INTRODUCTION TO
THE NEW ZEALAND DAIRY INDUSTRY

The dairy industry in New Zealand earns just under 20% (or about $4 billion) of the country's export income and thus is a major contributor to New Zealand's economy. About 95% of the milk produced by the country's 2.9 million dairy cows is manufactured by 12 co-operative dairy companies into processed dairy products such as butter, cheese, milk powders, nutritional products and infant foods, casein and whey products and lactose. The remaining milk meets New Zealand's domestic requirements for liquid milk products, for example whole milk, skim milk, trim milk and fresh cream, together with yoghurt and cottage cheese. In the 1995-96 season, the average New Zealander's consumption of milk products was just over 8 kg butter, about 9 kg cheese and 91 L milk.

Although New Zealand produces less than 2% of the world's milk, it is a major player in world trade, as the country's dairy exports amount to about one quarter of the international trade in dairy products.

Milk contains a very wide range of essential nutrients. The major components in New Zealand cows' milk are carbohydrates, mostly lactose (4.5-5%), fats (mean 4.6-4.7%), proteins (caseins (about 2.8%) and whey proteins (about 0.7%)), minerals (0.7%) and vitamins (0.15%), the remainder being water.

PRODUCTION AND TRADE

The New Zealand dairy industry is a major contributor to the economy of this country. In the 1995/96 trade year, exports of dairy products earned New Zealand $3.8 billion, equivalent to 18.5% of its total export earnings of about $20.5 billion. In the 1996/97 year, dairy product exports earned $4.4 billion (Hall, 1997).

New Zealand has approximately 2.9 million dairy cows (nearly one per person), the number having grown steadily from 2.2 million in 1983/84. At present, 95-96% of their total milk production is used in the manufacture of processed dairy products, the remainder being used to meet domestic (New Zealand) requirements for liquid milk products. The amount of milk produced in New Zealand and the size of its dairy industry are shown in **Table 1**.

Because of the relatively small population in New Zealand, the domestic consumption of milk and fresh milk products (such as whole milk, skim milk, trim milk and fresh cream, together with yoghurt and cottage cheese) accounts for only a small proportion (4.6%) of the total output of the dairy industry, as indicated above. Actual consumption of milk and the main dairy products is shown in **Table 2**.

About 86% of New Zealand's milk is produced in the North Island, and half of that comes from the South Auckland-Waikato region. Approximately 17% of the country's milk is produced in Taranaki.

Table 1 - Milk production and size of cow herds in New Zealand (1995/96) (rounded data)

Total milk production	9800 million litres
Total milk for processing[a]	9300 million litres
Total milk cows	2 936 000
No. of seasonal supply cows[b]	2 718 000
No. of seasonal supply herds	13 700
Average size of seasonal supply herds	198 cows

Note[a]: Excludes liquid milk for domestic consumption.
Note[b]: The remaining cows produce milk for domestic consumption.

Table 2 - Domestic market sales of liquid milk and the main dairy products for the 1995/96 season

Milk product	**Total consumption**	**Consumption *per capita***
Butter	29 600 tonnes	8.2 kg
Cheese	32 000 tonnes	8.9 kg
Milk powder	3 900 tonnes	
Liquid milk	340.0 million litres (L)	90.8 L
Fresh cream[a]	$17 million	$4.60
Ice cream[a]	$96 million	$26
Yoghurt[a]	$71 million	$19

Note[a]: Estimated spending by private New Zealand resident households for the period April 1995-March 1996 (McLaren, 1997).

In October 1997 milk was processed by 12 co-operative dairy companies - four in the North Island and eight in the South Island. The largest co-operative was the New Zealand Dairy Group (approximately 50% of all manufacturing milk). Other major companies were Kiwi

Co-operative Dairies (Hawera) (26.9%) and Northland Co-operative Dairy Company Ltd (Whangarei) (9.9% of all manufacturing milk). The amount of dairy products made in New Zealand in 1995/96, together with the volume and value of New Zealand's dairy exports for that period, are shown in **Table 3**.

