

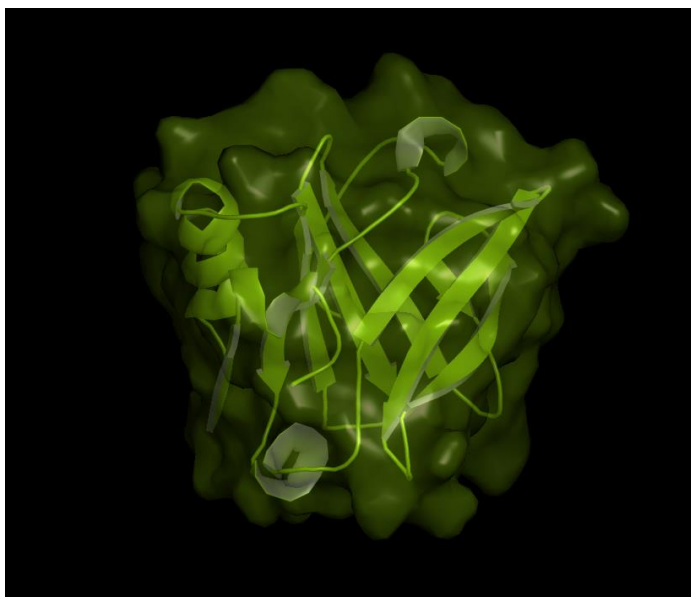
**Project number:** 6290

**Funding source:** Department of Agriculture,  
Food and The Marine

**Date:** Jan 2018

**Project dates:** Dec 2011- Nov 2016

## Whey Protein Functionality in Beverages



### Key external stakeholders:

Dairy ingredient manufacturers, Lifestyle beverage manufacturers including infant formula & sports nutrition

### Practical implications for stakeholders:

Whey proteins are increasingly used in the formulation of nutritional beverages such as infant formula and sports nutrition products due to their wide range of functionalities and high biological value. However, due to their heat sensitivity, their use can create processing and stability challenges, such as fouling on heat exchangers or phase separation and gelation, respectively.

- Pre-heating whey proteins can improve the viscosity and heat stability of nutritional beverages that contain whey proteins

### Main results:

- Pre-heating whey proteins can have a profound effect on their subsequent heat stability.
- Small amounts of calcium can have a negative effect on the heat stability.
- The aggregation of whey proteins is more influential than denaturation in determining viscosity development during the heat-treatment of IMF.

### Opportunity/Benefit:

This project helps to understand process-induced changes in the interaction of ingredients, which can improve processing efficiency and product stability.

### Collaborating Institutions:

UCC

**Teagasc project team:** Dr André Brodkorb (PI)  
Dr Mark Fenelon

**External collaborators:** Dr Seamus O'Mahony, UCC

### 1. Project background:

During the last two decades, whey protein products have become major commodity products for Irish ingredient manufacturers. Providing customers with exact product properties regarding stability and processability in complex food products can be a major competitive advantage. However, unlike caseins, whey proteins are inherently instable with regard to processing stresses (e.g. pH, salt, shear). Minor inconsistencies in the product characteristics (e.g. mineral content, degree of denaturation or pH) can also be challenging during subsequent incorporation in complex food matrices, such as infant formula, causing the uncontrolled denaturation, aggregation (mainly with caseins) and destabilisation of the food product.

### 2. Questions addressed by the project:

- Process-induced improvements in the heat stability and viscosity of beverages containing whey proteins
- Understanding of how and why whey proteins can be stabilised by pre-heat treatment

### 3. Experimental studies:

There are some known approaches to minimise whey protein instability when heated in formulated products. For example, nutritional beverage manufacturers require protein-based ingredients that have been heat treated under controlled conditions prior to use. This thermal pre-treatment of whey proteins causes partial denaturation and controlled self-aggregation. The surface characteristics and reactivity of the proteins/protein particles change, which in turn reduces their affinity to associate with casein and themselves. This study used a systematic approach to minimise the loss of stability in nutritional formulations due to excessive whey protein aggregation and identify key controlling factors for high viscosity developments. It used both lab and pilot-scale heating treatment of whey protein products in the absence and presence of caseins and additional minerals. In addition, the effect of heat-treatment on the *in vitro* digestive behaviour was investigated.

