Membrane filtration for consistent cheese

Research at TEAGASC Moorepark is comparing methods of membrane filtration in milk protein standardisation in order to improve cheese quality.

Introduction

World cheese production has grown at an average rate of 1.9% per annum since 2010, and amounted to ~23 million tonnes in 2015 (IDF, 2016). Irish cheese production grew from 172,000 to 207,000 tonnes in the same period, and utilises ~31% of total milk produced. The increased demand for cheese is driven by a rise in global population, an increase in living standards, wide availability of different varieties, and adaptability of cheese to modern food service practices. Simultaneously, the requirement for more consistent quality, nutrient density (e.g., levels of fat, salt, lactose) and functionality has increased. Such demand is driven by higher consumer expectations, health agencies, legislators, and suppliers and retailers in pursuit of greater market share. Nevertheless, inconsistency does occur in cheese composition and quality, a major cause being seasonal variation in milk composition in conjunction with the use of standard operating procedures (SOPs) that do not account for such seasonal variation. In particular, variation in the concentrations of milk protein and casein over the cheese-making season (e.g., from 3.3-4.2%, and 2.5-3.2%, respectively) are conducive to changes in key compositional parameters such as moisture, pH and salt-in-moisture, which in turn impact on ripening and quality of cheese.

Standardisation of milk for cheese making

It is now almost universal practice in modern cheese manufacture to standardise the protein-to-fat ratio of the cheese milk (typically by removal or addition of cream) to a target value, the magnitude of which differs according to cheese variety and the brand of cheese being manufactured. The use of curd washing to standardise the content of lactose, and hence lactic acid, is applied in the manufacture of Dutch-style cheeses such as Gouda and Leerdammer to ensure consistent pH and texture in the final cheese; the degree of washing is proportional to the lactose content of the cheese milk. Standardisation of milk protein content to a target value (e.g., 4.5%) is now widely practised in many countries such as the USA, Australia, New Zealand and parts of Europe, to ensure cheeses with consistent composition, texture, flavour and functionality. Despite the relatively large seasonal variation in milk composition in Ireland, standardisation of milk protein is not widely practised.

The use of membrane filtration to standardise milk protein content

Membrane filtration is a pressure-driven separation process, which allows for selective retention and concentration of some components from the feed stream. The membrane porosity determines which components are retained and concentrated as a retentate, and which migrate through the membrane as permeate. Ultrafiltration (UF) and microfiltration (MF) are membrane processes applied during milk processing to concentrate total milk protein (casein and whey protein) or casein, respectively.

The main difference between UF and MF is that whey proteins are retained during UF and permeated during MF (**Figure 1**). The migration of whey proteins during MF results in a whey protein-enriched permeate stream, frequently referred to as 'ideal whey', because, unlike cheese whey, it is not contaminated by other milk components such as colloidal milk salts, casein macropeptide, fat, cheese starter cultures or colourants. The 'ideal whey' can be used to make high-quality whey protein products such as whey protein isolates and whey protein fractions (e.g., α-lactalbumin, lactoferrin), which may be used in an array of high-end applications such as nutritional, sports and therapeutic beverages.

Low concentration factor membrane ultrafiltration (LCFUF) or microfiltration (LCFMF) refers to ultrafiltration or microfiltration processing where the protein or casein content of the milk is increased by a factor of ~1.4-1.8, e.g., from a typical protein content of 3.3-3.6%

