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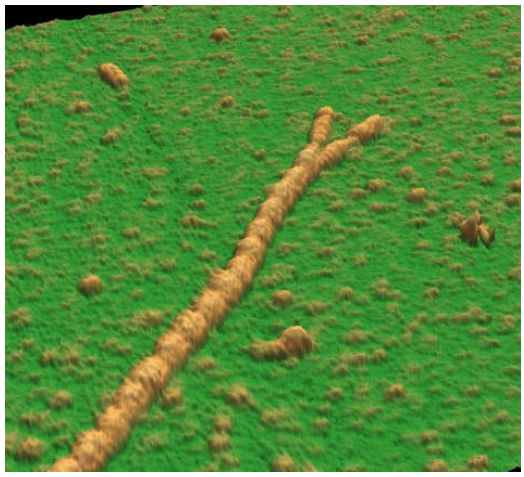
Properties of nano-fibrillar whey proteins



Key external stakeholders:

Dairy Industry
Food and Ingredient Manufacturers
Biotechnology companies
Academic Institutions

Practical implications for stakeholders:

The main objective was to produce fibrillar whey proteins at the nano-scale and assess their potential as functional ingredients. Main outcomes included:

- Optimised conditions for producing stable nanofibrillar whey proteins
- Nanotechnology expertise in characterising the structure and formation mechanism of fibrillar proteins
- Shown that nanofibrils can be used to create low salt gels, foams and biofilms
- Development of nano-fibrils into a spray dried ingredient
- Established a research platform of expertise in food nanotechnology

Main results:

Mechanism for forming nanofibrillar whey proteins has been established.
Functionality of the nanofibrils has been assessed
Spray dried nanofibrils have been produced
New atomic force microscopy expertise has been gained

Opportunity / Benefit:

This has established Ireland's first food nanotechnology platform based on nano-engineering food structures. Whey-based nanofibrils have unique functionality, in particular they are excellent foaming agents that can be used to replace more expensive ingredients such as egg-white. In addition, nanofibrils can be used as texturing agents in food products, for example to produce low-salt gels.

Collaborating Institutions:

Materials and Surface Science Institute, University of Limerick
Institute of Food Research, Norwich
Wageningen University

Contact Mark Auty Email: mark.auty@teagasc.ie

Teagasc project team: Dr. Mark Auty (PI)
Dr. Lizhe Wang
Ms Daniela Oboroceanu
Dr Andre Broskorb

External collaborators: Prof Edmond Magner, MSSI, UL.
Prof Vic Morris, IFR, Norwich
Dr Paul Venema, Food Biophysics, University of Wageningen

1. Project background:

Recent research has demonstrated that many globular food proteins, including bovine whey proteins such as β-lactoglobulin, can self-assemble into fibrils ("nano-fibrils") at high temperature and low pH. Nano-fibrils typically have a thickness of 2 - 5nm and are highly poly-disperse with lengths up to 15 μm. Whey, a major by-product of cheese processing, represents an indigenous source of these novel food structuring agents. The potential of these nano-fibrillar assemblies as functional ingredients in foods has yet to be exploited.

2. Questions addressed by the project:

The objectives of this project are to optimize conditions for nano-fibril assembly and to investigate their stability and potential as food ingredients. This research will also establish a new food nanotechnology platform, enabling development of new scientific techniques, novel food structures and functional ingredients at the nano-scale.

3. The experimental studies:

The project comprised these key tasks:

- Elucidate mechanism of formation and determine nano-fibril stability.
- Characterization of nano-fibril microstructure and length distribution.
- Preparation and characterization of nano-fibrillar hydrogels.
- Functional properties (foaming, gelling, emulsification) of nano-fibrils as potential food ingredients.

