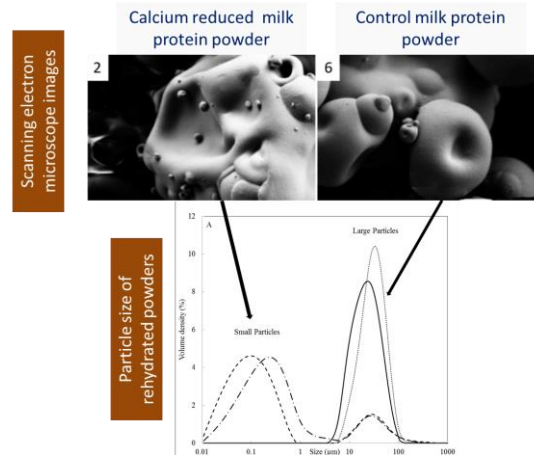


**Project number:** 6714  
**Funding source:** Teagasc

**Date:** July 2020  
**Project dates:** Oct 2015 – Nov 2019

# Influence of calcium chelation and protein enzymatic modification on the hydration characteristics of high protein dairy powders



## Key external stakeholders:

High protein powder producers  
 Infant and nutritional milk manufacturers  
 Academic and research institutes

## Practical implications for stakeholders:

- Milk protein concentrate (MPC) powders have numerous commercial applications and are integral ingredients in high quality functional dairy products and beverages. However, such high protein dairy powders pose significant technical challenges during processing and rehydration, due to high viscosity and poor powder particle dissolution, respectively.
- The objective of this research was to investigate the impact of depleting calcium in micellar casein systems after either enzymatic dephosphorylation or enzymatic crosslinking and to examine viscosity, particle size,  $\zeta$ -potential and colour of the protein solutions and subsequent rehydration properties of these spray dried systems. Calcium depletion was achieved through either addition of a chelating salt (sodium hexametaphosphate; SHMP) or through ion exchange.
- The outcomes of this research have applications in the formulation of MPC powders with improved dissolution properties, reduced viscosity and in the production of dairy products with altered mineral contents.

## Main results:

This project has highlighted that there is a significant advantage to depleting calcium levels in micellar casein systems with the aim of improving powder solubility and that enzymatic crosslinking can help reduce in-process fouling during manufacture by maintaining relatively low visco-elastic properties.

## Opportunity / Benefit:

The results of this research can be accessed through peer-reviewed publications allowing primary MPC manufacturers and end-users such as infant formula and medical nutritional companies to make informed decisions relative to the physical properties of their high protein ingredients.

Also a number of new methodologies have been employed during the course of this project to characterize the behavior of high protein powders. These methods may be useful for industry partners that are interested in gaining additional insights and knowledge on their own specific protein powders.

From an academic point of view the project has contributed to the on-going research field of casein micelle structure and stability which is integral to the processing of dairy protein streams.

## Collaborating Institutions:

University College Cork, Ireland

**Teagasc project team:** Dr. Noel McCarthy (PI)  
Dr. Mark Fenelon  
Orla Power (Walsh Scholar)

**External collaborators:** Dr. Seamus O'Mahony (UCC)

---

### 1. Project background:

Rehydration of high protein dairy-based powders is a time consuming process and is significantly affected by several parameters, such as the heat-treatment of the skim milk, protein and mineral content, spray drying temperatures, storage conditions of the subsequent powder (i.e., time and temperature) and the rehydration process (i.e., temperature of reconstitution and mixing conditions).

---

### 2. Questions addressed by the project:

- Could milk protein powder solubility be improved through the use of calcium chelation using phosphate salts or ion exchange?
- What effect does calcium chelation have on protein solution viscosity?
- Could enzymatic crosslinking of protein molecules maintain casein micelle structure and retain low solution viscosity during calcium chelation?
- What role do the phosphoserine groups play in micelle hydration and viscosity?

