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## The dairy product value chain: new opportunities from a holistic approach?

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### ABSTRACT

The value chain for dairy products extends from on-farm production, through manufacturing and distribution, to the final consumer. Using an integrated approach across the value chain, it is possible to produce products that better suit consumers' needs or preferences and that return more value to the farmer using on-farm methods. This approach requires a change in mindset for the manufacturing industry, and can be successful only in an industry that is fully integrated from cowshed to consumer. Some examples are described in the context of the value chain, and set the framework for the following papers.

**Keywords:** value chain; on-farm modification; milk composition; processing; dairy products; consumers.

### INTRODUCTION

New Zealand has a strong dairy industry, supplying almost one-third of the internationally traded market for dairy products. The industry accounts for more than 20% of New Zealand's export receipts, and has been an important, and often dominant, contributor for more than 100 years (Ward, 1975). The success of the industry has been largely based on an efficient pastoral farming system, which has ensured the survival of the industry. Over the latter part of last century, both government support schemes for the industry and privileged access to overseas markets largely disappeared. This has necessitated changes in the industry, to develop its capability across the value chain towards the consumer. Because of the co-operative structure of most of the New Zealand dairy industry, dairy farmers own the industry from production right through to the in-market sales and marketing organisations. This opens up new possibilities to manage across the value chain, so that maximum value is given to the consumer and maximum profits are returned to the farmer.

The chain for a manufactured dairy product can be defined as five segments: Raw material (milk); primary manufacturing (into dairy ingredients); production of the final (consumer) product; distribution (into markets and to retailing outlets); and retailing (to the consumer). Sometimes the second and third steps are combined, in one company or even in one factory. Note that this definition differs somewhat from the corporate value chain model defined by Porter, and is adapted from Galbraith (1991).

#### The raw material

The dairy industry belongs to a small group of manufacturing industries based around coping with an incoming flood of short-lived raw material, which must always be processed within hours of production, or dumped. Cows continue to produce every day, and the milk must be processed regardless of the demand for product or the capacity for processing. Manufacture, distribution and marketing are based around adding value to this raw material.

Little attention has traditionally been paid to the

quality of, or adding value to the raw material beyond a few basics, and payment for milk has been based on a fairly simple system, often just the volume. In New Zealand, milk for manufacturing has been paid for on the basis of milkfat content or, more recently, milkfat and protein content.

Milk is a biological product, with wide variations in composition as a consequence of cow genetics, feed, season and animal husbandry. It is not of the ideal composition for most of the products for which it will be used, and different products ideally require different kinds of milk for most efficient manufacturing and best product quality. With a closer matching between milk and consumer needs, more value could be obtained from our raw material and consumer needs could be better met.

As an example, milk for making cheese is generally paid for on the basis of total protein and fat. In fact, it is only the casein fraction of the protein that is made into cheese; the whey protein is a by-product. This has important consequences for the way in which the farm will operate, because breeding and managing for more total protein on-farm will be counter-productive if the milk contains that extra protein as whey protein and the desired product is cheese. If the proportion of whey protein increases too much, it can even become impossible to make a good cheese curd. This issue becomes particularly important in the case of breeding, where decisions can impact for two decades or more.

This scenario was the background of a recent trial in which the suppliers of the Kaikoura cheese factory were encouraged to breed their herds to bulls carrying the alleles for the  $\beta$ -lactoglobulin B variant only (Boland *et al.*, 2000; Boland & Hill, 2001). This variant has an upstream difference in the DNA (Lum *et al.*, 1997) that results in decreased synthesis of this protein in the milk, leading to decreased whey protein and increased casein. The selection of variants of  $\kappa$ -casein for cheesemaking in a small Swiss factory has been previously reported (Jakob, 1992). However, because of a lack of consistency in the relationship between the  $\kappa$ -casein variants and the casein content as a proportion of total protein, this mode of selection cannot be recommended (Boland & Hill, 2000).

In the New Zealand situation today, where the bulk of

the milk is transported long distances and processed at large, multi-product sites, it is not generally possible to target milk to specific products. The main objective must therefore be to work towards milk that has the best compromise composition for all products for these sites. However, a clear case can be made for targeted production to go to smaller, more specialised facilities in order to capture the benefits from selected milks (assuming these exceed any additional costs). For the New Zealand industry, a mixture of the two approaches is possibly the best solution.

Sophisticated changes in milk composition, leading to desirable product properties, can be made by feeding specific supplements or breeding for specific variants. Some of these are described in the following papers in this issue.

### Primary manufacturing

As New Zealand addresses the global market, the emphasis has moved increasingly from consumer butter and cheese to food ingredients, powdered products and recombined liquid products. The industry has developed the capability to take milk apart and reformulate its components. Distance from market has necessitated the development of powders as stable, compact forms of milk solids.

