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Milk characteristics: an industry perspective

MILK CHARACTERISTICS:

AN INDUSTRY PERSPECTIVE

PROJECT

SUBMITTED IN PARTIAL FULFILMENT OF THE

REQUIREMENTS OF THE

KELLOGG RURAL LEADERSHIP COURSE XIV

LINCOLN UNIVERSITY

1997

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In writing this project I would like to thank the Livestock Improvement Corporation for sponsoring me on this course and for there assistance in making material available for the research on this project.

I would also like to thank Dr Mike Boland of the New Zealand Dairy Research Institute for his assistance and for making internal industry documents on milk characteristics available.

And finally I would like to thank the staff, particularly Alastair McArthur, the presenters and the other participants involved with the Kellogg Rural Leadership Course who made it a very stimulating, challenging and enjoyable programme.

There are many different components in bovine milk which change between farms, herds, individual cows, stage of lactation and types and levels of nutrition.

Any variation in milk composition must have a return to either the consumer, the manufacturer or the farmer.

It is believed that there are real economic advantages in the manipulation of the composition of milk. However, the industry must be careful it is not simply transferring costs from one section of the industry to another

The vertically integrated nature of the dairy industry and in particular the structure of the Livestock Improvement Corporation puts this organisation in a very strong position to facilitate changes to milk composition.

It will be imperative that appropriate economic drivers are put in place to capture the benefits available in the manipulation of milk characteristics.

There are also many potential pitfalls for participants in the dairy industry in following different milk composition strategies.

It is recommended that research is continued at all levels of the industry in this field and that a long term plan is agreed to capture the benefits of changing milk composition for the benefit of New Zealand dairy farmers.

1. INTRODUCTION

1.1 Purpose

The purpose of this report is to gain an understanding of the effect the manipulation of milk characteristics can have on the New Zealand dairy industry as a whole and more particularly to ascertain what part the Livestock Improvement Corporation can play in capturing the benefits that may accrue to the dairy industry from producing specific mth specific characteristics to meet market requirements.

1.2 Milk Characteristics

For many years the dairy industry has paid dairy farmers for the amount of fat and protein they produce after deducting a charge for volume. The evaluation and breeding of dairy animals has followed this economic model. Milk can however be broken down into far more constituent parts. These components change between farms, herds, individual cows, stage of lactation and levels and types of feeding. Presently this milk is mixed together in tankers and silos and taken apart again at processing fact

The farmer and the processor however view milk quite differently as can be seen in Table 1.

Table 1. Farmer / Processor view of milk.

Farmers' view of milk	Processors' view of milk
Water 87%	Water 87%
Proteins 3.6%	Proteins 3.6% Casein 80% Whey 20% alpha 39% alpha lactalbumin 3% beta 29% beta Lactoglobulin 12% kappa 10% bovine serum albumin 3% gamma 2% immunoglobulins 2% protease - peptones< !%
Fat 4.6 %	Fat 4.6% fatty acids free fatty acids B - carotene fat soluble vitamins sterols Lactose 4.5% Non - protein nitrogen 0.05 % Minerals Ca Na Mg P etc. Vitamins Hormones Enzymes Cells

Fig. 1: Adapted from Arnold Bryant; Dairy Exporter July 1995.

Some within the dairy industry believe economic gains can be made by manipulating milk composition to gain a processing, yield or functional benefit.

The factors that effect a cows milk composition are genetics, nutrition, health and seasonal factors. Factors other than genetics are being investigated jointly by the New Zealand Dairy Research Institute (DRI) and the Dairy Research Corporation (DRC). The genetic elements are being studied by the Livestock Improvement Corporation (LIC) among others.

The dairy industry is taking the issue of milk characteristics very seriously, funding research to the extent of five million dollars per year.

1.3 New Zealand Dairy Board

The New Zealand Dairy Board (NZDB) is a wholly owned farmer co-operative with the mission to:

> *"Maximise the sustainable income of New Zealand dairy farmers through excellence in the global marketing of New Zealand origin dairy products".*

The dairy industry has a vertically integrated structure with the integration of production, processing and marketing. The DRC, DRI and the LIC are all fully owned subsidiaries of the Dairy Board. This should have a significant advantage to New Zealand dairy farmers in exploiting any benefits from milk differentiation back to the dairy farmers.