4. Main results:

- The optimal conditions for nano-fibrillar production from β-lactoglobulin or WPI and potential scale-up are now established: pH 2.0, 80 ^{o}C/60min.
- β-lactoglobulin forms much longer fibrils (> 15 μm long, 3 nm thick) compared to other food proteins.
- Whey protein isolate (WPI) or concentrate (WPC) can equally be used to generate nano-fibrils: purified BLG is not necessary**.**
- Unique atomic force microscopy expertise is now established in Teagasc.
- Technology transfer - Nano-fibril length characterization by flow birefringence (Wageningen University).
- Effect of high pressure processing on nano-fibril length characterised.
- Weak gels can be formed at lower protein concentrations (< 5 %) when using fibrillar whey proteins compared to non-fibrillar counterparts.
- Both freeze- and spray dried nano-fibrillar powders were produced; rehydration confirmed the presence of intact nano-fibrils.
- Nano-fibrils are effective foaming agents and produce more stable foams than non-fibrillar protein or egg white (ovalbumen).
- Microfluidization of nano-fibrils enhances foaming capacity significantly.
- Multi-lamellar films comprising sodium alginate, sodium caseinate and calcium chloride were prepared and overlaid with WPI nanofibrillar films.

5. Opportunity/Benefit:

Whey protein in the form of nano-fibrils < 5 nm thick, have unique functional properties. In particular nano-fibrils can be used to 1) form low-salt food gels and 2) produce food foams.

6. Dissemination:

Presentations

- Auty, M.A.E., Wang, L., Oboroceanu, D. and Brodkorb, A. (Invited presentation). Characterization of Nanofibrillar Whey Proteins by Atomic Force Microscopy. Asylum Research UK Forum. St. Johns

Contact Mark Auty Email: mark.auty@teagasc.ie

College, Oxford, 16 April 2007.

- Wang, L., Oboroceanu, D. and Auty, M.A.E. 2008. Characterisation of nanofibrillar assembly of beta-lactoglobulin. 14th World Congress of Food Science & Technology, Shanghai, China October 19 – 23.
- Wang, L., Oboroceanu, D.,Nijboer, A., Brodkorb, A., Magner, E., Venema, P. & Auty, M.A.E. 2009. Nano-fibrillar milk protein assemblies as precursors to novel food structures,IDF World Summit, Berlin 20 – 24 September 2009.
- Auty, M.A.E. (Invited Presentation). Food Structure Research, 5th Council Meeting of Chinese Association of Animal Product Processing Research. Nanjing, China, 24 October 2008.
- Auty, M.A.E. (Invited Presentation). Food Microstructure Research. Key Laboratory for Dairy Science, Harbin, China, 27 October 2008.
- Auty, M.A.E. (Invited Presentation). Agro-Food Structure Research. Institute of Quality Standards & Testing Technology for Agro-Products, Beijing. 31 October 2008.
- Auty, M.A.E. (Invited keynote speaker) A review of the latest imaging techniques for characterizing food structure in "Emerging Imaging Techniques" session at IDF Dairy Microstructure Symposium, Tromso, Norway, 11 June 2010.

Main publications:

Publications

- Oboroceanu, D., Wang, L., Brodkorb, A., Magner, E., Auty, M.A.E. 2010. Characterization of β-lactoglobulin fibrillar assembly using atomic force microscopy, polyacrylamide gel electrophoresis and in situ Fourier transform infrared spectroscopy. *Journal of Agricultural and Food Chemistry*, *58:* 3667–3673.
- Oboroceanu, D., Wang, L., Kroes-Nijboer, A., Brodkorb, A., Venema, P., Magner, E. & Auty, M.A.E. 2011. The effect of high pressure microfluidization on the structure and length distribution of whey protein fibrils. *International Dairy Journal*, **21:** 823 – 830.
- Oboroceanu, D., Wang, L., Magner, E. & Auty, M.A.E. 2014. Fibrillization of whey proteins improves foaming capacity and foam stability at low protein concentrations. *Journal of Food Engineering*. **121**: 102 – 111.

Popular publications:

7. Compiled by: Mark A.E. Auty

Contact Mark Auty Email: mark.auty@teagasc.ie