy protein products be predicted based on thermal heat treatment and solids content, and can viscosity be reduced?

3. The experimental studies:

- Assess heat treatment, evaporation, homogenization and spray drying parameters, and the effects of each on product functionality.
- Evaluate the effect of proteins, lactose and mineral interactions during processing.
- Apply novel technologies such as reverse osmosis, cavitation, hydrolysis, etc. to achieve lower viscosity during milk protein concentration.
- Design a software model for assessing whey protein nitrogen index based on processing temperatures.

4. Main results:

(Results below are only those performed at Teagasc):

- Protein standardization media and heat treatment significantly affects viscosity and physicochemical properties of skim milk concentrate.
- The viscosity and heat coagulation properties of milk protein concentrate are influenced by pH and heat treatment.
- Changes in milk protein concentrate viscosity during and after thermal heat treatment were

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successfully predicted using kinetic data

- Hydrodynamic cavitation can create heat stable whey protein ingredients; however, its commercial scale application remains a challenge.
- Energy usage was reduced during the concentration of skim milk using a combination of microfiltration, reverse osmosis and evaporation.
- Whey protein nitrogen index values of skim milk were successfully predicted using modeling software, across an unlimited number of heat treatment steps.

5. Opportunity/Benefit:

Across all collaborating institutes a significant number of confidential reports were issued to industry partners as listed below:

- Total reports issued: 55
- General reports issued: 20
- Industrial site visits: 43

The reports circulated to the industry partners have allowed for confidential uptake of the results and information that was generated throughout the lifetime of the project.

6. Dissemination:

Main publications:

- Drapala, K.P., Murphy, K.M., Ho, Q.T., Crowley, S.V., Mulcahy, S., McCarthy, N.A., O'Mahony, J.A., (2018). Short communication: Multi-component interactions causing solidification during industrial-scale manufacture of pre-crystallized acid whey powders. Journal of Dairy Science, 101, 10743-10749.
- Murphy, K.M., Ho, Q.T., Drapala, K.P., Keena G.M., Fenelon, M.A., O'Mahony, J.A., McCarthy, N.A. (2018). Influence of protein standardisation media and heat treatment on viscosity and related physicochemical properties of skim milk concentrate. International Dairy Journal, 81, 143-148.
- Ho, Q.T., Murphy, K.M., Drapala, K.P., Fenelon, M.A., O'Mahony, J.A., Tobin, J.T., McCarthy, N.A. (2019). Modelling the changes in viscosity during thermal treatment of milk protein concentrate using kinetic data. Journal of Food Engineering, 246, 179-191.
- Ho, Q.T., Murphy, K.M., Drapala, K.P., O'Callaghan, T.F., Fenelon, M.A., O'Mahony, J.A., McCarthy, N.A. (2018). Effect of pH and heat treatment on viscosity and heat coagulation properties of milk protein concentrate. International Dairy Journal, 85, 219-224.

Popular publications:

Conference presentations

- Innovative technology to increase energy efficiency during drying of protein ingredients - Poster- DPTC Knowledge Day March 2017.
- The influence of protein standardisation and heat treatment on the rheological properties of skim milk concentrate - Poster- 10th Nizo Dairy Conference, 01-03 October, 2017, Papendal, The Netherlands.
- Physicochemical properties of whey protein enzymatic hydrolysates generated at 5 and 50□C - Presentation-10th Nizo Dairy Conference, 01-03 October, 2017, Papendal, The Netherlands.
- Modelling heat-induced viscosity of milk protein concentrate using kinetic data – Poster -ISFRS Conference in Zurich, 17-20, June, 2019.

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