2. BENEFITS

Any genetic variants in milk composition must have a return to at least one of the following three stakeholders; the *consumer*, who must perceive a benefit for them to purchase the product; the *manufacturer*, who must perceive a benefit or they will not process this type of milk and finally the *farmer* who will not produce the particular characteristic unless there is some potential reward.

There are three main types of benefit that can occur from genetic variants of milk. The first type of benefit is a processing benefit. An example of this is beta-lactoglobulin B milk which doesn't foul UHT heat exchangers in the manufacture of milk powders. This has no effect on yield or consumer preference.

The second is a yield benefit, where more product is gained from the same amount of milk. The best example of this is the BB type milk (see s.2.2. below) which has a higher cheese yield than other types of milk.

The third type of benefit is a perceived functional or health benefit. An example of this is the claimed link between the onset of diabetes in susceptible people and A1 type milk.

2.1 Processing

Processability refers to the behaviour of the milk or product during processing. In these cases the benefits apply only to the processor, some examples of processing problems are highlighted in Table 2 below.

TABLE 2: Processing problems associated with the variability in milk components:-

Product	Cause	Effect
Butter	High beta-carotene	Strong yellow colour
	High solid fat content	'Hard' butter, difficult to spread
	High copper	Off-flavour
Milkpowder	Abnormal protein & low urea	Poor heat stability during drying
	High casein to whey protein ratio	Poor heat stability during drying
Cheese	Low casein	Low cheese yield
	Low Kappa-casein	Poor curd firmness & structure
	High free-fatty acids	Off-flavours, poor curd structures
	High Somatic cell count	Reduced cheese yield and shelf life
UHT milk	High in proteolytic enzymes	Short shelf life

Adapted from Dairy Exporter; July, 1995 p.62

Many of these processing problems may not have sufficient economic benefit to warrant the manipulation of the dairy herd to alleviate the problems, but by the same token it may be worth not inadvertently breeding for those characteristics. Manufacturers will need to clearly identify the costs associated with some of these processing difficulties and then do cost benefit analyses on the viability of breeding or managing for different characteristics.

2.2 Yields

Product yield refers to the amount of product that can be made from a volume of milk.

The best example of this yield effect is the Beta-lactoglobulin B type milk. The different phenotypes of beta lactoglobulin in the predominant whey protein are AA, BB or AB, which have an effect on the different products produced. AA contains more whey protein and BB more casein. If the amount of whey protein in milk goes up the amount of casein goes down by about the same amount and vice versa. This has a marked effect on yields. Research has shown that BB type milk will produce three to five percent more cheese than milk from a 'normal' dairy company supply with all variants mixed together, and AA milk will produce three to five percent less cheese than standard milk. The different milk leads to no variations in either taste or length of maturation of the cheeses.

If cheese is valued at $US 2200 per tonne and butter (the opportunity cost of making that much more cheese) at $US 1750 per tonne (as at October 1997) there is a clear economic advantage to both the consumer and producer in producing the BB type of milk for cheese manufacture, all other things being equal.

Research is also being carried out on milkfat hardness. Some cows produce softer fat and others harder fat. This varies with stage of lactation and also varies between cows. Although not established there appears to be some genetic correlation. There are many products that are effected by the hardness of the milkfat, not least of which is the spreadability of butter.

2.3 Functional and Nutritional

Are product attributes such as flavour or consistency which may or may not be desired by the consumer.

In the case of a functional or nutritional benefit it is the consumer who benefits. To make these types of products the customers must be prepared to pay at least the extra cost of producing these products or it will not be in the farmers or processors interests to make these products. Unless, as in a BSE type example the product needs to change because the existing product is unsaleable.

3. ON FARM

Farm management is believed to have a substantial impact on milk composition. Feeding levels, the type and quality of the cows diet, mastitis, somatic cells and the stage of lactation are some of the farm management factors known to effect the composition of milk.

> *'Feed intake and diet can influence the protein composition in milk. NZ research has shown moderate underfeeding reduces the concentration of whey proteins. Overseas researchers reported that increasing the concentrate in a total mixed ration had raised protein percentage and changed the relative concentrations of different proteins: a better diet increased alpha-casein and beta-lactoglobulin and reduced the milk serum albumins and other nitrogen fractions. Milkfat composition can also be changed by diet'. (Bryant, July 1995)*

Weather may be another influence on milk characteristics.

