Cheese structure-function — the basis for export growth

Diarmuid Sheehan and Tom Beresford
Teagasc, Food Research Centre, Moorepark, Fermoy, Co. Cork

Summary

- Irish cheese production continues to grow, and is now the focus of significant industry expansion and investment.
- Cheese is a highly complex and dynamic biological system produced from milk of seasonally changing composition.
- Cheese structure-function properties determine how it performs under various end use applications including requirements for shredding, slicing, melt profile, etc.
- Modifications to cheese manufacture and ripening processes have been shown to modify cheese functional properties.
- Cheese is a highly nutritious food providing much of the daily recommended allowance for protein and key minerals and vitamins. Recent research has also indicated that it could be considered a bio-functional food providing health benefits beyond basic nutrition.
- New research focused on casein-polymer interactions is targeting new markets for cheese such as China and other Asian markets.

Irish cheese production: An industry in flux

Irish cheese production has grown by over 250% since 1995, with exports of 225,000 tonnes in 2018, valued at €815 m (CSO). Traditionally, Irish cheese has been dominated by export of Cheddar to the UK, and although the reliance on the UK market is lessening, the UK still imports about 115,000 tonnes of Irish cheese annually. The outcome of Brexit has serious implications for this industry, not least the potential imposition of tariffs of €1,671/tonne of Cheddar, which is generally valued at approximately €3,000/tonne.

In a move to lessen the importance of the UK market, the Irish cheese industry has increased exports to other EU countries, the Middle East, North Africa and Japan. It is also substantially investing in processing facilities: co-location of a new Jarlsberg (continental-type) cheese plant at Dairygold Mogeely, Co. Cork by Tine; a €78 m diversification project including development of Mozzarella cheese production by Carbery; and, a joint venture between Glanbia and Leprino for a 45,000 tonne Mozzarella cheese plant in Portlaoise, Co Laois and with Royal A-ware for a €140m Continental cheese plant to process 450 million litres of milk annually at Belview in Co Kilkenny.

Cheese: A complex subject matter

Cheese differs from many other dairy products in that it is a highly complex and dynamic biological system, produced from a raw material with continuously changing composition. While products such as powders are relatively stable, cheese contains a live and continuously evolving microbiota and enzyme compliment that remain active throughout ripening, chilled distribution and ultimately to the point of consumption. Furthermore, cheese ripening and quality is the product of a complex interplay between the components (e.g. moisture, fat, protein), the physico-chemistry of the cheese matrix and the metabolic activity of pockets of bacteria dispersed throughout cheese blocks (Figure 1).

Cheese consumers and end-users are increasingly demanding enhanced functional properties, sensory and nutritional quality, and optimal usage characteristics, all at a reasonable cost. This is primarily driven by factors such as growing consumer awareness of the role of diet in health and well-being, the potential to use structure to influence flavour release and sensory experience, and the extensive use of cheese as an ingredient in food applications. Such expanding consumer demands have triggered the focus of food researchers and cheese producers to enhance the quality of existing products or the design of new innovative products. Producing diverse, market-led products of consistently high quality within the context of an Irish seasonal milk production system poses considerable technical challenges.

Cheese structure-function

It is now well recognized that many of the desirable properties of cheese are largely determined by its structure. For example, structure plays an important role in determining the mechanical, rheological, and cooking properties of heated and unheated cheese (e.g. Cheddar, Mozzarella), eye formation in several types of hard (e.g., Swiss type or Emmental) and semi-hard cheese (e.g., Maasdam type) and texture perception. Functional characteristics of importance include performance under shredding and slicing, and melt and flow properties under heating. The customer's requirement for these different properties reflects diverse applications in food service and as ingredients in prepared consumer foods, and also the growing market in Asian countries.

More recently, it has also been reported that food structure plays a key role in flavour release and in the digestion and the absorption of nutrients. Apart from containing basic nutrients, the nutritional value of food can also be enhanced by introducing health-promoting and bioactive compounds, such as polyphenols and peptides. In this context, the cheese matrix can potentially be used as a delivery vehicle for bioactives and probiotics. Thus, a better understanding of the complex interrelationship between structure and functionality (i.e., the so-called structure-function relationship) is necessary to design cheese types with specific functionalities.

