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# Dairy ingredients on the up and up

The CalPoly Dairy Ingredients Symposium, held in San Francisco, US in March, drew expert speakers and delegates from around the globe. Dr Geoffrey Smithers was there.

The CalPoly Dairy Ingredients Symposium, first held in the late 1990s, is a must-attend event on the global dairy calendar. The program always strikes a good balance between the business aspects of dairy ingredients and the science and technology of their production, characterisation and application in the food and related industries. This year's Symposium was no exception. Below is a summary of the Symposium's key messages, with particular reference to the issues that affect the Australian dairy ingredients sector.

## Global dairy ingredient market

Rapidly expanding biofuel production and strong demand for calories and protein from the burgeoning South-East Asian middle class have strongly contributed to the rising global agricultural prices in the past five years. While such trends are historically cyclical, they highlight the issue of food security that has become an important aspect of public policy debate.

The growing global population creates opportunities for milk and dairy products. The global demand for dairy products is growing by 4% per year, and dairy consumption in South-East Asia is set to more than double by 2040.

The Australian dairy industry is well-placed to capture opportunities in Asia over the next 20-30 years. This is particularly true of China. In 2011, China imported about 300,000 megatonnes (mt) of whole milk powder, about 130,000 mt of skim milk



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powder and about 14,000 mt of whey protein concentrate. A vast 80% of these imports were sourced from New Zealand.

While most of the US milk production is consumed domestically, in 2011 it exported the equivalent of 8% of the total milk production as stable products, including about 17,000 mt of whole milk powder. The US is looking to increase dairy exports, particularly to China. As such, the US and New Zealand, together with the UK and other major dairy producers in Europe and South America, are increasing their dairy ingredient production capacity, notably in the area of higher value whey-based products. Australia needs to keep a close watch on the situation and be proactive to protect our markets, particularly in Asia.

## Demineralised whey techniques

Growing marketplace demand for demineralised whey (e.g. 90% demineralised whey powder for infant formula) has led to an evaluation of demineralisation technologies, particularly those suited to large-scale commercial application. The techniques in question

include cross-flow nanofiltration, electrodialysis and ion-exchange chromatography. Each process in isolation, as well as in combination, has been assessed for its cost effectiveness and flexibility.

Nanofiltration is effectively a monovalent demineralisation technology and can generate up to 30% demineralised whey powder. This technology results in negligible loss in whey proteins or lactose, and has an operating cost of about \$15-20/t of dry solids.

Electrodialysis results in the removal of monovalent and some divalent ions, and works most efficiently at high whey conductivity (i.e. pre-concentrated whey with 20-22% solids is optimal). The use of heterogeneous membranes (e.g. Ralex) allows for more uniform ion transfer rates. Such membranes are composites of several materials with an open structure that allows for repeated drying and hydration without loss of performance. Electrodialysis results in a small ( $\leq 2\%$ ) loss in whey proteins or lactose, and has an operating cost of about \$30-40/t of dry solids.

Ion-exchange chromatography results in the most efficient removal of all ions from whey and is ideally suited to demanding demineralisation specifications and specific ionic profiles. It is mainly used for the production of 90% demineralised whey powder and as a 'polishing' technique post nanofiltration and electrodialysis. It has an operating cost of about \$50-85/t of dry solids as a polishing technique and about \$130/t of dry solids as stand-alone process.

*The message from dairy ingredient users was remarkably consistent – dairy is a ‘gold standard’ for performance, functionality, bio-activity and nutritional profile, but it’s expensive.*

A combination process involving all three techniques, operated in series, was identified as the ideal solution for manufacturing different demineralised whey powders when capital investment, operating costs and flexibility were all considered.

### Complex oligosaccharides as dairy ingredients

Increasing knowledge of bio-active factors in human milk that benefit babies – including influence over intestinal microbiota, protection against pathogens, enhanced immune function and reduced hypersensitive reactions – has led to a search for similar factors in cows’ milk.

It’s known that certain prebiotics in human milk (oligosaccharides containing fucose and/or sialic acid) encourage the growth of intestinal probiotic bacteria (e.g. bifidobacteria). However, current oligosaccharide prebiotic offerings are not like those found in human milk.

Advances in analytical techniques have facilitated the identification of more than 50 previously unknown complex oligosaccharides in cheese whey permeate that closely resemble those in human milk. The challenge now is to explore and develop suitable, cost-effective isolation technologies to ensure adequate supply and homogeneity of composition of these human-like oligosaccharides from whey permeate.

A small human clinical trial is under way to evaluate whether the whey oligosaccharides (low and high dose) influence intestinal function as determined by analysis of blood, urine and stool.

### Freeze drying of heat-sensitive materials

Freeze drying represents the only technology capable of achieving gentle drying and low water activity at the same time. As a batch process, it is best suited to relatively small volumes (10-500 kg water/hour) and where quality is critical.

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Capital and operating costs remain an issue influencing widespread commercial application of freeze drying, but such costs may be justified for high-value dairy ingredients, where retention of bioactivity is critical. Examples include lactoferrin, lactoperoxidase, immunoglobulins, colostrum and some probiotic bacteria.