Research carried out on the nutritional effects on milk components showed that better nutrition in early lactation achieved a seven percent increase in the contents of milk protein and casein and a 13 percent rise in whey proteins. Milk urea went down by 6.5% and non-protein nitrogen by nine percent. Improved feeding in late lactation saw a decrease in immunoglobulins of 37 percent and serum albumins by 53 percent. This milk would be beneficial in the production of many products. (Dairy Exporter, July 1995 p.66).

In preliminary trial work at the DRC the protein composition of milk from BB cows was seen to vary more widely under contrasting nutritional regimes than from AA cows (DRC, Dec., 1996).

It is possible to produce soft milkfat by feeding certain diet such as sunflower or linseed meals and hard milkfats with the feeding of coconut or palm meals or root vegetable tops.

Seasonal calving causes marked variations in the composition of milk supplied to processors across the season. It appears from DRC trial work that stage of lactation significantly effects composition of milk (DRC, March, 1997).

Some of these results could lead to the conclusion that there may be more to be gained in milk characteristics by changing farm management than altering genes.

4. IS IT WORTH DIFFERENTIATING MILK?

A question that needs to be addressed is, is it worth going from a national breeding objective of a compromise "one size fits all milk" to a range of specialised differentiated milks. It is commonly agreed within New Zealand processing that there is a general desire across all products for more protein and less volume per kilogram of milksolids. Other milk characteristics will be more product specific. Some believe there are large benefits to be gained in the manipulation of milk. There will however be a range of costs on farm and within manufacturing sites that will need to be taken into account.

It is obviously very difficult to establish the economic benefits of different milk characteristics because the future prospects are so uncertain and one effect can not be taken without an evaluation of all possible other effects.

4.1 On Farm Costs

To change the milk characteristics of a herd of cows genetically a great deal of cost would be involved. Initially all animals in the herd will need to be "typed". As many as five times as many animals outside the herd will also need to be typed. This will allow animals of the "wrong" type to be sold or culled and animals with the "right" type to be purchased until the herd contains only the correct variants. Typing should only cost a few dollars per cow but the large numbers involved may make it expensive. Culling otherwise efficient cows could be very costly.

All replacement stock breed and replacements bought in (due to replacements being of the wrong type) would all need to be typed. The herd will only be able to be mated to bulls with the specific traits desired which could lead to a very high opportunity cost in genetic gain if those bulls are not the top bulls in productive merit. It would presently and increasingly limit the genetic pool for sire selection.

To change the composition of milk by farm management may also be very expensive. Supplementary feeding or changing the timing of lactation would add significantly to on farm costs.

4.2 Manufacturing Costs

The industry presently spends $100m on CIP. A considerable part of this is assumed to be for milk powder plant fouling (which a variant of milk causes) so there may be considerable savings here. This will lead to longer manufacturing runs requiring less capital expenditure for peak milk processing. Production of soft milkfats will reduce the cost of making spreadable butter. Better yields will also improve manufacturing performance.

There will also be costs added to the processors. It is likely this milk will need to be collected in separate tankers, have separate reception facilities, be separated and pasteurised separately and will also need to be held in separate silos. All this would not require vast amounts of capital although it is likely to be logistically difficult and lead to less than optimum utilisation of assets. The costs at the laboratory are almost certain to rise as staff are trained to use different tests and require different testing equipment to measure the specific milk characteristics. Most products containing different milk characteristics will require separate manufacturing runs, packaging, labelling and marketing inputs.

Internal dairy industry reports however signal that overall very useful savings can be made in the area of manufacturing.

5. LIVESTOCK IMPROVEMENT CORPORATION

It appears that there is significant potential to change milk characteristics through artificial breeding. The Livestock Improvement Corporation with its core competencies in Genetics, Information and Advice will be integral to the New Zealand dairy industry to effect and facilitate the introduction of different milk compositions.

The LIC holds the herd test licence for dairy animals, controls the national dairy data base and runs the animal evaluation unit as well as the industry funded extension unit - Advisory. So LIC is obviously well placed to assist in any implementations.

LIC in its roll in genetics is looking at genetic markers. In the future it will be possible to determine the milk protein genes a bull is carrying by directly testing his DNA without having to wait for his first crop of daughters to produce milk to determine actual milk proteins.