### 4. Main results:

- The outcome of this project demonstrated the profound effect of pre-heating on the heat-stability of whey proteins in whey protein isolates. Heating times of 1-2 min at 75 to 105°C can increase the heat coagulation time at 120°C by up to three times.
- Small amounts of calcium have a negative effect on the heat stability.
- Results showed that the aggregation of whey proteins is more influential than denaturation in determining viscosity development during HTST treatment of IMF.
- Heat-induced unfolding and aggregation of whey proteins in WPI accelerates the *in vitro* digestion of both  $\beta$ -lactoglobulin and  $\alpha$ -lactalbumin.

### 5. Opportunity/Benefit:

The primary stakeholders for this research are manufacturers of nutritional beverages containing whey proteins. The study has demonstrated that pre-heating whey proteins causes unfolding and subsequent aggregation. It is however the aggregation which is responsible for the stabilisation of the formulation containing whey proteins. It was also shown that relatively short heating times can be beneficial for stabilising the protein product.

### 6. Dissemination:

#### Main peer-reviewed publications:

- Joyce, A. M., Brodkorb, A., Kelly, A. L., & O'Mahony, J. A. (2017). Separation of the effects of denaturation and aggregation on whey-casein protein interactions during the manufacture of a model infant formula. *Dairy Science & Technology*, 96, 787-806. doi:10.1007/s13594-016-0303-4
- Joyce, A. M., Kelly, A. L., & O'Mahony, J. A. (2018). Controlling denaturation and aggregation of whey proteins during thermal processing by modifying temperature and calcium concentration. *International Journal of Dairy Technology*, 71(2), 446-453. doi:10.1111/1471-0307.12507
- Brodkorb, A., Croguennec, T., Bouhallab, S., & Kehoe, J. J. (2016). Heat-Induced Denaturation, Aggregation and Gelation of Whey Proteins. In P. L. H. McSweeney & J. A. O'Mahony (Eds.), *Advanced Dairy*

Chemistry (Vol. Volume 1B: Proteins: Applied Aspects, pp. 155-178): Springer New York.

Buggy, A. K., McManus, J. J., Brodkorb, A., Hogan, S. A., & Fenelon, M. A. (2018). Pilot-scale formation of whey protein aggregates determine the stability of heat-treated whey protein solutions—Effect of pH and protein concentration. *Journal of Dairy Science*, 101(12), 10819-10830. doi:10.3168/jds.2017-14177

**Publications / abstracts including those presented at conferences:**

Kanniganti, S.K., M.A. Fenelon, J.A. O'Mahony and A. Brodkorb. Effect of pilot scale heat treatment on the structural and functional stability of whey proteins; Oral presentation at the 43<sup>rd</sup> Annual Food Research Conference on the 10-11 December 2014 hosted by UCD.

Joyce, A.M. Understanding and controlling whey protein denaturation and aggregation during thermal processing. Oral presentation at the UCC/Dairygold Research Communication Day held in University College Cork on the 15th October 2014.

Joyce, A.M., Alan L. Kelly, André Brodkorb and James A. O'Mahony 'Pre-denaturation/aggregation of whey proteins to optimise their physico-chemical functionality in infant nutritional products' presented at the 44th Annual Food Research Conference on the 14th December 2015 held in Teagasc, Moorepark, Fermoy, Co. Cork.

O'Mahony, J.A. , oral presentation at the International Dairy Federation (IDF) 6th International Symposium of Dairy Dried Products (SDDP), Dublin, 11-13th April 2016, entitled 'Separation of the effects of denaturation and aggregation on whey-casein protein interactions during the manufacture of a model infant formula'.

O'Mahony, J. A. Oral presentation at the 19th Dairy Ingredients Symposium, Cal Poly, California, 22-23rd February, 2017 entitled, 'Perspectives on current and future protein ingredients for infant nutritional product formulation'.

Brodkorb, A., Sandeep K. Kanniganti, Aoife Buggy, Seamus A. O'Mahony, Ken H. Mok, Ji Y. Kim and Mark A. Fenelon Oral presentation at the 10th NIZO Dairy Conference, 01- 03 October 2017, Papendal, The Netherlands "Stability of whey protein isolate during lab and pilot scale heat treatment"

**7. Compiled by:** Dr André Brodkorb