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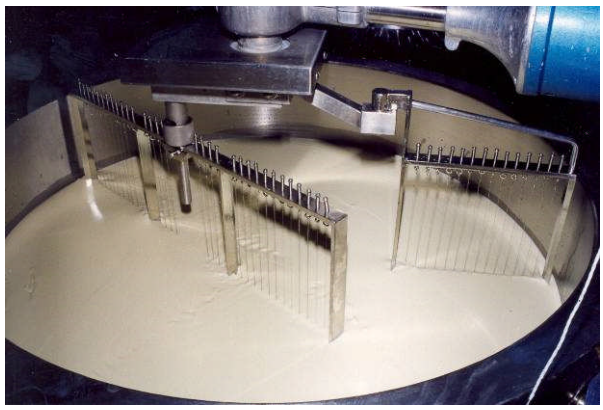
Updating Cheesemaking Efficiency



Key external stakeholders:
Irish Cheese and Dairy Industry

Practical implications for stakeholders:
The outcome/technology or information/recommendation is:

Manufacturing efficiency is a key aspect of cheese manufacture which influences cheese composition, milk component recoveries and plant profitability.
A major outcome of the project is the provision of new information on the comparative effects of bovine chymosin and camel chymosin on Cheddar cheese making efficiency, and the effects of high heat treatment of milk at different pH on its rennet gelation and curd forming characteristics. It also provides an extensive compendium on the effects of milk quality and cheese manufacturing conditions on cheese making efficiency and quality in the form of 2 monographs (Moorepark Monographs 1 and 2) published in 2010.

Main results:
1. The use of chymosin of camel origin (*Camelus dromedarius*) or *Rhizormucor miehei* rennet in place of bovine chymosin (*Bos taurus*) as coagulant in the experimental manufacture of Cheddar cheese had significant effects on recovery of fat from milk to cheese, cheese yield, and age-related changes in primary proteolysis and texture. These effects depended on the level of coagulant (number of milk clotting activity units added) and firmness of the milk gel at cutting.
2. The effects of increasing pH from 6.6 to 7.5 during high heat treatment of milk (80 °C for 5 min) resulted in depletion in the content of k-casein on the casein micelle and an increase in the level in the milk serum to an extent depending on pH. Desk-top cheesemaking studies indicated that increasing the milk pH during heating accentuated the adverse effects of high heat treatment on the rennet coagulability of the milk at pH 6.55 and its cheesemaking characteristics.
3. Two monographs (Moorepark Monograph 1. Cheese manufacture: Quality Characteristics of the milk; Moorepark Monograph 2. Cheese Manufacture: Control and prediction of quality characteristics), on the effects of milk quality and cheese, manufacturing conditions on cheese making efficiency and quality were prepared and distributed to Irish Dairy industry in 2010.

Opportunity / Benefit:
The research makes available to the dairy industry a database of information on the effects of key cheesemaking parameters on manufacturing efficiency and cheese quality. The comparative study on different coagulants provides statistically validated, practically-applicable information on the impacts of the bovine chymosin, camel chymosin and *Rhizormucor miehei* coagulants on cheesemaking efficiency and changes in the proteolysis and texture of Cheddar cheese during maturation. The cheese manufacture monographs provide a user-friendly reference source of practical information directly applicable to optimization of cheese manufacturing efficiency and quality.

Collaborating Institutions:
None

Contact Tim Guinee Email: tim.guinee@teagasc.ie

Teagasc project team: Dr. Tim Guinee (PI)
Dr. Donal O'Callaghan,
Dr. Bernadette O'Brien
Ms. Catherine Mullins
Mr. James Kelly
External collaborators: None

1. Project background:

Irish cheese production '000 tonnes) has undergone a marked increase in the last decade from ~ 115, 000 tonnes in 2002 to ~ 180, 000 tonnes in 201 11, and now utilizes ~ 31% of total domestic milk production. Similarly, global production has grown dramatically in the same period and is now estimated at ~ 18 million tones annually. Such growth reflects an increasing global population, higher living standards and the adaptability of cheese to modern food service practices. This has resulted in a large expansion of international cheese trade leading to greater distances between the producer and the consumer. Coinciding with this, there has been an increase in demand for more consistent quality and innovative cheese products, differentiated with respect to sensory properties, usage characteristics, and nutrient profiling. Such demand is driven by higher consumer expectations, health agencies, legislators, suppliers and retailers in pursuit of greater market share. This in turn has necessitated a more rigorous approach to engineering cheese quality / characteristics, compliance with international standards (e.g. *Codex Alimentarius*), quality consistency and cost-effective manufacture.