The use of genetic engineering, by putting a new 'modified' gene into an embryo, will allow many generations of genetic selection to be achieved in only one or two generations. The basic techniques for this are already available and

in a few years cost effective techniques of producing these animals will allow rapid well planned genetic improvements. There is likely to be consumer resistance to products produced from transgenic animals. An education programme may not be enough to change the public's perceptions. The New Zealand dairy industry will need to weigh up these concerns very carefully to design a path for the future.

The LIC introduced a new animal evaluation model in 1996 that targeted animal efficiency as opposed to animal production alone. It seems certain that LIC will need to change the evaluation of dairy animals to suit the individualised requirements of certain dairy companies or groups of suppliers within a dairy company.

5.1 The Kaikoura Dairy Company.

The Kaikoura Dairy company is a cheese manufacturer based at Kaikoura on the East Coast of the South Island. The company has 31 suppliers and only produces cheese. The Kaikoura dairy company in conjunction with the LIC and the NZDRI have decided to implement a beta lactoglobulin B strategy within its supply.

The predominant whey protein has two genetic variants A and B. Each cow will, depending on which gene its parents have be either AA (A gene from both sire and dam), BB (the B gene from both) or AB (A from one, B from the other). The New Zealand Jersey population is 12% AA, 47% AB and 41% BB. The corresponding phenotypes in the Friesian population are 16%, 49% and 35% respectively

The LIC has genotyped its sires and is selling a package of semen of the BB type. All cows in the supply area have been phenotyped. The value to the Dairy Company of following a 100% BB strategy could realistically add $250,000 ($8,000 plus per supplier) to Kaikoura's bottom line (Dairy Exporter, October, 1997) at no immediate cost apart from a change of breeding philosophy. This is based on the superior yield expected from BB milk. However, the special pack of BB bulls presently lag the national BW of bulls.

New product specific breeding indexes will almost certainly need to be introduced to follow this strategy.

5. PRICING SIGNALS

As the research proves the financial gains for the dairy industry New Zealand dairy farmers will be faced with the challenge of producing the right type of milk. To do this farmers will need appropriate economic drivers.

The current system (Fat + Protein - Volume) assumes a zero value for whey protein (a $NZ 60m business) and lactose or the type of protein produced which has different effects on different products.

If it is decided to pursue a strategy of say, BB variant milk for improved cheese yields a payment for casein would have to be introduced as this is the appropriate economic driver. A new breeding index for the economic evaluation of cows would need to be devised or adapted so that farmers will breed for the desired characteristics. A new payment system has to be introduced at Kaikoura to encourage people to use BB semen. The Kaikoura dairy company are currently struggling with a shift to a casein based payment system (Exporter, Oct., 1997). If it is desired for a single company or even process within a site to be differentiated there may be a need to develop different animal evaluations for different requirements.

The change in the animal evaluation model last year saw a major swing to Jersey semen being used on the national herd in that year. From a milk characteristics point of view this may be a disadvantage in terms of colour and hardness of milkfat and milk powder fouling. As there is no economic signal in the animal evaluation model for these aspects breeding *may* continue to drive in the wrong direction.

Different companies and factories in New Zealand have different mixes of products that they produce. It will be up to individual companies in consultation with their suppliers to make their own decisions on specific breeding programmes.

Time lags will be long with the full effect of a breeding programme not being seen for ten to fifteen years. Identifying cows within the national herd and shifting them around the country would speed this process. Although it would raise a plethora of other issues.

6. POSSIBLE NEGATIVE EFFECTS

Significant research will have to be carried out to ascertain the potential negative effects of breeding cows that produce certain milk characteristics. An attempt to breed for greater production of a specific protein may lead to an undesirable trait in another characteristics of milk, say hard milkfat.

The alleged link between diabetes and milk containing the mutant casein protein called A1 is a very good example.. Cows all over the world have been bred for higher protein, and hence A1 casein production. Iceland which operates a genetically 'closed' national herd and the Masai of Africa are examples of the very few sources of the A2 casein left in the world. This research unveiled in Palmerston North in February, 1997 received intense media interest and had the ability to severely impact the consumption of dairy products world wide.