Table 3 - Volume of dairy products manufactured and exported during the 1995/96 dairying season[a], and value of those exports

Dairy product	Quantity manu-factured ('000 tonnes)[b]	Quantity exported ('000 tonnes)[c]	Value of exports (NZ$ million)[c]
Creamery butter	242	193	703.7
Anhydrous milkfat (AMF)	56	44	155.6
Frozen cream	9		
Cheese	229	173	617.4
Whole milk powder	298	278	942.6
Nutritional products/Infant food	35		
Skim milk powder	172	127	425.7
Buttermilk powder	30		
Casein products	79	72	557.1
Lactose	20		
Whey products	22		
TOTAL	1233	1007[d]	**3792.2**

Note[a]: The manufacturing period is from 1 June 1995 to 31 May 1996, whereas the data shown for exports cover the period 1 July 1995 to 30 June 1996.

Note[b]: Data are rounded.

Note[c]: The total includes "Other" dairy products, amounting to 120 000 tonnes and valued at NZ$390.1 million.

Note[d]: The disparity between manufacture and export is (1) consumption within New Zealand (cheese, butter) and (2) product held in storage or sold from storage (AMF and casein).

International trade in dairy products accounts for only some 5% of the estimated 527 million

tonnes of milk produced throughout the world. Although New Zealand produces less than 2% of that milk, it is a major player in the international trading of dairy products, in which it accounts for about 24% of the world's exports, as shown in **Table 4**.

Table 4 - New Zealand in the world dairy market

Country or region	Milk production[a] (1996)		Population[d] (millions) (estimated mid-1997)	Production of milk equivalent (kg/*capita*)	International trade (% of total trade)
	(million tonnes)	(% of total)			
World	527	100	5840	90	
EEC	124	23.5	349.7	355	47
Eastern Europe, including CIS Republics	100	19.0	408.7	245	
United States	71.1	13.5	267.7	266	8
New Zealand	9.8[bc]	1.9	3.7[e]	2649	24
Australia	8.9[b]	1.7	18.5	481	10
Canada	7.7	1.5	30.1	256	

Note[a]: Source: International Dairy Federation (1996) (forecast data).
Note[b]: For 1995/96 dairying season.
Note[c]: Source: New Zealand Dairy Board (1997).
Note[d]: Source: Population Reference Bureau (1997).
Note[e]: Source: Statistics New Zealand (1997).

The data presented in the introductory comments and in Tables 1-3, unless stated otherwise, are derived from New Zealand Dairy Board (1997) and Statistics New Zealand (1997).

COMPOSITION AND PROPERTIES OF MILK

Whole milk contains a very wide range of essential nutrients. A typical composition for manufacturing milk is shown in **Figures 1** and **2**. This is higher in milk solids than the milk shown in **Table 5** which is produced for domestic (New Zealand) consumption from herds consisting mainly of Friesian cows. Manufacturing milk, on the other hand, is produced from both Friesian cows and Jersey cows and the milk from Jersey cows has a higher solids content than that from Friesian cows.

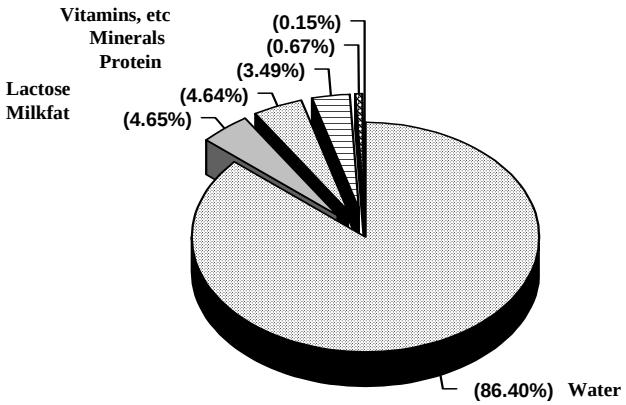


Figure 1 - Typical composition of cow's milk. *Minerals* include Ca^{2+}, Na^{+}, K^{+}, Mg^{2+}, Cl^{-} and PO_4^{3-}. *Lactose* includes other minor carbohydrates. *Vitamins* include other minor nutrients. Data derived from Enterprise New Zealand Trust (1992).

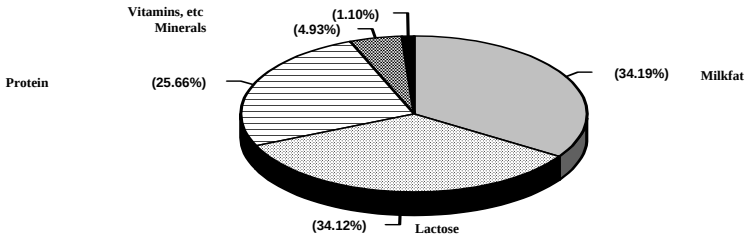


Figure 2 - Typical composition of cow's milk solids (derived from Figure 1).