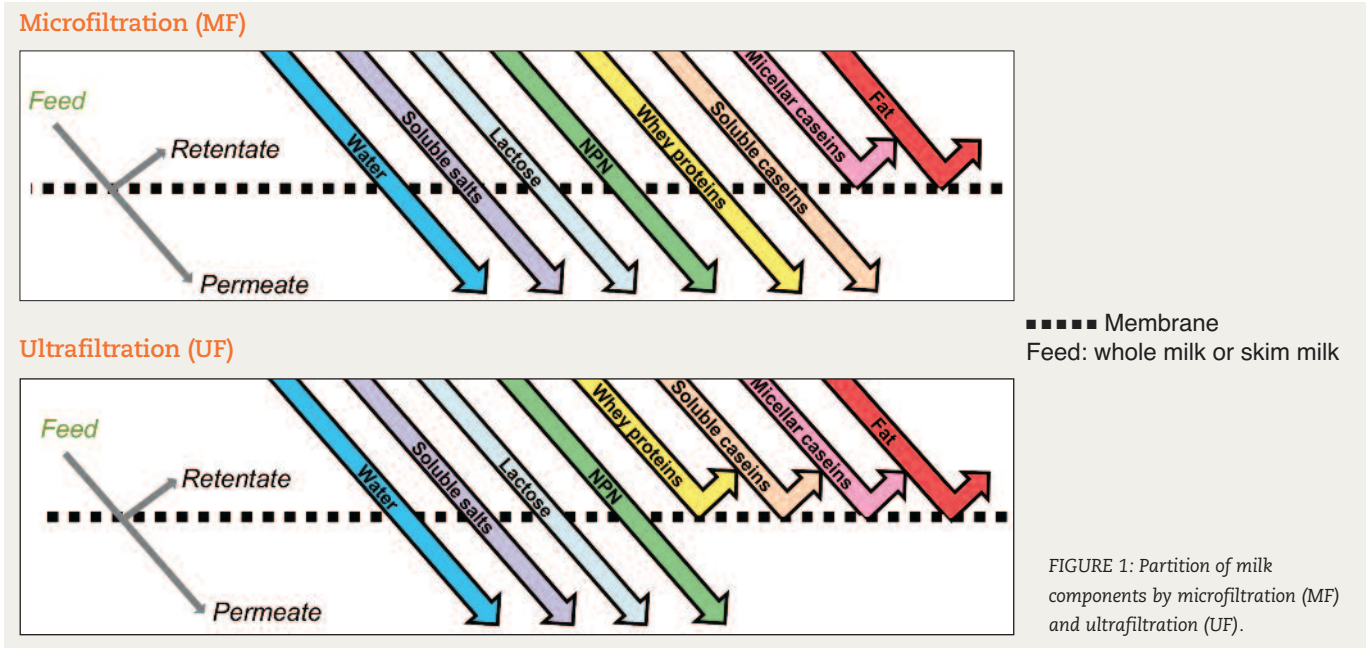

FIGURE 1: Partition of milk components by microfiltration (MF) and ultrafiltration (UF).

in the raw milk to a target value of 4.5-5.0% in the protein-standardised milk. Milk protein standardisation provides greater compositional and quality consistency, especially in large modern plants with milk volumes of 1-3m litres of milk per day and with minimal intervention of developed SOPs to ensure smooth plant running and consistent throughput. Other potential benefits of milk protein standardisation include higher plant throughput and a lower cheese vat capacity. The choice between LCFUF and LCFMF for milk protein standardisation depends on a variety of factors, including the impact on cheese quality, site processing capability, product mix, required capital expenditure for membrane plant (higher for MF), and operating costs.

Moorepark study

A study entitled 'Optimisation of milk protein standardisation for improving the quality (texture and flavour) of cheese from a seasonal milk supply' is currently being undertaken at Teagasc Food Research Centre, Moorepark, and funded through the Dairy Processing Technology Centre. The project is on low-concentration membrane filtration and focuses specifically on:

- a review of the published literature on the state of the art of LCFUF and LCFMF for milk protein standardisation for cheese;
- the effect of warm and cold LCFUF or LCFMF on potential permeation of casein and minerals (e.g., calcium); and,
- the comparative effects of LCFUF and LCFMF on various aspects of Cheddar cheese, including composition, fat and protein recovery, yield, and biochemical and textural changes during maturation.

The cheeses are made using both a Teagasc standardised operating procedure and a non-standardised operating procedure, where the former involves adding starter culture and coagulant pro rata with protein content in the standardised milk, cutting the gel at a defined strength, and undertaking different steps such as setting and whey drainage at defined pH values, while the latter primarily involves undertaking cheese making processing steps at defined time points. While the study is ongoing, preliminary results indicate that membrane type and operating temperature affect mineral and protein permeation. However, membrane type (LCFMF, LCFUF) had little effect on cheese composition or manufacturing efficiency.

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Reference

International Dairy Federation. (2016). 'The World Dairy Situation 2016'. Bulletin of the International Dairy Federation 485/2016.

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