---

### 3. The experimental studies:

- Dephosphorylation of caseins in milk protein concentrate alters their interactions with sodium hexametaphosphate
- Influence of sodium hexametaphosphate addition on the functional properties of milk protein concentrate dispersions containing transglutaminase cross-linked proteins
- Water sorption and hydration properties of high protein milk powders are influenced by enzymatic crosslinking and calcium chelation
- Calcium depletion using ion-exchange influences the physical properties of milk protein concentrates containing enzymatically crosslinked caseins
- Calcium reduction using ion-exchange alters the rehydration and thermal stability properties of milk protein concentrate powders

---

### 4. Main results:

- Examined collectively, the studies conducted in this project have developed and applied novel methods, generating new insights to improve the rehydration characteristics of MPC powders, while controlling associated increases in viscosity. Enzymatic crosslinking of MPC dispersions proved a useful method to reduce dispersion viscosity and to retain dispersion turbidity in the presence of a strong calcium chelator.
- MPC powders produced from crosslinked casein protein dispersions had improved water sorption and rehydration characteristics, addressing a key challenge of MPC application as a value-added ingredient. Both calcium ion exchange and calcium chelation proved effective in reducing the calcium content, while it was demonstrated that ion exchange resulted in significant increases in viscosity in extensively calcium depleted crosslinked casein protein dispersions. Relatively few studies have focused on a combined approach of concurrently altering both the casein micelle structure and mineral profile of MPC powders.

---

### 5. Opportunity/Benefit:

The outcomes of this research have applications in the formulation of MPC powders with improved dissolution properties, reduced viscosity and in the production of dairy products with altered mineral profiles.

---

## 6. Dissemination:

### Main publications:

- Power, O. M., Fenelon, M. A., O'Mahony, J. A., & McCarthy, N. A. (2019). Dephosphorylation of caseins in milk protein concentrate alters their interactions with sodium hexametaphosphate. *Food Chemistry*, 271, 136-141.
- Power, O. M., Fenelon, M. A., O'Mahony, J. A., & McCarthy, N. A. (2020). Influence of sodium hexametaphosphate addition on the functional properties of milk protein concentrate dispersions containing transglutaminase cross-linked proteins. *International Journal of Dairy Technology*, 104, 104641.
- Power, O. M., Maidannyk, V., McSweeney, D. J., Fenelon, M. A., O'Mahony, J. A., & McCarthy, N. A. (2020). Water sorption and hydration properties of high protein milk powders are influenced by enzymatic crosslinking and calcium chelation. *Powder Technology*, 364, 680-688.
- McCarthy, N. A., Power, O., Wijayanti, H. B., Kelly, P. M., Mao, L., & Fenelon, M. A. (2017). Effects of calcium chelating agents on the solubility of milk protein concentrate. *International Journal of Dairy Technology*, 70(3), 415-423.

### Popular publications:

#### Oral presentations

- International Dairy Federation (IDF) Conference, Teagasc Ashtown, Co. Dublin (2018)
- Society of Dairy Technology (SDT) Conference, University College Cork, Co. Cork (2018)
- Marie Curie Cork Discovers Culture Night, Co. Cork (2019)
- 46th Annual Walsh Fellow Seminar Food Chemistry heat, Teagasc, Ashtown, Co. Dublin (2019)- awarded Best Presentation
- 46th Annual Walsh Fellow Seminar Final, Teagasc Johnstown Castle, Co. Wexford (2019)- awarded Institute of Food Science and Technology of Irelands (IFSTI) award for best overall food science and technology presentation
- International dairy Federation (IDF) conference, University College Cork, Co. Cork (2019)

#### Poster presentations

- International dairy Federation (IDF) world dairy summit in Rotterdam (2016)
- International dairy Federation (IDF) world dairy summit in Belfast (2017)
- Society of Dairy Technology (SDT) Conference, in University College Cork, Co. Cork (2018)

---

## 7. Compiled by: Dr Noel McCarthy

---