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Cheese 2030 – new technology platform

Key external stakeholders:

Manufacturers of cheese and milk protein ingredients

Practical implications for stakeholders:

A novel SMART cheese technology platform has been developed for the manufacture of specialised protein powders and recipes for converting these into cheeses with different functional properties. Key features of the technology include:

- cheesemaking process without whey release in cast cheeses or limited whey release in structured cheese (e.g., ~ 25-30% of normal);
- complete retention of any added materials (e.g., pre-biotics, minerals, vitamins) in cast cheese types;
- enables cheesemaking operations in regions where fresh milk is not readily available
- ingredient manufacturing step resulting in production of clean 'whey' ideal for the manufacture of specialised whey products, e.g., functional whey protein fractions, powders for inclusion in infant milk formula;

This platform technology provides more opportunity to design/control cheese characteristics such as texture, cooking properties and greater potential for development of new generation health cheeses.

Main results:

1. A technology was developed for the manufacture of milk protein ingredients (MPI) with characteristics suited to the manufacture of cheeses with different physical properties
2. The dispersion, hydration and gelation properties of the MPI were affected by mineral composition, protein concentration, time, solvent quality factors (including ionic strength, pH, temperature)
3. A process for the conversion of MPI into:
    a. 'cast' cheese variants with dry matter levels ≤ 50% without whey expression
    b. 'structured' cheese variants (with ≥ 50% dry matter) by subjecting the cast cheese to further curd handling and whey expression steps.
4. The composition, physical and sensory properties of the cheeses were altered by the following process variables: formulation (type and level of MPI, salt level, pH), ingredient dispersion/blending conditions (shear, temperature, duration), sequence of ingredient addition, gelation conditions (coagulant type, pH, temperature, time), curd handling processes, and addition of polysaccharides.

Opportunity / Benefit:

This technology allows the development of prototype functional MPI ingredients with unique technological characteristics for conversion into cheeses. Irish dairy companies have an opportunity to supply export markets with cheese ingredient solutions (MPIs and cheese conversion processes) which can be converted by *in-situ* re-hydration into local products.

Collaborating Institutions:

N/A

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1. Project background:

Global cheese production has increased on average by ~ 3 % per annum in the last decade and now amounts to ~ 18 million tonnes. Contributory factors include *inter alia* the increases in population and living standards, and increased demand in non-traditional emerging markets (e.g., China, India). While the increasing demand is causing a milk supply gap in many countries, it provides an opportunity for Irish dairy companies to export dairy-based ingredient solutions, based on specialised high protein powders and technology for converting into cheeses. Until now, such solutions have not been possible owing to technological constraints and functional limitations to reconstitute available dairy ingredients in the concentrated form that corresponds to the final compositional specification of targeted cheese types.

2. Questions addressed by the project:

The following questions were addressed by the project;

1. Can cheese without whey as a by-product be manufactured by a technology platform involving reconstitution of MPIs and other ingredients?
2. If so, what categories of cheese (soft, semi-hard, hard) is the technology applicable to and are modifications of the general technology necessary to cover the different categories?
3. What factors affect the properties of cheeses produced using this technology platform?
4. Is the technology capable of delivering customized cheese solutions with desired compositional, physical and sensory properties?

3. The experimental studies:

A novel approach was developed to manufacture cheese without whey expression from high protein (~ 80%) MPIs, milk fat, water and other ingredients. The technology consists of three basic processes:

- manufacture of high protein MPIs varying with different mineral-to-protein ratios and physical properties,
- dispersion of high protein powders, milk fat and other ingredients in water-salt solutions for preparation of reassembled milks (with dry matter of final cast cheese),
- addition of coagulation agents (rennet, starter culture and/or acidogen) to the re-assembled milk and filling into the mould or final package
- *in-situ* gelation of reassembled milks to form cast cheese.

This procedure is suitable for the manufacture of soft, semi-hard cheeses cast cheeses with dry matter levels of ≤ 48% dry matter. The cheeses are described as cast because of their smooth uniform, non-granular structures. Cheeses comply with CODEX Alimentarius Commission (FAO/WHO) definition for natural cheese (Standard A-6; FAO/WHO, 2007a), with some variants complying specifically with the standard for 'unripened cheese including fresh cheese' (Standard 221; FAO/WHO, 2007b).
The technology may be extended to semi-hard and hard cheese with dry matter contents ≥ 48% by a process which involves structuring the cast cheese, expression of whey (up 25% of the weight of cast cheese), and the addition of optional ingredients such as moulds. The resultant cheeses are described as 'structured' owing to their more inhomogeneous, curd-like structure which is typical of hard cheeses made by conventional cheesemaking technology.
The physical (viscoelastic characteristics, texture) and sensory properties of the cheese can be altered by changing a variety of manufacturing parameters including:

- characteristics of the MPI (for example method of manufacture, casein-whey protein ratio, calcium phosphate-protein ratio, ionic strength);
- formulation and composition of cheese, including contents of protein, fat, moisture and salt, protein-to-fat ratio, pH, calcium-casein ratio;
- method of cheese manufacture, including hydration conditions, sequence of ingredient addition, degree of shearing and temperature treatments;
- Gelation conditions, including time, temperature and pH.