Cheese manufacture *per se* essentially involves gelation of cheesemilk, dehydration of the gel to form a curd which is treated and ripened according to the variety of cheese. Curd manufacture and maturation are highly complex processes that involve controlled fermentation of lactose to lactic acid, protein aggregation and syneresis, enzymatic-induced hydrolysis of proteins and fat, and other biochemical/microbiological events that are variety specific. Cheese composition and quality are effected by the interactive effects of many factors including milk composition and quality, range and magnitude of control variables applied to the milk and curd during manufacture, and ripening conditions.

The current projects examines the effects of milk quality and manufacturing conditions on cheesemaking efficiency, and on the composition and quality of cheese, with emphasis on Cheddar cheese – the principal variety produced in Ireland.

2. Questions addressed by the project:

- How do different commercially-available coagulants, and especially the recently-introduced Camel chymosin, affect cheesemaking efficiency and key changes in the cheese during maturation?
- Can the cheesemaking potential of high-heat treated milk be improved by alteration of pH during heating?
- Is there a ready-available user-friendly information source of information on the factors affecting milk quality and on cheesemaking efficiency and quality (based on results from Moorepark and published literature) available to professions in the Iris Dairy and Cheese Industries?

3. The experimental studies:

Three different coagulants were evaluated in pilot-scale Cheddar cheese manufacture: Bovine chymosin (BC), camel chymosin (CC) and *Rhizormucor miehei proteinase* (Hannilase; Han). The MCAs of the rennets at pH 6.55 and 35 °C was monitored using the Foss Lattodinamograffo coagulometer. The resultant 5 treatments were undertaken based on added milk clotting activity units (MCA) and gel firmness (GF) at cut, as measured using low amplitude strain oscillation rheometry on the rennet-treated cheesemilks: BC (MCA, 11.6; GF 30 Pa), Han (MCA, 11.6; GF 30 Pa) CC1 (MCA, 11.6; GF 30 Pa), CC2 (MCA, 8.7; GF 20 Pa), CC3 (MCA, 8.7; GF 30 Pa). The treatments were undertaken in quadruplicate in March/April 2011. Component recoveries (fat and protein) and yield were measured using a mass balance on the composition and weights of inputs (cheesemilk, rennet, salt) and outputs (cheese, whey streams). Cheeses were stored at 8 °C and monitored for composition (14 days), proteolysis (30, 90, 180 days) and texture/rheology at 75 % compression (180 days).

Milk samples were pH adjusted to 6.5, 7.0 and 7.5, heated to 80 °C for 5 min, cooled to 20 °C, re-adjusted to

Contact Tim Guinee Email: tim.guinee@teagasc.ie

pH 6.55, and evaluated for rennet coagulation properties using low strain oscillation rheometry. Following heat treatment and re-adjustment to pH 6.55, the milks were ultracentrifuged at 100, 000 g. The unheated milks, heated milks, and ultracentrifuged supernatants were analyzed for protein composition using reversed phase HPLC and particle size using ZetaMaster. Simultaneously, curds were manufactured at bench level from these milks (heated at pH 7.5, 7.0 and 6.5) and evaluated composition and meltability.
Published literature and Moorepark data (previously published and unpublished) was reviewed for impacts of variations in milk composition and quality, and manufacturing conditions, on cheesemaking efficiency and quality. Monographs for distribution to the Irish Dairy Industry were compiled using this review.