Current research at the Teagasc Food Research Centre Moorepark has focused on the structural characteristics of cheeses (particularly non-Cheddar types) produced from Irish milk, and in particular, how these are influenced by the relative role of hydrolysis of α_{S1}-casein and β-casein or solubilisation of calcium during ripening. The results highlight that (1) inhibition of rennet activity during ripening; (2) reduction of rennet activity during ripening; and (3) reduction of ripening temperature decreased the hydrolysis of α_{S1}-casein by ~95%, ~45%, or ~30%, respectively, after 90 d of ripening. During the same ripening period, ~35% of β-casein was hydrolysed for all cheeses, except for those ripened at a lower temperature (~17%). The proportion of insoluble calcium as a percentage of total calcium decreased significantly from ~75% to ~60% between 1 and 90 d. Further results obtained showed that although modulation of α_{S1}-casein hydrolysis is an effective means to maintain the strength of the cheese matrix during ripening, maintaining higher levels of intact β-casein or insoluble calcium content (or both) within the cheese matrix results in reduced shortness or brittleness of cheese texture. Such approaches could be applied to design cheese with specific properties and to control functionality.

Cheese matrix effect

Dairy fat consumed as cheese has different effects on blood lipids than dairy fat consumed in other formats. This includes a favourable reduction in total cholesterol. It is unknown whether the effect is specific to fat interaction with other cheese nutrients (calcium, casein proteins), or to the cheese matrix itself. Further work is underway to better understand the net effect of calcium on fatty acid bioaccessibility. Eventually, the findings of this study could lead to additional evidence to further substantiate beneficial health claims, as well as the discovery of novel nutritional aspects that could be adapted for the food industry to control nutrient release and deliver bioactive molecules.

"Cheese for China"- Research on casein-polymer interactions

It has already been observed in Japan, Taiwan and South Korea that as consumers become more westernized, the proportion of dairy consumed as cheese increases significantly. Although its nutritional properties are desired, most Chinese consumers have limited experience of cheese, and the sensory properties of conventional cheeses may not appeal to them. Research is currently being undertaken to profile Chinese consumer preference for cheese sensory traits, and exploit colloidal and casein-polymer sciences to incorporate non-dairy ingredients familiar to Asian consumers into cheese formulations/ fermentations to achieve desired sensory properties (flavour and mouth-feel). The overall objective of this research is to develop a platform technology for cheese innovation to target emerging Chinese and Asian markets in a post-Brexit environment.

Conclusions

The portfolio of cheese types continues to increase and market demands are ever-changing. The cheese research platform of the Teagasc Food Research Programme is focused on exploiting cheese Structure-Function interactions to provide an internationally competitive and innovative edge for Irish cheese products in export markets.

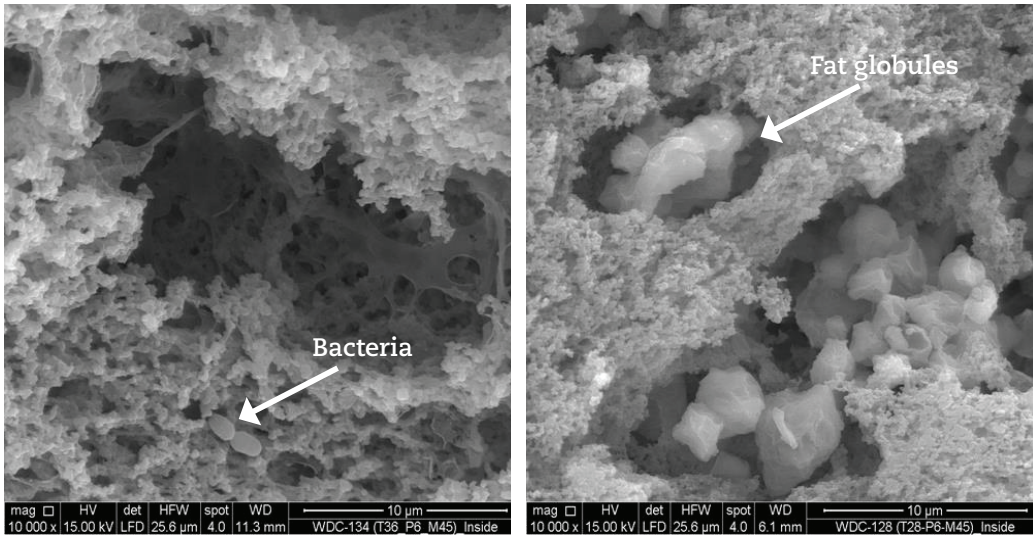

Figure 1. *Fat globules and bacteria entrapped within the cheese protein matrix*