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Hence, the technology is capable of delivering customized cheese solutions with different characteristics.

4. Main results:

1. A reproducible standard procedure was developed for preparation of both cast cheeses with dry matter levels ≤ 48% and protein-fat ratio ranging from 0.7 to 1.3, and structured cheeses with dry matter content of up to ~ 64 %. The protein used to make the cheese were milk protein isolates (MPIs) varying in protein in casein-whey protein ratio, degree of mineralization and protein content.
2. The properties (protein hydration, viscosity, rennet coagulability) of protein dispersions (2-15% protein) were significantly affected by the following parameters: level of protein mineralization and ionic strength of the MPI; and by the protein content, ionic strength, heat treatment and hydration time of the dispersion.
3. For a given dry matter level, the hardness and fracture stress of cast cheese can be altered by changing protein-to-fat ratio, calcium phosphate-to-protein ratio and reducing salt content.
4. There was an interactive effect between salt content and pH of the solvent phase on the hardness, fracture stress and chewiness of unheated cast cheese and the fluidity (loss tangent) of the melted cast cheese. These changes coincided with alterations in the levels of bound water and the contents of protein and calcium in the expressible serum.
5. The heating-induced meltability of cast cheese can be altered by changing the calcium phosphate-to-protein ratio, casein-to-whey protein ratio of the reassembled milk, and the shear applied during preparation of reassembled milk.
6. The textural and viscoelastic properties of the cast cheese were significantly altered by type and level of hydrocolloid (e.g., ratio of κ-to ι- carrageenan), the thermal load (temperature and time) applied to the reassembled milk, and concentration/type of cations presented in the reassembled milk.
7. Structured cheeses (55- 59 % dry matter) had comparable fracture and melting properties to commercial Gouda and Gouda cheeses (62 – 66% dry matter). Similarly, structured cheese resembled commercial hard cheeses with respect to the decrease in firmness and increase in meltability during ripening at 8 °C; these changes coincided with an increase in primary proteolysis, as measured by the levels of pH 4.6 soluble protein.

5. Opportunity/Benefit:

This technology allows the development of a novel range of prototype functional casein-based ingredients whereby the pH, buffering capacity and casein-to-whey protein ratio of the resultant cheeses may be manipulated to suit end-uses. Cheeses may be categorized as cast (≤ 48% dry matter) or structured (up to 64 % dry matter). The absence of whey expression and complete retention of all added materials in the manufacture of cast cheese makes the technology ideally suited to cheese products implying the addition of functional/bio-functional ingredients such as biopolymers, bioactive compounds, minerals and vitamins.

6. Dissemination:

The technology for which a patent application has been filed is available to companies under IP agreement for the development of customized products.
Companies were invited to review the technology by way of:

- technology showcase at Teagasc Food Research Centre Moorepark, involving demonstrating key technical aspects of the technology and presentation/evaluation of prototype cast and structured cheeses;
- Technology offer presented in TResearch 2008, and a technical article on the technology in TResearch 2010; and
- Technology capsule document (PDF adobe documents) forwarded to milk protein manufacturers.

Main publications:

Guinee, T.P., Kelly, O'Kennedy, B.T. and Kelly, P.M. (2009) 'Micellar casein powders with different levels of calcium and cheeses prepared therefrom' *Patent Application* WO 2009/150183 A1

Lodaite, K., O'Kennedy, B.T. Kelly, P.M. and Guinee, T.P. (2009) 'Physicochemical and rheological properties of native phosphocasein suspensions' *4th IDF Dairy Science and Technology Week, Programme, Abstracts of Oral Presentations and Posters*, pp. 49-50, Rennes, France. 20 – 24 April 2009

Piska, I. Byrne, B. and Guinee, T. P. (2011) 'Effect of sodium chloride on the properties of a model cheese

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system' The *Eight Cheese Symposium Moorepark 2011*, Programme and Book of Abstracts, pp. 43. Presentation: http://www.teagasc.ie/publications/2011/1039/index.asp

Popular publications:

Guinee, T.P. (2010) 'New Cheese Technology Platform' *TResearch* 5: (2) 20-21 http://www.teagasc.ie/publications/2010/9/9_TResearch_201005.pdf.

Walsh, M. (2008) 'Technology promotion: novel cheese-making technology' *TResearch* 3: (3), 43. http://www.teagasc.ie/publications/2008/18/18_tresearch200808.pdf

Guinee, T.P. (2008) 'Cheese 2030 – New Technology Platform for engineering cheese structure and function', EI Next Wave V1, Cork, November 25th.

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