The breeding of a national herd for certain milk characteristics immediately limits the options for genetic gains for other characteristics. This of course will limit the ability to capitalise on the swings in consumer preference in the market place. Milkfat colour requirements vary according to market. A breeding policy to one colour of milkfat could be a limitation if there was a swing in desired markets. Most importantly, breeding in a direction may restrict the ability to

capitalise on new manufacturing technologies or new, presently unthought of, products consumers may require in the future.

The establishment of payment systems designed on the payment of certain milk characteristics makes the assumption that these desired characteristics have commercially viable tests to measure them. If tests are available they will undoubtedly be more expensive, although they may only need to be done spasmodically (1-4 times per year).

If there were a lot of different milk characteristics required throughout different sites around the country it could place great costs and logistical problems in the proving of suitable bulls and the distribution of semen.

The Industry must be careful that it does not simply shift costs from one section of the industry to another without any overall economic benefit or in the worst case an economic loss. An example of this would be the use of supplementary feeding on farm to produce better throughputs and yields at the factory. The costs on farm in terms of supplements, labour or reduced efficiency (through lower stocking rates) must be more than outweighed by the savings at the factory.

Further potential downside exists in the 'moveability' and 'saleability' of animals and herds if they are bred for particular processes or products. This may require herds to be effectively tied to individual factories. This is obviously a major issue in the New Zealand dairy industry where the sharemilking system that has provided much of the industry's dynamism requires a degree of flexibility. Concerns are already being made by sharemilkers in Kaikoura that their animals could immediately devalue on leaving the district. The obvious answer to this would be to bond the herd to the farm or the district. This however may result in difficulty in attracting high calibre sharemilkers.

The effect on animal health of breeding for, or on farm practices designed to effect milk composition needs to be understood more fully. The reason some desirable variants do not exist naturally in a breed may not have occurred by chance and these variants may have unrecognised undesirable traits.

The time lags involved in breeding dairy animals, almost three years between inseminating a cow to having an animal in the milking herd with possibly only half the desired characteristics producing milk, highlights the amount of time that would be required to change the national herd.

The issue of the future shape of the dairy industry needs to be thought through. In Kaikoura's case what would happen if they were taken over by a larger company and there milk was 'mixed' and sent to a mega site. The current breeding programme may have put them behind in genetic merit for the new company's payment system.

There are also ethical considerations, the publics response to, say, trans-genic animals needs to be assessed.

7. CONCLUSIONS

Of utmost importance is that any changes lead to farmers having more money in their pockets. The savings at the factory or the increased prices realised in the market place are not negated or in fact surpassed by costs on the farm as could easily happen by the introduction of expensive supplementary feeding regimes on farm. As most of the rest of the world's milk is consumed in a liquid form international research in this area is limited. This may be an opportunity for the New Zealand dairy industry to gain a competitive advantage in this area with fairly high barriers based on technology and long lead in times.

It appears that there is the ability to create substantial gains for New Zealand dairy farmers from variant selection. However capturing these gains may incur substantial costs at different levels of the industry. The New Zealand dairy industry's cost competitiveness is a key strength that should not be compromised. Each possibility will need to be investigated individually to ensure that there is a net benefit to the farmers involved. Studies will need to be undertaken to relate the value of milk to specific processes and products.

Animal welfare, the environment, food safety and public perception are all important factors to consider when devising a plan for the future.

To continue competing in the international market place the dairy industry needs a better understanding of the potential for raw milk. The causes of much of the variation in milk characteristics throughout the season are still unknown. Recent advances in gene technology, through direct genetic manipulation and the identification of genetic markers has highlighted the need to first understand the industry's requirements. Research needs to be well focussed and for this to occur the dairy industry must define a consistent message of what it wants. This must be market led.

The New Zealand dairy industry is well positioned to take advantage of any gains through its farmer owned vertically integrated structure, where dairy farmers own and control marketing, manufacturing, research and development genetics and animal evaluation.

There are major problems in quantifying the benefits because of the various scenarios. A clear 15 - 20 year guiding strategy is required to be able to exploit these technological opportunities otherwise unacceptable costs will be incurred in chasing too many options.

8. RECOMMENDATION

It is recommended that the New Zealand dairy industry put together a long term plan to capture the benefits that could accrue to New Zealand dairy farmers from changes in milk composition. It is also recommended that research continue at all levels of the vertically integrated industry, on farm, processing and marketing to ensure the greatest economic benefits are captured.

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