The value chain approach means that milk going to the primary manufacturing industry must be of the best possible quality for dairy product manufacture. It also means that the manufactured product must be best suited for the market. An example of this is the selection of variant-specific milk for making powder that is to be recombined and processed into UHT milks in-market (Hill *et al.*, 2000). In this case, the immediate customer is the ingredient milk powder purchaser who will recombine the product and then sell it as a consumer product. An important aspect of UHT processing is the formation of insoluble material on the plate heat exchangers in the UHT plant. In the UHT process, milk is heated to 140°C under

pressure; thus, stability of the recombined milk under these conditions is important. Fouling of the UHT plant is particularly bad if milk containing only the A variant of  $\beta$ -lactoglobulin is used and is very low if milk containing only the B variant is used (Figure 1). As the A and B variants are under genetic control, and it is possible to type the DNA in bulls to determine which genes they carry, it is in principle possible to breed for a milk that will give low fouling. More importantly, the bulls being used for artificial insemination must be monitored to ensure that the A variant gene does not become dominant in New Zealand herds.

### Distribution (into markets and to retailing outlets)

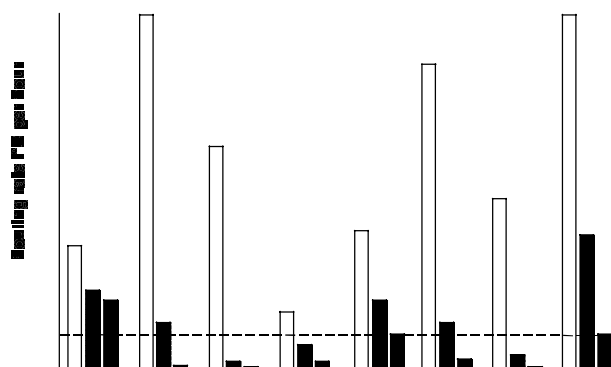
The New Zealand dairy manufacturing industry was enabled by the availability of refrigerated shipping. The sailing of the Dunedin in 1882 is mostly remembered for the first shipment of meat to the UK, but there was also a small shipment of butter (Philpott, 1937). From that time until the early 1970s, cheese and butter to "Mother England" were the bulk of the production of the New Zealand dairy industry (Yerex, 1989). More recently, changes to market access have led to two trends: a much wider global distribution of customers, and a change from almost total dependence on cheese and butter to a preponderance of dried products.

New Zealand is unique in the world in that the bulk of its milk (around 95%) is destined for manufacture for export (Statistics New Zealand, 2000), whereas the bulk of the milk in most other countries is destined for local consumption, largely as liquid milk or fresh product. New Zealand milk must be made into products that will survive lengthy shipping processes with no significant deterioration of quality. Further, because of the seasonal nature of our dairy production, it is necessary to stockpile product during the peak of production, in order to supply customers when the cows are dry. Consequently, a large proportion of milk is made into product that is in the form of a relatively stable dry powder, such as skim milk powder or whole milk powder. Drying of this milk incurs a high energy cost and a high capital cost for evaporator and spray drying plant for the removal of water. The water in milk also incurs a volume and weight cost in the collection and transportation of milk. Clearly, more concentrated milk from the cow would be very desirable, and inclusion of a volume penalty in the current New Zealand payment formula reflects this. Unfortunately, the current breeding trend for increased milk solids production is also resulting in a proportionately increased volume — see Figure 2. Recent data for the percentages of milk solids and protein (Table 1) reveal that the Jersey breed may offer some advantages. Unfortunately Jersey cows also produce a disproportionately high level of fat, which is undesirable. A way of segregating these traits would be valuable.

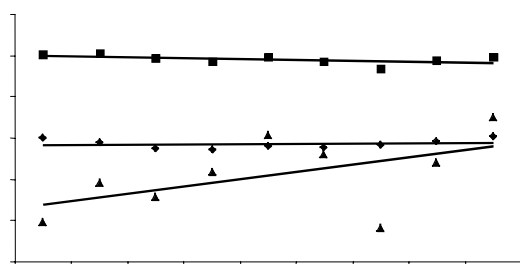
An alternative way of coping with volume is on-farm concentration; although there have been trials of this in New Zealand and elsewhere, the relatively high capital and maintenance costs for the concentration plant and other factors have resulted in a failure to adopt this technology.

**FIGURE 1.** Effect of genetic variant on fouling of UHT plants by re-constituted whole milks.

Legend: A, milks containing only  $\beta$ -lactoglobulin AA variant; B, milks containing only  $\beta$ -lactoglobulin BB variant; C, control milk (mixed variants). Treatments during powder manufacture were: HH, 120°C, 180 s; MH, 95°C, 20 s; LH, 72°C, 15 s. Data from Hill *et al.* (1997).