### Separating milk into value-added fractions

Over the past 20-30 years, advances in membrane materials/design and chromatographic resins/techniques have allowed for the fractionation of milk components into a vast array of dairy isolates, many with high value.

Commercialisation of these technologies has allowed dairy manufacturers to make tailored products to meet the demands of different and wider food applications, and specific consumer segments. Examples include milk, whey and casein concentrates and fractions, minor purified proteins and peptides, lactose, permeate and milk minerals.

An analysis of a simple membrane process for manufacture of  $\beta$ -casein was highlighted at the Symposium, including the potential of this ingredient in aeration applications, where solutions showed high and stable overruns.

Potential future applications of membrane or chromatographic separation technologies may include on-farm fractionation of minor heat-sensitive therapeutic proteins, isolation of oligosaccharides from whey and permeate streams and fractionation of milk fat globule membrane components. In any



*Asia will remain a significant and growing market for Australian dairy ingredient manufacturers.*

fractionation process, the existence and fate of by-products must be managed and any regulatory aspects carefully considered.

### Health & nutrition opportunities

In 2010, the medical nutrition market was valued at about \$23 billion. This included infant, enteral and parenteral nutrition segments. This market is growing by about 6% a year and represents a significant opportunity for Australia's dairy ingredients.

The most readily accessible segment for dairy ingredients is the enteral nutrition market, valued at \$8.7 billion. Drivers include an aging population, improvements in diagnosis of disease and clinical patient management. A relatively 'open' regulatory environment also assists access when compared, for example, with the pharma and infant formula sectors. More than 600 new products were launched into this market between

2006 and 2010, with milk. Whey protein ingredients represented key components in many of these products.

Another area of opportunity for dairy ingredient manufacturers is digestive health. Evidence for the link between a range of disease states and digestive health is growing. In the US alone, about 60-70 million people suffer from digestive health issues, resulting in about \$140 billion in healthcare costs annually.

A growing body of scientific evidence is supporting the view that a balanced intestinal microbiota leads to proper immune function, reduced inflammation, reduced risk of Type II diabetes and increased weight control.

Unique components in dairy ingredients, such as oligosaccharides, can positively influence the gut microbiota. Components in milk fat may also be responsible for preserving digestive tract integrity when under 'attack.' There is also scientific evidence for an association between yogurt consumption and lowered weight gain.

### Dairy ingredients structures for improving health

The Symposium heard an intriguing analysis of current consumer demands for food (safety, taste and enjoyment, nutrition, health and wellness, abundance, convenience and affordability) and the ability of dairy-derived food structures to meet these demands, at least in part.

By using specific processing techniques and conditions, colloidal structures can be generated from dairy proteins and other molecules that meet many of the current consumer demands. These colloidal

structures can serve as affordable flavour and bioactive carriers that provide texture and satiation. Examples include the use of whey and casein mixtures and emulsion-based particles to improve the heat stability of whey proteins in beverages; the use of inhomogeneous gels to reduce both sugar (by 20%) and salt (by 29%) in products while maintaining quality (same sweetness and taste perception); and the use of micro-phase separation in whey protein gels to influence texture.

### End-user needs, applications and opportunities

One of the most valuable aspects of the Symposium involved feedback from key representatives of dairy ingredient end-user companies, including their experience in the application of such ingredients in a wide range of products and process conditions, and their 'wish list' for dairy ingredient characteristics.

These end-users included leading companies that manufacture beverages, chocolate, and infant and enteral formulations.

Their message was remarkably consistent. Dairy ingredients represent the 'gold standard' for performance, functionality, bio-activity and nutritional profile, but they're expensive. Alternative ingredient suppliers (e.g. soy) are making rapid technological advances and have the cost advantage, so dairy cannot rest on its laurels.

End-users wanted to see:

- protein content in the bag, not 'as is'
- low lactose content
- milk protein concentrates that do not age
- rapid and consistent solubility of whey
- protein products
- control of mineral balance, notably calcium activity
- consistent heat stability
- neutral flavour in whey protein products' specific fractions (e.g. lactoferrin,  $\alpha$ -lactalbumin, sialic acid,  $\beta$ -casein, peptides), but only if cost-effective.

The 2012 CalPoly Dairy Ingredients Symposium highlighted a bright future for dairy ingredients within the modern food and related industries, and in a world increasingly dominated by food security issues.

For more information on the Symposium visit the CalPoly DPTC website at [www.dptc.calpoly.edu](http://www.dptc.calpoly.edu) or contact Geoffrey Smithers. ■

### About the author

Dr Geoffrey Smithers is an experienced research scientist, scientific entrepreneur and industry consultant based in Melbourne. His services include R&D planning, troubleshooting, innovation, strategic and operational planning, and technology audits. He can be reached on [geoff.smithers@gmail.com](mailto:geoff.smithers@gmail.com) or [www.geoffreysmithers.com](http://www.geoffreysmithers.com)



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