In very simplified terms, milk is an emulsion of the fat (cream) in skim milk. Skim milk is a colloidal suspension of micelles or very tiny particles composed mainly of casein (protein), calcium and phosphate, with soluble protein, carbohydrate and minerals dissolved in the water. Thus, butter made from cream is mainly fat, cheese made from whole milk is rich in both protein and fat, casein made from skim milk is mainly protein, and the solids in the whey from these two last-named product groups consist mainly of carbohydrate.

The composition of milk is described in more detail below, and the later articles describe the main processes used and the products manufactured in the New Zealand dairy industry, as outlined in **Figure 3**. Table 5 shows the quantities of certain nutritive components in various milk products.

THE MAJOR COMPONENTS OF COW'S MILK

Carbohydrates

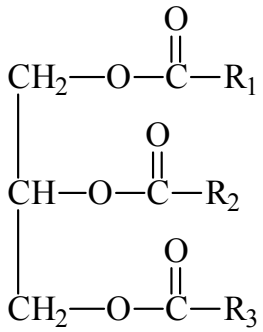
The main carbohydrate in milk is the disaccharide, lactose. It is important in the manufacture of cheese and lactic acid casein. Lactose can be fermented by lactic acid-producing bacteria (known in the dairy industry as "starter" or "starter bacteria") to produce lactic acid in accordance with the simple reaction shown below:

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 4\ CH_3CH(OH)COOH$$

In this fermentation, the pH of the milk is reduced as the acidity (as lactic acid) increases. Both cheese and lactic acid casein contain all the casein protein, and the watery by-product of the manufacture of these two classes of dairy products is whey. The principal component in whey from cheese and casein (after water) is still lactose (4.5-5%) as only a small proportion of the total lactose in milk is utilised in the fermentation mentioned above. As noted in more detail in the articles on lactose and whey products, whey is used in the manufacture of lactose, in ethanol production, for use in baby foods and for the manufacture of whey powder.

Fats (or lipids)

Milkfat consists mainly of triglycerides, esters of glycerol and three of about 20 carboxylic acids (fatty acids):



where R_1, R_2 and R_3 represent the hydrocarbon chains of the different fatty acids.

Compared with vegetable oils, the fatty acids in milkfat have a fairly low degree of unsaturation and are relatively high in the proportion of short chain (C_4-C_{10}) acids. Because of this low degree of unsaturation, milk fats are less readily autoxidised and keep better than vegetable oils. Lipolysis, the enzymatic hydrolysis of triglyceride to give free fatty acids, causes lipolytic rancidity, with butanoic acid especially providing much of the sharp taste of rancid butter. This reaction is important in the production of cheeses such as Blue Vein, Provolone and Parmesan.