**FIGURE 2.** Nine-year trends in New Zealand milk production and composition (data from Livestock Improvement Corporation, 2001).  
 Legend: ■, average milk solids (protein + fat) concentration, (g, L<sup>-1</sup>); ♦, protein:milkfat ratio (% w/w); ▲, average milksolids production per cow per year (kg, right hand scale)



**TABLE 1.** Breed differences in New Zealand milk composition (calculated from Livestock Improvement Corporation, 2001)

Breed	Milksolids %	Protein %	Protein:Fat %
Jersey	9.8	4.1	71
Friesian-Jersey Cross (F1, F2)	8.7	3.7	75
Friesian	7.9	3.5	79
Ayrshire	7.9	3.6	81

### Purchase by the consumer

One of the most frustrating aspects of our international dairy business is the lack of access for consumer products to many markets, particularly in Europe and North America, which are the most affluent markets. The loss of much of the key UK market in the 1960s led to a change of thinking in the industry and the targeting of markets in East Asia, particularly Japan, in the Middle East, in South East Asia and, more recently, in Latin America. In each market, consumer taste preferences vary, and there is variation in the way in which dairy products are used. Market research has been needed in all these cases to understand what each consumer group requires, and then to meet these needs (as is the case for any consumer product).

In the days of export to the UK, milkfat was the principal valuable component and was the only component for which payment was made. In many cases, only cream was supplied to the factory, for the manufacture of butter, and the skim milk was often used to feed pigs. The market and the payment consequences meant that the Jersey breed was favoured for milk for manufacturing, whereas the Friesian (Holstein) breed was favoured for the separate—“town supply” herds, which received payment based on volume. With the entry of the UK into the EEC in 1973, and the progressive removal of government supports in the 1980s, the New Zealand dairy industry stands almost alone in the world as a modern, unsubsidised dairy-based food industry completely exposed to market forces.

The biggest difference in requirements for milk that has resulted from the change in markets is that milk protein is now by far the more valued component. This has led to emergence of the Friesian as the predominant breed across the country, because of its higher ratio of

protein to fat. Once the product is actually in the market, consumer preferences come into play. The modern consumer has a wide choice of foods available, and many factors influence what is purchased. Fortunately, in most markets, dairy holds the nutritional high ground, is well recognised as a source of high quality protein and calcium and is often described as one of the four basic food groups (Nutrition Taskforce, 1991). However, today's consumer trend in most markets is towards less fat in the diet, with increasing popularity of low-fat dairy alternatives, and the present ratio of protein to fat in milk may no longer be appropriate. The New Zealand dairy industry currently pays for both protein and fat at rates that are fixed each year, based on projected demand. However, with milkfat production increasing at a rate at least equal to the rate of protein production (Figure 2), and demand decreasing, it is questionable how much each additional kilogram of milkfat is worth. It is inevitable that we will soon reach a situation where the marginal value of milkfat is zero. Given the high energy cost of milkfat production, ways of increasing the protein to fat ratio in milk need to be considered. Genetic, feeding and dietary intervention approaches have all been tried to modify this ratio, with varying degrees of success (Vos & Groen, 1998; Keady, 1999; Baumgard *et al.*, 1999), but none is in commercial use in New Zealand.

Less well recognised is the nutritional value of milkfat; with the trend towards low-fat and skim milks in the supermarket, the benefits of milkfat in the diet are being lost. Essential fatty acids found in milkfat are important for vision and brain function (Gurr, 1995). There is increasing evidence that conjugated linoleic acid (CLA), found only in animal fats, may have an important protective effect against some cancers (Parodi, 2001). Milks with fat containing elevated levels of desirable fatty acids such as CLA may be a consumer need for the future. New Zealand has a particular advantage in this respect, as pasture-fed cows produce milks with much higher levels of CLA than corresponding northern hemisphere grain-fed animals, typically around 10 mg/g for New Zealand milkfat (MacGibbon *et al.*, 2001), and ways to further increase these levels have been identified (Palmquist, 2001).

Beyond nutrition, there are many other factors that affect demand in the market. Many are market specific, and some relate to specific groups within a population. Considerations include format of product (including labelling and packaging), taste, traditional values, fashion, safety, country of origin, brand loyalty and price. Although many of these are beyond the scope of an on-farm push down the value chain, country of origin will continue to be an issue for an important group of consumers, and our on-farm record on environmental issues and animal welfare must be exemplary.

In today's environment, so-called “organic” products are popular with a sub-set of consumers, particularly in European markets. It seems likely that this is driven to a considerable extent by fears about product safety, in particular concerns about organophosphate pesticide residues and the use of hormones to stimulate production. The term “organic” seems to have a wide variety of

definitions from one country to another; until international agreement can be reached and a set of logically based standards is fixed, it will be difficult to gauge the usefulness of this term. Significant progress is being made on this front in New Zealand and elsewhere. Whatever the future of the organics movement itself, there is no doubt that retailers and consumers will increasingly require traceability of their food right back to the farm, with appropriate guarantees about the quality and safety of their food. Traceability is a particularly difficult issue for the dairy industry when operating at large scale, and will require considerable future effort.

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