4. Main results:

1. The use of camel chymosin as coagulant, under the conditions specified for treatment CC2, significantly increased fat recovery and cheese yield relative to the corresponding values for bovine chymosin (treatment BC). Camel chymosin treatments (CC1 and CC3) did not significantly affect the latter parameters. Conversely, *Rhizormucor miehei* (Han) reduced fact recovery and cheese yield, compared to BC.
2. Camel chymosin treatments (CE1, CE2, CE3) significantly reduced the level of primary proteolysis during maturation but did not significantly affect the texture of the cheese. In contrast, *Rhizormucor miehei* (Han) did not significantly affect the level of primary proteolysis, but significantly reduced the firmness, fracture stress or fracture strain of 180 day-old cheese.
3. Increasing pH of milk at high heat treatment from 6.5 to 7.0 - 7.5 increased in the concentration of all caseins in the serum, as monitored by reverse phase HPLC, especially □-casein which increased from ~ 30% of total κ-casein at pH 6.5 to ~ 90% at 7.5. Moreover, it also led to an increase in the levels of whey proteins remaining in the serum following heat treatment, from ~ 41% of total at pH 6.5 to 100% at 7.5. These changes coincided with the development of two particle types in the heated milk, namely a κ-casein-depleted casein micelles (typically ~ 200 nm) and κ-casein-denatured whey protein particles (κCnWPPs; typically 40 – 50 nm diameter). Increasing the pH at heat treatment reduced the rennet gelation time (RGT), but significantly reduced gel firming rate and gel firmness. The reduction in curd firmness, which impaired the suitability of the heated milk for coagulation, was more pronounced at pH 7.0 than at 7.5. The poorer rennet coagulation properties at the higher pH values of heating caused a marked deterioration in curd quality, with the curd becoming wetter, softer and more difficult to recover, especially at pH 7.0. The adverse effect on results suggest that hydrolysis of the caseino-macropeptide region of the κ-casein from the κCnWPPs leads to their destabilisation in the presence of κ-casein-depleted micelles, and these aggregates sterically impede the fusion/aggregation of casein micelles into a gel.
4. Moorepark Monograph 1 discusses the effect of following on milk quality for cheese manufacture: composition, state of the components (ratio of globular: free fat; degree of hydrolysis of casein or fat), the levels of indigenous and contaminating enzyme activity (from bacteria, somatic cells), and levels of contaminants and chemical residues. It concludes that milk quality concept is a dynamic entity, and a continuous quality improvement approach is required to meet the requirements of different stakeholders including the cheese manufacturer and the consumer. Moorepark Monograph 2 considers the effects of variations in various cheesemaking parameters including milk pre-treatments, gelation conditions, curd-whey treatments in cheese vat, and curd treatments ex-vat. It concludes that owing to this complexity, it is essential that the raw material, the unit operations and ripening conditions are strictly controlled to ensure that the desired properties are consistently achieved. To this end, Monograph 2 proposes a basic approach to quality assurance to reduce variation in cheese composition and quality; the approach advises the implementation of a Quality Assurance scheme that focuses on more objectively-defined standard operating procedures (SOPs), process validation and continuous quality improvement.

5. Opportunity/Benefit:

The research provides an extensive database on the effects of different factors (milk quality, cheesemaking conditions including coagulants) on cheesemaking efficiency and cheese quality and proposes a QA scheme for same. It also how the interact effects of heat treatment and pH on milk vis-à-vis its cheesemaking properties and provide insights into the development of novel dairy ingredients (κ-casein depleted micelles, k-casein-whey protein aggregates) which may provide find potential use in areas such as specialized nutritional beverages or smart ingredients for food formulation or milk protein standardization.

Contact Tim Guinee Email: tim.guinee@teagasc.ie

6. Dissemination:

The results of this project have been transferred in large part to the Irish Dairy manufacturers by way of circulation of Moorepark Monographs 1 and 2, group discussions with companies, and interactions with individual companies.

Main publications:

Guinee, T.P. and O'Brien, B. (2010) 'The Quality of Milk for Cheese Manufacture' In Technology of Cheesemaking (eds. B.A. Law and A.Y. Tamime), 2nd edition, pp. 1-67. John Wiley & Sons Ltd, Chichester, West Sussex, UK. ISBN: 978-1-4051-8298-0.

Guinee T.P. and O'Callaghan, D.J. (2010) 'Control and Prediction of Quality Characteristics in the Manufacture and Ripening of Cheese' In Technology of Cheesemaking (eds. B.A. Law and A.Y. Tamime), 2nd edition, pp. 260-329. John Wiley & Sons Ltd, Chichester, West Sussex, UK. ISBN: 978-1-4051-8298-0.

Popular publications:

Guinee T.P. and O'Brien B. (2010) 'Moorepark Monograph 1, Cheese Manufacture: Quality characteristics of milk', Teagasc Food Research Centre: Moorepark, Fermoy, Ireland. ISBN 1-84170-559-4.
Guinee T.P., & O'Callaghan D.J. (2010) 'Moorepark Monograph 2, Cheese Manufacture: Control and prediction of quality characteristics', Teagasc Food Research Centre: Moorepark, Fermoy, Ireland. ISBN 1-84170-561-6.

7. Compiled by: T.P. Guinee and D.J. O'Callaghan

Contact Tim Guinee Email: tim.guinee@teagasc.ie