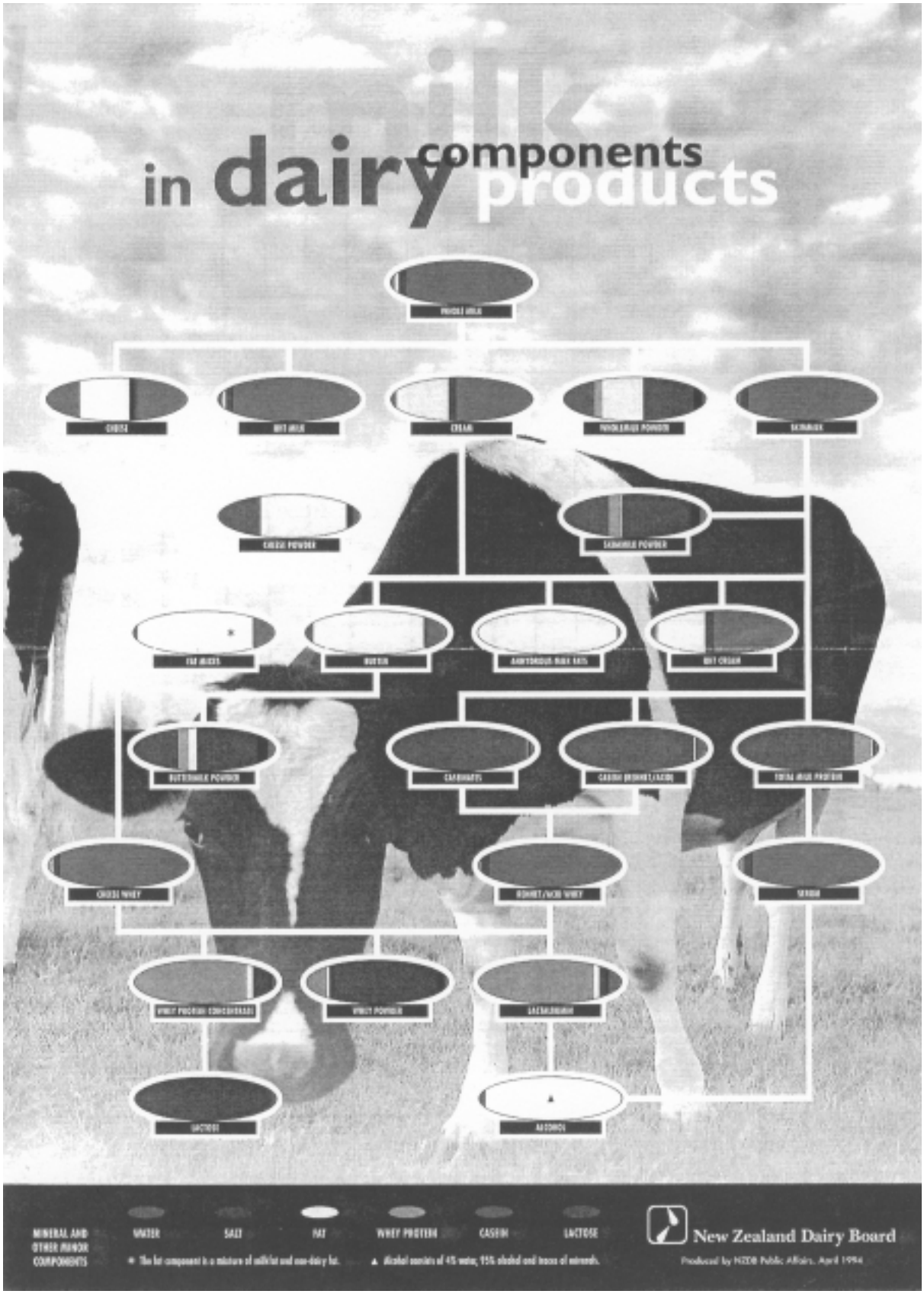


Figure 3 - Products from whole milk

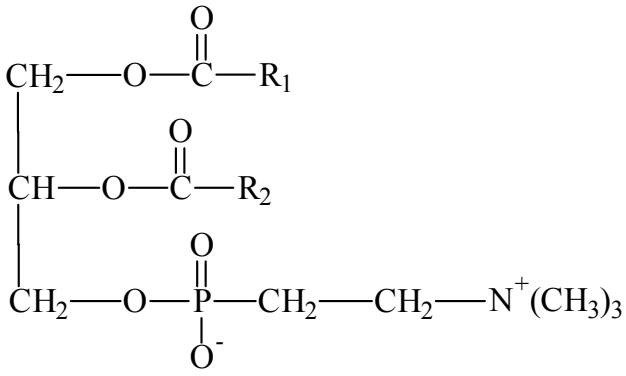
Table 5 - Quantities of certain nutritive components in milk and milk products[a] (100 g portions)

Milk product	Major components					Minerals			Vitamins			
	Water (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbo-hydrate as lactose (g)	Ash (g)	Calcium (mg)	Phos-phorus (mg)	A[b] (µg)	B_1 (mg)	B_2 (mg)	Niacin (mg)
Whole milk (pasteurised)	87.7	67	3.28	4.0	4.7	0.71	114	87	84	0.1	0.2	0.11
Standard cream	54.9	380	2.0	40.0	3.0	0.38	55	51	420[c]	0.06	0.14	-
Skim milk	91.2	34	3.46	0.2	4.9	0.73	128	96	NA	0.06	0.20	NA
Trim milk	88.9	42	4.3	0.42	5.6	0.92	146	113	NA	0.03	0.26	0.11
Butter	15.6	740	0.55	81.5	0.62	1.5	22	20	980	NA	NA	NA
Cheddar cheese (mild)	34.7	420	24.9	35.2	-	3.8	720	470	200[c]	0.06	0.5	0.06
Processed cheese	43.6	340	21.3	27.9	-	5.30	620	480	260	NA	NA	NA
Cottage cheese	79	96	14	3.5	2.1	1.29	60	120	65[c]	0.02	0.25	-
Whole milk powder	2.6	490	30.2	26.4	34.8	5.8	960	770	220[c]	0.29	2.1	-
Instant skim milk powder	5.2	350	38.7	1.3	48.5	7.7	1220	950	NA	0.25	2.1	-
Sweetened condensed milk	25.6	330	9.2	8.2	55.2[d]	1.84	290	220	60[c]	NA	NA	-

Milk product	Major components					Minerals			Vitamins			
	Water (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbo-hydrate as lactose (g)	Ash (g)	Calcium (mg)	Phos-phorus (mg)	A[b] (µg)	B_1 (mg)	B_2 (mg)	Niacin (mg)
UHT evaporated milk	74.2	140	7.5	7.6	9.9	1.62	240	230	60[c]	NA	NA	-
Sweetened fruit-flavoured yoghurt	77	92	4.4	1.8	14[e]	0.89	110	90	50[c]	NA	NA	NA
Ice cream (plain vanilla)	65	190	3.8	10.8	19[f]	0.95	120	110	10[c]	0.04	0.29	-
Recommended adequate daily intake for healthy adult men[g]							600		750	1.2	1.7	18

Note[a]: Source: Visser *et al.* (1991).
Note[b]: Includes total activity from retinol and β-carotene, unless stated otherwise.
Note[c]: As retinol.
Note[d]: Of which 43.9 g is sucrose.
Note[e]: Of which 9 g is sucrose and 1.10 g is glucose + fructose + galactose.
Note[f]: Of which 13 g is sucrose.
Note[g]: Data from New Zealand Nutrition Advisory Committee, as reported by Visser *et al.* (1991).
NA: Not analysed.
- : Not listed.

Phospholipids are also important. They are surface-active compounds and are found mainly in the fat globule membrane in products such as milk and cream where they stabilise the oil-in-water emulsion. Lecithin is an example of this class of compound. It has the following structure:



Further information on all these compounds is found in the article on milkfat products.

Proteins

The two major classes of milk proteins are the caseins and the whey (serum) proteins.

1 Caseins exist in milk as colloidal suspensions of micelles (clusters of casein molecules associated with calcium and inorganic phosphate). These give the milk its white appearance, as the micelles are large enough (20-200 nm) to scatter (reflect) light. There are several different caseins - α_{s1}-, α_{s2}-, β- and κ-casein, so-called according to their behaviour during electrophoresis (*i.e.* movement in an electric field). The α_s- and β-caseins generally consist of about 200 amino acid residues and have a molecular weight of 23 000 - 25 000, whereas κ-casein has somewhat fewer residues and a consequently lower molecular weight.

κ-Casein is believed to be located on the surface of the micelles, where it provides a stabilising effect in the milk system. In milk, the micelles carry a net negative charge which is important for maintaining their stability. A reduction in the pH (increasing the acidity) or addition of chymosin (a milk-clotting enzyme) decreases this charge, causing precipitation of the casein or coagulation of the milk. This forms the basis of the industrial production of casein.

Caseins contain a higher percentage of (organically bound) phosphorus than most proteins and are consequently considered to be phospho-proteins.

2 Whey (serum) proteins, in contrast to caseins, are soluble, and do not precipitate under conditions that cause the caseins to precipitate. They are rich in the sulphur-containing amino acids (cysteine and methionine), and are not chemically combined in milk or whey with either phosphorus or calcium.

Minerals

Metal ions present in milk in significant concentrations are Ca^{2+}, K^+, Na^+ and Mg^{2+}. About 70% of the calcium in the milk is bound to casein in the micelles (in a colloidal form), together with a similar proportion of the inorganic phosphate in the milk. Most of the

remaining calcium is bound to inorganic phosphate. The non-colloidal calcium is present either as dissolved salts (mainly with inorganic phosphate) or in an ionic form. Inorganic phosphate accounts for two-thirds of the total phosphorus content, the remainder being organically bound phosphate in casein or phospholipids.

Vitamins

Milk contains a number of important vitamins, *e.g.* vitamins B_1 (thiamine), B_2 (riboflavin) and niacin, that are soluble in water, and the fat-soluble vitamins A and E (tocopherols).

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Written by C. R. Southward (Consumer and Applications Science Section) and L. K. Creamer (Food Science Section), New Zealand Dairy Research Institute.